GLOBAL CLIMATE CHANGE AND NATIONAL PARK SERVICE MANAGEMENT

A THESIS

Presented to

The Faculty of the Department of Environmental Science

The Colorado College

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Arts

By

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May 2015

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On my honor, I have neither given nor received unauthorized aid on this thesis project.

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Abstract

The National Park Service (NPS) manages over 84 million acres of public lands in the United States. Its landscapes include some of the most visually stunning and ecologically pristine areas of the country. The parks, monuments, wildernesses, and protected areas that encompass the NPS are largely protected from human development, but that does not mean they are immune from disturbance or damage. In the past, impacts to these landscapes were largely due to poor land use decisions, such as overgrazing by cattle and fire suppression. However, a new threat – global climate change – threatens to significantly disturb these pristine areas. The NPS faces a substantial challenge in formulating effective management strategies to mitigate the impacts of climate change. This thesis investigates the system-wide response by the NPS to climate change in two ways. First, a comprehensive review of environmental management strategies was explored, with a focus on responses that could be particularly effective in a directionally changing climate. Second, a series of interviews with NPS managers and scientific researchers was conducted in order to contextualize the unique challenges that individual parks face regarding climate change. Interview responses were then discussed alongside the literature findings in order to explore the NPS' response to climate change. The thesis concludes with specific recommendations for how the NPS can improve its strategies to mitigate the impacts of climate change on its landscapes.

Chapter One

Introduction

1.1 Overview

The National Park Service (NPS) was established in 1916 by the National Park Service Organic Act. Before the establishment of the NPS, individual park units, such as Yellowstone and Yosemite, were independently managed. The Organic Act brought these distinct units under a single management structure and chartered the NPS to, "conserve the scenery and the natural and historic objects and wild life therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for future generations." This statement is often shortened to "conserve unimpaired" and has formed the basis of NPS management.

Though conservation has always been a hallmark of NPS management strategies, the NPS has prioritized different aspects of park management, such as visitor experience and iconic species health, throughout its history. These management priorities have been oft-debated with the development of conservation science and ethics. In fact, the NPS has had an intimate relationship with several of the most controversial land and environmental issues of the past century: the role of fire on landscapes, predator reintroductions, and optimal strategies for saving endangered species, to name a few. However, the NPS faces a new environmental challenge –global climate change. Given the current and projected impacts of climate change, the NPS must carefully consider best practices to "conserve unimpaired" the landscapes which they protect.

Management philosophies within the NPS are dependent upon current scientific understanding of ecological systems. In 1916, anthropogenic climate change was many decades from being an understood, or even investigated, phenomenon. Therefore, the initial management priorities of the NPS focused on preservation of the "natural" state. Secretary of the Interior, Franklin Lane, instructed the first NPS director, "Every activity of the Service is subordinate to the duties imposed upon it to faithfully preserve the parks for posterity in essentially their natural state" (Cole and Yung 2010, 12). Combining this emphasis of "natural" with an ecological worldview that emphasized static, end-state ecosystems, the present condition of protected lands became the blueprint for what to "conserve unimpaired."

Unfortunately, land management is not this straightforward; conditions change, species move, and disturbances occur. Climate change will make these complicating factors more frequent and greater in impact. The most recent Intergovernmental Panel on Climate Change (IPCC) report (2014) notes that, "Many terrestrial, freshwater, and marine species have shifted their geographic ranges, seasonal activities, migration patterns, abundances, and species interactions in response to ongoing climate change" (51). Global climate change impacts are well-studied and relatively predictable, but regional and local effects remain extremely difficult to forecast. This presents many challenges to NPS managers: what are the best strategies for managing landscapes that are rapidly changing? How do we identify a "natural" state in a directionally changing climate? What values are most important to conserve within parks in a changing climate?

These questions and more prompted the NPS to evaluate the role of climate change in parks and its effect on management strategies. In 2010, the Climate Change

Response Program (CCRP) was funded, which investigates effective climate change impact strategies for implementation in parks. The NPS has released several publications outlining their responses to climate change on a national scale, including the *Climate Change Response Strategy* (2010), the *Climate Change Action Plan 2012-2014*, *National Park Service Science in the 21st Century* (2004), and *Revisiting Leopold: Resource Stewardship in National Parks* (2012). Within these documents, the NPS acknowledges the ongoing and future impacts of climate change and its need to reevaluate its management practices and policies. A full discussion of these and other NPS publications can be found in Chapter 3.

1.2 Goals of Thesis

The central goal of this thesis is to examine how the NPS is mitigating the risks of climate change in terms of its policies and practices. Climate change response involves developing national responses that can be broadly applied while also implementing park-specific plans. In order to critically examine these strategies, a large review of effective environmental management strategies was conducted. This material includes both general environmental management literature and also NPS publications. By comparing these two sets of literature, we may evaluate if the NPS is adopting strategies recommended by the environmental management community at large.

Reviewing specific environmental management strategies through the lens of climate change is a central focus of this thesis. Climate change is forcing land managers to reconsider best practices to protect landscapes and ecosystems. A few of these ideas, such as assisted migration and managed relocation, are controversial. Others, such as

managing for ecosystem resilience, are not. These strategies are evaluated both generally and how they specifically fit into park management plans.

Furthermore, concepts of "naturalness" and their influence on park management strategies are explored. A historical perspective on "naturalness" is given, along with a contemporary review of changing ideas due to climate change. The applicability of managing for the "natural condition" is also discussed in the context of a directionally changing climate.

The final goal of this thesis is to evaluate and synthesize the variety of opinions within the NPS about best practices for dealing with climate change impacts. By gathering information from local experts, the challenges of climate change mitigation are contextualized and thus better understood. Furthermore, the applicability of national policies and recommendations from the NPS can be explored on local scales. Local park managers face challenges of funding, scale, and human resources that national policies may not recognize. If they are unable to successfully manage landscapes and ecosystems in response to climate change, then the NPS will have to develop new strategies for climate change mitigation. The thesis will conclude with a discussion of potential improvements of NPS policies and practices to better face the challenges of climate change.

1.3 Preview of Thesis

This thesis is split into chapters that explore the many facets of NPS management. Chapter Two begins with a historical review of management within the NPS. Scientific understanding and management priorities have always influenced the decisions of the

NPS. These historical management strategies are explored to give context to the current and unique challenges the NPS faces. Also, the role of naturalness in environmental management is explored. Concepts of naturalness have long influenced management decisions as the preservation of the "natural" or historic state was viewed as the primary goal of management. As ecological understanding developed, so did concepts of naturalness, which invariably impacted management strategies. This development of thought is explored throughout the second chapter.

Chapter Two also includes a discussion of a variety of strategies that attempt to mitigate climate change impacts. Climate change forces managers to go beyond simple preservation of existing landscapes; they must be proactive in promoting ecosystem health in a changing climate. This active management requires more frequent ecosystem intervention, which may be controversial as parks strive to preserve wildness within their borders. Managers will be challenged to determine which strategies are appropriate in a changing climate. A full discussion of the role of managing for ecosystem resilience and the potential for assisted migration is given in Chapter Two.

Chapter Three focuses on contemporary NPS publications regarding climate change. In recent years, the NPS has made a strong public commitment to reducing the negative impacts of climate change in parks. In 2010, the NPS established the Climate Change Response Program, to study climate change mitigation strategies and to support park-specific projects with scientific expertise. Also, the NPS has published a series of documents that outline the climate change management strategies to be implemented in the coming years. These publications include the *Climate Change Response Strategy* (2010), the *Climate Change Action Plan 2012-2014*, *National Park Service Science in the*

21st Century (2004), and *Revisiting Leopold: Resource Stewardship in National Parks* (2012).

Chapter Four discusses the methodology of the qualitative interview process, the key element of this thesis project. Six interviews were conducted with various experts and managers in the NPS. The interviewees worked in landscapes across the American West, providing a broad regional perspective. The interviews focused on specific management strategies and their implementation in a changing climate. Sub-topics of discussion from the interviews include concepts of naturalness and their effect on management, potential improvements upon the NPS response to climate change, and the need to move beyond preservation as a management goal. Interviewees' responses were recorded and utilized in Chapter Five, which discusses the results of the interviews in relation to the literature reviews.

A full overview of the interview results is given in Chapter Five. Interview statements are analyzed along the findings of Chapters Two and Three. The statements conveyed by the interviewees are often quite varied and lead to robust discussion about the different aspects of certain management strategies. Specific attention is given to the role of naturalness in management, the strategy of managing for ecosystem resilience, and the potential for assisted migration projects within the NPS. Two case studies of management projects in response to climate change are also explored, which provide necessary context to the often generalized debates about certain management responses.

Chapter Six concludes the thesis and provides specific recommendations for the NPS to implement. Endorsements about the types of specific management strategies the

NPS should pursue are given, along with general policy actions for consideration. Overall, the NPS is responding strongly to the challenges posed by climate change, but there are specific areas that must improve upon if they hope to protect their landscapes for generations to come.

Chapter 2

Literature Review

Environmental management decisions are based on a number of factors, such as ecological understanding, priority level, and future projection. The current and potential impacts of climate change affect all of these aspects, thereby making managers' decisions more difficult. Scientific consensus is also inconsistent in regards to what management strategies are most effective in a changing climate, leaving managers at a loss. This chapter will review many of these debated management strategies and explore how a changing climate and evolving ideas about naturalness require land managers to reevaluate how to most effectively protect species, ecosystems, and landscapes.

2.1 A History of National Park Service Management

In order to fully appreciate the challenges that managers face with climate change, it is necessary to look back and study the development of management strategies, both generally and within the NPS. Sellars (1997) gives an excellent overview of NPS ideologies and policies through time in Preserving Nature in the National Parks. Sellars argues that the wording of "conserve unimpaired" used in the 1916 Act essentially meant "maintain natural conditions" because that was the language used in enabling legislation that created individual parks, such as Yellowstone, before they were organized under the NPS (1997, 22) He also notes that "there seems to have been no serious attempt to define what it meant to maintain natural conditions," which led to it being "an ambiguous concept related to protecting natural scenery and the more desirable flora and fauna" (Sellars 1997, 22) Furthermore, early national parks were established for visitor

enjoyment, not wilderness preservation. Managers were more concerned with protecting the scenery and wildlife that would promote tourism; naturally, this mindset continued when the NPS was established. Sellars effectively describes this situation:

> The treatment of nature in the early national parks set precedents that would influence management for decades… activities such as combating poaching and grazing, fighting forest fires, killing predators, and manipulating fish and ungulate populations constituted the backbone of natural resource management.

Instead of researching the scientific relationships that would facilitate the protection of flora and fauna, the park service focused on removing disturbances that would decrease the scenic beauty of the parks.

In 1917, Secretary of the Interior Franklin Lane issued the Service's "basic creed" to Director Stephen Mather (Sellars 1997, 57). The letter, which came to be known as the Lane Letter, declared the national parks to be a 'national playground system' and "to be made accessible 'by any means practicable'" (Sellars 1997, 57). The next decade of park management was highlighted by building roads and improving facilities at parks in order to increase and improve tourism. Another feature of the decade was the reliance on outside sources for scientific expertise. The Park Service "assumed that its unique mandate to leave parks unimpaired did not require special scientific skills and perceptions" (Sellars 1997, 69). Consequently, the Park Service failed to establish resource management plans that were preservation-oriented. Instead, they focused on "façade management- preserving the scenic façade of nature, the principal basis for

public enjoyment" (Sellars 1997, 70). For example, the Park Service even began killing predators, such as coyotes, wolves, and cougars, in order to preserve this "façade" that the public craved. By the mid-1920s, wolves and cougars were extinct in Glacier, Yellowstone, and Rocky Mountain National Parks. The practice of predator killing was indicative of the poor scientific understanding of ecology at the time, but also of the importance that the NPS placed on removing any potential disturbances that could decrease the pristine nature of parks. (Sellars, 1997)

Ironically, by attempting to keep ecosystems and landscapes as "natural" as possible by removing all forms of disturbance, the NPS was actually creating unnatural and unhealthy systems. Fortunately, ecological research projects carried out in the 1930s started to inform management decisions. The establishment of a wildlife division resulted in the influential Fauna No. 1 report, which began to recognize the dynamic nature of ecosystems and the need for buffer zones around parks to protect migratory species. (Sellars, 1997)

Momentum for scientifically-based decision making continued with the publication of the *Wildlife Management in the National Parks* (1963), better known as *The Leopold Report*. Aldo Starker Leopold, son of Aldo Leopold, authored the report and emphasized the need for scientific research and hands-on management in parks. The report urged "the expansion of the research activity in the Service to prepare for future management and restoration programs" (Leopold et al. 1964, 7). It also acknowledged that effective management "may involve active manipulation of the plant and animal communities" (Leopold et al. 1963, 4). *The Leopold Report* also affirmed developing ecological ideas about change and disturbance by stating "most biotic communities are in

a constant state of change" (Leopold et al. 1963, 4). Previous ecological thought had emphasized the static, end-state nature of ecosystems, which is what led to the historical removal of disturbances in national parks. Even though Leopold recognized the dynamism of ecosystems, the report still recommended that "biotic associations within each park be maintained or where necessary recreated as nearly as possible in the condition that prevailed" and that "A national park should present a vignette of primitive America (Leopold 1963, 5).

In this way, *The Leopold Report* (1963) represents both historical and modern conceptions of ecology. It emphasizes the ideal of preserving the past while recommending modern techniques to accomplish it. *The Leopold Report* (1963) was written in a time where directional climate change was not a consideration, so preserving or restoring past ecosystems was seen as a tangible goal. This commitment to the past, the "primitive vignette," was tied to the idea that the natural state was equivalent to the historical condition of landscapes when Europeans first found them. In fact, concepts of naturalness have always informed environmental management, but climate change is forcing managers to reconsider how naturalness should inform their decisions.

2.2 The Role of Naturalness

The effect that the ideal of naturalness has on management decisions cannot be overstated; Hobbs et al. (2010) state that, "Naturalness is the central guiding concept in park and wilderness law and policy, the basis for deciding where, when, and how to intervene in biological and physical processes" (31). "Naturalness," however, has many different meanings that cloud how it should be applied in management decisions. Aplet

and Cole (2010) explore these various meanings. The first is "naturalness implies a lack of human effect," so "ensuring that the current composition, structure, and functioning of ecosystems are consistent with the conditions that would have prevailed in the absence of humans," becomes the management goal (Aplet and Cole 2010, 13). Another meaning is "freedom from intentional control" where "nature is self-willed, autonomous, left to its own devices" (Aplet and Cole 2010, 13). This definition directs managers to a hands-off approach, which can be detrimental in stressed ecosystems. A third influential meaning is that "a natural area is one that is true to the historical condition of the ecosystem" (Aplet and Cole 2010, 13). This interpretation points managers toward strategies that attempt to preserve or restore ecosystems towards a condition that may not be ideal with ongoing climate change. These various meanings of naturalness give managers differing recommendations on how to effectively manage their landscapes. More importantly, these management strategies related to naturalness may be flawed in a rapidly changing climate. (Aplet and Cole, 2010)

The first definition, "naturalness implies a lack of human effect," is somewhat flawed because it gives a vague target for what a "natural" ecosystem is (Aplet and Cole 2010, 13). At what point is an ecosystem affected by humans? Are managers supposed to consider the role of indigenous populations on the landscape? Aplet and Cole (2010) discuss the role of Native Americans and how they had a significant impact on the landscape through hunting and burning.

> On sites that have been highly affected by human activity for millennia, the distinction between natural and artificial becomes blurred. If the purpose of protected areas is to preserve natural conditions and yet there is

> no objectively determined condition that can be called natural, the very purpose of protected areas is called into question (18).

The second interpretation of naturalness directs managers to a detached approach that is hotly debated in the context of climate change. Peter Landres defends a hands-off approach in Beyond Naturalness as a way to protect wildness, reduce the chances of adverse consequences in ecosystems, and foster scientific humility (2010). Unfortunately, a hands-off approach may not be ideal given how protected lands are still substantially affected by humans. The fact that protected lands are surrounded by unprotected areas often results in negative effects within park boundaries. As Stephenson et al. (2010) state in reference to Hansen and Defries (2007):

> Land use changes around a protected area, such as residential development, conversion to agriculture, or timber harvests, can have substantial effects on the reserve itself, such as through changes in ecological flows into and out of the reserve, loss of habitat crucial to mobile organisms, increasing exposure to invasive species along reserve edges, and changes in effective reserve size. (53)

With increasing human pressures around protected areas, a hands-off approach could simply compound the impacts that reserves experience as a result of the land practices outside their boundaries. Furthermore, the role of ecological thresholds becomes even more important with climate change. Managers must avoid situations where "the ecosystem has been altered so fundamentally that eliminating the original cause of the

problem, or simply leaving that system alone to restore itself, no longer resolves the situation" (Cole and Yung 2010, 3).

It seems counterintuitive that promoting naturalness in parks may require more hands-on management. Cole (1996) refers to this as the "dilemma of wilderness management" (15)–"maintaining historical ecosystems or keeping ecosystems on the trajectory they would be on in the absence of human effects entails intentional and repeated human intervention" (Aplet and Cole 2010, 21). Minteer and Collins (2010) state that environmental management in the 21st century "will require us coming to grips with a significantly more activist and hands-on approach to species conservation than we have taken in the past" (1802). Active management can also be extended to policy and management structures. Hobbs et al. (2011) discuss the increasing prevalence of interventionist methods and state "interventions may also include altering policy and broader socioeconomic settings" and "changing rules and governance approaches may have a much more profound effect than tinkering with ecosystem properties" (443).

Even though ecologists have come to appreciate the dynamism of ecosystems, managers are still focused on the restoration of a past state. Stephenson et al. (2010) note that *Management Policies 2006* "call for the restoration of naturally functioning ecosystems and, if this is not possible, for the restoration and maintenance of 'the closest approximation of the natural condition'" (51). A full account of NPS policies and publications is given in the next chapter, but this single anecdote illustrates the influence that naturalness still has on policy and how traditional restoration remains a primary goal within environmental management. Aplet and Cole (2010) state that, "This notion of historical fidelity is rooted both in a nostalgic connection to history and in an ethical duty

to pass on to the future what was inherited from the past" (13). Stephenson et al. (2010) maintain that managers must divorce themselves from this historical perspective:

> [I]n the face of a suite of novel environmental conditions, restoration of ecosystems to resemble those of the past provides no guarantee of their sustainability into the future and in fact might lead to the catastrophic loss of some of the very ecosystem elements intended for preservation. (58)

These three primary interpretations of "naturalness" and their resultant management objectives are all flawed after considering climate change. For this reason, Cole and Yung (2010) urge managers that, "It is time to think beyond naturalness, to articulate park purposes in terms that are both more specific and more diverse than naturalness and adopt a wider array of management approaches to achieve these purposes" (2). The following section covers many of these possible management strategies within the context of climate change.

As ecological understanding has developed, conserving biodiversity has emerged as the primary goal of park management. However, this prioritization of ecological health over more utilitarian purposes does not imply that ecologists and managers have perfectly figured out how to optimally conserve biodiversity. Ecosystems are inherently complex, and the interactions that keep ecosystems healthy, such as disturbance events, are still not fully understood. Climate change further compounds the complexity of managing for biodiversity, and there is widespread debate about how to optimize biodiversity in a changing climate. The following section will cover many strategies that are aimed at managing for biodiversity and how they can be effectively applied to the NPS.

2.3 Managing for Ecosystem Resilience

One of the central management strategies in a changing climate is managing for "ecosystem resilience." "Ecosystem resilience" is similar to "naturalness" in the fact that it has many definitions that affect how it is used in management. "Ecosystem resilience" often refers to "the ability to sustain environmental shocks and stresses without undergoing an undesirable and irreversible change in conditions" (Stephenson et al. 2010, 63). Hobbs et al. (2010) give a much more flexible definition:

> Managing park and wilderness areas for ecological resilience might emphasize retaining ecosystem function over preserving specific species in situ. It might require letting go of the way landscapes look today, as conditions change, and identifying key processes to retain in the face of change, such that, although many other variables shift around, core functions and processes are preserved (488).

When managing for "ecosystem resilience," it is completely plausible for a manager to have multiple, viable options depending on what values he or she is trying to protect. A manager could manage for resilience by attempting to protect a keystone species or by stabilizing hillsides to reduce erosion. Managing for resilience can also be challenging because it is not explicitly clear as to what the best practices are. For example, if a manager has a species-oriented approach, it is often quite clear what strategies are best for optimizing the health of that one species. Managing for ecosystem resilience is harder to conceptualize. Hobbs et al. (2010) give some suggestions, such as "building linkages across multiple scales" and "allowing sufficient disturbance so that systems can adjust to persistent changes in underlying controls" (488).

Interestingly, allowing natural disturbances to run their course can actually make ecosystems more resilient. Folke et al. (2004) describe this process:

> Disturbance releases the climax state and is followed by renewal and reorganization. We refer to those phases as the back-loop of ecosystem development (Gunderson & Holling 2002). Functional roles in the back-loop and sources of resilience are critical for sustaining an ecosystem within a desired state in the face of change (Nystrm & Folke 2001). (571)

In the American West, fire is the most common disturbance, and certain ecosystems are dependent upon semi-frequent fire regimes to be sustainable. The NPS only has to look at the Yellowstone fire of 1988 to see what can happen when disturbance regimes are not allowed to run their course. The removal of small-scale surface fires set the stage for destructive landscape-scale, crown fires. By allowing small-scale disturbances to play out, managers reduce the chances of catastrophic disturbances, thereby making ecosystems more resilient. Given that disturbances such as drought and extreme weather events will happen more frequently with climate change, learning how to properly manage disturbance regimes is imperative for the NPS.

2.4 Active Intervention in Ecosystems

Allowing disturbances to occur, or even promoting them, requires that managers take a more active approach in managing their landscapes. However, constant intervention in ecosystems is not very popular because it is viewed as unnatural. It seems counterintuitive that promoting naturalness in parks may require more hands-on management. Cole (1996) refers to this as the "dilemma of wilderness management"

(15): “maintaining historical ecosystems or keeping ecosystems on the trajectory they would be on in the absence of human effects entails intentional and repeated human intervention” (Aplet and Cole 2010, 21). Minteer and Collins (2010) state that environmental management in the 21st century “will require us coming to grips with a significantly more activist and hands-on approach to species conservation than we have taken in the past” (1802). Active management can also be extended to policy and management structures. Hobbs et al. (2011) discuss the increasing prevalence of interventionist methods and state “interventions may also include altering policy and broader socioeconomic settings” and “changing rules and governance approaches may have a much more profound effect than tinkering with ecosystem properties” (445).

Ideally, ecosystems would be healthy enough that active intervention would be unnecessary because they would always return to a productive state, but a history of land use malpractice and poor management decisions have made that goal unattainable. Hobbs et al. (2010) state, “Given the unprecedented environmental changes of the twenty-first century, simply recognizing that the old rules do not necessarily apply is an important initial step toward a realistic view of how ecosystems work,” (45) and also, “human intervention in ecosystems may be essential to protect critical values in parks and wilderness areas” (51).

Taking a more active role in ecosystem management can vary from the uncontroversial, promoting ecosystem resilience, to the highly disputed, intentionally moving species. There is a spectrum of intervention with the movement of species. Some methods, such as reintroduction, are often not very controversial within the scientific community given modern conceptions of ecology. Controversy can arise in public sector,

such as with the reintroduction of wolves in the Rocky Mountains. Other methods, such as assisted migration and managed relocation (defined below), are highly debated in both the scientific and public domains. Schwartz et al. (2012) put the severity of the situation in perspective, "The magnitude of projected climate change… suggests that humans may be forced to choose between the unfortunate alternatives of witnessing extinctions and intentionally manipulating species' distributions in efforts to prevent extinction and maintain biodiversity" (732). The potential loss of species has prompted many researchers to investigate the widespread potential of species movement.

Assisted migration and managed relocation are the two most commonly debated methods of species movement. Though often used interchangeably, the two actions are quite different. Assisted migration is the act of "introducing a species into a new location by bringing propagules or individuals and releasing them" (Schwartz et al. 2012, 733). Managed relocation is "the intentional act of moving species, populations, or genotypes to a location outside a known historical distribution for the purpose of maintaining biological diversity or ecosystem functions as an adaptation strategy for climate change" (Schwartz et al. 2012, 733). Which of these methods is proposed depends on the specific struggles that a species is facing. For example, Joshua Tree National Park is planning a managed relocation project to plant Joshua Trees in more northern climates to help the species persist. Joshua Tree National Park is projected to be inhabitable for its iconic species due to climate change, and it is unlikely that Joshua Trees will be able to migrate quickly enough to suitable habitats.

Minteer and Collins (2010) argue that the effects of climate change will be so severe that moving species is the only option for preventing extinctions in some cases.

They envision ecosystem managers' role changing to be "makers of novel ecosystems for stressed populations" (Minteer and Collins 2010, 1802). They argue for the use of managed relocation because "traditional in situ conservation methods are no longer sufficient to save threatened species due to climate change" (Minteer and Collins 2010, 1803). They also defend managed relocation from a moral standpoint because humans have traditionally worked to protect species, and this is just the next logical step: "saving at least some species will require solutions more radical than creating parks and shielding endangered species from bullets, bulldozers, and oil spills: It will require moving them" (Minteer and Collins 2010, 1801).

Moving species around has the potential for significant unintended consequences, especially in the context of a changing climate. The potential for unintended and disastrous consequences as a result of the movement of species is well-covered in academic literature. Ricciardi and Simberloff (2009) argue that conservation biology does not have an adequate understanding of the impacts of introduced species to justify the managed relocation of species. The first reason they give is that "shifts in species range associated with prehistoric episodes of climate change occurred over much longer time periods and allowed for coevolution with recipient communities" (Ricciardi and Simberloff 2009, 248). The pace of contemporary climate change is much greater than studied examples in the past, which raises doubts about the movement of species, even to similar environments that they could theoretically adapt to given enough time. Ricciardi and Simberloff (2009) use the example of *Mysis relicta*, a species of shrimp that was introduced from the Great Lakes to Flathead Lake (Montana) to enhance the diet of non-native kokanee salmon. However, due to a lack of upwelling currents in the lake, the

shrimp were not available to the kokanee salmon, causing the salmon population to crash via competition for food. The crash of the salmon population had disastrous consequences for the eagle population that relied on the salmon as their primary food source. This sad situation shows that even well-intentioned, intra-continental species translocations can backfire. Ricciardi and Simberloff (2009) state, "we cannot safely assume that an introduced plant or animal will be benign solely because it appears similar to a resident species," and that "competition with native species is also more likely to occur when a functionally similar species is introduced, and cause the exclusion of the native species" (250). Ricciardi and Simberloff (2009) also warn against assuming that a translocation has been successful after no negative consequences have been detected for a few years. They state:

> Lag times in the spread or onset of impacts of invaders are a common phenomenon. The impacts of an introduction might not be fully realized until decades after the human-assisted transfer and cultivation of a species. Thus, introductions that initially inconsequential can later prove to be harmful when it is no longer feasible to control them. One factor contributing to this phenomenon is the interaction of the invader with multiple environmental drivers that change with time, including climate change. (251)

A history of failed introductions and uncertainty about the future cause Ricciardi and Simberloff (2009) to conclude, "assisted colonization is tantamount to ecological roulette and should probably be rejected as a sound conservation strategy by the

precautionary principle" (252). Other authors feel that such sweeping generalizations about assisted migration and managed relocation are unwise.

Olden et al. (2011) argue that managed relocation must be evaluated on regional or case-by-case bases. They believe it is unwise to simply support or oppose the movement of species in all cases in response to climate change. To illustrate this point, they investigate the potential for the movement of freshwater species and the various conditions that would improve the chances of successful movement. They chose freshwater species as a case study because of the barriers to migration that many freshwater species face. It will be easier for terrestrial species to migrate in response to climate change because they will not encounter terminating barriers such as waterfalls, dams, or saltwater boundaries. This makes the prospect of managed relocation for freshwater species more applicable. Olden et al. (2011) only support the movement of species within their historic range, saying, "It is highly unlikely… that non-native species will be candidates for managed relocation" (43). They reject the prospect of managed relocation partly because "geographically proximate river basins are often so genetically and ecologically distinct that new colonizations, even from nearby source populations, could have large ecological effects" (Olden et al. 2011, 43). Potential approaches for reducing the risk with the movement of species include only moving species within their historic range, relocating species above large barriers to prevent downstream movement, and focusing on species with low maximum rates of population growth. They also recommend only relocating species to "areas that have not been highly affected by human activities or non-native species" (Olden et al. 2011, 45). The process of this approach is applicable to all environment types. Evaluating the potential for assisted migration and

managed relocation in a case-by-case, objective fashion has the potential to significantly reduce the risks surrounding artificial species movement and improve the future prospects for imperiled species.

Chapter Three

National Park Service Literature Review

In recent years, the NPS has released a series of publications regarding management strategies and climate change. These publications have coincided with widespread scientific and public acknowledgement of ongoing and future climate change impacts. This chapter will review these various publications and compare NPS management practices and policies to the general management methods discussed in the previous chapter. The documents to be reviewed include *Management Policies 2006*, the *Climate Change Response Strategy* (2010), *Revisiting Leopold: Resource Stewardship in the National Parks* (2012), the *Green Parks Plan* (2012), and the *Climate Change Action Plan* (2012).

3.1 *Management Policies 2006*

Management Policies 2006- The Guide to Managing the National Park System is the most recent publication for all NPS employees that directs day-to-day activities and decisions. The NPS management policies are revised "at appropriate intervals… to respond to new laws and technologies, new understandings of park resources and the factors that affect them, or changes in American society" (2006, 5). Although, the NPS has not released a new management guide since 2006, the documents listed above discuss the role of climate change in the park system at length.

Climate change concerns are not an explicit focus in *Management Policies 2006*. In fact, the phrase "climate change" appears only twice in the entire document: first, in the context of collecting meteorological data to monitor climate change and again when

discussing the ability of parks to educate the public about unique issues. However, specific instructions related to management strategies in the face of change are included. As referenced in the previous chapter, *Management Policies 2006* mandate:

> Biological or physical processes altered in the past by human activities may need to be actively managed to restore them to a natural condition or to maintain the closest approximation of the natural condition when a truly natural system is no longer attainable. Prescribed burning and the control of ungulates when predators have been extirpated are two examples. Decisions about the extent and degree of management actions taken to protect or restore park ecosystems or their components will be based on clearly articulated, well-supported management objectives and the best scientific information available. (37)

This statement contains a few encouraging phrases about the options that NPS managers have at their disposal. First, it allows for active intervention methods towards overall ecosystem health. Also, it recognizes that returning to the "natural system" is not always attainable (2006, 37). However, there is still a strong dependence on the concept of "natural" without any clear definition of what "natural" means.

Management Policies 2006 also direct managers to work cooperatively with adjacent land entities in order to reduce impacts within parks. As discussed in the previous chapter, land use practices outside of parks have a profound impact on ecosystems within parks, so it is encouraging to see this concept exhibited in park policy.

3.2 *Climate Change Response Strategy* (2010)

The *Climate Change Response Strategy* (2010) provides the clearest information regarding the effects of climate change on NPS practices and policies. The report acknowledges that "Global climate change threatens the integrity of our national parks. It challenges the NPS mission to leave park resources unimpaired for future generations unlike any threat in our history" (2010, 3). It also concedes that "climate change is likely to create conditions and ecosystems unlike any found today, upholding our mission may require updating interpretations of policy, mandates, and approaches to resource stewardship" (2010, 3) Individual responses to the idea of changing policies, and even the NPS mission, will be covered in Chapter Five.

The *Climate Change Response Strategy* (2010) also recommends an active management approach, stating: "The lack of certainty about specific impacts does not mean we should not act. In fact, inaction may be the riskiest decision of all because climate change is a long-term problem that carries a huge procrastination penalty" (5). This active approach strives to be adaptive, incorporating knowledge to inform management decisions as they are executed. A crucial report objective is to "Evaluate and enhance existing cultural and natural inventory and monitoring programs to address climate change and establish new programs as needed" (13).

As part of their climate change investigations, the NPS is also investigating the concepts of ecosystem resilience and connectivity. The report states "Many best-management practices for conventional ecosystem stressors also reduce the tendency of these stressors to intensify climate change effects;" (2010, 15) managing for ecosystem resilience has the potential to do just that. The report goes on to say, "By focusing on resilience, NPS ecosystem adaptation goals and practices reflect current understanding of

ecosystem dynamics, which allows managers to accommodate and respond to emerging knowledge of climate change effects and alternative management strategies that can lessen the impacts" (2010, 15). In terms of connectivity, the report directs managers to "Collaborate to develop cross-jurisdictional conservation plans to protect and restore connectivity and other landscape-scale components of resilience" (2010, 16O.

Two of the report's primary objectives increase information and understanding about climate change and its impacts, for both the public and the park service employees. Climate change will be a pivotal issue of the 21st century, and it is imperative that the public understands how to reduce their own environmental impacts.

The *Climate Change Response Strategy* (2010) also considers the potential for changing policy regarding climate change. The report states "Most resource protection laws with which the NPS must comply were not written in considering a changing climate" (2010, 23). The NPS further considers the following hypothetical questions as a result of climate change:

> How does the NPS reconcile its definition of "natural" (absence of human dominance over the landscape) with the effects on resources resulting from climate changes that are understood to be caused, at least in part, by human activities? How does the NPS comply with mandates and policies for conservation and maintenance of natural conditions? (23)
>
> How does the NPS comply with the "no impairment" mandate when the geographic range and even existence of resources is threatened by climate change? (23)

> Under what circumstances is active manipulation/intervention (e.g., assisted migration or colonization) desirable or warranted to save a species? (23)

These key questions were explored in the interviews conducted for this project and will be discussed in Chapter 5.

3.3 *NPS Climate Change Action Plan 2012-2014* (2012) and the *Green Parks Plan* (2012)

The *NPS Climate Change Action Plan 2012-2014* (2012) and the *Green Parks Plan* (2012) complement the *Climate Change Response Strategy* (2010) by focusing on specific actions the NPS can implement. The *NPS Climate Change Action Plan 2012-2014* (2012) "is meant to provide overall guidance to help park and program managers prioritize decisions so that, as a whole, high-priority NPS actions are coordinated, focused and integrated" (10). The *Climate Change Action Plan 2012-2014* (2012) will be revised every two to three years by the Climate Change Response Program. One of the main objectives of the *Climate Change Action Plan 2012-2014* (2012) is to identify high or near-term priority actions that can be accomplished on a limited budget. The report focuses on "high-priority no-regrets actions… that can be initiated now and are beneficial regardless of how future conditions unfold" (13). The report identifies eight areas of emphasis:

1. Enhance Workforce Climate Literacy
2. Engage Youth & Their Families
3. Develop Effective Planning Frameworks & Guidance
4. Provide Climate Change Science to Parks

5. Implement the *Green Parks Plan* (2012)
6. Foster Robust Partnerships
7. Apply Appropriate Adaptation Tools & Options
8. Strengthen Communication (

All of the "high-priority no-regrets actions" to which the NPS is currently committed meets one of the eight objectives listed above (2012, 13). Examples include: "Require all projects submitted to Developmental Advisory Board (DAB) address climate change impacts," "provide scenario planning guidance and training," and "Create regional climate change strategies" (2012, 21). Implementation of these "no-regrets actions" will help inform the NPS of how to effectively manage for climate change while simultaneously improving the resilience of parks (2012, 13).

The *Green Parks Plan* (2012) seeks to improve sustainability and reduce greenhouse gas emissions within the NPS. Though the energy used by the NPS has a negligible impact on climate change, it is using its unique position as an environmental leader to set an example of proper sustainable action in the 21st century. The NPS has established nine objectives to act more sustainably:

1. Continuously Improve Environmental Performance
2. Be Climate Friendly and Climate Ready
3. Be Energy Smart
4. Be Water Wise
5. Green Our Rides
6. Buy Green and Reduce, Reuse, and Recycle

7. Preserve Outdoor Values
8. Adopt Best Practices
9. Foster Sustainability Beyond Our Boundaries

3.4 *Revisiting Leopold: Resource Stewardship in the National Parks* (2012)

In light of climate change and improved understanding of ecological phenomena, the NPS published *Revisiting Leopold: Resource Stewardship in the National Parks* (2012). This document serves to update and improve upon the original *Leopold Report* (1963) to address the modern natural resource challenges that NPS currently faces. The report examined three critical questions:

1. What should be the goals of resource management in the National Park System?
2. What policies for resource management are necessary to achieve these goals?
3. What actions are required to implement these policies? (2012, 8)

The NPS found that many of the original *Leopold Report* (1963) conclusions remain "valid and significant" (8). These include the need for active intervention in ecosystems, the importance of scientific research as the basis for decision-making, and the need to recognize a diversity of management strategies for various problems. *Revisiting Leopold* (2012) also extends many of the strategies from the original report to modern ecosystems in a directionally changing climate. *Revisiting Leopold* (2012) emphasizes the need for connectivity between parks in order to increase ecosystem resilience. It also takes an ecosystem-oriented approach, stating, "the functional qualities of biodiversity, evolutionary potential, and system resilience matter as much as observable features of iconic species and grand land- and seascapes" (2012, 10).

The NPS further acknowledges the challenges of climate change in answering one of the fundamental questions of the publication: "The overarching goal of NPS resource management should be to steward NPS resources for continuous change that is not yet fully understood, in order to preserve ecological integrity and cultural and historical authenticity" (2012, 10). The NPS is also committed to specific strategies to mitigate the impacts of climate change on park ecosystems. These include "prioritizing the protection of habitats that may serve as climate refugia, ensuring the maintenance of critical migration and dispersal corridors, and strengthening the resilience of park ecosystems" (2012, 14-15). In terms of the NPS's proposed actions, incorporating "climate change science" is a key step (2012, 20). It also acknowledges that "structural changes and long-term investment are necessary to preserve the natural and cultural resources of the National Park System" (2012, 23). Overall, *Revisiting Leopold* (2012) updates and improves upon the original report by advocating a more adaptive approach that moves beyond the idea of preserving "vignettes of America" (Leopold et al. 1963, 5).

Chapter Four

Methods

This research project investigated the on-the-ground work that the NPS is conducting in various parks and monuments in response to climate change. The NPS has publicly acknowledged the need for climate adaptation work within the park system, so this research project served to review whether the NPS is effectively accomplishing their publicly stated goals. The project relied on a qualitative research process that consisted of conducting interviews, transcribing the interviews, coding responses, and organizing the responses into pertinent themes for use in. Following is a description of each individual step of the qualitative research process.

Potential interviewees were selected based on their role in the National Park Service and their involvement with climate change-related issues. Individuals in management positions or with direct research experience were contacted. Potential interviewees were contacted by email and asked about their availability. To support the interview process and support travel to various national parks or management locations, I received $1000 from the Colorado College Venture Grant Program. In total, six interviews, in groups of up to three individuals, were conducted. Information regarding the interviews can be found in the Appendix.

Interview participants were informed of the purpose of the interview and were ensured that any comments they made would not be used out-of-context and would not be directly tied to them. Participants were all asked an identical core set of questions, but

miscellaneous person or location-specific questions were also included. For example, questions about threatened and endangered species varied across interviews.

In-person interviews were recorded with either a recorder or on the "Voice Memos" app found on the iPhone. Phone interviews were recorded with the "TapeACall: Pro" app available on the iPhone. Interviews were then either directly transcribed from the device or uploaded to Express Scribe Transcription Software to allow for easier transcription. Interviews were transcribed word-for-word as accurately as possible.

Upon completing the transcription process, interviews were coded, as described in Interviews in Qualitative Research (King and Horrocks, 2010). The first step of the coding process was "descriptive coding," which involved listing brief comments or "codes" that corresponded to participants' responses. This was done by hand on hard copies of the transcripts. These descriptive codes did not attempt to elucidate deeper meaning from what the speaker was saying, they simply recognized the topic of conversation for organizational purposes. Next, similar descriptive codes were grouped into interpretative codes for the purpose of grouping similar ideas. Individual interviews usually consisted of about 40 interpretative codes. Finally, similar interpretative codes were grouped into overarching themes. For example, the interpretative codes "resilience and restoration," "meanings of resilience," and "measuring resilience" are all grouped under the overarching theme of "ecosystem resilience." A full list of overarching themes and their corresponding interpretative codes can be found in the Appendix.

By utilizing this coding process, it is possible to compare responses from interviewees in a systematic format. Furthermore, it allows for their responses to be referenced in the Discussion section while covering various topics.

Chapter Five

Discussion

This chapter utilizes direct quotes from interviews to compare the personal perspectives of NPS employees with general literature and NPS publications concerning environmental management and climate change. It will also focus on three specific case studies of interesting projects that the NPS is carrying out, supporting, or considering in response to climate change impacts.

5.1 The Role of Naturalness in Management

A variety of topics were discussed in each interview, such as ecosystem resilience, assisted migration, and the role of disturbance. However, the primary focus in all of these conversations was the role of naturalness and how it continues to affect decision-making in the NPS. To review, "Naturalness is the central guiding concept in park and wilderness law and policy, the basis for deciding where, when, and how to intervene in biological and physical processes" (Yung and Cole 2010, 31). However, naturalness as a guiding concept is vague and may lead to differing management actions depending on individual interpretation. Climate change further complicates managing for naturalness because "Anthropogenic change is both ubiquitous and directional, and restoration of key aspects of naturalness (such as historical fidelity) is likely to be both unattainable and undesirable" (Stephenson et al. 2010, 57).

I asked all interviewees how concepts of naturalness influence the decisions they make as managers or researchers. One interviewee emphasized the functionality of ecosystems, rather than their exact historic state, as their important natural characteristic:

> Concepts of naturalness, that's, you know, sort of in wilderness and in Park Service sort of philosophies, and…to me it's sort of like…working with the potential of the land, of the species that you have, and the landscape you have, and trying to realize something that's sort of functional and stable, something that works.

Another interviewee concurred, stating: "Another definition is to say naturalness consists of an ecosystem that can accomplish this, that, and the other." One final statement about the developing ideas surrounding naturalness in the NPS follows:

> Natural is less about a particular, historic plant community composition that was believed to have been in place in 1900, or, you know, some historic time in the past. Naturalness is less about that than it is about the functioning of natural processes like pollination, establishment, and unaccelerated mortality, and migration

These comments regarding naturalness reflect contemporary understandings of the dynamism of ecosystems. The NPS has separated themselves from the hands-off and historical interpretations of naturalness discussed in Chapter 2. This is not to say that the idea of naturalness is being ignored within the NPS. It is still incorporated into management practices and policies, as seen in *Management Policies 2006*. A few interviewees feel that the NPS must continue to explore and define what "natural" means in a changing climate.

> I think we are definitely grappling with the prevalence of the concept of naturalness in our policies and that's happening on a few different levels.

> What are those desired conditions we want to see in parks and that's really the big challenge is coming up with those measures, what do we want to see, what is natural under continual directional change? That's the real difficult question in that there's no simple answer to that.

The continuous evaluation of the effect of naturalness on management is a crucial task for the NPS. As discussed in Chapter Two, definitions of "natural" vary between individuals and also change with developing ecological thought and human-environment interactions. Regarding the relationship between naturalness and management, one interviewee stated that "every generation of resource managers cycles through this question." Climate change is demanding contemporary discussions about naturalness. The next major consideration that resource managers face is referenced above: "what is natural under continual directional change? That's the real difficult question in that there's no simple answer to that."

Directional change is a prime consideration for the NPS, as it fundamentally alters how managers attempt to "maintain the closest approximation of the natural condition when a truly natural system is no longer attainable" (NPS 2006, 37). What do managers shoot for when there is no "closest approximation?" How do they prioritize various factors of a healthy and functioning ecosystem? One interviewee said the following: "climate change isn't one of those disturbances where you go back to some previous equilibrium, this is directional change and we're headed into a different trajectory and the future won't look exactly like the past." This challenge has prompted many within the NPS to call for additional guidance as management decisions become increasingly difficult and landscapes lose their historical character.

5.2 Guidance versus Flexibility for Managers

Climate predictions are notoriously unreliable on the regional or local scales required by managers to incorporate climate change impacts into their management plans. It is difficult, if not impossible, for managers to know what the new natural state is and how to best manage it. Some argue that national guidelines are needed to ensure managers optimally respond to climate change impacts while others believe that managers need flexibility in order to effectively protect the landscapes that they know best. This debate is evidenced in the diversity of comments below (each comment is from a different speaker):

> [F]or managing and making good decisions in a dynamic, directionally-changing climate, we have to figure out how to provide more specific guidance.
>
> I think that, that autonomy is what allowed this park to do the ecological treatment
>
> Yeah, and I actually believe it's a conversation that we need to have as, for the National Park Service to give clearer direction, but I'm not uncomfortable, and I'm sure many of my colleagues, other superintendents, are not with the, with the flexibility we have, but I think it's time [for] some guidance on what we can and can't do.
>
> right now, without that guidance, but then, you know, 50 years from now when people look back at our work, they say "god, what were those people thinking?" [laughs] And they do have, maybe have some guidance, then,

> you know, maybe it won't be so good, it's really hard, you know, there is no, there are no procedures in place, there are some strategies out there, there are things you know about, things you hear about, and then you look at your piece of land, and you go "Ok I think this would be a good thing.

Striking the right balance between guidance and flexibility will be crucial for the NPS as its managers confront climate change issues. One critical strategy that may reduce the need for supervision is improving managers' understanding of climate change impacts and what strategies mitigate these effects. "Enhancing workforce climate literacy" is the first listed priority of the *Climate Change Action Plan 2012-2014* (NPS 2012, 20). In commitment to this goal, the NPS attempts to "ensure that managers can address climate change as part of routine operations" (2012, 20). One way the NPS will achieve this goal is by hosting a video training series led by park superintendents that have effectively implemented projects that helped mitigate climate change impacts.

Although many within the NPS feel that more guidance is necessary in light of climate change, implementing national recommendations may prove difficult given the diversity of landscapes and ecosystems. Mandating managers to treat all endangered species, stressed ecosystems, or disturbance events in a similar fashion could prove illogical and ineffective. For example, Grand Canyon National Park is currently running a successful captive breeding program for California condors, an endangered species. However, captive breeding is by no means the ideal option for all endangered species. Adopting regional approaches that focus on sharing scientific data and effective management strategies must be implemented amongst managers of similar environments.

5.3 Managing for Ecosystem Resilience

"Ecosystem resilience" is a term of increasing prevalence as climate change impacts become more obvious and severe across ecosystems. To review, "ecosystem resilience" has multiple definitions that lead to various management foci depending on interpretation. Definitions range from the ability to bounce back to a previous state to a focus on ecosystem processes and functions, such as pollination and migration. Interviewees' statements below reflect these varied interpretations of "ecosystem resilience" and also its importance in management.

> Basically, it means the ability to recover from a disturbance back to something similar to what you had.

> Some of the definitions for resilience involve bouncing back to a preexisting state.

> you know, you're still maintaining processes even though the players on the landscape, species, are completely different. You still have a functioning system.

> one of the concerns with that term 'resilience,' that comfort factor that people assume that they can keep what they had in the past, and that may be appropriate in some cases, and certainly in the short term in many cases, and in the long term and for many vulnerable resources, that's not going to work.

The difference between the "bounce back" mentality and the ecosystem processes focus is indicative of contemporary ecological thought. The dynamism of ecosystems is broadly accepted, as previously discussed with the *Leopold Report* (1963), but ecological restoration with the goal of preserving historical fidelity remains a common aim of land management. This is often due to the emotional tie that people have between a place and its appearance. Climate change is forcing both land managers and the public to rethink how lands are managed and whether a preservationist focus is appropriate. Managing for climate change will likely entail accepting fundamental changes to how specific ecosystems and landscapes look, a difficult transition for many to accept.

5.4 Restoration for Resilience

Though the climate and landscapes are changing, restoration work can still be effective, especially if it helps improve "ecosystem resilience." I use the definition of "ecosystem resilience" that focuses on ecosystem function. Many effective restoration projects treat areas with a history of poor land use practices. The restoration work actually helps the ecosystem become more "natural" while also mitigating the impacts of climate change on the ecosystem. I had the opportunity to discuss various restoration projects with land managers during the interview process. Two projects stand out for their ability to reduce the effects of past land use decisions and to improve the resilience of the ecosystem through a restoration project.

The first is taking place in Bandelier National Monument. The situation at Bandelier National Monument is unique because of its role in protecting Pueblo Indian historical sites. Discussion surrounding a potential overreliance on preservation of natural

resources was covered in Chapter Two, but the situation with cultural resources is quite different. Preservation of cultural resources is often appropriate given the controllable nature of cultural sites. Parks such as Bandelier frequently contain impressive natural features, but were originally chartered to protect cultural resources. As such, management priorities are weighted towards protecting the cultural resources. Interestingly, the protection of natural and cultural resources is coupled at Bandelier National Monument.

The main problem at Bandelier is accelerated soil erosion that threatens both ecosystem health and the integrity of cultural sites. The soil erosion problem is tied to a long history of poor land use decisions. Decades of overgrazing within the park destroyed the understory. Livestock ranching was permitted within the park until 1932, and feral burros were not removed until the 1970s (Sydoriak et al. 2000). Destruction of the understory also decreased the prevalence of widespread surface fires that thinned stands of pinyon and juniper. Fires were further suppressed on an institutional level by the federal government. The removal of periodic fire on the landscape has allowed pinyon and juniper to more effectively compete for water and nutrients, preventing the establishment of grasses and shrubs on the mesa. This positive feedback has allowed a closed-canopy system to develop. Sydoriak et al. (2000) succinctly describe the problem of a closed-canopy environment:

> Bandelier's PJ woodlands were formerly more open, with well-developed herbaceous understories that: 1) protected the soils from excessive erosion during intense summer thunderstorm events, and 2) provided a largely continuous fuel matrix, which allowed surface fires to spread through the

> woodland zone from the adjoining ponderosa pine and grassland types (211).

The development of a closed-canopy system and years of overgrazing have created an environment incapable of healing itself. Vegetation regrowth has not occurred in many places where cattle and feral burros used to graze, and the increasing fuel load has led to destructive landscape-scale fires. The restoration project at Bandelier seeks to treat both of these problems simultaneously. The project, described as a "thinning and slash mulch treatment" by an interviewee, hopes to "boost the, the understory first to hold the soil, and then to make it, to make it possible for the system to sort of bounce back after drought and fire and other kinds of disturbances." The process involves "cutting many smaller piñon and juniper trees, and lopping and scattering the branches across the barren interspaces between trees" (Allen 2002, 5). The restoration project has been very effective so far, for "undesirable losses of soils, herbaceous vegetation, and cultural resources can be mitigated through active management (Sydoriak et al. 2000, 212). Furthermore, "the treated areas, though initially dominated by biannual forbs, are increasingly becoming populated by native perennial grasses, which represent conditions that are more natural and sustainable" (Sydoriak et al. 2000, 212).

This strategy clearly and effectively mitigates the impacts of both past land use (overgrazing, fire suppression) and future climate change (more frequent drought and intense thunderstorms). It also promotes a "natural" state by encouraging the growth of the historical open canopy ecosystem. Finding similarly effective restoration projects is challenging, but an interviewee and I discussed a restoration project in the Gunnison

Basin focused on improving Gunnison Sage-grouse habitat because of its potential to improve species health and ecosystem resilience in response to climate change.

The Nature Conservancy and the Gunnison Climate Working Group were the primary organizers of the project, but the Black Canyon of the Gunnison served as a critical logistic and funding source of the restoration work. This type of cross-jurisdictional cooperation is necessary as climate change exacerbates problems across landscapes and public and private boundaries. This successful restoration project highlights how environmental problems can be addressed on ecosystem-wide scales in a changing climate.

Gunnison Sage-grouse was listed as "threatened" in November 2014 by the U.S. Fish and Wildlife Service. The Gunnison Sage-grouse is a distinct sub-species of the Greater Sage-grouse found across the West. Gunnison sage-grouse require healthy wet meadow or riparian habitats for successful chick rearing in the fall. These habitats are also important for "neo-tropical migratory birds, elk, deer, as well as domestic livestock" (The Nature Conservancy 2013, 6). Gunnison Sage-grouse habitat is threatened by fragmentation due to human development (roads, power lines, etc.) and erosion due to livestock grazing. Climate change further threatens these habitats because droughts and high intensity precipitation events are projected to increase. Wet meadow habitats in the Gunnison Basin are also struggling; their water tables are lowering because less surface water is being retained due to erosion and down-cutting of streams. The erosion and water retention problem will only worsen with climate change, so a restoration project aimed at increasing ecosystem resilience and improving Gunnison Sage-grouse habitat was implemented. (The Nature Conservancy, 2013)

The restoration project lasted for two years and improved over 700 acres of wet meadow and sagebrush habitat (The Nature Conservancy, 2013). Four wet meadow sites were selected as being suitable for the project. Bill Zeedyk, author of *Let the Water Do the Work: Induced Meandering, an Evolving Method for Restoring Incised Channels* (2012), designed the restoration treatment, which consisted of "grade control structures, flow dispersal structures and headcut control structures" (The Nature Conservancy 2013, 6). These structures were built to reduce the impacts of "channel incision… accelerated erosion and livestock trailing… [and] increase the water storage from surface water flows and raise water tables" (The Nature Conservancy 2013, 7). Vegetation, geomorphological, groundwater, and time-lapse photography monitoring programs were also organized in order to evaluate the continued success of the structures. Many of the sites have already seen sediment buildup at the structures and spread water across the meadow, allowing native plants to recolonize. Invasive plants, such as Canada thistle and musk thistle, have also been removed at a few of the sites. The Gunnison Conservation District and The Nature Conservancy have already and continue to secure funding to implement the project on a basin-wide scale. The project is too young to correlate any change with the Gunnison Sage-grouse populations, but improved habitats bode well for their survival and health, as well as all the other species that rely on wet meadow habitat. (The Nature Conservancy, 2013)

5.5 The Role of Assisted Migration

As discussed in Chapter 2, assisted migration is "introducing a species into a new location by bringing propagules or individuals and releasing them" (Schwartz et al. 2012, 733). Assisted migration is gaining traction as an idea due to the stresses that climate

change place on species. Many species will not survive in their current ranges and will need to be moved in order to persist. Famous examples of proposed species for assisted migration include the Joshua Tree, American pika, and whitebark pine. Assisted migration is an oft-debated topic among managers and ecologists because of the potential for unintended ecological consequences. However, it has the capacity to aid specific species that may not survive without direct and active intervention. I discussed the potential for assisted migration projects within national parks throughout the interview process.

Interview participants had many opinions about how the NPS views assisted migration generally. They also discussed their individual experiences with assisted migration projects and had differing views about the potential for assisted migration projects within parks. They also had vastly different levels of experience with assisted migration projects. One interviewee feels that there is potential for these projects if they are researched effectively:

> Well, I guess my general view is that, we should be careful. We should be careful with that concept, but at the same time, we should also consider the concept… We should carefully proceed on the basis of best available science, but we should proceed prudently… But, you know, consider carefully, and there's different scales, and there's different scales of assisted migration

Other interviewees are more pessimistic about the ecological consequences of moving species. The following quotes are from an interviewee who was utilizing the term

"managed relocation," a more interventionist form of assisted migration. The definition for "managed relocation" used in Chapter Two is "the intentional act of moving species, populations, or genotypes to a location outside a known historical distribution for the purpose of maintaining biological diversity or ecosystem functions as an adaptation strategy for climate change" (Schwartz et al. 2012, 733).

> Those are pretty new concepts, and pretty far out on the Park Service philosophical standpoint, the idea that, you know, the real problem with any of that is really knowing, knowing or believing that you know that some scenario is going to play itself out to the point that you're going to intervene at that level, so, … you know … not just the parks, but all the public land agencies have had trouble just doing more basic stuff… we really know very little about, you know, potential ranges for species and, you know, where they should be or shouldn't be, so it's really, you know, it's very limited, I mean I think that there are probably some opportunities to do that.

The same interviewee also feels that intentionally moving species is "unnatural" and should be examined from that perspective.

> I'm not really a fan of introducing those new things proactively because I'm not quite at that point yet. I don't feel like I really, anytime you start introducing plant materials, you start, to me, you've… sort of crossed a line.

> Well it becomes sort of agricultural. There's something artificial and unnatural about that. You've sort of made some choices, anyway, to me, there's enough of a mix of stuff out there I'm feeling like something's going to, some set of species are going to be able to deal with things

This is another perspective where climate change affects the naturalness conversation. Clearly, moving species to protect them is not ideal. However, climate change is stressing species and forcing land managers and ecologists to consider moving them even if it is perceived as "unnatural." I was able to discuss two assisted migration projects, one that has been implemented and one that is hypothetical, during the interview process.

In addition to their work with the wetlands restoration project, the NPS also aided Gunnison Sage-grouse by moving birds within the basin to boost the Crawford population. One interview participant said the following in response to a question about general views regarding assisted migration within the NPS and any individual experience with specific projects:

> I don't really know if there's a general view about it with the Park Service, I do know that we're doing it here as part of the partnership for sage-grouse…We have actually moved birds from the Gunnison Basin population, which is a stable population… over to the North Rim. The Crawford population was actually estimated to be down to 25 birds... as a satellite population. So, we've been actively trapping Parks and Wildlife, with BLM folks, Park Service is also involved … actively trapping birds

> and moving them to boost the Crawford satellite population, so … I think it is more case-by-case probably, but we are, we are one of those cases.

This project is effective for a variety of reasons. First, by only transplanting the birds within their historical range and across a relatively small area, the risk for unintended ecological consequences is significantly reduced. Chapter Two discussed the disastrous consequences of moving *Mysis relicta* outside of its historical range into Flathead Lake. Next, there is a focus on greater ecosystem health in addition to the species health component of this action. Gunnison sage-grouse are considered a keystone species within the region, so boosting the Crawford population may have positive impacts region-wide. One interviewee summed up this point incredibly well:

> And then, sort of the context in which we're thinking of it currently is not assisted migration for the species' sake, assisted migration to benefit restoration efforts that enhance ecosystem resilience to climate change. I think that's a nuance, I think that's a nuanced aspect to the concept of assisted migration.

Assisted migration to improve entire ecosystem health and resilience is a much more productive goal than single species preservation, especially in a changing climate. One interviewee described a hypothetical assisted migration project with this goal of helping a landscape in its entirety:

> How do we, how can we best restore native plant diversity in these areas in the context of a drying climate? And so, we're thinking about, well maybe we should consider using, plant material, seed material

> from plants at lower elevations that are already adapted to drier conditions…
>
> …I mean we're not talking about… introducing plant material from the Sonoran Desert… [One thing] that we would consider is, and particularly if we had some research to support the feasibility of this and the effectiveness of this, and the benefits of this, we would say consider collecting grass seed at lower elevations, you know, directly adjacent to our parks, but maybe, a little outside the park boundaries, or maybe at the lowest elevations in the park, in our parks, plural, and using that seed in a seed mix at higher elevations, you know, we would consider, you know, frankly we're already considering that kind of thing.

This type of thinking is exactly what is needed for parks to promote resilience in a directionally changing climate. It may seem somewhat agricultural, but ecosystem health must be the primary goal of parks, and creative ways to attain that goal should be supported even if they seem "unnatural."

5.6 Barriers to Effective Management

Both the Bandelier National Monument and Gunnison Basin restoration projects are incredibly effective at improving habitat, reducing erosion, and restoring a sense of "naturalness" to the landscape. Though they require active intervention in the environment, the visual impact is relatively small. Chainsaw markings and manmade rock structures are a small price to pay for a healthier and more resilient ecosystem. The

main problem is finding the resources- monetary, scientific, and human- to scale these types of projects up to the landscape level. The NPS is in a unique position to implement these types of projects on a wide scale given the number of landscapes they protect, but interviews with managers suggested they need to make key changes.

Every year, an incredible amount of scientific research occurs in parks. One would think that this research would be largely carried out by the NPS and would help inform management decisions; unfortunately, this is not the case. One interviewee is very frustrated by this and had a few strong statements regarding the lack of NPS-sponsored research and the lack of funding available to conduct it:

> So there's research that happens in at least two different ways in National Parks, one is the National Park agrees to host research activities. The other one is the National Park is saying "we need to have answers to this question to address our land management needs." That [second category of research] is… under-funded, by any reasonable measure.

> Yeah, and I don't know what the exact number would be. But then another separate number would be the National Park Service resource manager saying "we need to research this, that, and the other to address information needs so that we can do land management and address climate change," and that's particularly in the last few years, it has been extremely difficult to get grants, or to… successfully request funds to do that work.

> We find that we have very little within the agency to push ahead with our lines of inquiry, and we have to work really hard and be entrepreneurial in order to get any resources together in order to make anything happen, and, you know, this is not an ill intention on the part of the agency. What it is, is the agency is simply under-funded for purposes of dealing with collecting basic scientific data.

Lack of funding is an oft-mentioned barrier to success within government agencies, but this situation is especially frustrating. If managers do not have the ability to investigate their landscapes, how can they make scientifically sound decisions to plan for climate change? One effective way to address funding shortages is to work cooperatively with other agencies and both public and private groups in order to combine resources and investigate topics of mutual interest. The Gunnison Sage-grouse project is a strong example of how this can be done effectively. The NPS should also begin giving preference to outside research projects that incorporate climate change into their focus and those that will significantly contribute to baseline scientific data necessary for parks monitoring of plant and animal species.

Chapter Six

Conclusion

By looking at the cumulative evidence of published literature, interview statements, and case studies, it is clear that the NPS is strongly responding to the challenges of climate change. In recent years, it has released multiple publications that highlight its commitment to scientifically-based interventions that promote ecosystem health and resilience across landscapes. Furthermore, the NPS is pursuing many projects, such as the ones in Bandelier National Monument and the Gunnison Basin, that align with the recommendations in environmental literature at large: focus on ecosystem processes or take an approach that promotes specific species health along with that of the greater ecosystem. The NPS should continue to research and implement ecosystem resilience projects across their varied landscapes in order to help protect essential ecosystem functions in the face of an uncertain future.

Though the NPS is effectively mitigating the impacts of climate change in certain areas, there are a few ways it could improve its system-wide management response. First, the NPS should seriously consider and investigate the potential for assisted migration projects. The thought of moving species around scares many managers and researchers, but the reality of the situation is that assisted migration projects can help promote ecosystem health by preserving necessary ecosystem functions in a changing climate. However, there is an important distinction to make: assisted migration projects should be pursued for the ecosystem's benefit, not the species'. These projects can be very simple, yet highly effective.

One example not covered in the previous chapter concerns grass species in Utah. One interviewee described a project where seeds of the same species as those in the national parks, but from lower elevations, would be introduced on the parks' landscapes. The lower elevation seeds would have the advantage of being more drought-tolerant and heat-resistant. In a hotter and drier climate, these seeds would help the entire ecosystem be more resilient by helping hold soil together, retaining moisture in the soil, and serving as a food source for certain species. These types of low-risk, high-reward assisted migration projects have the potential to significantly aid ecosystems during future disturbance events. The NPS would be unwise to ignore the potential benefits of assisted migration projects because of the fact that it seems unnatural and uncontrollable.

The NPS must also figure out a way to more effectively balance the demands of managing for naturalness with the reality of a directionally changing climate. Phrases such as "maintain the closest approximation of the natural condition" (NPS 2006, 37) still appear in its management policies and employee directives. That being said, many interviewees emphasized a dynamic view of what they consider "natural." There seems to be a slight disconnect between the goals that NPS publications state with those of on-the-ground managers. The NPS should seek to unify these two points of view. This does not require the NPS to fundamentally alter its mission statement, but in their forthcoming *Management Policies* publications, the NPS should give greater focus to climate change and the fact that it profoundly limits managers' ability to "maintain… the natural condition" (NPS 2006, 37). The NPS should adopt a more flexible framework for their management goals, one that focuses more on ecosystem processes than the appearance of the landscape or the exact species assemblage that lives on it.

The NPS should also continue their work to increase dialogue between managers from different parks. Managers across parks will respond to the impacts of climate change in a variety of ways, with differing levels of success. Mandating specific national responses to climate change impacts seems impractical and unwise given the variety of landscapes and ecosystems the NPS protects. However, certain strategies can be effectively applied across landscapes, and managers should be familiar with what other parks are doing to minimize negative climate change impacts. The NPS should capitalize on the momentum of the *Climate Change Action Plan 2012-2014* (2012) to ensure that managers have a variety of management strategies at their disposal to effectively respond to the challenges of climate change. Furthermore, the NPS should continue their strong commitment to cross-jurisdictional collaboration. Many parks, monuments, and wilderness areas are negatively affected by outside sources that the NPS cannot control. Continuing to work with local agencies, private stakeholders, and other government entities will be a crucial aspect of its overall climate change response.

As the NPS approaches its centennial year (2016), the time is ripe for implementing substantial improvements to its management practices and policies. These alterations do not need to be sweeping changes to the current management structure. Instead, focusing on updating particular strategies to recognize the dynamism of ecosystems, the need for active intervention in ecosystems, and the need to move beyond naturalness as a central guiding concept will result in practical improvements that will help the NPS face the diverse and unpredictable challenges of climate change. The NPS must research all potential management strategies, such as assisted migration, while continuing to pursue landscape-scale, ecosystem processes-focused projects. It must also

not delay in its response to climate change. The time for proactive "high-priority, no-regrets" action is now (NPS 2012, 13). If the NPS commits to this new model of environmental management, one focused on scientifically-backed, active intervention, it will effectively protect its landscapes and ecosystems for generations to come.

Appendix A

Interview Information

Interview One: October 16, 2014

Participants: Cat Hoffman, National Adaptation Coordinator for the Climate Change Response Program, Nick Fisichelli, Ecologist with the Climate Change Response Program, and Melinda Keslow, Scenario Planner with the Climate Change Response Program

Type: In-person, Fort Collins, CO

Interview Two: October 20, 2014

Participant: Dan Wenk, Superintendent of Yellowstone National Park

Type: Phone

Interview Three: October 21, 2014

Participant: Barbara Judy, Chief of Resources at Bandelier National Monument

Type: In-person, Bandelier National Monument

Interview Four: October 21, 2014

Participant: Brian Jacobs, Botanist, Bandelier National Monument

Type: In-person, Bandelier National Monument

Interview Five: October 23, 2014

Participants: Danguole Backus, Ecologist, Black Canyon of the Gunnison National Park and Curecanti National Recreation Area, and Forest Frost, Park Archaeologist, Black Canyon of the Gunnison National Park and Curecanti National Recreation Area

Type: In-person, Black Canyon of the Gunnison National Park

Interview Six: November 4, 2014

Participant: Mark Miller, Chief of Resources for Southeast Utah Group

Type: Phone

Appendix B

Overall Interview Themes

Listed below are the major themes gathered from the qualitative interview process, with their corresponding interpretative codes listed as well. These major themes were identified and grouped using the methodology described in Chapter Four. The major themes became the focus of the discussion section in Chapter Five due to their applicability to all interviewees and across regions.

1. Cultural Sites
    a. Prevalence of archaeological sites
    b. Erosion and archaeology
    c. Prehistoric resource issues
    d. Reasons for moving cultural resources
    e. Climate change and architectural resources
    f. Cultural resource management and climate change
    g. Cultural resource abundance
    h. Impacts on cultural resources
    i. Erosion and cultural sites

2. Western Environmental Issues
    a. Landscape-scale fires
    b. Aspen management in Yellowstone

c. Ungulate management in the West

d. Fires and droughts

e. Ungulates and migratory species

f. Native fish conservation strategies

g. Lodgepole pine and fire

h. Management of threatened/endangered species

i. Importance of Colorado and Green Rivers

j. Climate change and the Colorado River Basin

k. Human depletions of water

3. The Role of Fire

a. Landscape-scale fires

b. Combination of old and new disturbances

c. Changing ideas about fire management

d. Role of vegetation and fire

e. Fires and droughts

f. Fire programs in the West

g. Fires in large vs small parks

h. Constraints on fire

i. Managing fire in Yellowstone

j. Fire in Bandelier

k. Improving understanding of fire

l. Lodgepole pine and fire

m. Post-fire mediation

n. Fire management plans

4. Naturalness

    a. Discussions about naturalness

    b. Balance of natural systems

    c. Climate change and naturalness

    d. Naturalness and management strategies

    e. Naturalness and the NPS

    f. Naturalness and land management

    g. “Unnatural” scenarios

    h. Examining concepts of naturalness

    i. Definition of “natural”

    j. Ambiguity of “naturalness”

    k. Need for guidance with naturalness

    l. Natural disturbance under climate change

5. Guidance vs Flexibility

    a. Lack of uniformity

    b. Need for flexibility

    c. Challenge of broad action

    d. Need for guidance

    e. Need for intentionality

f. Use of flexibility in decision-making

g. Need for guidance with naturalness

h. Difficult management decisions

i. Need for guidance in management philosophy

6. Landscape-scale management

a. Operating on larger scales

b. Differing opportunities for large vs small parks

c. Outside influences on parks

d. Agency mission and its effect on adjacent park lands

e. Movement of species outside of parks

f. Working at larger scales

g. Working across jurisdictions

h. Lack of role in land acquisition

i. Management areas around parks

j. Buffer zones around parks

7. Assisted Migration

a. Intervention in ecosystems

b. Species migration

c. Land management foci

d. Amount of intervention

e. Iconic species and assisted migration

f. Experience with assisted migration

g. Assisted migration in the NPS

h. Assisted migration for the sake of the ecosystem

i. Opinions on assisted migration

8. Disturbance

a. Combination of new and old disturbances

b. Landscape-scale fires

c. Climate change as a disturbance

d. Directional change

e. Previous notions about disturbance

f. Role of disturbance regimes

g. NPS and dynamic ecosystems

h. Disturbances and climate change

i. Role of invasive species

j. Time scale of disturbance regimes

k. Disturbance regimes in the region

l. Natural disturbances under climate change

9. Climate Change

a. Climate change as a disturbance

b. Climate change and land use history

c. Changing ecosystems

d. Directional change

e. Climate change in parks

f. Landscape-scale fires

g. Disturbances and climate change

h. Climate change and management strategies

i. Climate change and connection to other issues

j. Climate change and decision-making

k. Climate change focus within NPS

l. Climate change and vegetation management

m. Present climate change impacts

n. Climate change disturbance in the region

10. Challenges for Parks

a. Land use history

b. Combination of old and new disturbances

c. Differing opportunities for small vs large parks

d. Lack of climate change research in parks

e. Types of research in national parks

f. Lack of funding

g. Rate of change in federal agencies

h. Prioritization of funding

i. Challenge of broad action

j. Amount of intervention

k. Working across jurisdictions

l. Role of management policies

m. Lack of guidance

n. Difficult management decisions

o. Shifting park ethics

11. Preservation in the NPS

a. Contemporary ideas about preservation

b. NPS and preservation

c. Naturalness and preservation

d. Preservation and dynamism

e. Preserving values

f. Shifting park ethics

12. Ecosystem Resilience

a. Land use history

b. Combination of old and new disturbances

c. Restoration projects

d. Landscape-scale projects

e. Resilience and restoration

f. Meanings of resilience

g. Resilient species

h. Managing for resilience

i. Public ideas about resilience

j. Resilience as a functioning system

k. Popularity of term “resilience”

l. Range of definitions for “resilience”

m. Ecosystem resilience and vegetation management

13. Active Intervention in Ecosystems

a. Wilderness and intervention

b. Amount of intervention

c. Combination of new and old disturbances

d. Adaptation work

e. Difficult management decisions

f. Shifting park ethics

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