THESIS

COLLABORATIVE CLIMATE CHANGE MANAGEMENT:

EXPLORING NEW MANAGEMENT TECHNIQUES

Submitted by

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WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY ASHLEY COBB ENTITLED COLLABORATIVE CLIMATE CHANGE MANAGEMENT: EXPLORING NEW MANAGEMENT TECHNIQUES CAN BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE.

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ABSTRACT OF THESIS

COLLABORATIVE CLIMATE CHANGE MANAGEMENT:

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Global climate change requires a shift in natural resource management practices and increased collaboration among land managers and surrounding communities. This qualitative study explores opportunities to enhance collaboration through collaborative conservation practices and scenario planning. I studied the Crown of the Continent Ecosystem in the northern Rocky Mountains to explore how partnerships between land management agencies can adapt to the challenges of climate change. In this thesis, through participant observation and a literature survey I examine the complexity of climate change impacts on ecological and sociological communities in the Crown. I also study the process of scenario planning as it was applied to climate change management in two case study parks in the National Park Service. I explore how scientists and decision-makers participating in the process of scenario planning challenged their assumptions about environmental management and negotiated the amount of scientific certainty needed to move forward with management. Through the exploration of these two case studies I conclude that climate change may be the window of opportunity for land managers to reconsider their roles, management objectives and partnerships.

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CHAPTER ONE

Introduction

Global climate change requires a shift in natural resource management practices and increased collaboration among land managers and surrounding communities. Glaciers and snow packs are melting, climate patterns are leading to heat waves and drought, both locally and regionally (Hall & Fagre, 2003; NPS, 2008). As researchers work to understand the complex interaction between the changing climate and fragile ecosystems, impacts of climate change are becoming increasingly apparent and alarming. The Intergovernmental Panel on Climate Change (IPCC) stated in their 2007 report:

> Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global sea level (p. 108).

Modeling and projections such as those done by the IPCC illustrate a wide variety of causes and effects of climate change that may severely degrade fragile ecosystems and therefore negatively influence the natural environment as well as social experiences for which protected areas were established. The complexity of climate change impacts requires innovative management techniques to enable conservation practitioners, scientists, NGOs, local and regional communities to understand and manage for biological and societal changes.

Problem Statement

The uncertainty and complexity associated with climate change impacts undermine current environmental management techniques and mandates. Two innovative management techniques; collaborative conservation and scenario planning, are currently being explored by federal land management agencies to address and manage for the uncertainties and complexities associated with the changing climate.

The uncertainty of climate science and climate predictions can combine with the complexity of social and ecological systems to form a complicated web of climate change impacts. Due to time and funding constraints as well as variable leadership and public interest, climate change management has been a challenge. Organizations as well as ecosystems must adapt to the changing climate by building resiliency from within. Climate change may be the window of opportunity land managers need to adapt their management practices and reexamine their roles within the organization. By exploring new management techniques and revisiting the goals of their organizations and partnerships land managers in protected areas can use climate change as a catalyst for organizational adaptation.

The purpose of this research project is twofold. The first phase of this project involved an analysis of observational data and relevant literature related to a collaborative conservation workshop *Climate Change in the Crown of the Continent: Identifying Multi-Jurisdictional Strategies,* which explored how multiple agencies work together to manage climate change impacts. The workshop focused on adaptive management techniques with an emphasis on climate change management tools and an exploration of the benefits and barriers of collaborative management. I observed how collaborating organizations negotiate the incorporation of innovative natural resource management techniques into the collaborative process.

I also analyzed a National Park Service (NPS) scenario planning workshop which enabled me to focus on the process of knowledge creation and negotiation among natural resource scientists and managers. Over the course of 6 months I participated in numerous conference calls and meetings which culminated in a 3 day workshop in Denver, Colorado April 28-30, 2009. During the workshop participants negotiated the amount of science necessary to move forward with management and explored how scenario planning can help decision-makers and scientists challenge their assumptions about environmental management and climate change. These two phases of the research project were analyzed as individual case studies of climate change management at multiple scales.

Research Questions

My research questions were tailored to address the two distinct foci of this research project: the potential for collaborative conservation to address the complexities associated with climate change impacts (1) and the application of scenario planning to climate change management (2). The first phase of the research project involved my participation in the *Climate Change in the Crown of the Continent: Identifying Multi-Jurisdictional Strategies* workshop, held in Whitefish, Montana December 1-3, 2008. For this project my research question explored how collaborating organizations can manage climate change issues on multiple scales within an ecosystem.

RQ: How do multiple agencies collaborate to manage the spatial, ecological, and socioeconomic complexities associated with climate change impacts?

To address this research question I was a participant observer at the Crown of the Continent Ecosystem (Crown) workshop and extensively reviewed relevant literature related to the Crown and other collaborative initiatives. I used the data from the workshop as a case study of collaborative conservation.

The NPS scenario planning workshop is the second phase of my research project. My research questions explore the process of workshop design and the scenario planning method. My overarching question examines the process of scenario planning as it is applied to climate change management. The other two research questions are specifically tailored to the exploration of the intersection between science and management.

RQ: How does scenario planning work in the context of climate change management?

a) *How are science and conceptual information tested and validated during the process of scenario planning?*
b) *How do managers and scientists determine when they have enough science to move forward with management?*

By exploring these two aspects of climate change management this research promotes a broader understanding of the implications of climate change for environmental management and provides detailed case studies, illustrating how decision-makers, scientists, and collaborating organizations have explored the application of collaborative climate change management techniques.

Relevance

Climate change may be a window of opportunity for managers to embark on new collaborative management initiatives and revisit the goals of their organizations and partnerships. Collaborative conservation, as I conceptualize from an organizational learning and systems theory perspective, allows land managers to address the complexity of social and ecological interactions on multiple scales within managed ecosystems. The complexity of climate change impacts must be understood at multiple levels, from the ecosystem to the species scale, as well as ecologically and socially. Collaborative conservation can promote deeper understanding of climate change impacts and better coordination of public outreach and management efforts by combining the expertise and experience of multiple land managers at the macro, meso, and micro scales within a region.

Conserving dynamic resources under climate change is increasingly difficult due to the degree of uncertainty associated with climate impacts. A systematic and scientific approach toward understanding natural resources must be adopted in order to manage effectively in the face of uncertainty (Baron et al., 2009). By providing a method for decision-makers and scientists to combine their expertise, scenario planning allows practitioners to create robust scenarios that address multiple uncertainties and promote management strategies that incorporate future climate uncertainties.

Legal mandates and societal concern also affect the flexibility and adaptability of environmental management techniques. Secretarial Order no. 3285 was issued on March 11, 2009, by Secretary of the Interior Ken Salazar. The Order establishes a Department-wide approach for applying scientific tools to increase understanding of climate change and to coordinate and effective response to its impacts. Under the Order each bureau and office of the Department must consider and analyze potential climate change impacts when undertaking long-range planning exercises. The Order calls for the development of science-based adaptive management for natural and cultural resource managers. The scenario planning project is a direct response to this Secretarial Order. By incorporating the scenario planning technique into management initiatives NPS leadership can adjust land management practices to incorporate state-of-the-art climate science with adaptive management strategies.

By planning for the future and promoting increased flexibility within agencies scenario planning and collaborative management allow land managers to adapt their goals and practices to mitigate and manage climate change impacts on public lands.

Theoretical relevance

In order to adapt to climate change, organizations must innovate their practices and management processes. Organizations must become an innovative system. Innovation systems explore the flow of information among people and organizations is key to an innovative process. Innovation system theory studies the interaction between actors who turn an idea into a process (Freeman, 1995). System innovation theory guided my research project as I studied the flow of information among multiple land managers and land management agencies during the processes of collaborative conservation and scenario planning. I applied innovation theory to my analysis of the Crown workshop. As land managers discussed the integration of different agencies’ climate change management initiatives across the ecosystem, I explored how participants communicated the transition from individual to collaborative management. I also studied the transformation of climate change science into management decision tools during the scenario planning workshop. This research project can provide case studies of the application of the system innovation theory as it is used to understand land management innovation processes.

Personal relevance

As an environmentalist and a social scientist I have been concerned with the impacts of a changing climate both ecologically and socially. I started my academic career as an environmental scientist at the University of Denver. While studying the geology, geography, ecology, and meteorology of the West, I became increasingly aware of the far-reaching impacts of climate change. Glaciers are melting, weather patterns are changing, and fragile ecosystems are being disrupted. I began working for the NPS as an undergraduate and continued to work for the agency after graduation. The impacts of climate change were apparent in many different NPS parks, from melting glaciers in Glacier National Park to rising sea level in Cape Hatteras National Seashore. While land managers at NPS knew of these impacts they had few opportunities to adapt management practices to address the long-term implications of climate change.

As a graduate student I became very interested in the social aspects of climate change. Many respected scientists agree that anthropogenic causes are behind the current rate of climate change (IPCC, 2007). Dealing with the social implications of climate change means dealing with both the causes and the effects of this phenomenon. I am interested in studying collaborative processes as they are applied to decision-making strategies because I believe that collaboration may help managers and others to envision solutions to the ecological and societal problems posed by climate change.

Conceptual Framework and Concept Map

I define the concepts of collaborative conservation and scenario planning in a table of concepts in order to better explain their relation to my research questions. The table of concepts identifies conceptualized relationships among the collaborative conservation and scenario planning as a method to guide my study in the context of climate change management. Scenario planning can be seen as a subset of collaborative conservation, because it applies the processes of collaborative conservation to strategic planning for the future.

Table 1: Table of Concepts

Concept	Definition	Operationalization	Research Question
Collaborative Conservation Process Design	A process that allows managers to collaborate to solve problems	adaptive management, multi-agency process design, scenario planning process design	How do multiple agencies collaborate to manage the spatial, ecological, and socioeconomic complexities associated with climate change impacts?
Scenario Planning	A strategic planning method that some organizations use to make flexible long-term plans (Schwartz, 1991).	systems thinking, futurism, strategy, conflict resolution, organizational learning	How does scenario planning work in the context of climate change management?

My conceptual framework (Figure 1) examines the processes of scenario planning and collaborative conservation through the lens of systems innovation theory. One way to understand an innovation system is the exchange among actors belonging to different social systems which have a positive influence on an organization's innovativeness (Kaufmann & Todtling, 2001). Levels of innovation are influenced by the diversity of partnerships contributing to the system. For example, far-reaching innovations are generally promoted by external relations to partners outside the immediate system, whereas minor innovations are likely influenced by partners within the immediate system (Kaufmann & Todtling, 2001).

Increasingly, innovation is regarded as an evolutionary and interactive process between organizations and their environment (Malecki, 1997). The environment restricts the set of alternatives of any system, but the environment cannot control the system's behavior (Kaufmann & Todtling, 2001). I use system innovation theory as a lens to understand how a system maintains its independence and how it interacts with its environment. Interactivity of the innovation process refers to internal collaboration among several actors within the immediate system as well as to external partnerships with other agencies and knowledge providers such as universities.

The formation of systems can be understood as a way to reduce the complexity of the world we live in. The reality we must cope with is much less complex within a system because we use a common set of interpretations concerning the part of reality which is relevant for the system we are functioning in (Kaufmann & Todtling, 2001). All members of the system understand the common set of interpretations, which reduces ambiguity within the system but restricts alternative interpretations of reality (Kaufmann &

Todtling, 2001). Communication can be understood as a common set of interpretations within a system. Through a continuous process of sending, receiving and processing information communication is reproduced in a system. For example, while scientists involved in the NPS scenario planning workshop created the climate drivers tables they communicated about climate change impacts and created a common language and set of understandings. The terminology and assumptions adopted by the scientists might not have been fully understood by the other participants outside of the scientists' communication system. This discrepancy between assumptions and understandings was the focus of many negotiations among scientists and decision-makers during the workshop. Participants worked to create a common set of assumptions and definitions to ensure that everyone understood the complex issues being discussed. A common standard of communication within a system allows members to interpret internal processes as well as relations to the environment. Communication within a social system reproduces the system as it makes the system distinct from its environment and other systems.

The complexity of social systems leads to the emergence of specialized forms of communication. This specialization may eventually create functionally different subsystems which are responsible for higher tasks within a system. For example, the communication systems adopted by scientists may be different than those of the decision-makers who also participated in the NPS scenario planning process.

It is important to recognize the difference between systems and organizations. For the purpose of this research the term system is applied to entities which are based on communication of information, a common set of interpretations and a shared view of value and meaning. An organization is based on membership, within specific tasks for members and certain methods to perform those tasks. From this clarification it follows that individuals are involved in multiple systems while performing certain roles within an organization. For example, Dr. Dan Fagre, is a research ecologist and climate change research coordinator employed by the United States Geological Service (USGS). Because of his interests and expertise Dr. Fagre performs multiple roles in multiple systems while working for the USGS. The specific advantage of an innovation system is not about the system as a separate and autonomous entity, but the process of collaboration among actors who belong to different systems. The exchange of formerly unrelated information reinforces innovativeness (Kaufmann & Todtling, 2001).

I explored scenario planning theory and collaborative conservation process design in the context of systems innovation (See Figure 1).

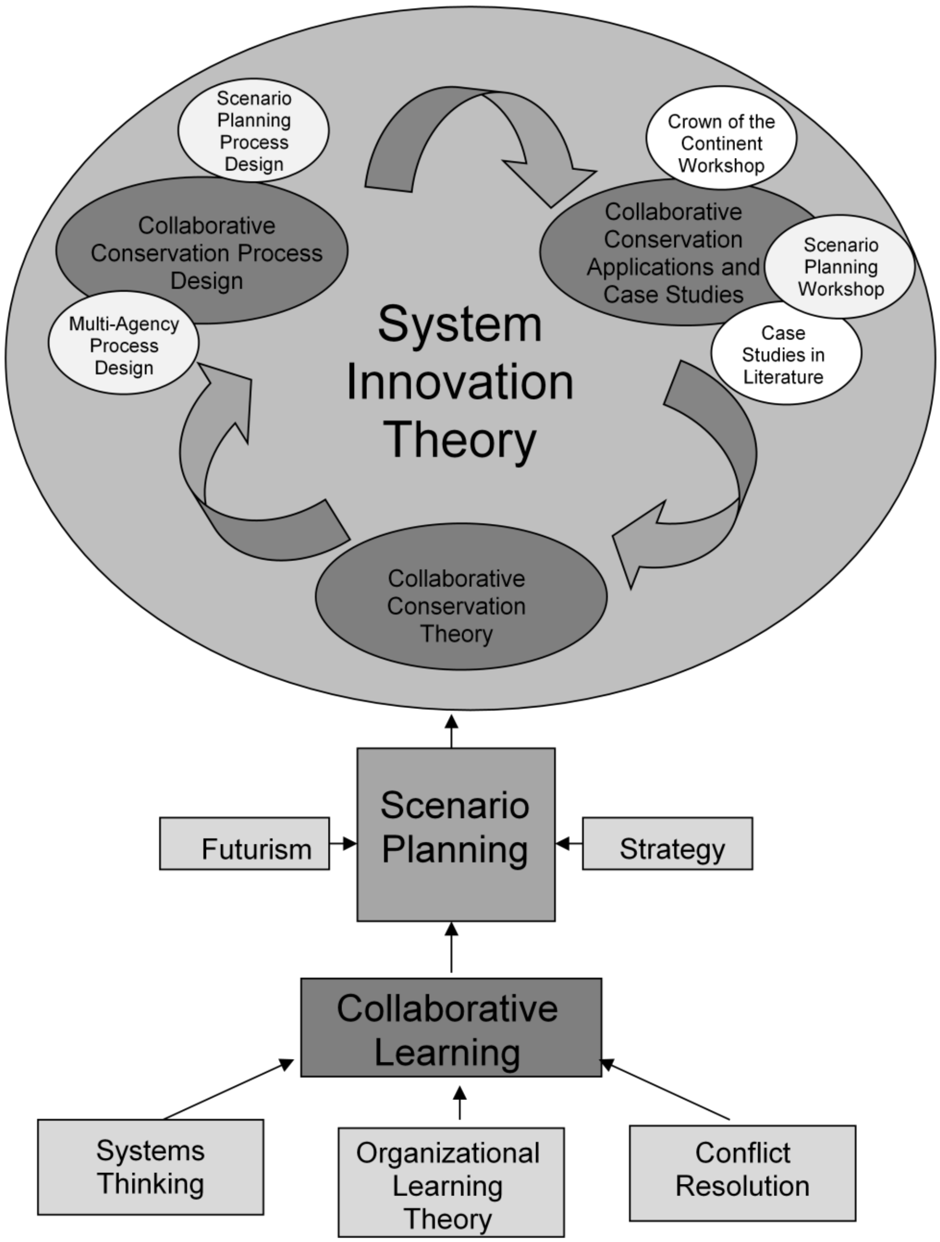

Figure 1: Collaborative Management Conceptual Framework

The theoretical roots of collaborative conservation and scenario planning are built upon collaborative learning which incorporates organizational learning theory, systems theory, and conflict resolution (Lindgren & Banhold, 2003). Specific aspects of scenario planning theory include futurism and strategy which focus on envisioning possible futures and strategizing the best possible outcomes of planning initiatives. The conceptual framework shows how these theoretical roots feed into the process of collaborative conservation. Multiple agency process design and scenario planning process design were examined as examples of collaborative conservation process design.

My initial literature review as well as my research process follows the research process illustrated in Figure 1. After examining the theoretical roots of collaborative conservation and scenario planning I conducted participant observation research at each of the workshops. During the workshops I paid close attention to how participants communicated their understanding of climate impacts on land management and the social and ecological environment. This project will contribute original research to the fields of collaborative conservation and process design by studying the interactions among multiple agencies and land managers through the lens of system innovation.

CHAPTER TWO

Collaborative Conservation: Addressing the Complexity of Climate Change

Climate change may be a window of opportunity for land managers to engage in new collaborative management initiatives and revisit the goals of their organizations and partnerships. The complexity of global climate change requires local, regional, federal, and international land management agencies to explore new and preexisting partnerships to promote ecosystem-scale collaborative management. The Crown of the Continent Ecosystem (hereafter the Crown) in the Northern Rockies is an example of a multiple-agency collaborative conservation effort within an ecosystem. The Crown encompasses 16,000 square miles within the Rocky Mountain region of Montana, British Columbia, and Alberta. The ecosystem spreads across two nations, one state, and two provinces and is influenced by numerous municipal authorities, Native American tribes, private landholders, and public land management agencies. The Crown faces diverse ecological and social challenges. With the intensification of human activity and observable and future effects of climate change, local, regional, and international agencies have recognized the need for transboundary collaborative approaches to ecosystem management (CMP, 2006). This research explores collaborative and participatory conservation and management as it is applied to issues of climate change complexity on multiple scales within the Crown ecosystem.

Background

The Crown Managers Partnership (CMP) was formed in 2002 during the Crown Annual Forum to pursue strategic projects and create networking opportunities within the Crown among the participating agencies and stakeholders (CMP, 2006). The CMP is open to all public and land management agencies within the Crown of the Continent region. The mission of the CMP is to build understanding and awareness of the ecological health of the Crown, execute individual agency mandates in alignment with the vision of the CMP and build enduring relationships and collaborations across mandates and borders. Partnerships are built upon on the belief that the social and economic health of the Crown is based on ecological health and the need for compatible management strategies across the landscape (CMP, 2006).

The impacts of climate change challenge the health of ecological and social communities in the Crown. Managers require a scientific understanding of implications of global climate change impacts on the local environment and society. Researchers have been monitoring the impacts of climate change on the environment at the Crown for over two decades and have produced some startling results. The area around Glacier National Park (GNP) which is one of the US National Parks within the Crown, has experienced a 1.6 degree Celsius increase in mean annual summer temperature from 1910 to 1980 (Hall & Fagre, 2003). This increase in warming has far-reaching implications for ecological and human communities. The melting of glaciers in the high-alpine impacts vegetation, hydrology, and fish species as well as other aspects of the ecological/sociological web. In 1850 GNP contained approximately 150 glaciers (Carrara, 1989) but by 1966 only 37 glaciers were large enough to warrant being named on maps (Prato & Fagre, 2007). Based on current emissions Dr. Dan Fagre a USGS ecologist, predicts that the glaciers in GNP will disappear by 2020 (Minard, 2009). This will have serious implications for a variety of ecological processes. Glaciers act as a bank of water that is released during dry periods of the year, keeping a continuous flow of water in streams that would otherwise be ephemeral. Once glaciers have disappeared from a watershed the overall water supply will diminish and aquatic communities will experience a more unpredictable environment (Prato & Fagre, 2007). This will affect fish species, such as the native cutthroat trout, which are dependent upon consistent water flows and lower stream temperatures during the summer from glacial runoff. Montana's coldwater trout and salmon are projected to lose up to 34% of their suitable habitat by 2060 due to rising stream temperatures (O'Neal, 2002). The health of the native cutthroat affects the local recreation industry and economy. Within the Crown hunting, fishing and outdoor recreation generates $2.5 billion annually and supports over 34,000 jobs (USGCRP, 2009). The loss or decrease of native cutthroat trout in the Crown due to warming waters could have serious effects on tourism and the economy of the region. This is an example of the need to understand the complexity of climate change impacts at multiple levels, from the ecosystem to the species scale, as well as ecologically and socially.

I was introduced to the CMP in December, 2009 during the *Climate Change in the Crown of the Continent Ecosystem: Identifying Multi-Jurisdictional Strategies* workshop. Participants at this workshop included: local, regional, and natural land management agency staff from the US and Canada as well as academic researchers from two universities, two tribal organizations, and multiple environmental non-governmental organizations (NGOs). The purpose of the workshop was to build capacity and improve the coordination of climate change management and adaptation efforts among management agencies. During the workshop scientists and managers shared their research and experiences related to climate change impacts in the Crown. Attendees identified key challenges for the coordination of transboundary and multi-agency collaboration and explored the application of techniques such as adaptive management to climate change management issues. During the workshop I facilitated a situation mapping activity which encouraged participants to create hand-drawn maps of the inter-relationships among climate change impacts, ecosystems dynamics, management priorities, management processes, and key stakeholders.

The purpose of this project is to explore how conservation partners understand the impacts of a changing climate on social and ecological processes and manage the complexity of climate change at multiple scales. The application of new management techniques is an important aspect of this research as well. How do conservation partners incorporate new climate change management techniques into a collaborative effort?

Addressing Complexities

The complexities associated with climate change are confounded by multiple agencies which govern and conduct land management on multiple scales. To understand the web of connections in the Crown we must define the meaning of macro, meso, and micro-scale climate impacts on management, ecology, and society. The definition of macro, meso, and micro scales varies depending on the field in which they are applied.

Because the Crown workshop is the focus of this research project, each of the scales are understood in relation to organizations that participated in the workshop. I understand macro-scale climate impacts on the national scale, exemplified by the United States Forest Service (USFS). The Montana Department of Natural Resources and Conservation (DNRC) is an example of meso-scale management of natural resources. At the micro-scale Waterton Lakes National Park in Alberta serves as an example of local management of the land. As well as the units of measure outlined above, smaller and larger scales of management and policy affect the Crown, including private landowners, federal governments of the US and Canada, and international treaties, but for the purpose of this manuscript I will focus on these three scales within the ecosystem. Other researchers may allocate management scales and examples of organizations differently, but by using specific examples of organizations that participated in the Crown workshop I can explore how and why representatives of these agencies interacted with one another to sustain the collaborative effort and explore the implementation of new management techniques.

To understand the interactions among different agencies and participants I must first examine the interests and concerns of the collaborating organizations. I will explore the management objectives for each of the three macro, meso, and micro-scale organizations to tell a broader story of how and why these organizations came together to manage climate impacts in the ecosystem. Gifford Pinchot, the first Chief of the Forest Service, dedicated the mission of the USFS to the provision of the greatest good for the greatest amount of people for the longest time. The USFS manages over 193 million acres in the US for productivity, biodiversity, and health of the forests. Recently Tom Tidwell, Chief of the Forest Service, stated that the USFS will focus on forest restoration at the landscape scale to build community prosperity and address the impacts of climate change. The management plan for Waterton Lakes National Park (2000) establishes a vision that integrates protection, experience and education in ways that are mutually supportive and inter-dependent. One of the main objectives of the Park is to promote stewardship and protection of the resources in the Park by raising public awareness and educating its visitors. The co-operation between Glacier National Park, which, with Waterton, forms the Waterton-Glacier International Peace Park World Heritage site, began with the formation of the World Heritage site and remains strong between the parks (Parks Canada, 2008). The mission of the Montana DNRC is to help to ensure that Montana's land and water resources provide benefits for present and future generations (DNRC, 2010). The Water Resources Management Division (WRMD) of the DNRC participated in the climate change workshop, adding their concerns and expertise regarding about water management and sustainable consumption. As we can see from these examples, each of these three organizations that participated in the Crown workshop brought different priorities and goals to the collaboration. Forest products, environmental education, and sustainable water use are just a few examples of the diversity of interests that climate change impacts. While their specific interests varied, each of the organizations saw collaboration as an opportunity to reach their own goals. Recognizing all of these interests is an essential aspect of the exploration of the complexity of climate change impacts.

During the Crown workshop participants discussed the ecological complexity of climate change as it relates to multiple scales of climate information. Many participants noted the problem of scale mismatch in relation to climate information and needs. Climate scientists use models to create plausible, physically-based scenarios, reflecting the current state of scientific understanding, to inform planning for the future. While these models can be useful for predicting trends at a global scale, the resolution of many of the climate models is too low to be useful for regional or local management needs. Natural resource scientists cannot do regional analyses with global models; they need downscaled models that illustrate the impacts of climate change on a local scale. For example, the global climate change models in the 2007 IPCC Fourth Assessment Report the spatial resolution of downscaled CCSM-3 projections of temperature and precipitation for the continental US is approximately 4.5 km (IPCC, 2007). Conversely, land managers cannot use local data from a specific park unit or forest and extrapolate globally. For example, climate models of vegetation change must incorporate the effects of disturbance, particularly fire, at broad spatial scales. Fire often provides critical constraints on vegetation type, but data on the ecological effects of fire at large spatial scales is scarce (McKenzie, Peterson, & Alvarado, 1996). To solve this problem some modelers have attempted to extrapolate up from data on the impacts of fire on specific stands of forest. Unfortunately, by extrapolating up modelers add high levels of uncertainty and assumption about the type of impacts fires have on forests at higher spatial scales. Land managers need a globally comprehensive understanding of climate effects as well as downscaled climate projections to broaden their ability to manage for the uncertainties associated with climate change.

Socioeconomic complexity also adds to the difficulty of defining climate change impacts in the Crown. Flathead County, Montana, located in the northern US portion of the Crown, is mostly designated (94%) national or state forest land, wilderness, agricultural, and corporate timber land, thus confining development to the remaining 6% of the area (Flathead County, 2010). From 1990 to 2008 the total population increased 49% compared to 22% for Montana and 23% for the nation (US Census Bureau, 2010). From 2000 to 2008 total employment rose 19% and median household income rose 30% in the county. Construction (15%), retail (13%), social services (15%), and recreational sectors (10%) employ the majority of residents in the county. The development of recreation and tourism attractions has greatly increased in recent years contributing to the influx of tourists and tourism based services. Because of the rapid growth and development in many communities within the Crown, many agricultural and forest lands have been converted to residential and commercial uses leading to the loss or degradation on wildlife and fish habitats, increased human-wildlife conflicts and the loss of open spaces (Prato & Fagre, 2007). Many people who live and work within the Crown are dependent upon the healthy functioning of the ecosystem. For example, a loss of forest lands for residential building removes native species such as the elk from their native habitat. This can cause problems with human-elk interactions, with elk eating agricultural products and landscaping vegetation. To prevent elk from feeding on agricultural crops many states have instituted elk feeding programs in the winter (Smith, 2001). Several negative consequences result from feeding elk including: the monetary cost of feeding, which diverts costs from other resource management programs, increased transmission of diseases between elk in close proximity such as chronic wasting disease, and public perceptions that may lead to the devaluing of habitat (Smith, 2001). Elk can be a great source of revenue for local parks and natural areas through wildlife viewing, but if they are crowded out of their natural habitat by humans they may be seen as pests by the local population.

While the socioeconomic, ecological, and managerial complexities are daunting, climate change may in fact be the opportunity land management agencies and the public need to better coordinate conservation efforts. By focusing collaborative efforts on adaptation and planning for the future, climate change may be the catalyst that encourages communities and organizations to reexamine their roles as partners in collaborative conservation.

Integrating New Management Techniques into the Collaborative Process

Organizational learning can support the integration of new management techniques into pre-existing collaborative processes by incorporating pragmatic and collaborative approaches to problem solving and decision-making. Three conceptual foundations underly the theory of organizational learning. The first is conflict management, which focuses on the causes, characteristics of, and responses to, conflict. The second foundation is learning theory, the purpose of which is to identify the procedural attributes and chronological sequencing of critical thought. The third foundation of organizational learning is systems thinking which assumes that many situations are characterized by a complex set of relationships (Daniels & Walker, 2001). The value of organizational learning comes from its foundation in contemporary thinking about how people process information, how they deal with different viewpoints and goals, and how they organize their thinking about complex situations.

The technique of situation mapping draws heavily upon the conceptual foundations of organizational learning. The purpose of situation mapping is to promote discussion, careful thought, and learning about a complex web of relationships through graphic representation of a situation. Situation maps encourage participants to focus on the big picture and the interrelationships within a collaborative effort, promoting systems thinking. The maps can portray the fundamental forces that drive, reinforce, and constrain stakeholder actions. We facilitated a situation mapping activity for the attendees at the Crown workshop focused on the resources affected by climate change and the relationships among stakeholders. Participants split into four groups and were asked to map out (by hand, using markers) the relationships among the resources and stakeholders affected by climate change. Figure 1 is an example of a map created during one group's discussion.

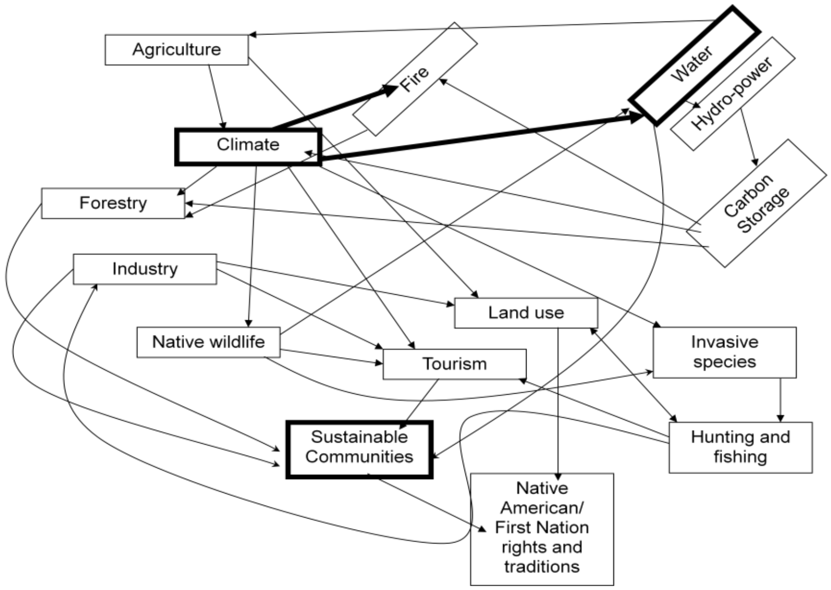

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Figure 1: Situation map illustrating one break-out group's understanding of the relationships among resources and stakeholders within the Crown

The graphic representation of relationships shown in a situation map, sometimes called a "spaghetti bowl" diagram, is less important than the dialogue that is prompted through the creation of the map. The situation mapping activity encouraged discussions and raised awareness of the implications of climate impacts on the ecosystem and communities in the Crown. As seen in Figure 1 the situation mapping exercise helped participants identify concerns, which for this group were climate, water, and sustainable communities

By focusing on issues instead of organizations the situation mapping exercise encouraged neutral discussions about concerns instead of the actions and responsibilities of particular stakeholders. Participants started by discussing how water systems are affected by climate change such as melting glaciers leading to lower summer flows. Then the discussion turned to how organizations in the Crown can promote water conservation to create and encourage sustainable community practices. To promote better water conservation and other sustainable actions organizations need to have consistent transboundary messages. Participants suggested working with NGOs and local businesses to reach out to the local community about climate impacts and actions.

After the activity, participants explored how the situation maps could enable decision-makers to visualize the complexity of the threats to natural and social resources posed by climate change. Situation mapping, with its foundation in systems thinking and collaborative learning, allows managers to consider a wide variety of impacts of climate change to develop strategies that comprehensively address the threats posed to human and ecological communities.

Participants' feedback on the situation mapping activity was nuanced. While some participants preferred discussions about projected impacts of climate change on specific resources, others enjoyed the broader qualitative discussions about the relationships among issues promoted during the situation mapping activity. During the post-assessment of the workshop participants commented on the use of situation mapping to build discourse and shared-understanding of the implications of climate change within the Crown. Trust and cooperation are necessary for implementing management actions that are designed to meet learning and other social objectives (Baron et al., 2009).

After the situation mapping activity participants explored adaptive management as a climate change management technique within the Crown. Adaptive management is a process of learning from management experiments as a method to manage uncertainties. This technique incorporates organizational learning theory as managers and scientists create and test hypotheses, and amend management practices based on the results.

Adaptive management focuses on developing hypotheses to describe (1) how ecosystem drivers interact and operate and (2) how human interventions may affect the ecosystem (Baron et al., 2009). Through monitoring and the creation and testing of hypotheses, adaptive management emphasizes managing based on observation and continuous learning. Adaptive management allows decision-makers to address varying degrees of uncertainty in their knowledge about current and future climate change impacts (West et al., 2009).

During the Crown workshop participants discussed how adaptive management could be applied to multi-jurisdictional issues such as climate impacts on forest fires within the ecosystem. Managers can increase resistance to stand-reducing forest fires by thinning the forest through prescribed fires and creating multi-age forest structures. For example, each spring and fall, weather permitting, Forest Service fire managers apply prescribed fire treatments to small areas of the forested landscape in the Lewis and Clark National Forest and many other forests for a variety of purposes. These prescribed burns can promote fuel reduction in areas where the forest interfaces with communities and private property, the replication of benefits that historical, naturally-occurring, low-intensity under-burns would have created (USFS, 2009). By proactively burning prescribed fires forest managers can increase the resistance to larger crown fires in the future. Participants discussed how adaptive management can increase adaptive capacity for managers throughout the ecosystem. Adaptive capacity is the ability to adjust to climate change by moderating potential damages, taking advantage of opportunities, or coping with the consequences of the impacts (IPCC, 2007). By managing across jurisdictions organizations can promote better planning before fires and create concurrence of objectives in fire management across agencies.

Multiple issues can create problems when implementing adaptive management as a climate change management technique. The complexity created by the temporal and spatial scale of climate change, as well as the dimensions of uncertainty and risks, can pose major barriers to the effective implementation of adaptive management (West et al., 2009). The critical challenge for collaborating organizations will be to create flexible policies and institutional frameworks under climate change (Gregory et al., 2009).

Barriers to Collaborative Climate Change Management

Land management objectives and mandates vary between macro, meso, and micro scale organizations. These differing objectives can confound the collaborative process by adding another layer of political and legal barriers to collaborative climate change management. For example, at the macro scale, the Endangered Species Act (ESA) aims to protect and recover imperiled species and the ecosystems upon which they depend. This Act is administered by the US Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration (NOAA) Fisheries Service. The ESA severely limits the capabilities of national agencies to adapt to climate impacts by promoting intensive focus on individual species' recovery. The Act prioritizes short-term recovery of listed species over long-term management of climate impacts. At the meso-scale states and provinces such as Montana and British Columbia face their own hurdles which include: lack of leadership; lack of state- and regionally specific scientific information; lack of expertise within state agencies; as well as lack of public awareness, engagement, and pressure to make adaptation a policy priority (Moser, 2009). These problems are mirrored at the micro-scale, within individual parks and forests in the Crown such as Glacier National Park and Lolo National Forest. In the face of so many other pressing concerns such as forest fires, pine beetle, drought, and public concerns, park and forest managers lack the catalyst to place collaborative climate change management and adaptation as a top priority.

Opposition by the public to the goals or methods of a collaborative project can also make it difficult for the effort to succeed (Yaffe, Wollondeck & Lippman, 1997). Public concerns about the reality and the implications of the changing climate may negatively influence the collaborative project in the Crown. Public interest groups also pose a threat to climate change management efforts. Some environmental and other public interest groups mistrust the perceived compromises inherent in collaborative management (Yaffe, Wollondeck & Lippman, 1997). High-profile adversarial approaches such as litigation and direct action increase public awareness of an issue and block management efforts to adapt to climate change proactively. Other public interest groups support collaborative efforts, such as the NGOs that participated in the Crown workshop. These organizations hold a wealth of knowledge about public participation and interaction. Through stronger and more diverse partnerships with local and national non-governmental organizations collaborative efforts such as the Crown can reach out to the public and promote social awareness and support for climate change management efforts. A participant at the Crown workshop noted: “Agencies only have a little bit of room to move on mandates. What will be needed are changes in societal consensus to drive changes in mandate legislation."

Discussion

Situation mapping and adaptive management strategies allow organizations to conceptualize and adapt to the complexities of climate change, but to achieve societal consensus and support for collaborative climate change management efforts agencies must reconsider how they interact with the public. Land managers must be prepared for legal challenges that accompany environmental decisions. Legal barriers have long been an issue for environmental managers. The US National Park Service (NPS) has been sued over issues such as snowmobiling in Yellowstone National Park and driving off-road vehicles on the beaches of Cape Hatteras National Seashore. As long as a legal trump card can be played in environmental disputes, there are no incentives to compromise and little incentive for stakeholders to come to the table. Adding to the already complex set of sociological issues, climate change is a highly political issue (Castree, 2010) which has the potential to polarize the public against adaptive management measures. For example, one of the measures proposed during the Crown meeting was to begin to plant non-native drought-resistant species in areas that are projected to become drier due to changes in precipitation and temperature. This proactive and experimental management initiative could be met with resistance from the public who do not fully understand the science behind such a unique management decision. To prevent litigation, organizations in the Crown need to build public trust regarding their institutions and actions. Collaborative conservation emphasizes local participation, sustainability, and inclusion of the disempowered, and focuses on voluntary compliance and consent rather than legal and regulatory enforcement (Brick, Snow, Bates, & Kemmis, 2000). This technique encompasses the social and ecological aspects of the sustainable environmental management of ecosystems. The foundational principles of collaborative conservation promote a shared understanding of the intersection between human communities and ecological systems and encourages practitioners to form partnerships with diverse stakeholders to create robust and inclusive management strategies. Building trust is a difficult process, but by promoting cooperation between agencies and the public, collaborative conservation may allow innovative climate change management initiatives to bypass the litigation process.

To better educate the public and build support for climate change initiatives, organizations must have consistent messages across political boundaries. Federal, state, and international agencies can also collaborate with NGOs to promote environmental education and outreach. For example, the Nature Conservancy (TNC) was one of the NGOs that participated in the Crown workshop. For over fifty years TNC has worked with local communities, businesses, tribes, and government organizations to preserve and protect ecosystems. By working with TNC, agencies such as the NPS, Parks Canada, and others can encourage collaborative dialogue in communities about land use planning, development, individual responsibility and climate change.

It is also important for management agencies to partner with NGOs from other sectors, which may or may not be able to impede the adaptive and collaborative management process. For example, developers, agriculturalists, and miners all have interests in the Crown, which may not involve preservation of the ecosystem. These organizations and individuals must be included in order to create a more robust and successful collaborative effort. Activities such as the situation mapping exercise can serve as a way to include disparate views and facilitate dialogue among potentially conflicting stakeholders. If trust and understanding can be built among these groups they can serve as a valuable ally to communicate climate change management efforts to the public.

Including non-intuitive partnerships and the broader public in collaborative efforts is often difficult and time consuming, and can yield unexpected and unintended results. Even if the organizations within the Crown create a comprehensive strategy for communicating climate change this information may not inspire the public to support Crown managers' decisions. Concerns such as quality of life, economic stability, and environmental hazards, may affect the public's perceptions about climate change management within the Crown. Managers and others must engage the public about potential solutions as well as problems currently created by climate change.

Summary and Future Research

Many environmental issues existed before climate change became an international concern. Climate change may be the catalyst organizations need to address the complex web of interrelated ecological and social issues within local ecosystems. By highlighting the work individual agencies are already doing and exploring techniques to manage the complexity of climate change in the Crown, this collaborative conservation workshop allowed participants to further consider the coordination of management efforts across multiple scales and boundaries. To overcome legal and structural barriers to adaptation, organizations must reach out to the public through environmental education and collaborative conservation initiatives. By including a wide variety of stakeholders within a community and an ecosystem, organizations can create robust and successful partnerships.

While collaborative conservation has been applied to issues such as grazing rights on public lands and water rights in the arid southwest (Brick et al., 2000), it is just beginning to be applied to complex issues like climate change. Collaboration is a complicated and time consuming process which requires patience and perseverance from participants. To fully explore the collaborative processes and interactions taking place in the Crown prolonged and persistent observation is needed. Further research may include facilitating an inter-agency workshop between the CMP and the public to discuss climate change and the impacts on the socioeconomic and ecological issues in the ecosystem. Through prolonged immersion into the collaborative project at the Crown researchers could gain valuable insight into how collaborative initiatives at the ecosystem level are sustained and how they change with the inclusion of the public.

CHAPTER THREE

Climate Change Scenario Planning: A Model for the Integration of Science and Management in Environmental Decision-Making

Global climate change requires a shift in natural resource management practices and increased collaboration between land managers and surrounding communities. Climate models illustrate a wide variety of impacts of climate change that may severely degrade fragile ecosystems and therefore negatively influence the natural environments as well as social experiences for which protected areas were established. As the climate changes, land management strategies must adapt to higher levels of uncertainty and risk. A systematic and scientific approach toward understanding natural resources must be adopted to manage effectively in the face of uncertainty (Baron et al., 2009). Decision-makers and scientists require an innovative technique to understand and adapt to both biological and societal changes.

Scenario planning has been used by organizations, federal agencies, and countries to address issues of great uncertainty and to provide plausible descriptions of possible future states of the world. The scenario planning process embraces uncertainty by identifying those unknowns that matter most in shaping the future of a focal issue. This technique can be a powerful tool for exploring general areas of risk and opportunity. An essential tenant of scenario planning is the idea that in a situation of uncertainty, planning becomes learning (van der Heijden, 1996).

Scenarios can serve as the catalyst for broader strategic conversations throughout an organization. The scenario planning approach has been applied to a number of environmental case studies (e.g. Maack, 2001; McCarthy, Canziani, Leary, Dokken, & White, 2001; Peterson, Cumming, & Carpenter, 2003) For decision-makers facing complex and daunting ramifications of climate change, the major benefits of scenario planning include increased understanding of key uncertainties, incorporation of alternative perspectives into conservation planning, greater resilience of management decisions, and an integrated foundation to build more nuanced environmental models.

Many fragile ecosystems in the United States are protected by the National Park Service (NPS). National Parks are prime climate change research locations because they contain relatively unspoiled, rare, and delicate ecosystems. The purpose of this project is to explore how climate knowledge and uncertainties are explored by decision-makers and scientists during the scenario planning process. The NPS recently hosted a series of climate change oriented scenario planning workshops for two case study parks. The project was designed to promote collaborative learning through scenario planning enabling NPS scientists and decision-makers to better address the consequences of climate change as they unfold in future years. Two Parks participated in this project, Assateague Island National Seashore (ASIS) in Maryland, and Wind Cave National Park (WICA) in South Dakota. ASIS is a barrier island located off the coast of Maryland. The Park encompasses 48,000 acres and is comprised of near-shore and estuarine waters as well as a constantly shifting sand bar. Some of the main management concerns regarding climate change at ASIS include recreation, multi-agency collaborative management, sea-level rise, and intensification of storms. WICA features one of the world's longest caves and 28,295 acres of mixed-grass prairie and ponderosa pine forest. Wildlife such as American bison, elk, pronghorn, and prairie dogs are among the many charismatic fauna in the Park. Climate change management concerns at WICA include recreation in the cave, fire, drought, and extreme precipitation events.

The overarching research question for this investigation is: *How does scenario planning work in the context of climate change management?* The NPS implemented the scenario planning project to raise awareness of and build capacity to engage in scenario thinking in order to better understand and address climate change issues for the NPS and other agencies. Here, I focus on two specific research questions related to the NPS project objectives: (1) *How are science and conceptual information tested and validated during the process of scenario planning?* This question explores the collaborative definition of scenario terminology how assumptions about science and management are challenged during the scenario planning process. (2) *How do managers and scientists determine when they have enough science to move forward with management*? During the scenario planning process scientists and decision-makers worked together to determine how climate science can be validated and applied to land management. Climate projections in the 2007 Intergovernmental Panel on Climate Change (IPCC) report project long-term and broad-scale impacts of climate change. During the NPS scenario workshop the information from the 2007 IPCC report was downscaled to the specific ecosystems in each of the Parks. By encouraging decision-makers and scientists to discuss the testing, validation, and application of climate science the scenario planning process promoted open communication between these two disciplines.

Scenarios are meant to be a tool for long-term strategic planning. In situations of great uncertainty scenarios need to be simple, dramatic, and bold – to cut through the complexity and aim directly at the heart of the decision (Schwartz, 1991). The scenario planning approach allows practitioners to incorporate a wide range of uncertainties and drivers into the planning process while keeping the decision-making process streamlined. Recently, a formal approach to scenario planning for environmental decision-making was created to promote collaborate environmental decision-making (Mahmoud et al., 2009). Under this framework scenario development is understood as an iterative process with five progressive phases including; definition, construction, analysis, assessment, and risk management (Mahmoud et al., 2009). The scenario planning process utilized for the NPS project was very similar to the framework outlined by Mahmoud et al. (2009). The NPS scenario process, created by the Global Business Network (GBN), progressed through orientation, exploration, synthesis, action, and monitoring. Scenarios are validated iteratively during each phase of the scenario planning process through discussions among the participants. The first three of the five stages in both of these formal scenario frameworks are very similar. Participants must define the problem through orientation, explore the scenarios during their construction, and analyze the scenarios through a synthesis of all of the different alternatives. The first three phases of the scenario planning process were conducted during the course of the NPS scenario planning workshop. Currently the Parks are assessing the validity of the scenarios for management and determining risks associated with each of the scenarios which were created. During the assessment phase decision-makers identify risks associated with the scenarios and devise plans to monitor and audit scenario plans and the resulting management strategies (Mahmoud et al., 2009). Assessment of scenarios requires extensive discussion among researchers and decision-makers. After assessment scenarios must be examined for risk management opportunities by decision-makers. Risk management activities include the implementation of strategies to reduce potential vulnerabilities, increasing resiliency, and positioning resources to exploit opportunities (Mahmoud et al., 2009).

The process of scenario planning creates compelling narratives of future environments in which decisions may be played out; which has the potential to inform the development of sophisticated environmental models. Furthermore, the participation of a large group of people in a systematic process of collecting, discussing, and analyzing scenarios builds shared understanding (Peterson et al., 2003). In the case of NPS scenario planning project, scientists and decision-makers built shared understanding by negotiating the greatest uncertainties surrounding climate change and the role of science in management. In the following sections I clarify the terminology of scenario planning, review the methodology used during this research project, analyze the process of knowledge creation as enacted by scientists and managers, discuss issues and problems with scenario planning, and make some recommendations for future research in scenario planning and environmental decision-making.

Background

Clarification of Terms

Scenarios are frameworks for structuring organizations' perceptions about alternative future environments in which their decisions might be played out (Ralston &Wilson, 2006). The IPCC defines a scenario as:

> A coherent, internally consistent, and plausible description of a possible future state of the world. It is not a forecast; rather each scenario is one alternative of how the future can unfold (IPCC, 2008, p. 86).

The purpose of scenario planning is to allow practitioners to conceptualize and manage for risk and uncertainty. It is important to define both risk and uncertainty in concrete terms to clarify the goals of the scenario planning exercise. Risk is the measure of the probability of severity of an adverse affect (Mahmoud et al., 2009). The risks related to climate change in environmental management have been studied extensively (e.g. Joyce et al., 2009; Millar, Stephenson, & Stephens, 2007). Characterization of risk in environmental management requires a broad understanding of natural resources and processes. General projections of climate change trends may be useful for the initial stages of risk assessment, but site-specific and detailed climate forecasts are best for characterizing the climate risks in specific parks.

Risk is inherently linked to uncertainty. Uncertainty is the inability to precisely determine the true magnitude and form of system/model variables or characteristics (Mahmoud et al., 2009). In order to create robust management strategies the best scientific knowledge available must be incorporated into decisions and the uncertainty inherent in climate change science must be acknowledged. Mahmoud et al. (2009) laid out three aspects of uncertainty that should be considered when approaching scenario construction and analysis. The first step in the characterization of uncertainty in scenarios is understanding uncertainty, which requires an exploration of the sources of uncertainty in the scenario project. During the scenario definition phase of the NPS scenario planning project decision-makers and scientists identified the sources of the greatest environmental and social uncertainties related to climate change in their Parks. The second step in the characterization of uncertainty is the estimation of uncertainty. During the scenario construction and analysis phases participants determined the magnitude of the uncertainties and how these uncertainties may propagate from one phase of the scenario planning process to the next. The final stage of the characterization of uncertainty is the communication of uncertainty to other stakeholders and decision-makers. This occurs during the scenario assessment and risk management stages.

Mahmoud et al. (2009) called for the proper consideration and communication of the uncertainty inherent in environmental projections. I respond to Mahmoud et al.'s call by examining a case study in which scenarios combined scientific and socio-political uncertainty regarding climate change. Park Service scientists and decision-makers collaborated to create robust scenarios that address multiple uncertainties and promote management strategies that incorporate future climate uncertainties.

Management Objectives

In order to understand the NPS' motivation for the scenario planning project it is important to understand the objectives of the agency as they relate to climate change management. *The Organic Act* established the NPS in 1916. The principle purpose of the Service is to:

> Conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations (para. 1).

The changing climate may complicate the NPS core mission established by *The Organic Act*. Conserving dynamic resources is increasingly difficult as the environment around the resources change.

The *National Park Service Management Policies 2006* provides the broad direction for adopting new management procedures. Section 4.7.2 of this mandate refers specifically to climate change:

> Although National Parks are intended to be naturally evolving places that conserve our natural and cultural heritage for generations to come, accelerated climate change may significantly alter park ecosystems. Thus, parks containing significant natural resources will gather and maintain baseline climatological data for reference (p. 54).

By acknowledging the evolving nature of the Parks and their ecosystems the management policies provide for the possibility that some aspects of the Parks may not remain *preserved*.

On January 16, 2009, former Secretary of the Interior Dirk Kempthorn signed Secretarial Order no. 3326A1, *Climate Change and the Department of the Interior*. This order provides guidance on climate change management and adaptation. In cooperation with other federal agencies, local governments, private landowners, and Tribes, Department of the Interior agencies should "develop adaptation strategies for managing natural and cultural resources affected by such changes" (Secretarial Order 3326A1, 2009, section 2). This order mandates that all NPS units begin to address climate change and adaptation in their management strategies.

Secretarial Order no. 3285 was issued on March 11, 2009, by Secretary of the Interior Ken Salazar. The Order establishes a Department of the Interior-wide approach for applying scientific tools to increase understanding of climate change and to coordinate an effective response to its impacts (Secretarial Order 3285, 2009, p. 1). Under the Order each bureau and office of the Department must consider and analyze potential climate change impacts when undertaking long-range planning exercises. The Order calls for the development of science-based adaptive management for natural and cultural resource managers. The scenario planning project is a direct response to this Secretarial Order. By incorporating the scenario planning technique into management initiatives NPS leadership can adjust land management practices to incorporate state-of-the-art climate science with adaptive management strategies.

Methodology

I used an inductive approach in this research project in order to explore the collaborative process of scenario planning and the implications for improved climate change decision-making models. Through participant observation I acquired an in-depth knowledge of the scenario planning technique and the application of this technique to NPS climate change management efforts. Participant-observation research is a qualitative research method that involves the direct observation of social phenomena. The participant observation approach is utilized when (1) the research problem deals with fields in which naturally occurring communication phenomena exist and (2) the research deals with phenomena that take place within a relatively limited space and time. The natural resource management field provides a unique opportunity for participant-observation research because of the nature of decision-making and the timeframe within which decisions are made. Decision-making during the NPS scenario project was a collaborative effort, with many specialists working together to incorporate a wide variety of social and ecological information into the scenarios. The NPS project also took place over the course of a limited amount of time, during the period of seven months from December, 2008 to July 2009.

I observed and participated in multiple conference calls, meetings, and webinars leading up to the NPS scenario workshop. Leading up to the workshops the meetings focused on familiarizing participants with the process of scenario planning introducing participants to the projects' goals, and negotiating the type of scenarios to be used at the workshop.This methodology allowed me to experience the process of scenario planning as I observed it.

I utilized a multitude of different qualitative data sources to evaluate the scenario planning project and the subsequent process of knowledge negotiation between scientists and managers. Data gathered included field notes, interviews, lectures, personal journals, mind-mapping exercises, phone conversation transcriptions, email chains, and extensive notes from the planning phases of the workshop. Qualitative coding of the data took place after all of the data was collected. I used open-coding techniques to explore the data and organize information into understandable and compelling categories. Utilizing a combination of relevant literature, personal notes, and observed trends during the workshops I created a coding scheme which allowed me to critically examine the data I collected during my observations and experiences.

After multiple iterations of the coding process I selected four codes which were most compelling and applicable to the study of the NPS scenario process. Once these codes were determined I returned to the data and organized it according to the coding scheme. These codes included: (1) challenging assumptions, (2) clarification of terms, (3) validation of science and scenarios, and (4) negotiation of amount of science in management. Each of the codes can be understood as a theme which was expressed during the scenario planning process. I then conducted further research within the relevant literature to assess the coding scheme's applicability applicability to this project and to gain a deeper knowledge of these four themes.

Because this research project is primarily qualitative and subject to the interpretation of the researcher the methodology included my own experiences as well as the data gathered through participation and observation. The participant-observation technique allowed me to develop an in-depth knowledge the process of scenario planning and to explore the testing, validation, and negotiation of NPS climate scenarios during this process.

Creation of Scenarios

The scenarios created during the NPS project challenged the participants' assumptions about environmental and social processes and allowed them to explore multiple different possible futures. The project also encouraged decision-makers and scientists to engage in an active dialogue about the uncertainties inherent in climate change management. By creating multiple scenarios participants tested decisions under a variety of plausible futures. The purpose of this exercise was to strengthen the NPS' ability to recognize, adapt to, and take advantage of, changes over time.

Scenario Type

With the help of the Global Business Network (GBN) a core team of NPS decision-makers determined the type of scenario that would be used for this project. Decision-makers and scientists attempted to create scenarios which were *anticipatory* in nature, describing desired or feared future conditions resulting from climate change impacts. These scenarios were *policy-responsive* and *expert-driven*, incorporating both political processes and scientific knowledge about climate change impacts into the scenarios. To address both the technical and conceptual aspects of climate change, participants created a *nested scenario*. The nested scenario will be further described in section 4.3. Scenarios must be internally consistent with the driving forces that are critical to the project at hand (Houghton et al., 2001). These driving forces were determined by exploring the most uncertain and most pressing environmental and social concerns that may affect the Parks in the future. Scenarios must also be both environmentally and socially possible. Storylines were created about potential scenarios to determine which were the most useful and plausible scenarios. For example, WICA examined multiple climate drivers before assigning *precipitation patterns* and *drought severity* as the axes for the nested environmental scenario.

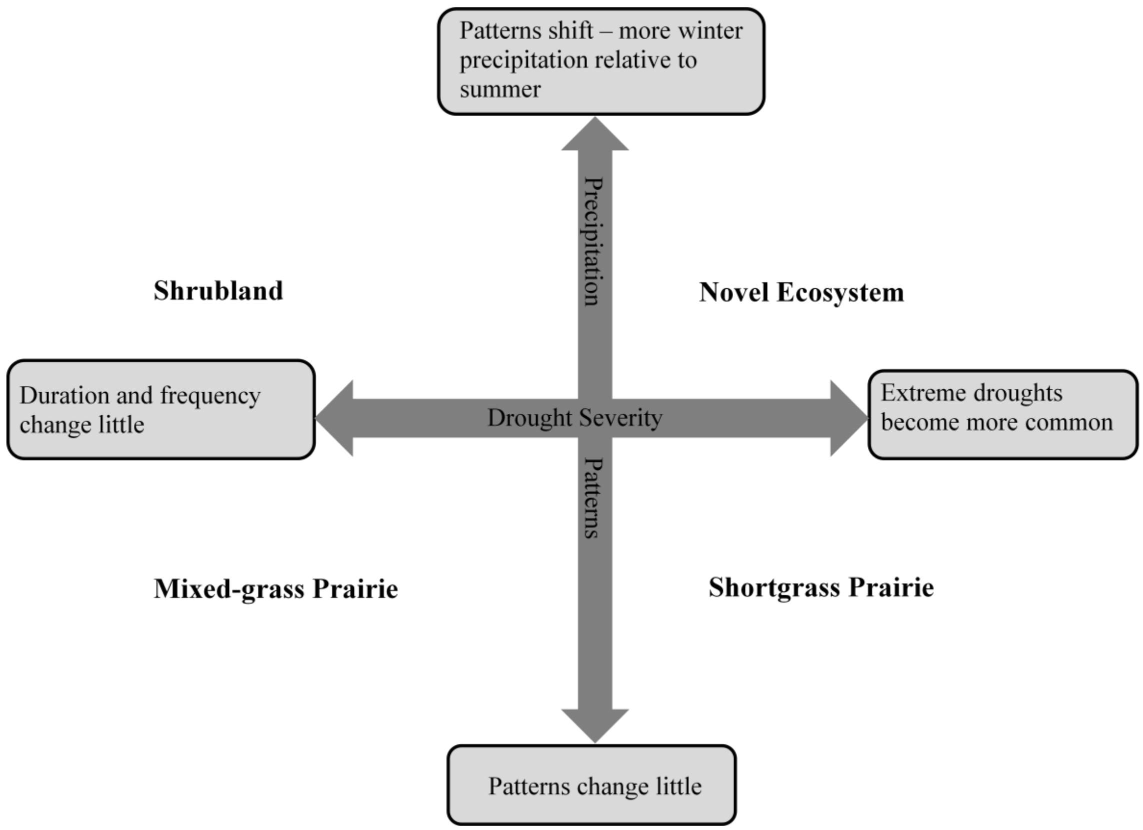

Figure 1: WICA climate change scenarios created using the Park's climate drivers matrix

Precipitation patterns were chosen as an axis because there is very little scientific consensus on future trends and the impact of precipitation on the vegetation above ground and the cave processes below ground may be a significant management concern. Drought severity is linked with precipitation patterns and in combination with extreme precipitation events can create an ecosystem much different than the current mixed-grass prairie at WICA. In the *Novel Ecosystem* scenario precipitation patterns shift to more precipitation during the winter relative to summer and extreme drought events become much more common in the ecosystem. This scenario envisions an ecosystem unlike anything the park managers have managed before. Under this scenario the ecosystem will exhibit characteristics similar to the southwestern United States. Species migration may not be able to keep up with the changes, causing fauna such as the American bison to be threatened by loss of habitat. Under the *Novel Ecosystem* scenario decision-makers at WICA will need to make difficult decisions about the above-ground mission of the Park.

In the past many land management agencies have built their management plans around the concept of stationarity, where past conditions and processes provide the guidance for contemporary management (Landres, Morgan, & Swanson,1999). Considering the uncertainty associated with future climates, managing processes based on previous trends is no longer appropriate. Multiple land management techniques have been explored to deal with climate uncertainty, including adaptive management and scenario planning. Adaptive management is applicable where it is possible to influence ecological processes but there is uncertainty regarding the best management practices (Baron et al., 2009). The capacity of an ecosystem to adapt to change is a critical starting point for adaptive management. Adaptive management requires ecological resilience to buffer systems from potential failure of management actions that are based on incomplete understanding of ecosystem responses (Baron et al., 2009). Scenario planning does not require ecological resilience as it creates buffers against uncertainty by exploring multiple and varied management actions.

Anticipatory scenarios make use of both past and possible future conditions (Mahmoud et al., 2009). These scenarios are best for creating storylines which are driven by very uncertain and very pressing concerns such as climate change impacts on social and environmental phenomena. The core team of NPS decision-makers chose the anticipatory approach because it best fit the climate change management objectives of the agency. These scenarios were policy-responsive and based in expert judgment to address the political and environmental aspects of the NPS mandates. Participants named each of the upper-level socio-political scenarios, to make the scenarios more memorable and distinct (See Figure 2).

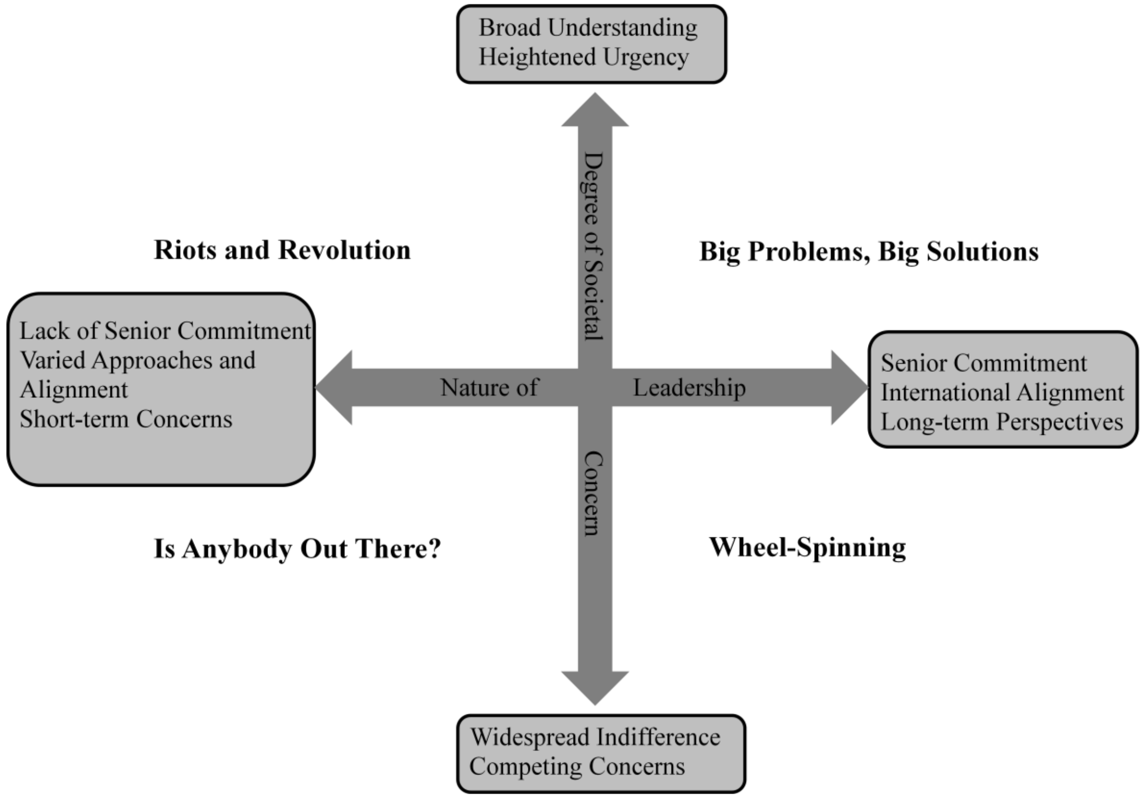

Figure 2. High-Level Scenario Framework. Critical uncertainties associated with the impacts of climate change on socio-political systems.

The *Is Anyone Out There?* scenario describes climate change as a variable concern that is often ignored by political leaders who are more interested in short-term concerns and varied climate management approaches. Under this scenario widespread indifference is common in society and competing concerns draw attention away from sustainable climate change management. By creating and discussing the implications of the *Is Anyone Out There?* scenario decision-makers were able to explore the management actions necessary in this socio-political environment.

Policy-responsive scenarios are outlined based on critical issues and constructed with the desired policy as the targeted future outcome (Mahmoud et al., 2009). This type of scenario is frequently used in organizational and governmental decision-making to better manage risks and uncertainties (e.g. Schwartz, 2000, Steinitz, et al., 2003, Baker et al., 2004). During the definition phase of the NPS scenario project began with a core team of decision-makers who determined the critical social and political issues that needed to play a role in the upper-level scenarios. Some of the critical uncertainties included; intensity of climate impacts on the average American citizen, degrees of cooperation among agencies, sense of public ability to make a difference, and economic prosperity. Because the NPS is a federal agency which manages public lands much of the focus of the upper-level scenarios was on public perception of climate change and public interest in National Parks.

Policy-responsive scenarios can either be driven by stakeholders or based on expert judgment (Mahmoud et al., 2009). The NPS chose to use expert judgment instead of stakeholder participation to create the climate scenarios. The local environmental climate drivers were determined by scientists from each of the case study parks and were informed by expert judgment from other climate specialists. Relevant scientific knowledge regarding climate change impacts was derived from projected future trends based on climate models from the 2007 IPCC climate assessment, observed climate trends in the Parks and local historic climate trends. The expert-driven scenarios allowed scientists and decision-makers to integrate the most relevant scientific knowledge about climate change with the very specific impacts observed at the individual Parks. Each Park unit created a set of climate drivers tables based on the best available science and expert judgment.

Table 1. Climate Drivers Table – ASIS National Seashore

Climate Variable	General Change Expected	Confidence - Level
Temperature	Increase, but not uniform	Virtually certain
Precipitation	Probably decrease in total annual precipitation	Low
Sea Level	Increase	Moderate
Length of Growing Season	Increase	High

The drivers tables were heavily relied upon during the scenario construction and analysis phases. The use of expert-judgment to create scenarios also allowed participants to reach a scientifically-based consensus about the possible impacts of climate change on the Parks.

Nested Scenario

The nested scenario approach was adopted by participants to address both the broader social drivers and the more local environmental climate drivers in the Parks. This approach combined two matrices, the broader socio-political drivers and the local environmental drivers (See Figure 3).

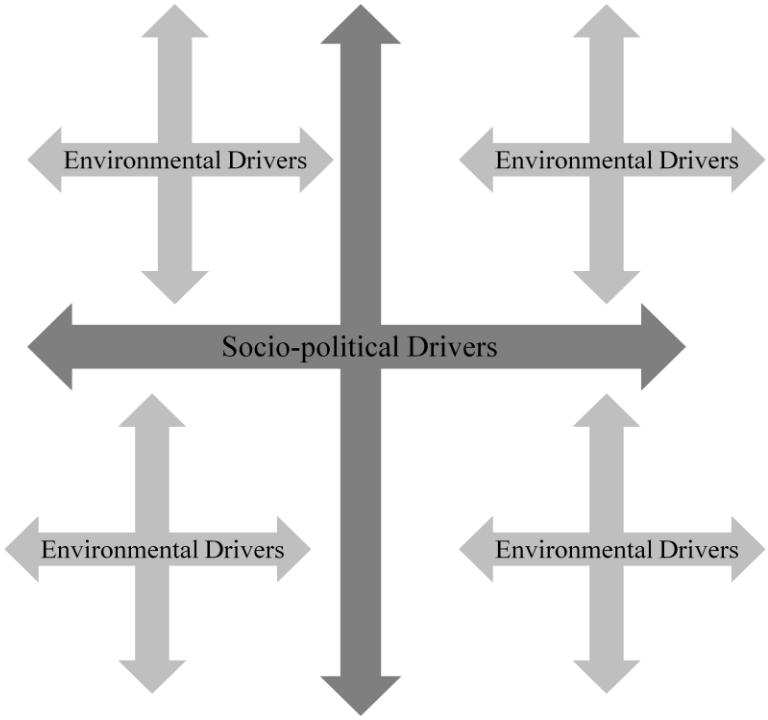

Figure 3. Model for the nested scenarios created during the NPS scenario planning workshop

This type of scenario best reflects the combination of conditions and constraints that Park leadership face regarding climate change. The broader social drivers were determined by the core team of decision-makers during the definition phase of the scenario process. After extensive discussions among core team members, negotiations culminated in a determination that the *nature of leadership* and the *degree of societal concern* were the most important and most uncertain societal drivers. During these negotiations core team members considered the timeframe, scope, and scale of the climate impacts as well as the mandated management objectives regarding climate change. Participants discussed the importance of political leadership on individual, organizational, and federal levels and analyzed the implications of strong and weak leadership. The varying degrees of societal concern were discussed in relation to climate change impacts, incorporating drivers such as economics, the media, and climate education. The nested scenario approach incorporates scientific and social drivers and ensured the political plausibility of the scenarios.

Scenario Themes

The complex interactions between the social and environmental forces at work in the NPS scenarios served as plot lines within the NPS narrative about future climate change management. Mahmoud et al. (2009) highlighted three types of scenario themes; good news and bad news, winners and losers, and growing or declining forces. While the scenario themes for the NPS project were never formally defined, the discussion of scenario themes occurred multiple times during the workshop. One participant noted:

> By framing the impacts in terms of winners and losers we recognize our filter of whether something is good or bad. This is a good communications piece to keep morale up. As natural resource managers we envision the current situation as good and change as bad. Sometimes we don't recognize this bias.

This comment highlights a number of important aspects of the scenario planning exercise. The participant recognized the use of scenario framing (themes) as a communications piece to explain the consequences of climate change on NPS management to the public. She also recognized the bias natural resource managers have toward the stationarity assumption. By recognizing this bias and voicing this concern participants were able to move beyond their assumptions and challenge their definitions of good and bad climate impacts.

Scope of Scenarios

Successful environmental scenarios generally combine elements of climate, socioeconomic, and environmental drivers. It is important to define the scale and scope of the scenarios early in the scenario creation process to encourage conversations about the stories the scenarios could tell and to encourage the involvement of decision-makers. Because scenario planning is commonly driven by decision-makers with a particular set of objectives, projects are usually focused on a particular set of future conditions which narrow the scope of the scenarios (Mahmoud et al., 2009). The NPS project created climate scenarios which were informed by climate projections as well as socioeconomic driving forces and observed environmental trends. The socioeconomic aspect of the scenarios was inherently complex because it required extrapolation and expert judgment to produce plausibly coherent scenarios (McCarthy et al., 2001). By combining climate, socioeconomic, and environmental factors participants greatly increased the scope of the NPS project. Natural resource scientists were assigned the task of researching and synthesizing the climate and environmental drivers while decision-makers and social scientists considered the social factors that could be affected by climate change.

Participants also discussed the implications of the scale of drivers and degree of climate impacts. One scientist asked, "Is societal concern local to the Park or national? There could be a big difference between these two scales at the Park. What would have more impact, local or Park?" If local concern about climate change differs from the amount of concern felt nationally there could be major implications for management. Decreased concern at the national level and increased concern at the local level could lead to lawsuits from local landowners and lack of funding for the NPS because of lack of national interest in climate change management in the Parks.

Participants bounded the scenarios both conceptually and temporally. With the inclusion of climate, environmental, and socioeconomic drivers it was necessary for NPS participants to define the temporal scope of the scenarios to keep the project manageable. For both of the case study Parks the timeframe for the scenarios was defined as the next 40 years, or until 2050. This timeframe is significantly longer than many planning documents currently used by the NPS. Because scenario planning is a long-term planning tool the timeframe of the project is significantly longer than the general management plan (GMP) for the Parks which scope of work is generally 15-20 years. A GMP is a broad plan that identifies desired resource conditions and visitor experiences that support the Park's purpose, significance, fundamental resources and values. Most plans are written in the context of the National Environmental Protection Act (NEPA) environmental impact statement (EIS). Linking the scenario planning process to planning activities increases credibility and acceptance from decision-makers (Maack, 2001).

Challenging Assumptions

The scenario process helps participants share their perceptions about uncertainty and risk and develop mutually understood contingency plans (Maack, 2001). The results of the NPS scenario project have yet to be seen, but by observing the process of collaborative learning enacted by decision-makers and scientists during this project we can explore how participants negotiated the management of climate uncertainties. Scenarios are designed to challenge the assumptions of the participants and to expose the underlying driving forces affecting the project. Throughout the course of the NPS scenario project participants examined and challenged their assumptions about natural resource management and climate science.

Management

During the exploration and synthesis phases of the scenario project decision-makers questioned their assumptions about their role as managers and the dynamic aspect of ecosystems. The role of the NPS is outlined in *The Organic Act of 1915*. As the climate impacts the natural resources managed by the Park Service the objectives outlined in *The Organic Act* may become outdated. In Glacier National Park climate models predict that the park's glaciers will disappear by 2030 (Hall & Fagre, 2003), what does this mean for management of the Park? NPS decision-makers were already grappling with these types of questions before the scenario planning project. The scenario planning process allowed decision-makers to openly discuss the implications of climate change on federal land management legislature and their role as land managers in a federal institution.

The stationarity assumption was a prevalent concern during decision-maker's discussions about climate change management. One decision-maker noted, "Land management has focused mainly on historic conditions. A new policy apparatus needs to shift to management toward future decisions." By challenging decision-makers' assumptions about the type of management that is needed regarding climate uncertainty the scenario planning process opened the door to discussions about different management techniques and improved adaptability of natural resource management. This process fostered a transparent intellectual process for decision-making at all levels.

Science

During the creation of the climate drivers tables scientists negotiated the greatest environmental climate uncertainties. This discussion challenged the scientists' assumptions about environmental climate drivers and the impacts of climate change in the future. The climate drivers tables were organized into three columns; climate variable, general change expected, and confidence level (See Table 1). Variables included temperature, precipitation, drought, length of growing season, and others. Determination of general change expected was based on the best available climate data and on observable trends in the Parks. Scientists determined the greatest uncertainties regarding climate change in the Parks based on output from 21 climate models run under the A1B emission scenarios from the IPCC Fourth Assessment report (IPCC, 2007). Once the critical uncertainties were determined they were crossed to create a matrix in which each of the four quadrants acted as the basis for a scenario about climate change impacts in the Park (See Figure 2). By collaboratively creating the scenario matrix scientists ensured plausible and technically valid scenarios of future ecosystems resulting from climate change.

The collaborative creation of the drivers tables also allowed the scientists to build a scientifically-based consensus about the impacts of climate change on the Parks, a consensus which was later a foundation of the discussions between scientists and decision-makers. Park scientists recognized their own bias during the creation of the climate drivers table. One scientist stated, “You are assuming certain things about what the climate is going to do. The purpose is to explore the meaning of those impacts. We are coming up with a list that has biases.” While scientists recognized that every climate drivers list contains biases, by incorporating diverse expertise and peer-reviewed information in the drivers table, scientists were able to identify each other’s biases and work together to create a more inclusive and objective analysis of climate drivers and impacts.

Amount of Science in Management

This project addressed a critical concern regarding the integration of science and management in the NPS. An April 2000 report in *Science* claimed that “inadequate science is hampering management decisions in the National Park system” (Kaiser, 2000, p. 34). Parsons (2004) argues that the long-term success of the NPS in preserving natural ecosystems depends to a large degree on the amount of support the agency can provide for the science that is necessary to understand natural ecosystems and the effects of human activities. The NPS recognizes that it has a two-fold responsibility to science – to use the best available science in park management and to encourage research in the parks that benefits society as a whole (National Park Service Advisory Board, 2004). In order to uphold the mandate of preservation of resources laid out by *The Organic Act* the NPS must master the science required to maintain ecological integrity under climate change in the Parks.

Due to the convergence of national interest in the NPS, the current administration's commitment to improving the application of science to decision-making, and the establishment of the position of science advisor to the NPS director, the NPS has an extraordinary opportunity to advance science within the agency (Machlis, 2010). Collaborative learning environments and improved information management are prerequisites for the integration of science and management (Bosch, Ross, & Beeton, 2003). Collaborative learning is one of the theoretical foundations of scenario planning, encouraging scenario practitioners to explore risk and uncertainty in the context of learning. The discourse during the scenario analysis phase between scientists and decision-makers regarding both technical and conceptual critical uncertainties allowed participants to define the amount of science necessary to move forward with management techniques. For example, WICA participants chose *drought severity* and *precipitation patterns* as the most important and most uncertain climate drivers for their local environmental nested scenarios (See Figure 1). During the scenario construction phase a scientist from WICA noted, "A decrease in drought is not a probable scenario, given the climate projections." The 2007 IPCC scenarios played an important role in determining the amount of science and certainty of science needed to create plausible scenarios. The climate drivers for the scenarios were collaboratively determined by scientists and decision-makers. After the drivers were chosen and the scenarios created, a WICA decision-maker asked, "If drought severity increases during the summer and precipitation patterns shift to more snow in the winter, how will we plan and manage for this scenario?" By incorporating highly technical science with the conceptual concerns of decision-makers the scenario planning process allowed scientists and managers to collaboratively create scenarios. Decision-makers and scientists negotiated the certainty of science and the implications of uncertain projections on management decisions. The scenario planning process allowed scientists and decision-makers to envision management techniques that promoted resilient ecosystems and management strategies under every scenario, such as prescribed fires, improved communication across boundaries, and better monitoring of at risk species. The purpose of the scenario planning project was not to eliminate uncertainty but to determine how much scientific certainty was needed to create plausible management initiatives.

Discussion

Advantages of Adopting the Formal Scenario Approach

By combining the technical and the conceptual aspects of future climate scenarios the NPS scenario project acted as a case study trial of Mahmoud et al.'s (2009) formal scenario development framework. This case study incorporated subjective (e.g. expert driven) scenarios with technically-based climate scenarios created by the IPCC (2007) to synthesize social and science-based scenarios. Because they contained multiple perspectives, specialties, and data sources the NPS scenarios were more robust management tools.

Scenario planning provides the starting point for active dialogue between scientists and decision-makers and encourages collaborative learning across disciplines. Collaborative learning gives researchers and participants the ability to recognize how individuals and organizations process and communicate new information. During the scenario planning process participants defined key terms such as risk and uncertainty and negotiated the implications of those terms as they are applied to climate change management. By creating a common framework and a common language among the participants scenario planning bridged the disciplinary gap between decision-makers and scientists. After bridging this gap scientists and decision-makers moved forward to collaboratively create scenarios which encompassed the expertise and concerns of all participants. Scenario planning encouraged collaborative learning among the participants and created a foundation of trust between decision-makers and scientists that may be used in the future to encourage further collaboration between the two disciplines.

Challenges during the Scenario Planning Process

Mahmoud et al. (2009) argues that the main advantage of a unified framework for scenario planning lies in the formation of a community-based effort. One of the challenges during the NPS scenario planning project was the potential for participants to overlook their agency bias toward social issues. While participants were able to address some of the biases associated with their individual specialties, the needs and concerns of the public were not fully incorporated into the planning process. Failure to gain support from stakeholders (e.g. the public) leads to scenarios that are not deemed credible (Maack, 2001). By choosing to conduct a scenario planning exercise informed by expert judgment instead of stakeholder concerns the NPS project potentially biased the scenarios toward the interests of the federal agency staff.

Other challenges during the NPS scenario planning project included the pressing demands of day-to-day operational issues. Mahmoud et al. (2009) argues that a high cost of failure or a high reward in correctly anticipating future conditions leads to higher incentives to expend available resources toward scenario planning projects. The NPS climate change management objectives broadly outline the necessary steps that must be taken to address climate change. These mandates do not give explicit incentives for NPS decision-makers to aggressively adapt management techniques to address climate change. Secretarial Order 3285 outlined broad objectives for climate change research and management in the DOI, but failed to issue exact mandates about how decision-makers should incorporate climate into everyday operations. Management objectives must be downscaled to promote aggressive climate action in individual Parks. Without explicit directions and mandates to address climate change, NPS decision-makers and scientists lack the catalyst to place climate change management and adaptation as a top priority.

Summary and Future Recommendations

In this project we have explored the application of the formal scenario framework created by Mahmoud et al. (2009) to the NPS scenario planning project. Mahmoud et al. (2009) argues that the lack of general guidance on how to approach formal scenario planning has discouraged environmental scientists and decision-makers from using scenarios in the past. The formal scenario approach utilized during NPS scenario project allowed participants to explore the application of scenario planning as a climate change management technique. It also encouraged active dialogue between decision-makers and scientists about critical uncertainties and risks and allowed participants to examine how the role of the NPS may be affected by climate change.

The purpose of the NPS scenario planning project was to raise awareness of, and teach capabilities in, scenario planning, so that NPS and related agencies would be better prepared to address the consequences of climate change as they unfold in future years.

> Identifying resources and processes at risk, defining thresholds and reference conditions, and establishing monitoring and assessment programs are among the types of scientific practices needed to support a broadened portfolio of management activities (Baron et al., 2009, p. 1033).

Using the nested scenario approach this project incorporated downscaled projections of climate impacts on specific Parks with broad socio-political impacts of climate change. By thinking in terms of scenarios, participants highlighted the biggest risks facing each Park, and discussed the types of management actions that are needed to plan for future conditions.

The central challenge to a formal scenario framework is the lack of understanding of scenarios and their incorporation and application toward a project's context (Mahmoud et al., 2009). By applying scenario planning to climate change management efforts in the NPS this project allowed NPS participants to explore the scenario planning process and create robust and plausible climate scenarios for their Parks. However, the scenario framework outlined by Mahmoud et al. (2009) and utilized by the NPS must be validated through continued application of the process in NPS climate change management projects and other environmental management initiatives. To validate the scenarios created during the NPS scenario planning project the scenarios must go through the assessment and risk management phases of the scenario process.

Mahmoud et al. (2009) suggests that the development of formal scenario approaches that can effectively combine expert and citizen-driven scenarios and research based scenarios can create more variable scenarios which can provide more constructive information. The scenario planning process has been proposed as a management technique that can be specifically tailored as an input to the GMP process. Scenarios that include active policy-planning processes are more likely to be successful (Mahmoud et al., 2009). As with all federal land management planning documents the GMP needs to go through the NEPA process. Under NEPA the NPS must engage the public in environmental planning efforts through public scoping, public meetings and/or a variety of media. These mandated actions take time, but can be invaluable in building relationships between the park, stakeholders, and the public. The NPS scenario project participants saw potential for scenario planning as a public communication tool because building scenarios is a conversational process. By incorporating stakeholders and the public into the scenario planning process the NPS can create more robust and valid scenarios. These scenarios can form the foundation of future environmental planning efforts by incorporating both the uncertainties associated with climate change and the perspectives of a wide variety of stakeholders and agency experts.

CHAPTER FOUR

Conclusion

Climate change may be the window of opportunity land managers and organizations need to reconsider their roles, management objectives, and partnerships. Many environmental issues existed before climate change became an international concern. By highlighting the work individual agencies are already doing and exploring techniques to manage complexity and uncertainty these two climate change management case studies allowed participants to challenge their assumptions about environmental management and consider the coordination of management efforts across multiple scales and boundaries. Management techniques based on collaborative learning such as scenario planning and collaborative conservation allow diverse stakeholders to voice concerns and combine their expertise. To overcome legal and structural barriers to adaptation, organizations must reach out to the public through environmental education and collaborative conservation initiatives. By including a wide variety of stakeholders, organizations can ensure robust and successful partnerships and management initiatives.

Land management agencies have been grappling with issues such as drought, extreme weather events, and forest fires for decades. In the Crown the native cutthroat trout are threatened by decreased stream flows resulting from melting glaciers and from human reallocation of water to agricultural uses. While climate change complicates the already complex issue of water use and allocation it does not rewrite the book on water management. Similarly, the decision-makers and scientists at Assateague Island National Seashore (ASIS) already deal with extreme weather events that reshape the fragile ecosystem located on the Park's barrier island. Climate change may cause sea level to rise and instigate stronger storm systems, but by exploring the possibility of multiple futures and scenarios the staff at ASIS can build their resiliency to climate impacts. Land managers can also draw upon management techniques already in place to cope with the uncertainty and complexity associated with climate change. Practices such as prescribed burns, emergency response teams, and interagency partnerships raise the resiliency of land management organizations to sudden or unexpected events such as forest fires. The sociological and ecological complexity of climate change complicates the uncertainty of climate science and impacts. By coordinating land management efforts across political boundaries organizations can increase their capacity to cope with the complexity of climate impacts.

Through participant observation, interviews, and an extensive review of relevant literature I was able to explore the processes of collaborative conservation and scenario planning. As a participant and an observer I immersed myself in the Crown and NPS scenario workshops, observing how participants negotiated collaborative conservation and the use of scenario planning as climate change management techniques. I amassed a wealth of data while conducting participant observation from the preparation to the evaluation phases of the workshops. At first, the sheer volume of data was daunting. Through many iterations of the coding process I began to cultivate an understanding of the stories that participants told during the workshops. Once I reached saturation, where the same themes began to repeat themselves, I started the second iteration of the coding process in which I consulted relevant literature and reexamined my codes. After reviewing relevant literature and discussing the codes with my committee I conducted the third and final iteration of the coding process. During this phase I considered how all of the codes fit together into the broader story of climate change management in protected areas. Systems theory and system innovation influenced my creation of codes by allowing me to see the broader picture of how climate change management is affected by uncertainty and complexity. I was able to gain a deeper understanding of how the processes of system innovation, collaborative conservation and scenario planning unfold by observing participants' interactions during the workshops. Eventually I concluded that the stories being told during these workshops were not about the challenges of climate change, but instead the opportunities climate change affords land managers to reconsider their goals and partnerships. I thoroughly enjoyed this research project. Each phase was an opportunity for me to explore how qualitative methods tie in to sociological theories. The workshops allowed me to observe negotiations among participants while contributing my own social science perspective to the conversations.

The research questions I explored for my thesis are process-based questions, asking how collaborative conservation works in the context of climate change and how managers and scientists work to validate climate science. These types of questions are appropriate when applied to underexplored processes such as climate change management. In the future it may be helpful to ask questions which explore organizational leadership and the structural issues underlying climate change management. By examining how leadership promotes organizational innovation we can study questions related to structure and agency as they are applied to climate change management.

Organizations can build public support and understanding for climate change management initiatives by coordinating public outreach and land management initiatives across scales, from local governments to international land management agencies. Climate change may be the catalyst that encourages communities and organizations to reexamine their roles as partners in collaborative conservation by focusing collaborative efforts on adaptation and planning for the future.

REFERENCES

Baker, J.P., Hulse, D. W., Gregory, S.V., White, D., Van Sickle, J., Berger, P.A., … Schumaker, N.H. (2004). Alternative futures for the Willamette River Basin, Oregon. *Ecological Applications, 14*(2), 313-324.

Baron, J., Gunderson, L., Allen, C., Fleishman, E., McKenzie, D., Meyerson, L., … Stephenson, N. (2009). Options for National Parks and Reserves for adapting to climate change. *Environmental Management, 4*(6) 1033-1042.

Bosch, O.J.H., Ross, A.H., & Beeton, R.J.S. (2003). Integrating science and management through collaborative learning and better information management. *Systems Research and Behavioral Science, 20*, 107-118.

Brick, P., Snow, D., Bates, S.F., & Kemmis, D. (2000). *Across the great divide: explorations in collaborative conservation and the American west*. Washington, DC: Island Press.

Carrara, P.E. (1989). *Late quarternary glacial and vegetative history of the Glacier National Park region, Montana.* U.S. Geological Survey Bulletin 1902. Denver, CO: USGS, 64.

Castree, N. (2010). The politics of climate change. *Sociological Review*, 58(1) 156-162.

Crown Managers Partnership (CMP). (2006). Strategic Plan. Miistakis Institute.

Daniels, S. & Walker, G. (2001). *Working through environmental conflict: The collaborative learning approach.* London, UK: Praeger.

Flathead County. (2010). About Flathead County. Retrieved from: http://flathead.mt.gov/about_flathead_county/index.php. (Accessed on March 2, 2010)

Gregory, R., Ohlson, D., & Arvai, J. (2006). Deconstructing adaptive management: Criteria for applications to environmental management. *Ecological Applications*, *16*, 2411-2425.

Hall, M.P., & Fagre, D.B. (2003). Modeled climate-induced glacier change in Glacier National Park, 1850-2100. *Bioscience, 53*, 131-140.

Houghton, J.T., Ding, Y., Griggs, D.J., Noguer, M., Van der Linden, P.J., & Xiaosu, D. (2001). Climate change 2001: The scientific basis. Contribution of working group 1 to the third assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

Intergovernmental Panel on Climate Change (IPCC). (2007). Climate change 2007: The physical science basis. Summary for policymakers. Cambridge University Press, Cambridge.

Intergovernmental Panel on Climate Change (IPCC). (2007). Fourth Assessment Report: Climate Change 2007. Cambridge, UK: University of Cambridge Press.

Intergovernmental Panel on Climate Change (IPCC). (2008). Intergovernmental panel on climate change. Retrieved from http://www.ipcc-data.org/ddc_definitions.html

Joyce, L. A., Blate, G. M., McNulty, S. G., Millar, C.I., Moser, S., Neilson, R.P., & Peterson, D.L. (2009). Managing for multiple resources under climate change: National forests. *Environmental Management*, *44*, 1022-1032.

Julius, S.H., & West, J.M. (2008). Preliminary review of adaptation options for climate-sensitive ecosystems and resources. Climate Change Science Program (CCSP) U.S. Environmental Protection Agency, Washington, DC.

Kaiser, J. (2000). Bringing science to the national parks. *Science*, *284*, 1747-1748.

Kauffman, A., & Todtling, F. (2001). Science-industry interaction in the process of innovation: the importance of boundary-crossing between systems. *Research Policy, 30*, 791-804.

Landres, P.B., Morgan, P., & Swanson, F.J. (1999). Overview of the use of natural variability concepts in managing ecological systems. *Ecological Applications, 9*, 1179-1188.

Lindgren, M. & Banhold, H. (2003). *Scenario planning: the link between future and Strategy.* New York, NY: HoundMills, Palgrave MacMillan.

Maack, J. (2001). Scenario analysis: a tool for task managers, Social Development Paper no. 36, Social Analysis: Selected Tools and Techniques, World Bank, Washington, D.C.

Machlis, G. (2010). Advancing science in the National Park Service: Introduction to the NPS science dialogues. USDA National Park Service, Washington D.C.

Mahmoud, M., Liu, Y.Q., Hartmann, H., Stewart, S., Wagener, T., Semmens, D., … Winter, L. (2009). A formal framework for scenario development in support of environmental decision-making. *Environmental Modelling and Software*. *24,* 798-808.

Malecki, J. (1997). *Technology and economic development*. Addison-Wesley Longman, Harlow.

McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J., & White, K.S. (2001). Climate change 2001: Impacts, adaptation, and vulnerability contribution of working group II to the third assessment report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge

McKenzie, D., Peterson, D., & Alvarado, E. (1996). Extrapolation problems in modeling fire effects at large spatial scales: A review. *International Journal of Wildland Fire, 6*, 165-176.

Millar, C., Stephenson, N., & Stephens, S. (2007). Climate change and forests of the future: Managing in the face of uncertainty. *Ecological Applications, 17*(8), 2145–2151

Minard, A. (2009, March 2). No more glaciers in glacier national park by 2020? *National Geographic News*. Retrieved from http://news.nationalgeographic.com/news/2009/03/090302-glaciers-melting.html

Montana Department of Natural Resources and Conservation (DNRC). (2010). About Montana Department of Natural Resources and Conservation. Retrieved from: http://dnrc.mt.gov/About_Us/about.asp. (Accessed March 1, 2010).

Moser, S. (2009). Governance and the art of overcoming barriers to adaptation. *IHDP Update. 3,* 31-36.

National Park Service Advisory Board. (2004). National Park Service science in the 21st century. USDA National Park Service, Washington D.C., USA.

National Park Service (NPS). (2008). *Climate change in national parks* [Brochure]

O'Neal, K. (2002). Effects of global warming on trout and salmon in U.S. streams. Defenders of Wildlife and the Natural Resource Defense Council. Retrieved from: http://www.defenders.org/resources/publications/programs_and_policy/science_and_economics/global_warming/effects_of_global_warming_on_trout_and_salmon.pdf?ht. (Accessed March 1, 2010)

Parks Canada. (2000). Waterton Lakes National Park of Canada management plan. Minister of Public Works and Government Services Canada, Ottawa, ON.

Parks Canada. (2009). State of the park report: Waterton Lakes National Park. Minister of Public Works and Government Services Canada, Ottawa, ON.

Parsons, D.J. (2004). Supporting basic ecological research in U.S. National Parks: challenges and opportunities. *Ecological Applications*, *14*(1), 5-13

Peterson, G., Cumming, G., & Carpenter, S. (2003). Scenario planning: A tool for conservation in an uncertain world. *Journal of Conservation Biology, 17*(2), 358-366.

Prato, T. & Fagre, D. (2007). *Sustaining rocky mountain landscapes: Science, policy, and management for the crown of the continent ecosystem*. Washington, DC: Resources for the Future.

Ralston, B. & Wilson, I. (2006). *The scenario planning handbook: Developing strategies in uncertain times.* New York, NY, Thompson Publishing.

Schwartz, P. (1991). *The art of the long view*. New York, NY, Doubleday.

Schwartz, P. (2000). The official future, self-delusion and the value of scenarios. *Financial Times.* May 2, 2.

Smith, B. (2001). Winter feeding of elk in western North America. *The Journal of Wildlife Management*, *65*, 173-190

Steil, G. & Gibbons-Carr, M. (2005). Large group scenario planning. *Journal of Applied Behavioral Science*. *41*, 15-13.

Steinitz, C., Arias, H., Bassett, S., Flaxman, M., Goode, T., Maddock III, T., …. & Shearer, A. (2003). *Alternative futures for changing landscapes: the Upper San Pedro river basin in Arizona and Sonora.* New York, NY, Island Press.

United States Census Bureau. (2009). State and County Quick Facts. Retrieved from: http://factfinder.census.gov/servlet/SAFFPopulation?_event=Search&_name=flathead+county&_state=04000US30&Submit.x=6&Su (Accessed March 1, 2010)

United States Global Change Research Program (USGRP). (2009). United States national assessment of the potential consequences of climate variability and change: A detailed overview of the consequences of climate change and mechanisms for adaptation. Washington, DC

United States Forest Service (USFS). (2009). Lewis and Clark National Forest news release. Retrieved from: http://www.fs.fed.us/r1/lewisclark/news/2009/2009-burn-plan-littlebelt-castlemtns.pdf. (Accessed on March 5, 2010)

Van der Heijden, K. (1996). *Scenarios: The art of the strategic conversation.* New York, NY, John Wiley and Sons.

West, J., Julius, S., Kareiva, P., Enquist, C., Lawler, J., Peterson, B., Johnson, A., Shaw, M. (2009). U.S. natural resources and climate change: Concepts and approaches for management adaptation. *Environmental Management*, *44*, 1001-1021.