National Park Service
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Natural Resource Stewardship and Science

Climate Change Scenario Planning for Central Alaska Parks

Yukon-Charley, Wrangell-St. Elias, and Denali

Natural Resource Report NPS/AKSO/NRR—2014/829

Scenarios Network
FOR ALASKA & ARCTIC PLANNING

ON THE COVER

Canoe on Wonder Lake, National Park
Photo by NPS http://www.nps.gov/dena/photosmultimedia/Scenic.htm

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Executive Summary

Changing climatic conditions are rapidly impacting environmental, social, and economic conditions in and around National Park Service (NPS) areas in Alaska. With over 50 million acres of parklands to administer, Alaska park managers must better understand possible climate change trends in order to better manage arctic, subarctic, and coastal ecosystems, as well as human uses of these areas. As such, NPS managers undertook an exploration of scenario planning as an innovative approach to science-based decision-making in the face of an uncertain future. Climate change scenarios are defined herein as plausible yet divergent futures based on the best available current knowledge of driving climate variables. These scenarios will help prepare NPS Alaska park managers for impending changes to make informed decisions for future outcomes.

This effort took off in 2010, when NPS national and Alaska regional offices released climate change response strategies for the National Park System and the Alaska Region, respectively (NPS 2010a, NPS 2010b). Scenario planning was identified in both strategies as a high priority for understanding potential climate change impacts to park resources, assets and operations. As a result, NPS and University of Alaska's Scenarios Network for Alaska and Arctic Planning (SNAP), a research group focused on climate change modeling and adaptation, embarked on a three-year collaborative project to help Alaska NPS managers, cooperating personnel, and key stakeholders consider potential consequences of climate change by developing plausible climate change scenarios for all NPS areas in Alaska. Final products include climate change scenario planning exercises, reports and other informational products for all NPS units in Alaska, with efforts organized around each of the four Inventory and Monitoring (I&M) networks.

The Climate Change Scenario Planning project began in August 2010, when the NPS Climate Change Response Program partnered with Jonathan Star of the Global Business Network (GBN) to initiate a series of scenario planning training workshops across the National Park System. A team of NPS Alaska Region and SNAP employees participated in the Alaska training workshop, learning how to develop scenarios based on nested frameworks of critical uncertainties, and fleshing out the beginnings of climate change scenarios for two pilot parks.

Building from that learning experience, Central Alaska was the fifth and last area in Alaska to be examined by NPS through a scenarios workshop held April 16-18, 2012. This workshop was based on the framework introduced by GBN, and led by a core team who had participated in at least one workshop beforehand. This April 2012 workshop focused on Yukon-Charley Rivers National Preserve (YUCH), Wrangell-St. Elias National Park and Preserve (WRST), and Denali National Park and Preserve (DENA).

Participants included representatives from the parks in question, NPS staff from the Alaska Regional Office, SNAP personnel, and key individuals from other agencies, nongovernment organizations, and communities with a stake in this region. These individuals contributed a wide range of perspectives and expertise to the process and outcomes of the workshop.

Participants identified key issues facing the parks in this particular region of Alaska. Key issues included the many possible effects of increased forest fire and thawing permafrost. More specifically, future scenarios focused on potential impacts to ecosystems and to the humans who

rely on them as fire, permafrost thaw, and general warming trends cause changes in vegetation, hydrology, wildlife, and subsistence species.

General findings and recommendations include: revisiting management policies; increasing invasive/introduced species management; introducing cooperative planning with tribes and other stakeholders; adjusting harvest regulations and seasons; increasing development of alternative energy sources in response to high fuel costs; and increasing interpretation and education efforts with respect to the changing landscape. In addition, better baseline data are needed for variables such as river flow, rare plants, and archaeological sites; and increased monitoring is needed for fire, glaciers, fisheries, and large mammals.

The climate change scenario planning process does not end with these workshops, reports, and presentations. Rather, this living process is intended to stimulate creative thinking to address changing but still undetermined future environmental and socio-political future conditions. The process should be refreshed periodically as important new information becomes available. In summary, park managers, park neighbors, and stakeholders can be best prepared for the future by using the best available scientific information and climate projections to create plausible, divergent, relevant, and challenging future climate change scenarios. These scenarios can help us all better prepare for uncertain future conditions in the face of a changing climate.

Acknowledgments

All of the National Park Service Scenario Planning Workshops were highly participatory, relying on input from every attendee. We would like to thank each of the individuals listed in Appendix B, as well as the organizations and communities that made it possible for them to attend.

List of Terms & Acronyms

CAKN	Central Alaska Network, the National Park Service's Inventory & Monitoring network of parks in interior Alaska
CCSP	Climate Change Scenario Planning
Climate driver	A climate variable that drives changes in weather, vegetation, habitat, wildlife, etc. Also referred to as a *critical force* or *scenario driver*.
Climate effects	Existing or potential consequences, outcomes, or results of changes in climate. Can appear beneficial or deleterious, depending on perspective.
Critical force	A climate variable that drives changes in weather, vegetation, habitat, wildlife, etc. Also referred to as a *climate driver* or *scenario driver*.
ENSO	El Nino-Southern Oscillation. A climate pattern that occurs across the tropical Pacific Ocean on an approximately five-year time scale, which can cause extreme weather events in many regions of the world.
Impact	A forceful or particularly significant consequence. An effect that is likely to warrant a response.
Narrative	In scenario planning, a story, in any variety of formats, used to visualize potential future circumstances.
Nested scenario	A set of projected future environmental conditions "nested" within a sociopolitical framework.
PDO	Pacific Decadal Oscillation. A pattern of Pacific Ocean climate variability that shifts between a cool (negative) phase and warm (positive) phase on a 20-30 year time scale.
Potential effects	Inherently possible, likely, or expected, but not necessarily certain, effects.
Scenario	A projected course of events or situations, used to understand different ways the future might unfold.
TEK	Traditional Ecological (or Environmental) Knowledge. A cumulative body of knowledge built up by a group of people over many generations of close contact with nature. Sometimes distinguished from other forms of local knowledge, developed over fewer years or generations of experience.
WRST	Wrangell-St. Elias National Park & Preserve, CAKN Network
YUCH	Yukon-Charley Rivers National Preserve, CAKN Network

Introduction

In this paper, we describe the Climate Change Scenarios Planning (CCSP) effort at several different levels. First, we introduce the rationale and need for such an effort, at the national, statewide, and local level. Next, we provide background on the particular Global Business Network (GBN) methods used in this project – as well as in parallel projects for the other park networks in Alaska. This background places GBN methods in the context of other possible planning tools. In this context, we discuss modifications that were necessary to best address the particular challenges of climate change planning.

In the Workshop Group Products section, we provide significant detail with regard to the products and outcomes of the scenarios process. This includes intermediate data from the brainstorming processes that took place during the three-day Scenarios Planning Workshop, although some of these products are linked only via appendices. These details are included in order to allow this paper to serve as not only a project summary, but also a roadmap or case study for any similar efforts that may take place in the future, either in Alaska or elsewhere.

The Common Implications, Actions, and Needs section of the paper pulls together these products into a more cohesive summary of outcomes. Finally, we discuss the ramifications of these outcomes from the perspective of management, future collaboration, and future research.

Project Rationale

Climate change is occurring at a global scale, and its effects are felt very strongly in Alaska (Chapin et al. 2005). We can no longer manage for old goals and priorities assuming a static climate. Given the complexities and multiple disciplines involved with climate-change challenges, collaboration and knowledge sharing among multiple disciplines are essential. Scenario planning is an educational process that helps park employees and others understand climate trends; anticipate future changes that may affect resources, assets, and operations in parks and surrounding areas; and consider a range of possible climate change response strategies. This effort represents a collaboration between the National Park Service (NPS) and the Scenarios Network for Alaska and Arctic Planning (SNAP), whose mission is to “develop plausible scenarios of future conditions through a diverse and varied network of people and organizations, which allow better planning for the uncertain future of Alaska and the Arctic” (www.snap.uaf.edu).

The focus of the workshop described in this report was largely on examples from central Alaska National Parks (Figure 1). However, concerns and effects of climate change are clearly not limited by property lines. The results from this scenario planning workshop can be equally relevant to residents and managers of surrounding areas.

Focal Question

The focal question of this workshop was "How can NPS managers best preserve the natural and cultural resources and other values within their jurisdiction in the face of climate change?" Although parks were a primary focus, participants were also invited from affiliated communities, and other areas for broader, regional-scale perspectives. Answers to the focal question were intended to be advisory rather than in any way binding. As will be discussed, the focal question was intended to be addressed in the context of scenario planning. Thus, some recommendations for managers are robust to all possible futures, while some are more heavily weighted toward preventing negative outcomes (or enhancing positive outcomes) associated with only one of several possible futures.

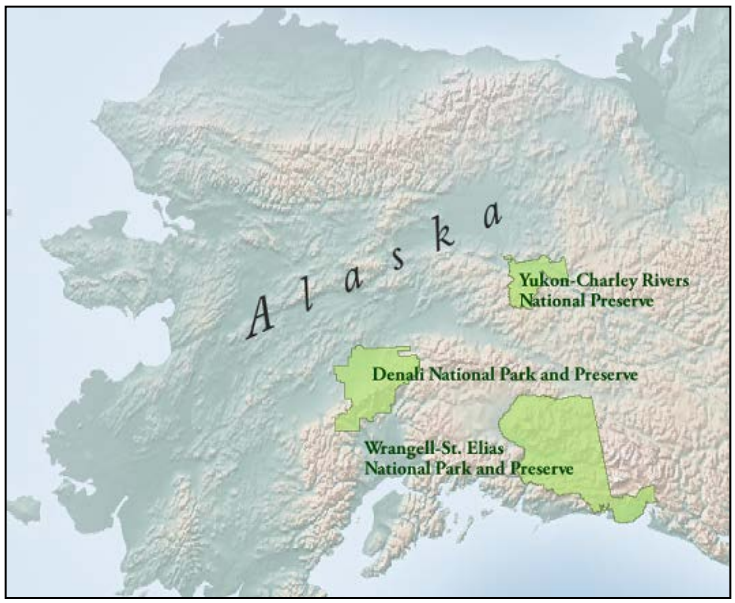


Figure 1: Central Alaska Network (CAKN) national parks.

Scenario Planning Process

Natural resource managers and others have explored multiple methods for making management decisions in the face of uncertainty and/or ongoing change. In cases where the future can be predicted via predictive modeling with a relatively small error margin, managers generally choose to seek optimal control. However, in the real world, natural systems uncertainty is often more uncontrollable and irreducible (Peterson et al. 2003, Schwartz 1996).

Under highly uncertain conditions, action based on a single predictive forecast can be extremely risky. Other available planning methods include adaptive planning (Walters 1986) and scenario planning. The two methods have some similarities, in that both recognize the role of uncertainty and the need for resilience in the face of unknown futures. However, in the case of scenario planning, management experiments are built into the models, rather than playing out over time.

Scenario planning explores multiple possible futures based on the best available information of future conditions. Peterson et al. (2003) note that: "Ideally, scenarios should be constructed by a diverse group of people for a single, stated purpose. Scenario planning can incorporate a variety of quantitative and qualitative information in the decision-making process. Often, consideration of this diverse information in a systemic way leads to better decisions. Furthermore, the participation of a diverse group of people in a systemic process of collecting, discussing, and analyzing scenarios builds shared understanding." This combined goal of building understanding and sharing high-quality information in a diverse group was key to this project.

Scenario planning, as outlined by the Global Business Network (GBN), has been used successfully by corporations, government and nongovernmental organizations, and was selected as the most effective way to create management tools and frameworks that would be both useful and flexible in the face of uncertainty (Schwartz 1996).

Unlike forecasting, scenario planning emphasizes multiple possible futures (Figure 2). Forecasts assume that the future is fairly predictable, at least within some range of variability. Scenarios conversely, are possibilities, not predictions about the future. Scenarios can use modeling output, but they recognize the inherent unpredictability of complex systems. Scenarios envision a range of plausible, relevant, divergent and challenging futures and then ask the question "What if this was to happen?" Consequently, scenarios provide a richer background for planning and decision making than traditional forecasting methods. These scenarios should be created and selected to be relevant, plausible, divergent and challenging.

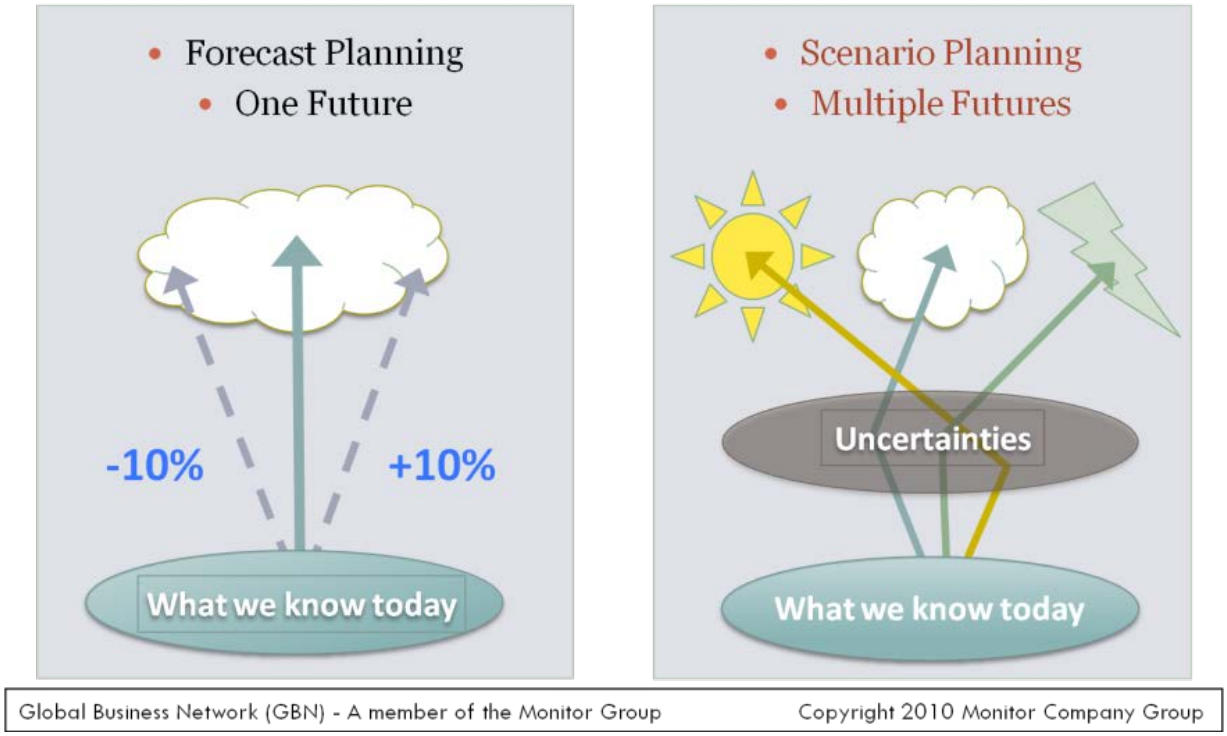


Figure 2: Difference between forecasting and scenario planning. Diagram courtesy of GBN.

The scenario planning process asks participants to orient on a focal question; explore and synthesize potential scenarios; act, by identifying and implementing actions appropriate to address potential outcomes; and monitor the results of these actions (Figure 3). The latter two steps (Act and Monitor) occur after the CCSP workshop.

Scenario synthesis is dependent on a multi-step process in which participants select two key drivers of change that are both important (likely to cause multiple significant effects) and uncertain (in terms of the magnitude or direction of the change). These drivers, when intersected, yield four possible futures (Figure 4). By selecting the drivers with the greatest importance and

uncertainty, workshop participants insure that these four futures represent highly divergent scenarios that approximate the full range of possibilities worth exploring in depth.

In this workshop, the primary drivers were biophysical drivers of climate change. Participants first fleshed out some of the details of the four outcomes suggested by these primary drivers, by creating bulleted lists of potential effects to humans, ecosystems, and infrastructure in and around parks. They then took the scenarios process to a higher level by examining each possible future in a sociopolitical framework that incorporated a wide range of societal concern and an equally wide range of institutional support (Figure 5). Selected divergent scenarios from this framework were fully described in both summary and narrative forms, and management actions were suggested based upon each selected scenario.

Scenario planning offers participants the opportunity to search for actions that perform well under all scenarios (often called “no-regrets” or “robust” actions), current actions the park should continue, and actions that are unlikely to make sense in any future scenario. These actions are often among the immediate and powerful scenario outcomes. There are also a variety of other strategic approaches that offer different levels of risk when developing a range of actions as illustrated in Figure 6.

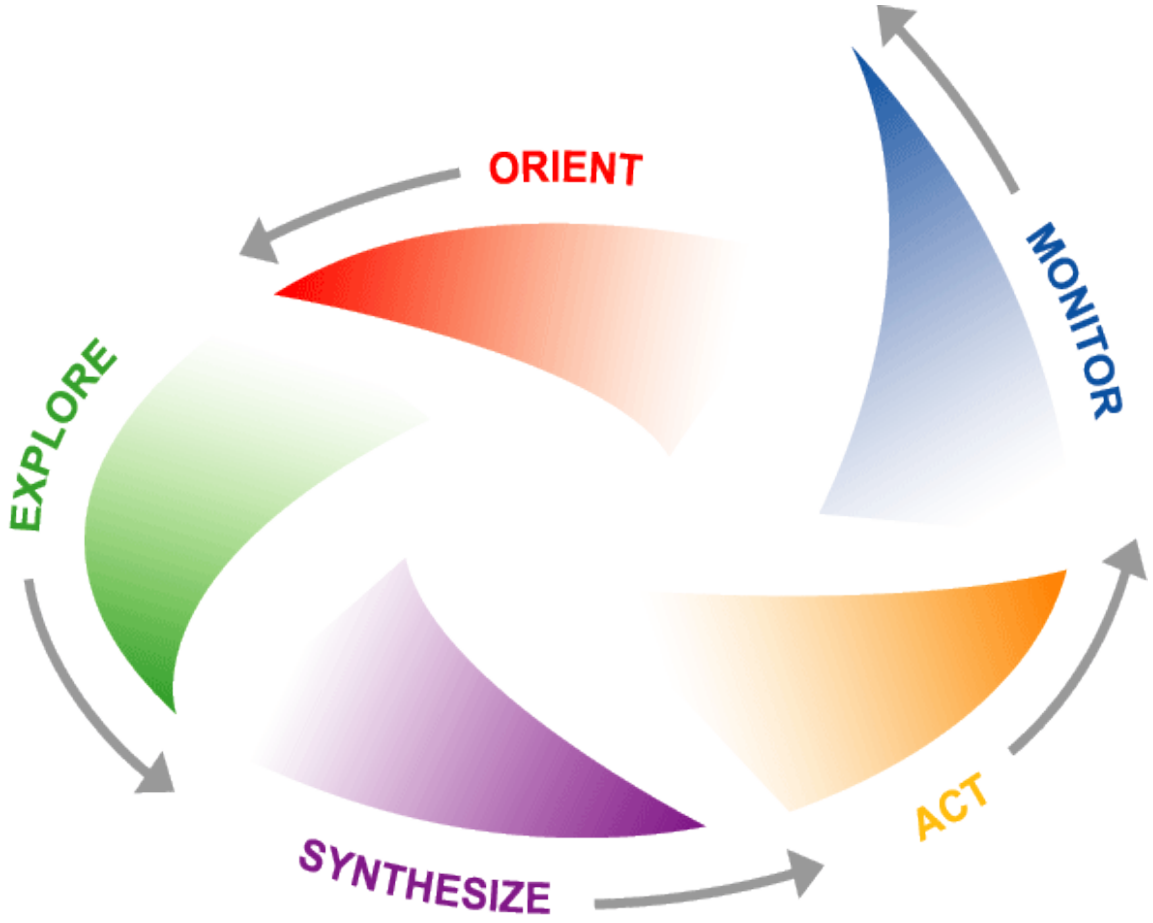


Figure 3: Stages in the scenarios building process. Diagram provided by the Global Business Network (GBN).

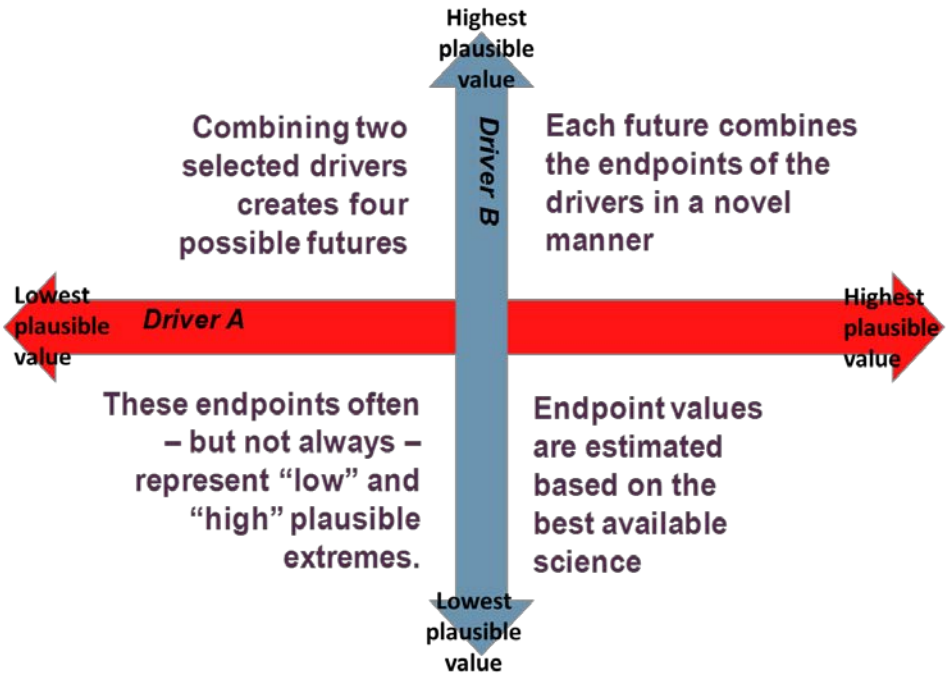


Figure 4: Creating a primary scenarios matrix. Two key climate-related drivers of change are crossed to create four possible futures.

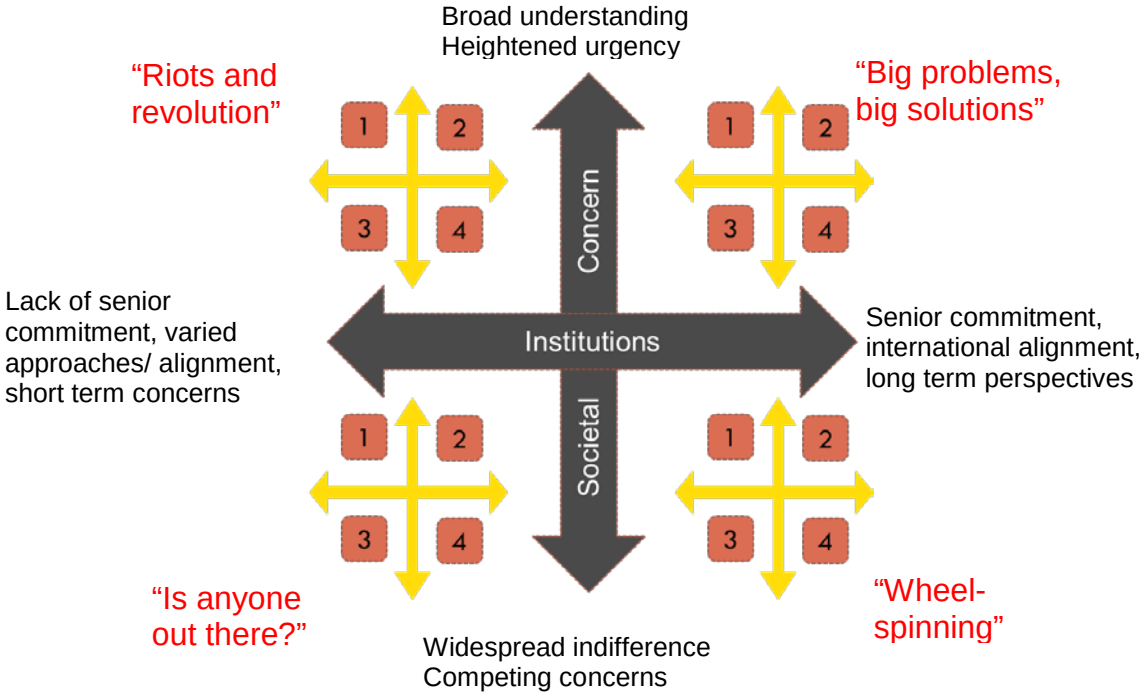
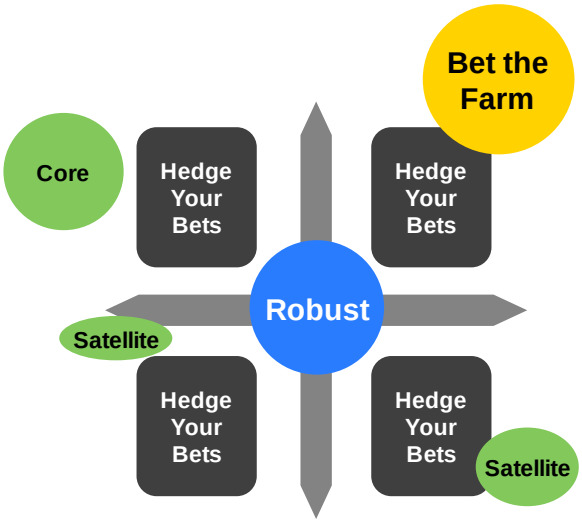


Figure 5: General design for a socio-political framework that incorporates the degree of societal concern in the future and the nature of future leadership. Adapted from the Global Business Network (GBN).



Robust: Pursue only those options that would work out well (or at least not hurt you too much) in any of the four scenarios

OR

Bet the Farm / Shaping: Bet the Farm / Shaping: Make one clear bet that a certain future will happen — and then do everything you can to prepare for that scenario becoming a reality

OR

Hedge Your Bets / Wait and See: Make several distinct bets of relatively equal size

OR

Core / Satellite: Place one major bet, with one or more small bets as a hedge against uncertainty, experiments, and real options

Figure 6: Categorizing options to help set strategy. Optimal planning depends on weighing choices based on their short-term and long-term outcomes. Diagram adapted from the Global Business Network (GBN).

Adapting the Scenarios Process to CCSP in Alaska

This report provides a detailed description and case study illustrating how managers can use scenario planning for land management in the face of climate change. In order to implement the strategies described above in the context of climate change planning in Alaska's National Parks, the project leadership team – consisting of individuals from the NPS Alaska Regional Office, NPS staff from outside Alaska already trained in scenarios planning, and SNAP climate modelers – set up a scenarios planning effort intended to meet the goals of diverse and intensive participation and reliance on the best available information.

As such, the leadership team pulled together project participants to participate in a three-day workshop preceded by informational webinars. These participants were intentionally selected to include NPS employees, local residents, and representatives from other agencies and businesses that had a stake in the region. The team also gathered, prior to the initiation of the webinars, extensive scientific information from published literature, climate models, and expert knowledge. These were summarized into tables and brief documents in order to facilitate access by all participants.

Pre-Workshop Webinars

Prior to the workshop, participants were invited to take part in two one-hour webinars. The goals of these webinars were to orient participants on the scenario planning process, introduce climate change maps and data, and share existing knowledge among the group. These webinars

contained information summarized from scenarios planning training with Alaska Region NPS staff, other NPS staff, and SNAP researchers, conducted in August 2010 by Jonathan Star of the Global Business Network (GBN) and Leigh Welling (NPS).

Webinar 1, led by Nancy Fresco of SNAP, covered an introduction to scenarios planning and introduced key climate-linked forces driving ecological, biophysical, or social change in the Central Alaska parks. (See Appendix F for a table of Central Alaska climate drivers). Webinar 2, led by Robert Winfree of NPS, was focused on climate change effects in the Central Alaska parks. Participants were asked to help rank the relative importance of these effects. (See Appendix G for the Central Alaska climate change effects table.) PowerPoint presentations and recordings of each webinar are available in the "Webinar 1" and "Webinar 2" folders at: http://www.snap.uaf.edu/webshared/NPS-CCSP/2012_Central_Alaska/

Models, Data, Maps, and Other Information

To help inform consideration of a range of possible futures, workshop participants were provided with data, maps, and summaries of climate projections specific to the interior Arctic region (Appendix D, Appendix E). Other climate change information, including drivers of change (Appendix F) and effects of those drivers (Appendix G), were shared prior to and during the webinars and workshop. This information was drawn from multiple sources. Prior to embarking on the project, NPS prepared regional summary documents on climate change impacts, including talking points on impacts to Alaska's boreal and Arctic regions (Appendix D). More quantitative assessments of ongoing change and projected future change to multiple climate variables were obtained from SNAP data and from peer-reviewed scientific literature.

Additional knowledge was drawn directly from project participants, including NPS employees and local residents, and Alaska Natives who were familiar with the landscapes and the management issues facing those landscapes. This traditional, historical and experiential ecological knowledge provided much of the core information and many of the key insights in the workshop process.

Partnering with SNAP allowed NPS access to cutting-edge climate data, maps, and models. SNAP employs a variety of modeling and research methods that have been approved by the scientific community through large-scale research programs and peer-reviewed publications (see Appendix C). Core SNAP climate data are derived from historical Climate Research Unit (CRU) data and five Global Climate Models (GCM) that have been shown to perform best in Alaska and the Arctic. Outputs from these models are downscaled using PRISM data—which accounts for land features such as slope, elevation, and proximity to coastline. A more complete description of SNAP methodology is available at http://www.snap.uaf.edu/methods.php. SNAP also contributed links to sources available via their many partners and collaborators, such as those at the University of Alaska Fairbanks (UAF) Geophysical Institute Permafrost Lab (http://permafrost.gi.alaska.edu/content/modeling).

In particular, SNAP provided data summaries from climate models (contained within the Climate Summary reports for individual parks, and incorporated into the Climate Drivers table in Appendix F). SNAP also provided maps depicting baseline (recent historical) climate and projections of future change to key variables, including monthly mean temperature, monthly mean precipitation, date of freeze, date of thaw, summer season length (Figure 7), and mean

annual ground temperature at one meter depth (Figure 8). Updated versions of a subset of these maps are available in Appendix E, and the complete set is available in the SNAP maps folder at http://www.snap.uaf.edu/webshared/NPS-CCSP/2012_Central_Alaska/

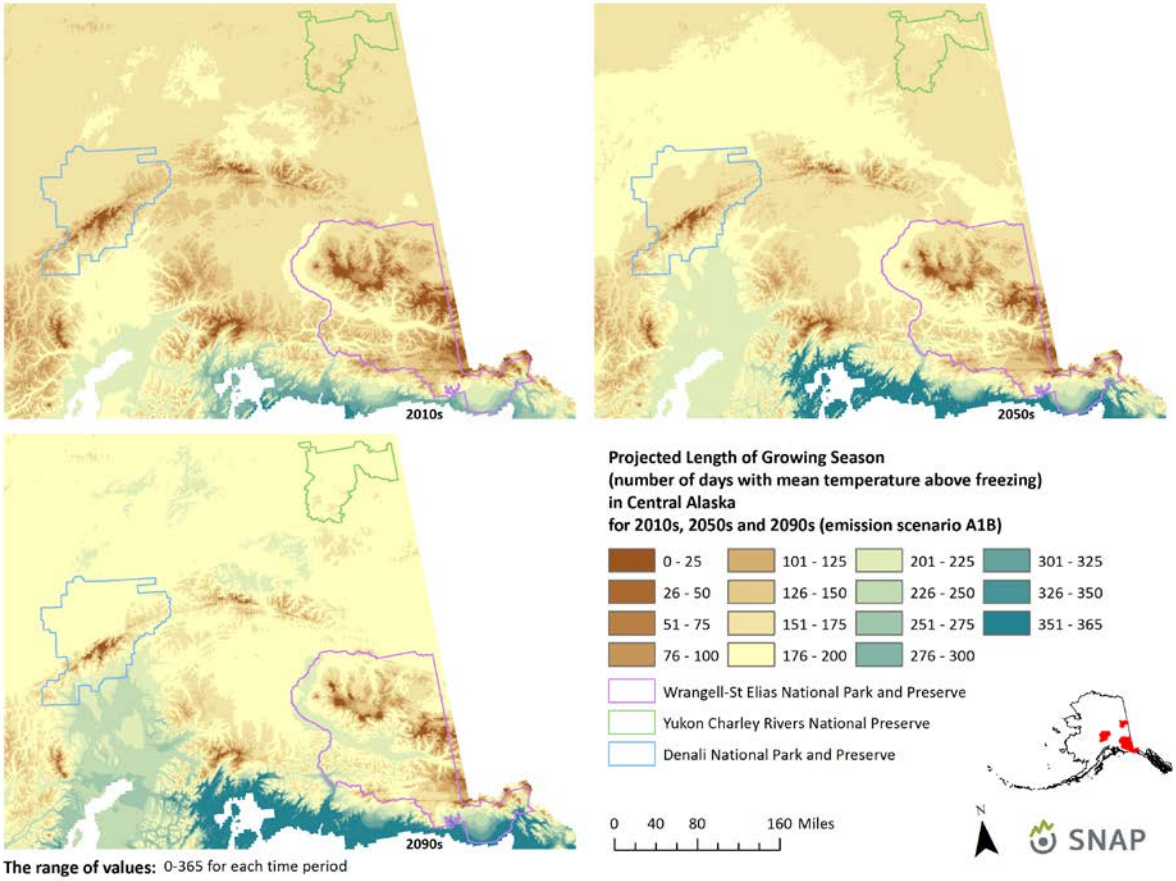


Figure 7: Mean summer season length. These maps show the projected number of days between the date the running mean temperature crosses the freezing point in the spring, and the date when that point is crossed again in the fall. Large areas of southeast Alaska are likely to be primarily unfrozen by the end of the 21st Century. See Appendix E for additional maps of projected thaw and freeze dates, ground temperature, growing season, and precipitation by season.

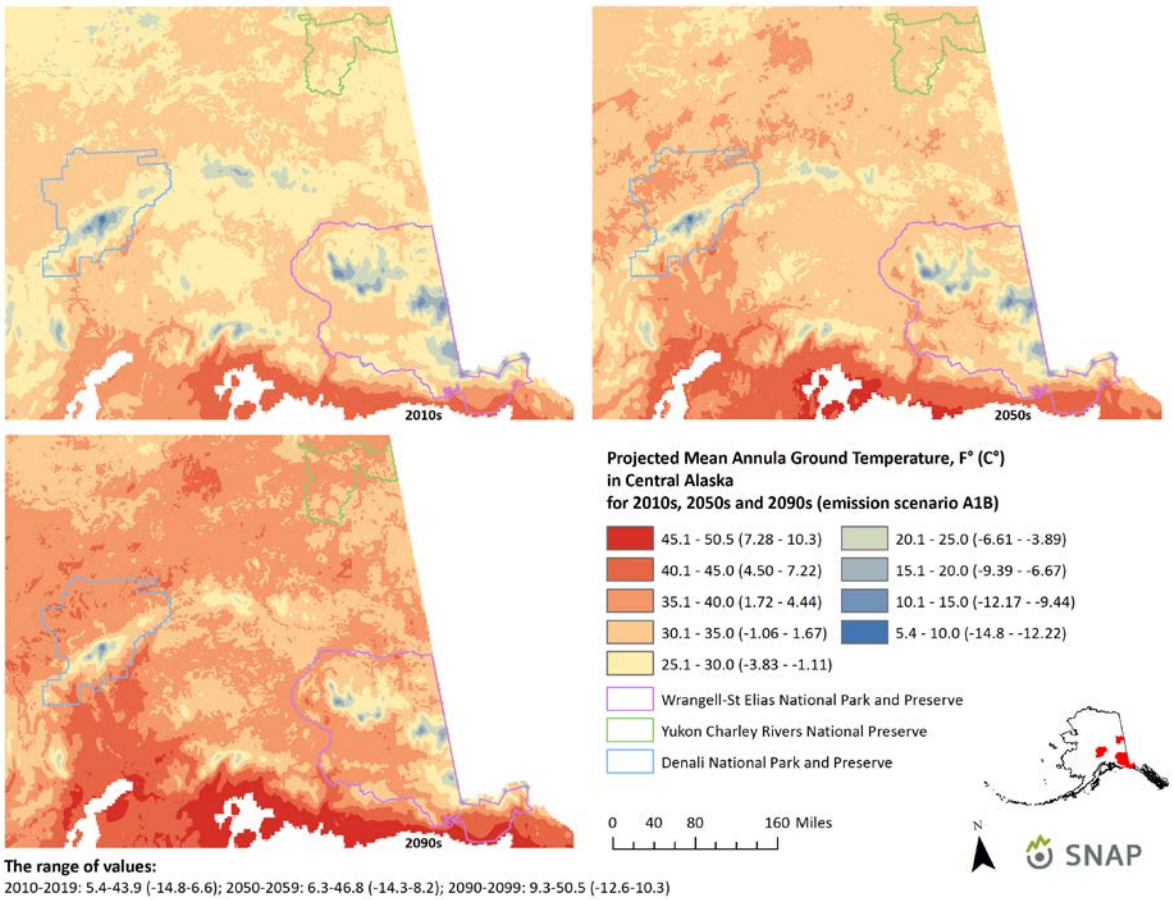


Figure 8: Mean annual ground temperature at one meter depth. Based on SNAP climate data and Geophysical Institute Permafrost Lab (GIPL) permafrost modeling, these maps depict projected ground temperature conditions. Across interior Alaska, most permafrost is projected to thaw by the end of this century.

Additional Workshop Documents, Maps, & Reference Materials

A reading list was provided before the workshop to orient participants on regional climate change observations and concepts on planning and management into uncertain futures (Schwartz 1996, Cole and Yung 2010, Jezierski et al. 2010, Marris 2011). Further details about the workshop described in this document are contained in the summary PowerPoint "Central Alaska Climate Scenarios," available in the Reports and Products folder at http://www.snap.uaf.edu/webshared/NPS-CCSP/2012_Central_Alaska/.

Documents are also posted online at: http://www.nps.gov/akso/nature/climate/scenario.cfm

Plenary Sessions

Three plenary talks were given by workshop organizers in order to flesh out topics introduced in the pre-workshop webinars, explain and clarify the available background information, and introduce new topics. Plenary sessions were interspersed with collaborative (working group) sessions, which comprised the bulk of the workshop.

Nancy Fresco of the Scenarios Network for Alaska Planning (SNAP) presented scientific information relevant to climate change, climate drivers and uncertainties, including climate modeling, downscaling, and available SNAP data for the parks. Nancy also introduced the project background and scenario planning process. This information familiarized participants who did not attend the pre-workshop webinars, and served as a review and elaboration for those who did. Rick Thoman of the National Weather Service talked about climate variability versus climate change, the effects of large-scale drivers such as Pacific Decadal Oscillation (PDO). Torre Jorgenson of UAF explained key processes relating to permafrost thaw, landcover change, and the response of wildlife to climate changes.

Project leaders described the sociopolitical framework relevant to Alaska, and provided examples of nested scenarios and narratives derived from these biophysical scenarios. They discussed implications for park management and potential decisions and actions to which park managers can apply insights from scenario planning. They also provided tips on communicating scenarios and formulating no-regrets actions.

These presentations are available at the above NPS site and as PowerPoint or PDF files in the "Workshop documents central Alaska" folder at: http://www.snap.uaf.edu/webshared/NPS-CCSP/2012_Central_Alaska/.

Workshop Work Group Products

Participants divided into two working groups for breakout sessions. Given the different management needs of frequently-visited and less frequently visited parks, participants divided based on park affiliation, into two groups: a Denali group and a Yukon-Charley and Wrangell-St. Elias group. Working group efforts included several stages of analysis, discussion, brainstorming, and creative effort, covering both the "explore" and "synthesize" components of the scenarios planning process.

Participants first assessed the relative importance and uncertainty of climate-related scenario drivers, and then selected two drivers with relatively high importance (in order to maximize the relevance of resulting scenarios) and relatively high uncertainty (in order to maximize divergence).

Crossing these two drivers produced four quadrants, each representing a different future or scenario. The biophysical effects or implications of all four different scenarios were fleshed out by workshop participants. Next, the four scenarios were nested in a social/institutional matrix (Figure 5), which yielded sixteen different scenarios that take into account the future socio-political environment as well as the biophysical effects of future climate. The participants in each group then selected two of the most divergent, plausible, relevant and challenging futures out of the sixteen nested scenarios and developed a narrative – as a story, play, song, skit, etc. – to describe the selected nested scenarios. These full-fledged scenarios were then assessed in terms of their management implications. Participants were asked to list appropriate management actions and research opportunities for each selected future. Finally, these actions and research opportunities were examined across all selected scenarios, to determine what no-regrets choices might be common to all the selected futures.

Climate drivers, scenarios, implications, research needs, and actions that emerged from each group's discussions are presented below, followed by management implications and actions that were common to both groups.

Denali Group

Denali Climate Driver Selection

The Denali group first assessed the relative importance and uncertainty of climate-related scenario drivers (Table 1, Appendix F). These drivers had been presented and discussed during pre-workshop webinars, and were reintroduced in workshop plenary sessions. For the purposes of scenario planning, the goal was to select two drivers with high importance (in order to maximize the relevance of resulting scenarios) and high uncertainty (in order to maximize divergence).

Table 1: Rankings of climate drivers for the Denali work group. The discussion ended up only including intensive discussion of drivers that group considered important, as demonstrated by the X's. Selected drivers are highlighted.

Climate variable/driver	DENA Impact (Importance)	Uncertainty
Temperature	X	Low with respect to direction, but wide range
Precipitation (rain and snow)	X	High
Length of warm season	X	High certainty that it will increase, uncertain range
Permafrost	X	Some very likely, uncertain as to timing and area
Snow	X	High with respect to both timing and total amount
Extreme weather events	X	High with respect to type and frequency

Importance has multiple dimensions. A driver can be important because it causes effects across a broad area (forests, tundra, alpine zones, and rivers); because it affects multiple sectors (tourism, subsistence, cultural sites) or because the effects in any one sector could be potentially catastrophic.

Discussion centered on the drivers that were likely to present the greatest management challenges, including changes in fire, snow cover, wildlife dynamics, and subsistence resources. The group narrowed down the options to four preferred pairings:

1. **Temperature** crossed with **Precipitation**: These are the "über drivers"—the group could build any story off these— but there was concern that they were too broad.

2. **Length of warm season** crossed with **Snow**: Season length is driven by temperature, snow by precipitation and temperature. This pairing might have huge impacts on flora/fauna and visitation, due to impacts on fire season and biota survival.

3. **Permafrost** crossed with **Extreme weather events**

4. **Fire** crossed with **Permafrost**

Ultimately, the selected pairing looked at **length of warm season** crossed with **snow**, although this was later amended to include all **precipitation**, meaning an increase in summer rainfall and winter snow depth (Figure 9). While the endpoints of the selected drivers in all cases indicated changed conditions (and increase in the number of days with mean temperatures above freezing, and an increase in precipitation), the magnitude of these projected changes provided significant uncertainty. The increase in summer season length ranged from 7 to 35 days, and increases in annual rainfall equivalent ranged from 1.2 to 8.7 inches.

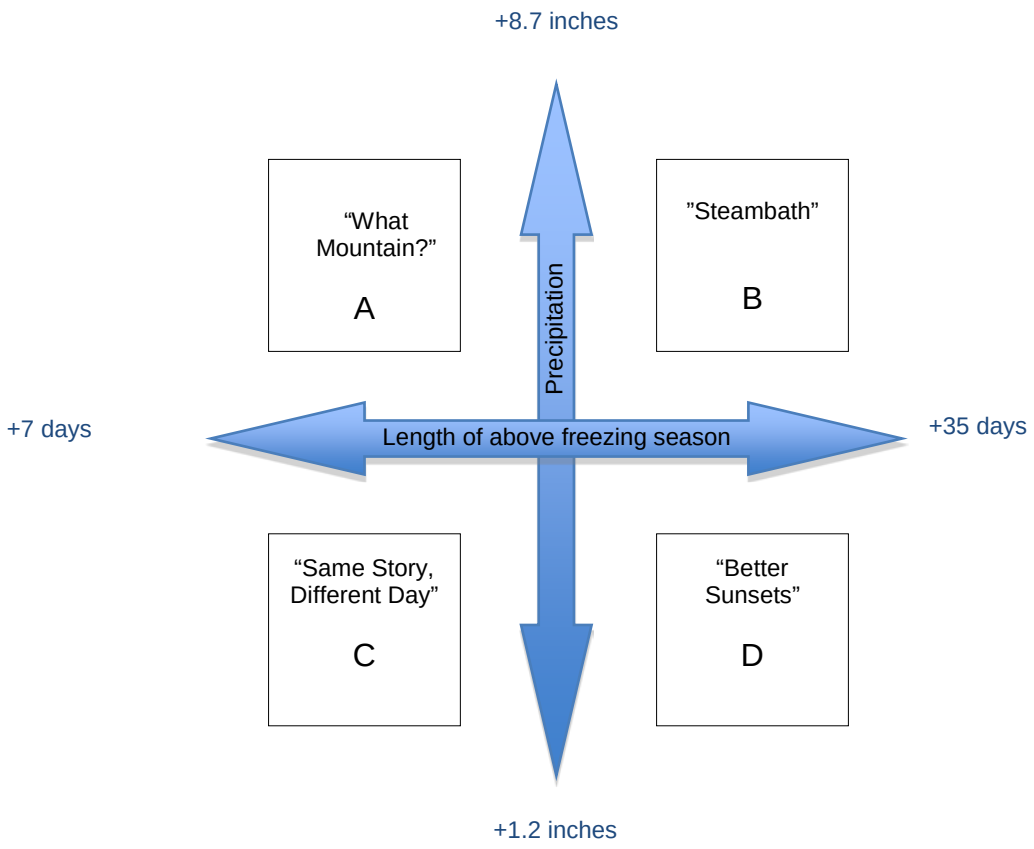


Figure 9: Primary matrix of climate drivers produced by the Denali group. Each quadrant represents a different combination of number of days above freezing and precipitation. Details of each quadrant are described in the text.

Denali Bio-physical Scenarios Developed from Selected Drivers

Each quadrant resulting from selected drivers represents a different scenario of potential future above-freezing season length and precipitation conditions (Figure 9). In order to flesh out each of these scenarios, participants referred back to the effects tables derived during the pre-workshop webinars, as well as scientific literature, maps, and other information shared during both the webinars and workshop plenary sessions. The diversity of each working group also allowed for expert knowledge input from those with first-hand knowledge of the parks, the surrounding area, and climate impacts already occurring.

The scenarios for the Denali group were:

A. "What Mountain", with an above-freezing season seven days longer than the historical norm, and an increase of about 8 inches in annual precipitation.
B. "Steambath", with an above-freezing season 35 days longer than the historical norm, and an increase of about 8 inches in annual precipitation.

C. "Same Story, Different Day", with an above-freezing season seven days longer than the historical norm and an annual increase in precipitation of only about one inch.

D. “Better Sunsets”, with an above-freezing season 35 days longer than the historical norm and an annual increase in precipitation of only about one inch.

The potential effects of each of the four future biophysical scenarios, as defined by the group, are fleshed out below.

Denali group scenario A: “What Mountain?”
The “What Mountain” scenario envisions a future with a slight increase in growing season and a large increase in precipitation. Potential effects of such conditions include:

- Woody vegetation differs on north and south slopes
- Increased biomass *where, anything more specific?*
- Older age vegetation (less fire)
- Visitors unhappy – don’t see mountain
- Earlier season for snowmachining
- Increase in berries, invasive species
- Increase in plant disease/pathogens
- Increase in washout conditions
- Improved access to basecamp
- Wildlife suffers with deep snowpack
- Restricted subsistence opportunities

Denali group scenario B: “Steambath”
The “Steambath” scenario envisions a future with a large increase in growing season and a large increase in precipitation. Potential effects of such conditions include:

- Vegetation biomass up, woody, shrubs
- More visitors in shoulder season (spring/fall)
- More flooding
- Loss of permafrost amplified
- Earlier breakup, longer fire season
- Decrease in caribou
- Increase in black bear and moose
- Loss of shallow lakes
- More extreme events (fires, droughts)
- Shrinking glaciers
- Forest insects increase
- Large infrastructure change

Denali group scenario C: “Same Story, Different Day?”
The “Same Story, Different Day” scenario envisions a future with a slight increase in growing season and a slight increase in precipitation. Potential effects of such conditions include:

- “Status quo”
- Little warmer/wetter, thus increased evapotranspiration leaves moisture unchanged

- Loss of sensitive permafrost
- Happy visitors in the summer
- Fire prone on north side
- Vegetation more vulnerable
- Shorter winter season

Denali group scenario D: "Better Sunsets?"
The "Better Sunsets" scenario envisions a future with a large increase in growing season and a slight increase in precipitation. Potential effects of such conditions include:

- Increase in fire frequency, size, duration
- Soil moisture deficit on south side
- North: shift to grassland
- South: lose poplars/understory
- Wildlife viewers, backpackers happy
- Easier to access – better hiking (south)
- Bison coming in, decrease in caribou
- Loss of shallow lakes, permafrost
- Phenological mismatches
- Shrinking glaciers
- Increase in invasive species

Denali Scenarios Nested in a Socio-political Matrix

The Denali group nested the four scenarios above in the social/institutional matrix (Figure 5). This framework explores how each story might play out in a world with greater or lesser degrees of societal concern and institutional commitment. Note that this framework was altered slightly from that presented by GBN, in which the horizontal axis was defined as "governmental" rather than "institutional" and was thus interpreted to take place at a national and international scale rather than at a national, state, and local scale.

While this theoretically yields 16 scenarios, they are not likely to all be divergent or plausible, and the group did not elaborate upon all of them. Instead, they first discussed the nature of the new matrix and the ramifications and plausibility of various combinations, then selected two nested scenarios to explore further. This narrowing of the field is in keeping with the scenarios planning methods outlined by GBN; the goal is to avoid redundancy and unnecessary use of time and effort, while maximizing the range of possibilities under consideration.

Through voting and additional discussion, the Denali group selected two scenarios for further development and discussion. These two scenarios are marked by blue stars in Figure 10.

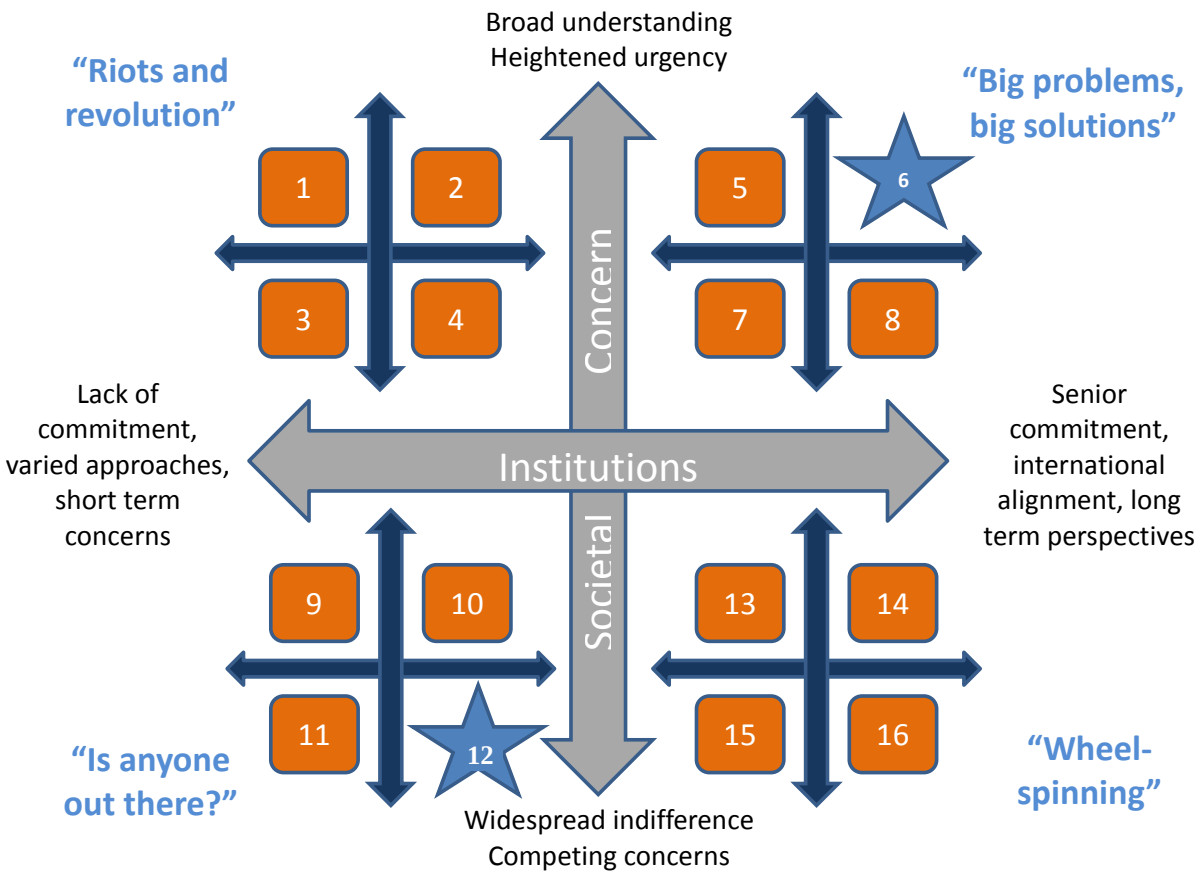


Figure 10: Denali nested scenarios. The selected scenarios are indicated by blue stars. The "Steambath" scenario (major increases in season length and precipitation) is nested in "Big Problems, Big Solutions" (strong and coordinated support for climate change at the local and institutional levels). "Better Sunsets" (only minor increases in precipitation but a large shift in season length) is nested in "Is Anyone Out There?" (little social or institutional support for climate change adaptation efforts). The implications, management actions, research needs, and narratives associated with these two scenarios are elaborated upon below.

First Denali nested scenario: "Denali, not Denial"

The following effects were identified by the Denali group as potential impacts in the event that the "Steambath" scenario (a wetter future with a much longer summer season) were to occur under the conditions described for the "Big Problems, Big Solutions?" quadrant (high societal concern and coordinated institutions with a heightened response ability) (Figure 10). The Denali group named this nested scenario "Denali, not Denial."

Describe this World in 2030

Alaskans are actively working to adapt to climate change with strong leadership from civil service to capitalize on opportunities and minimize biotic and economic losses.

Hunting seasons and patterns have shifted, with sufficient moose population but potentially bad access to preferred hunting areas. Growth of woody vegetation has changed wildlife viewing experience, and in order to maintain vistas increased use of prescribed fire may become an option. For climbers and other visitors, there will be a shift in season. There may be pressure on

trails, and changes in visitor activities. Climate change education will become a larger focus, as well as infrastructure improvements and maintenance.

Major Impacts to Bioregion

- More woody vegetation
- Decreased permafrost
- Increase in moose, decrease in caribou and sheep
- Bigger fires
- Wetland Shift

Issues Facing Management

- Changes in recreational opportunities (less viewability, fewer climbing opportunities)
- Pressure to provide for appropriate opportunities and showcase sustainability
- Sensitive and proactive to changing subsistence patterns. Adapting to changing subsistence patterns and seasons.

<u>Second Denali nested scenario: "Arctic Safari: Saunas & Sunsets"</u>
The following effects were identified by the Denali group as potential impacts in the event that the "Better Sunsets" scenario (a future with a much longer summer season but little increase in precipitation) were to occur under the conditions described for the "Is Anybody Out There" quadrant (low societal concern and poorly integrated institutions) (Figure 10). The Denali group named this nested scenario "Arctic Safari: Saunas & Sunsets."

Describe this World in 2030
Park operations will be funded 100% through various fees. Park facilities will continue to be carried out by concessionaires and cooperators including Alaska Native Corporations. Visitation in wilderness has reduced almost to nothing, except for consumptive uses, and resource development.

Major Impacts to Bioregion

- Subsistence competition between local and urban subsistence users
- Degradation of and increasing wetlands
- Dropping salmon population
- Huge surge in invasive species

Issues Facing Management

- Managing the expanding off road vehicle (ORV) trail networks due to increased subsistence activities
- Kennecott historic mining buildings require upkeep and maintenance
- Increased permitting and mineral activity
- Heavier rainstorms –causing slumping, erosion, damaged roads and trails – stress ability to maintain access, especially to in-holders (private land owners within park boundaries) and prevent resource damage
- Limited funding and staff for monitoring resource issues.

Wrangell-St. Elias/Yukon-Charley (WRST/YUCH) Group

WRST/YUCH Climate Driver Selection

The methods and procedures for the Wrangell-St. Elias and Yukon Charlie (WRST/YUCH) group were nearly identical to those described for the Denali group. However, the group's preferences and discussions resulted in a few differences. The WRST/YUCH group assessed the drivers as shown in Table 2.

Table 2: Climate driver assessment by the WRST/YUCH group. Selected drivers are highlighted.

Climate driver	Importance	High uncertainty
River/stream temps	X	X
Mean annual temp above freezing	X (varies by elevation and latitude)	X
Precipitation (snow/rain %, timing)	X	X
Extreme events /precipitation	X (especially near coasts)	X
Water availability	X	X
PDO	X	X
Length of warm season (above 0° C)	X	X
Wind events	X	X

Ultimately, WRST/YUCH opted to consider length of above-freezing season crossed with water availability. The endpoints selected for the length of summer season were +7 to +35 days, the same as for the Denali group; this was based on data available in the Climate Drivers Table (Appendix F). The endpoints for water availability ranged from a 20% decrease to a 20% increase from current levels.

WRST/YUCH Biophysical Scenarios Developed from Selected Drivers

Each quadrant resulting from the selected drivers represents a different scenario of potential future warm-season length and water availability (Figure 11).

The potential effects of each of the four future biophysical scenarios, as defined by the group, are fleshed out below.

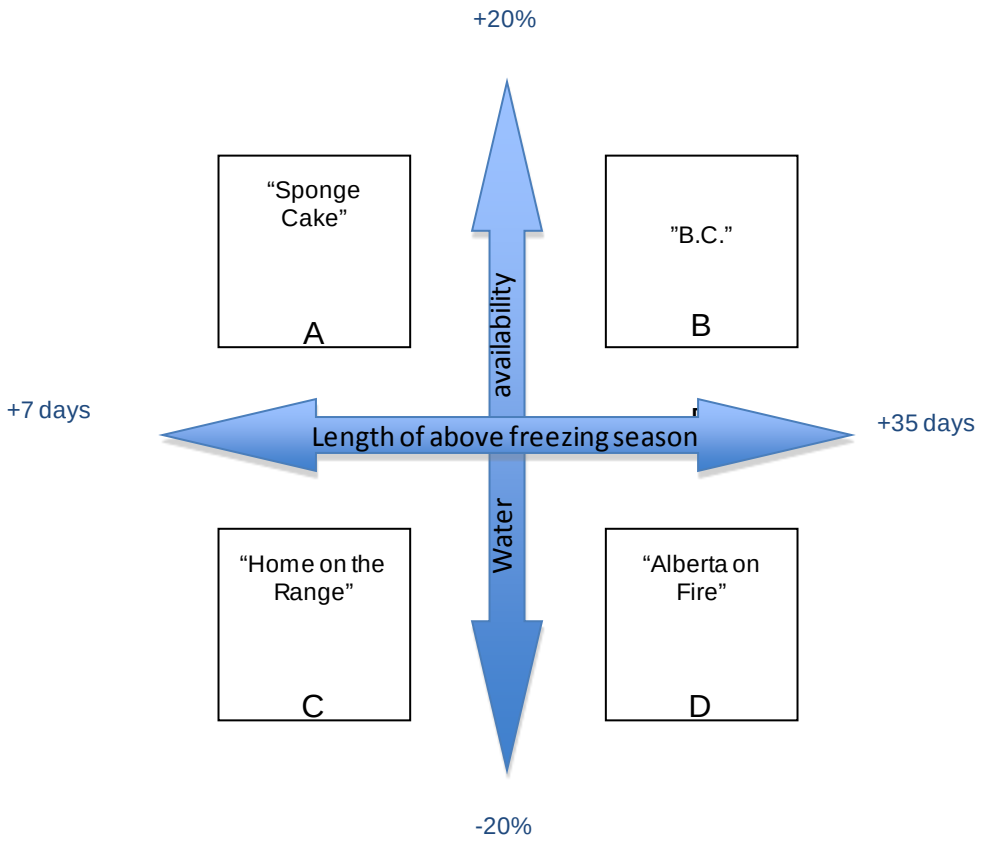


Figure 11: Primary drivers selected by the WRST/YUCH group. When crossed, these drivers create four divergent biophysical scenarios.

<u>WRST/YUCH scenario A: "Sponge Cake"</u>
The "Sponge Cake" scenario envisions a much wetter future, with a growing season 7 days longer than historical conditions. Potential effects of such conditions include:

- Lowest fire frequency
- Benefits to fish & wildlife
- Slower change in vegetation
- Existing spruce forests do better
- Winter travel more reliable
- Hunting seasons similar to present

<u>WRST/YUCH scenario B: "B.C."</u>
The "B.C." scenario envisions a much wetter future, with a growing season 35 days longer than historical conditions. Potential effects of such conditions include:

- Treeline elevation increases
- Increased wildlife productivity
- Increased vegetation productivity

- Increased soil nutrient availability
- Decreased fire was suggested as a possibility
- Timing shift in fish/wildlife harvest
- Altered migration times – birds come earlier and stay later
- Favors deciduous trees = increased tree cover

WRST/YUCH scenario C: "Home on the Range"
The "Home on the Range" scenario envisions a drier future, with a growing season 7 days longer than historical conditions. Potential effects of such conditions include:

- More fire
- Spruce decline
- More grasslands
- Bison/Moose populations increase
- Caribou population decreases
- Sheep habitat higher in elevation
- Fewer mosquitoes
- Fewer berries/greens

WRST/YUCH scenario D: "Alberta on Fire"
The "Alberta on Fire" scenario envisions a drier future, with a growing season 35 days longer than historical conditions. Potential effects of such conditions include:

- Most fires (among these scenarios)
- Small streams/lakes dry up
- Loss of wetlands
- Fisheries impacted in unpredictable ways
- Fish run times change or decrease
- More insect infestations
- Phenological mistiming
- Waterfowl impacted

WRST/YUCH Group Scenarios Nested in a Socio-political Matrix
The WRST/YUCH group nested the four above scenarios in the social/institutional matrix in much the same way that the Denali group did. While this theoretically yields 16 scenarios, they are not likely to all be divergent and plausible, and the group did not elaborate upon all of them. As in the Denali subgroup, this selection of the most divergent and challenging stories allowed more time to flesh out ramifications while avoiding redundancy. The group first discussed the nature of the new matrix and the ramifications and plausibility of various combinations, then selected two nested scenarios to explore further (Figure 12).

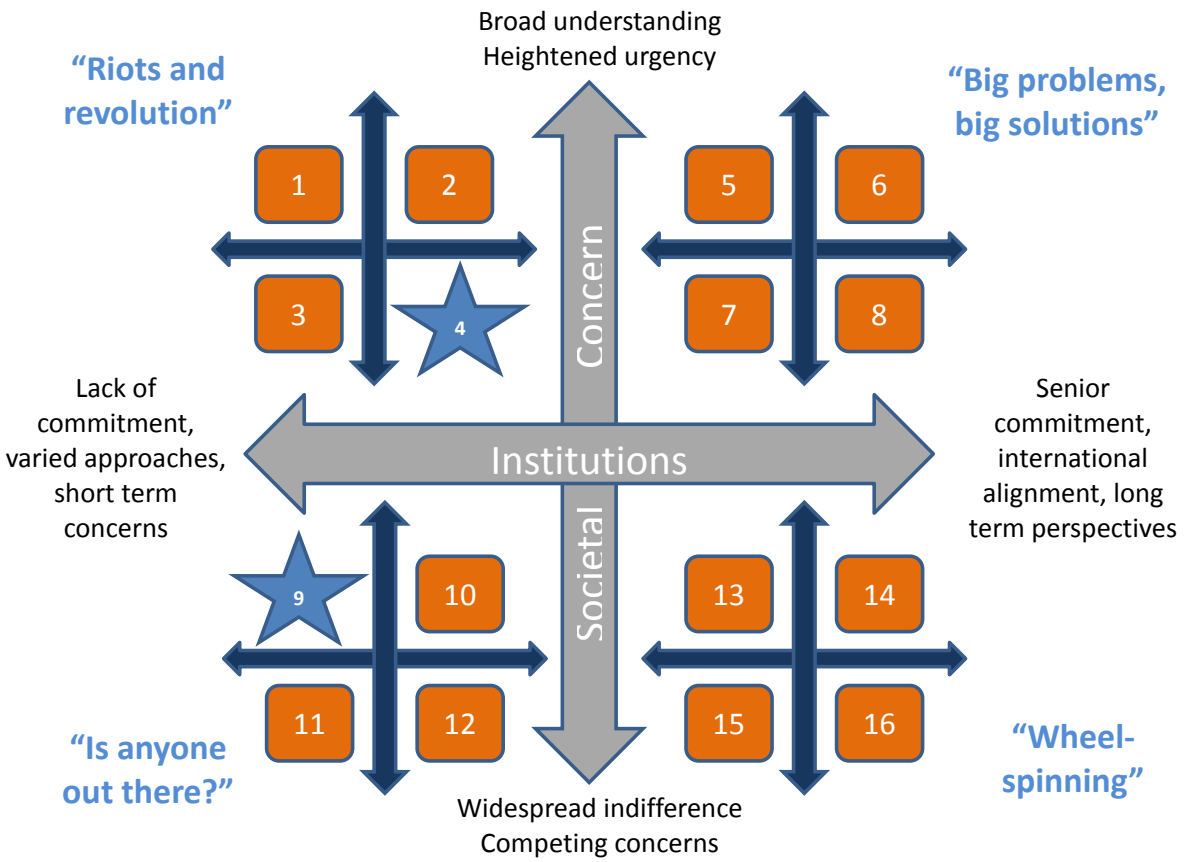


Figure 12: WRST/YUCH Nested Scenarios. The two nested scenarios selected by the WRST/YUCH group are marked by blue stars. The "Sponge Cake" scenario (a wetter future with a slightly longer growing season) is nested in "Is anyone out there?" (low levels of societal and institutional commitment to climate change issues), and the "Alberta on Fire" scenario (a drier future with a much longer warm season) is nested in "Riots and Revolution" (high concerns and engagement at the local level, but little institutional support).

<u>First WRST/YUCH nested scenario: "Bogged Down"</u>

The following effects were identified by the WRST/YUCH group as potential impacts in the event that the "Sponge Cake" scenario (a wetter future with a slightly longer summer season) were to occur under the conditions described for the "Is Anyone out there?" quadrant (low societal concern and little institutional support). The WRST/YUCH group named this nested scenario "Bogged Down."

Describe this World in 2030

- Not so much attention to WRST/YUCH (arctic areas are more extreme and events more dramatic so attention is drawn there) as well as fewer visitors than other parks
- Subtle bio-physical changes fail to attract attention of public, institutions and regulators
- Native people are first to notice the changes so they try to talk, but they need more front page news (state and federal agencies don't care)
- Non-unified local response
- Roads will be flooded (are already) so new bridges and possibly new locations of roads may be needed

- ORVs are more sophisticated and reliable
- Demand for improved ORV access
- McCarthy road improved in WRST
- Increased jet boat and guided fishing and in general more river travel
- Management plan won't change, but fishing becomes harder due to river level rise
- Not as many fish caught in Copper River system due to higher flows
- Increased demand for easier wildlife harvest
- Old oil sources have dried up and new pipelines have been built
- Electric power grid is connected along main highways
- Human population has decreased near YUCH and continues to decrease near WRST (unless there's a new gas pipeline)
- U.S. Federal Deficit is in crisis and affects federal spending levels

Major Impacts on the Bioregion

- Vegetation is more forested and brushier
- Less intense fires with less burning depth
- Permafrost retains due to thin active layer and moss layer thickens
- Wetlands are expended, ponds persist and waterfowl succeed

Issues Facing Management

- Continuing monitoring of bio-physical changes, particularly hydrology and salmon runs
- Decreasing visitation, except for affluent travelers (e.g. travelling in McCarthy and participating in guided hunts)
- Difficult for NPS to get funding and remain relevant to American public (lack of funding to manage issues)
- Primary issues remain subsistence management
- Co-management of lands inside WRST by NPS & Ahtna (an incorporation of 8 villages, and one of 13 Alaska Native Regional Corporation)
- ORV-trails require management and maintenance
- Resource development of inholdings for forestry and mining

<u>Second WRST/YUCH nested scenario: "Smoked Salmon Riots"</u>

The following effects were identified by the WRST/YUCH group as potential impacts in the event that the "Alberta on Fire" scenario (a drier future with a much longer summer season) were to occur under the conditions described for the "Riots & Revolution" quadrant (high societal concern, but poorly integrated support from institutions). The WRST/YUCH group named this nested scenario "Smoked Salmon Riots."

Describe this World in 2030

- Shortage of food supplies/fuel (very expensive)
- More conflict between state and federal agencies
- Endless meetings and committees
- Major subsistence resource changes – more marked change in the span of a lifetime

- Salmon shortages/die-offs
- Overfishing leads to unsustainability of fish numbers
- Commercial fishing depletes resources
- Declining moose and caribou populations
- Increasing deer, bison, cougar
- Agency distress
- Not enough cultural expertise to interpret changing species and resources
- Lack of funds leads to fewer employees
- Local citizens concerned over changing subsistence resources
- Bad economy brings people to the edge
- More reliance of native groups on international coalitions
- More public demonstrations
- PDO cool phase for next 20 years (more or less) but could flip to warm phase by 2030; a flip to warm phase increases societal concern

Major Impacts on the Bioregion

- Loss of spruce = more shrubs at higher altitudes, more grasslands at lower altitudes
- Increased fire frequency and intensity
- Smoke/air quality affect large population centers
- More local agriculture
- Increase in visitors, and McCarthy Road is paved
- Loss of smaller, non-glacial streams/rivers
- Wildlife population changes
- Bears extirpated (extinction of local subpopulation)
- Ocean acidification increases, salmon numbers decline
- Phenological mistiming for vegetation pollinators, migratory birds, and other mammals

Issues Facing Management

- Pressure from urban areas to manage fires
- Protection of people and infrastructure from fire
- Loss of spruce = loss of firewood
- Flight services affected by large-scale fires
- Fishery disputes = lawsuits against agencies
- Hunting and fishing regulations not keeping up with changes

Narratives

Climate change scenarios can be used to create multiple outreach tools to assist land managers and to educate the public. One such product is a set of narratives or stories that help to visualize and synthesize a range of plausible yet divergent futures.

The fictional narratives created by participants in this workshop (included in Appendix H) were a collaborative and creative effort to turn relatively dry lists of bulleted climate-change impacts into vibrant and memorable stories. The format for these stories was open to interpretation and imagination. Thus, one group wrote a heartfelt if somewhat tongue-in-cheek monologue from the point of view of Mother Earth; another group imagined an interactive online map full of information-rich pop-up windows and associated photos; a third group wrote a park superintendent's annual report; and the fourth created new words for a familiar song.

While such products could be considered unscientific, or even frivolous, from a management perspective, they serve several useful purposes. First, they offer an opportunity for workshop participants to make their own immersive experience more memorable through creative collaboration. Second, they create products – or ideas for products that might be further developed later – that speak directly to the public, with minimal jargon and the strongest possible emotional connection. Although care must be taken to present such stories within a scenarios context, they can bring home the message that while climate change may seem abstract, its effects will be very real to those who are impacted in and around Alaska's national parks.

Common Implications, Actions, and Needs

A good set of common needs can be an excellent starting point for responding to change through "no regrets" (robust) actions that would make good sense under any conditions, such as when determining safe locations for new facilities.

Scenario planning enables participants to assess potential vulnerabilities (effects and implications) and identify appropriate responses to address the implications and manage risks. Divergent scenarios typically yield different effects and implications. Serious differences in implications typically warrant different responses, especially when the effects could be catastrophic. When the same actions are listed for multiple scenarios, either a suite of no regrets actions has been identified, or the scenarios were not sufficiently divergent.

If the recommended actions appear to closely reflect current practices, complacency can create a false sense of security. It is important to revisit the implications for the individual scenarios, and to flag any that could potentially be catastrophic if they were to occur (such as rapid erosion near critical facilities). Such effects warrant careful consideration of appropriate monitoring and responses. As shown in Figure 6, robust strategies are not the only ones that make sense in terms of policy selection. In many cases, the potentially negative results of climate change effects that appear in only one, two, or three of the outlined scenarios may nonetheless be serious enough to warrant hedging of bets.

Management actions and research needs identified by both work groups and common to all four nested scenarios selected for this planning workshop are outlined below.

Important Common Management Actions Common to Denali Groups

- Revisit management policies
- Identify bottlenecks to change in management and address need to expedite process
- Increased invasive/introduced species management
- Cooperative planning with tribes to address changing resources, etc.
- Policy and harvest regulations for new species
- Adjust harvest regulations and seasons for traditional species
- Cross-boundary collaborative management approach – need to partner with other countries, agencies, stakeholders, etc.
- Management planning needed for issues related to roads and access (e.g., erosion, permafrost thaw)
- Development plan needed (for trails, road, access, facilities, etc.)
- Increased development of alternative energy sources (response to cost of fuel)

Research and Information Needs Common to Denali Groups

- Baseline data on river flow
- Baseline archeological research to address potential loss
- Increase research on phenological timing/mis-timing
- Increase capacity for interpretation/education
- Improve monitoring on fire effects, glaciers, fisheries, megafauna
- Increase social science to reach citizen scientists increase technological capabilities

Other Issues Common to Denali Groups

- Secondary effects of ocean acidification
- Predator control (primarily wolves)
- Lack of funding/personnel/support
- Economic limitations (beyond park funding, e.g. for communities)
- Increased pressure for resource extraction
- Motivate management to focus on climate change issues
- Potential demand for increased resources via intensive management, e.g. moose farming, reindeer herding, or more fish hatcheries
- Potential new Wilderness designations would protect lands, but be socially and politically controversial
- Pressure to redefine park boundaries/zoning (split up large parks?)
- Volcanic eruptions/earthquakes
- Federally designated historical rights-of-way known as “RS2477s” could be turned into roads
- Prepare for evolving health & safety issues (e.g. bird flu, West Nile disease)
- More hazards management and training for NPS employees

Important Management Actions Common to WRST/YUCH Groups

- Develop a strategy for assisted migration, e.g. wood bison
- Maintain genetic diversity for core species (Dall sheep)

- Manage fire and prescribed burns by park staff
- Create interpretive materials, interact with existing and new educational groups, and direct one-on-one interactions
- Big-picture planning
- Redo all park plans for robustness under climate change
- Build new roads to improve recreation opportunities and megafauna viewing to offset lost visitors
- Build stewardship and contacts with children
- Expand school programs with longer season
- Build capacity for climate change messaging
- Develop in-park messaging that addresses climate change issues and implications to ensure improved and more consistent understanding among park staff
- Increase engagement with subsistence leaders to improve understanding of change and collaborate to create messages and garner support to address issues
- Change the regulation process to be more flexible and provide a quicker response to the needs of subsistence users. Work with Subsistence Resource Commission, Office of Surface Mining, and Regional Advisory Council
- Foster and encourage subsistence lifestyles and local sources of knowledge based on this connection with the land
- More fuels reduction – "Fire Wise" program
- Greater work with communities
- Examine whether use of wildland or prescribed fires can be used as a tool to help avoid catastrophic fires
- Partner with the Department of Environmental Conservation to address health issues related to smoke

Research and Information Needs Common to WRST/YUCH Groups

- Identify and study ecological change so as to attribute cause and effect, e.g. are caribou fading due to climate change, or being scared away by bus traffic? Collect information on hunting seasons and wildlife viewing.
- Improve monitoring of rare plants
- Assess human preferences and tolerances regarding smoke and fire effects from natural and prescribed fire
- Anticipate consequences of ecological actions: bringing in wood bison, and/or losing caribou, Dall sheep, pika

Discussion

The scenario planning process is not prescriptive; it does not set or determine policy. However, it does offer useful information for policymakers, land managers, and other stakeholders as they face the task of planning for an uncertain future.

The Central Alaska project began with the focal question, "How can NPS managers best preserve the natural and cultural resources and other values within their jurisdiction in the face of climate change?" Through the workshop process described in this report, not only was this question addressed, but so too was the broader question of protecting the natural and cultural landscape in which the Central Alaska Network parks exist.

Two important factors enriched and strengthened the process. First, the group that came together – first via teleconference and later in the workshop itself – represented a broad range of interests, experiences, and knowledge. Not only was NPS represented at the Park and Regional level, but these experts were joined by modelers and climate researchers from SNAP; representatives of Alaska Native subsistence, and other local interests; representatives from nonprofit conservation organizations; and experts from other government agencies. Participants were engaged in the process, and contributed to the inputs, the analysis, and the outcomes. Second, although representation of uncertainty is built into the scenarios process – and is indeed integral to interpretation of the outputs – the analysis performed by workshop participants was based on the best available science. SNAP's maps, data, and tools offer cutting-edge climate science in formats that help stakeholders connect raw data to real landscape changes and pertinent environmental and human effects. Moreover, the maps created specifically for this project have uses and implications that extend beyond the limits of this project, since they are publicly available and have direct pertinence for stakeholders region-wide who are concerned about issues ranging from construction and development to ecological diversity, and human health and safety. (For all maps, including region-wide and park-specific maps, see Appendix E and www.snap.uaf.edu/webshared/NPS-CCSP/2012_Central_Alaska

SNAP's website (www.snap.uaf.edu) offers further insights into the inherent uncertainties associated with climate modeling, including unknown future emissions rates of greenhouse gases; the complexity of creating and interpreting global circulation models (GCMs) that fully account for the distribution of heat and moisture via atmosphere and oceans; and the challenges of scaling down GCMs to the local level. Forecasts for precipitation are particularly challenging, because of the innate variability of rainfall and snowfall across fairly small-scale landscapes and short time periods. Given these uncertainties – but also given the existence of some clear trends and ongoing evidence of climate change – the scenarios process creates a unique way of exploring possible futures.

Because Alaska is such a geographically large and diverse state, spanning many cultures and many ecosystems, project outputs from climate change scenario planning workshops vary by region, although some recommended management actions may be applicable in all park networks. Holding these workshops on a regional basis proved an effective means of providing regional focus within a statewide framework.

Climate change impacts of particular concern in Central Alaska, as identified via this process, include fire and permafrost thaw and their effects on cultural and historical resources, natural resources, communities, subsistence, and even Park mandates. This potential change is primarily driven by loss of frozen ground, shortened fire cycles, and accompanying changes in vegetation and wildlife. Thawing ground and fire can threaten NPS infrastructure, and ecosystem shifts can drastically alter human experience of both visitors and locals. New economic opportunities associated with changes to terrestrial ecosystems are likely to complicate management choices, both inside and outside national parks.

As shown in Figure 3, the scenarios process is multi-step and iterative. The 2012 Central Alaska workshop took the process through the orienting, exploring, and synthesizing steps, and offered suggestions to promote or direct action. Near the end of the workshop process, participants referred back to the strategy-setting diagram provided by GBN (Figure 6). As outlined, the group assessed which management strategies and information needs were robust and common to all scenarios. However, discussion of strategies that offer ways to hedge bets or plan for uncertain but potentially catastrophic effects are also valuable, and these strategies should not be overlooked. An immediate “bet the farm” approach may be needed in places where severe effects from coastal erosion are a near certainty. “Wait and see” may be the preferable approach (and consistent with NPS policy) for dealing with range shifts in native species. Hedging might be the appropriate solution for exotic species: education, prevention, and control where the risks are high, and for low-risk species acceptance may be the best approach.

The climate change scenario planning process does not end with these workshops, reports, and presentations. Rather, they are intended to stimulate creative thinking to address changing but still undetermined future environmental and socio-political future conditions. Post-workshop, long-term monitoring and feedback to the process are still necessary. Scenarios are a learning process, and new or unexpected information can make it important to revisit or repeat the scenario planning process. The process should be refreshed periodically as important new information becomes available to validate existing scenarios or to create new ones.

One of the most useful outcomes from this process can be the development of a suite of tools that can be used to communicate climate change impacts, choices, and potential outcomes to a wide range of stakeholders, including park staff, park visitors, administrators, Alaska Natives, schoolchildren, and the general public. Potential products include video productions, podcasts, interactive displays, posters, fact sheets, interactive web sites, and more.

In summary, park managers, park neighbors, and stakeholders can learn from the future by using the best available scientific information and climate projections and a thoughtful and creative group of stakeholders to create plausible, divergent, relevant, and challenging future climate change scenarios. These scenarios can help us all better prepare for uncertain future conditions in face of climate change.

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Appendix A: Participant Agenda

Central Alaska Network (CAKN) National Parks
Climate Change Scenario Planning Workshop
Wood Center, University of Alaska Fairbanks
April 16-18, 2012
FINAL AGENDA

Monday April 16

10:00 am		**ARRIVAL and SIGN IN**
10:30 am	Plenary	➢ Welcome: Include: restrooms, snacks, coffee, eateries, group dinner, vehicles/transportation, lodging etc. Introductions & Participant Expectations ➢ John Morris: *Workshop objectives, agenda, ground rules*
11:00 am	Plenary	➢ Explain Scenario Planning, Review Scenario Process, Introduce the Focal Question, Climate drivers, uncertainties, and PDO
11:15 am	Plenary	➢ Present scientific information on climate change • Rick Thoman: *Climate, climate variability and climate change in and around Central Alaska parks* • Nancy Fresco: *Linking potential effects/impacts to selection of scenario drivers*
12:30 pm		**LUNCH**
1:15 pm	Plenary	➢ Video of CC Scenario, break into groups
	Groups	➢ Identify key climate drivers with "high uncertainty" but "high impact and importance" leading to challenging, plausible, relevant, and divergent futures. **Keep in mind the effects tables when identifying "high impact."** Also identify relatively certain climate drivers. ➢ Select climate drivers and test matrix combinations. Draw from impacts table to detail implications for each scenario (e.g. natural & cultural resources, facilities, interpretation)
3:00 pm		**BREAK**
		➢ Continue to detail implications for each scenario ➢ Report-out: Groups share draft climate driver frameworks with key characteristics of scenarios
4:45 pm	**Plenary**	**FINAL THOUGHTS / QUESTIONS/ADJOURN for Day**

Tuesday April 17

8:00 am		**ARRIVAL**
8:15 am	Plenary	➢ CC Video ➢ Second thoughts and overnight insights ➢ Re-cap process (*what we did and where we are going, including the next step to build a matrix with climate drivers*)
8:45 am	Groups	➢ Continue to detail implications for each scenario
9:30 am	Plenary	➢ Report-out: Groups share draft climate driver frameworks with key characteristics of scenarios
10:00 am		**BREAK**
10:15 am	Plenary	➢ Describe Socio-Political Framework relevant to Alaska
10:30 am	Plenary	➢ Explain nested scenarios
11:00 am	Groups	➢ Explore Socio-Political drivers and implications. Combine selected "bioregional climate drivers" and "socio-political" frameworks to develop nested scenarios leading to challenging, plausible, relevant, and divergent futures. Discuss all 4 climate driver scenarios within each quadrant of the socio-political framework.
12:00 pm		**LUNCH**
1:00 pm	Groups	➢ Continue to create nested scenarios. Select 2 nested futures to develop and build robust narratives for these scenarios. Draft two scenario narratives. (Groups may wish to subdivide into 2 scenario teams)
2:30 pm	Groups	➢ Groups report out internally the process for climate driver selection and nested scenario selection and describe the selected nested climate futures (stories) and refine as needed for report out to larger group.
3:00 pm		**BREAK**
3:15 pm	Plenary	➢ Groups share process for selecting 2-3 nested scenarios for challenging, plausible, relevant, and divergent futures and re-cap selected scenarios and narrative storylines (15 min each, plus discussion)
4:15 pm	Groups	➢ Work on creating narratives and flesh them out (may need to be finished in the evening if necessary)
4:45 pm	**Plenary**	**FINAL THOUGHTS / QUESTIONS/ADJOURN for Day**

Wednesday April 18

8:00 am		**ARRIVAL**
8:15 am 8:30 am 9:00 am	Plenary Plenary Plenary	➢ Video of Climate Change Scenario ➢ Overnight Insights ➢ Groups read/report on narratives ➢ Explain management implications & actions ➢ Jeff Mow: *From implications to recommended actions to management decisions*: various ways to use insights from scenarios; tips on communicating scenarios and formulating no regrets actions
10:15 am		**BREAK**
10:30 am	Groups	➢ Identify potential actions for each of 3-4 chosen nested scenarios based on management implications. Focus on no-regrets actions that apply to all selected climate futures, when possible. Consider the best way to communicate the issues.
12:00 pm		**LUNCH**
1:00 pm	Groups	➢ Groups finalize management implications, and if time permits, work on scenario narratives ➢ Groups present management implications to the larger group, and discuss.
3:15 pm		**BREAK**
3:30 pm	Plenary	➢ NEXT STEPS How do we use this work and where do we go with it? ➢ What actions apply to all scenarios → least regrets actions? ➢ Incorporate scenario planning into landscape-scale collaboration and adaptation (working with neighbors and across jurisdictions) ➢ Need for follow-up discussions/teleconferences to flesh out scenarios and actions for up to 3 examples for each administrative unit ➢ Draft report from SNAP, web links and access to data ➢ Public Outreach and sharing CC scenarios within and outside NPS units
4:45 pm	**Plenary**	**FINAL THOUGHTS / THANKS/ADJOURN**

Appendix B: Workshop Participant List

Lead team

Bob Winfree: Regional Science Advisor – NPS Regional Office
Nancy Fresco: Coordinator – SNAP
Nancy Swanton: Subsistence Manager – NPS Regional Office
Corrie Knapp: Research Associate – ACCAP
John Morris: Interpretation – NPS Regional Office
Bud Rice: Environmental Protection Specialist – NPS Regional Office
Lena Krutikov: Climate Science Analyst – SNAP
Piia Kortsalo: Visiting Scientist – SNAP

Participants

Denali Group

1. Andrew Ackerman (NPS)
2. Tara Callear (UAF)
3. Denny Capps (NPS)
4. Mark Clark (USDA)
5. Julie Collins (Denali resident)
6. Elwood Lynn (NPS)
7. Philip Hooge (NPS)
8. Molly McCormick (NPS)
9. Sierra McLane (NPS)
10. Ingrid Nixon (NPS)
11. Rick Obernesser (NPS)
12. Carl Roland (NPS)
13. David Schirokauer (NPS)
14. Miriam Valentine (NPS)
15. Eric Veach (NPS)
16. Larry Weddle (NPS)

Group 2

1. Guy Adema (NPS)
2. Jennifer Barnes (NPS)
3. Deb Cooper (NPS)
4. Eileen Devinney (NPS)
5. Joe Durrenberger (NPS)
6. Steve Gray (USGS, CSC)
7. Kassie Hauser (UTenn)
8. Larry Hinzman (IARC)
9. Ken Hodges (USGS)
10. Maggie MacCluskie (NPS)
11. Suzanne McCarthy (PWSCC)
12. Judy Putera (NPS)
13. Amanda Robertson (FWS, LCC)
14. Pam Sousanes (NPS)
15. Gloria Stickwan (Ahtna, Inc.)
16. Todd Stoeberl (NPS)
17. Miranda Terwilliger (NPS)

Appendix C: SNAP Tools for Planners

SNAP Climate Projections: *tools for planners*

SNAP
Scenarios Network for Alaska Planning
www.snap.uaf.edu

What are SNAP climate projections?

The Scenarios Network for Alaska Planning provides predictions of how average temperatures and precipitation may change in Alaska as a result of global climate change. Communities, businesses, and agencies work with SNAP to link these projections to ecological, social, and economic changes, and to plan for the future.

How are projections derived?

IPPC Global Climate Models

- The Intergovernmental Panel on Climate Change (IPCC) used fifteen different General Circulation Models (GCMs) when preparing its Fourth Assessment Report. Each model was created by a different nation or group using slightly different data and assumptions. Thus, models can be expected to perform with varying degrees of accuracy in any particular region. Accuracy can be checked by comparing model output for past years to actual climate data for the same time period.

Model Selection

- SNAP investigator Dr. John Walsh and colleagues analyzed how well each model predicted monthly mean values for three different climate variables (surface air temperature, precipitation, and sea level air pressure) over four overlapping northern regions (Alaska, Greenland, latitude 60-90°N an latitude 20-90°N) for the period from 1958–2000. They noted that models that performed well in one northern region tended to also perform well in others. SNAP climate models rely on output from the five models that provided the most accurate overall results.

Scaling down model results

- Results are scaled down to match local conditions using data from Alaskan weather stations and PRISM (Parameter-elevation Regressions on Independent Slopes Model), an analytical tool that uses point data, a digital elevation model, and other spatial data sets to generate gridded estimates of monthly, yearly, and event-based climatic parameters, such as precipitation, temperature, and dew point.

Presentation of data

Data can be accessed via our website (www.snap.uaf.edu) as ASCII files for GIS, or as GoogleEarth maps. Data include mean monthly temperatures and precipitation, as well as derived values such as decadal means, thaw dates and growing season length. Data for 353 communities statewide are also available, in tabular form.

Time periods

SNAP offers climate projections from the present to the year 2099. We also have historical data derived from Climate Research Units and downscaled using PRISM. Data from 1980 onwards is available on our website.

Scale and resolution

Climate projections have been scaled down to 2km resolution. Thus, each pixel in a climate map represents a $4km^2$ area.

Linking climate to resources

Estimating future air temperature, rainfall, and snowfall are just the first steps towards planning for change. Stakeholders who want more detailed information can create collaborative agreements with SNAP in order to work on projects that link climate data to variables such as permafrost thaw; timing of autumn freeze-up and spring breakup; frequency of flooding events; sea level change; and changes in evapotranspiration. These changes can, in turn, be linked to factors of direct concern to communities and land planners, such as ecosystem shifts; forest fires; agricultural opportunities; risks to infrastructure; and movement of game animals.

UNIVERSITY of ALASKA
Many Traditions One Alaska

for more information contact Network Coordinator Dr. Nancy Fresco:
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University of Alaska Fairbanks, P.O. Box 757200, Fairbanks, AK 99775-7200

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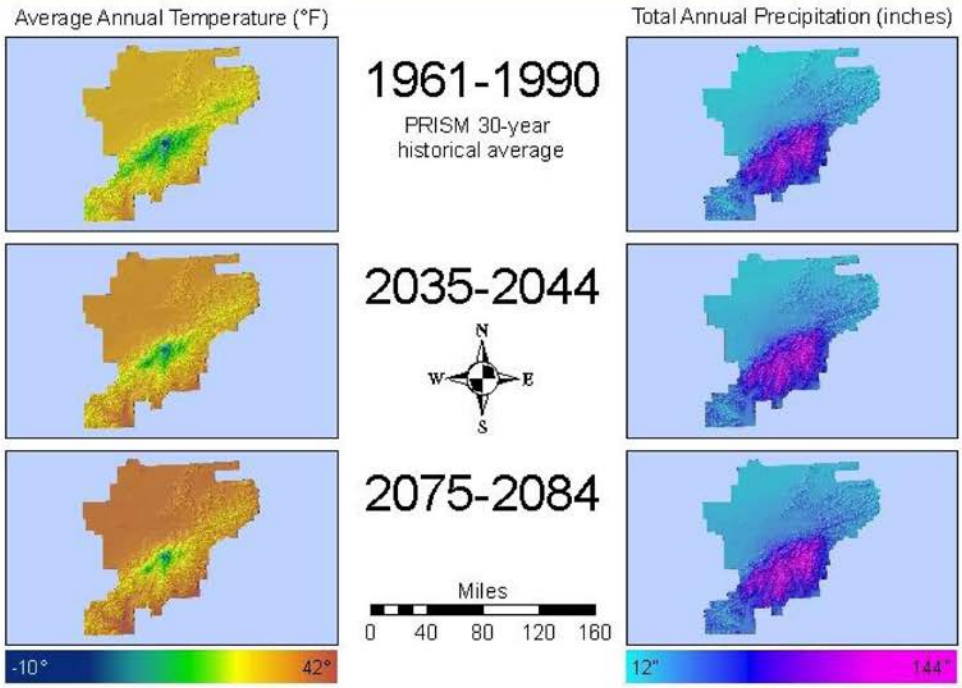
University of Alaska Geography Program
uagp

Appendix D: Climate Summary Reports

Projected climate change scenarios for Denali National Park & Preserve



Magnitude of climatic change

Projected Temperature (TEMP) Change (°F)				Projected Precipitation (PRCP) Change (in.)				
Season	Time	Avg. TEMP	Δ TEMP*	Season	Time	Total PRCP	Δ PRCP*	% Δ PRCP*
Annual	Hist	24.0 ± 1.6	NA	**Annual**	Hist	40.9 ± 9.7	NA	NA
	2040	28.6 ± 1.6	4.6		2040	45.2 ± 9.8	4.3	11%
	2080	32.3 ± 1.6	8.3		2080	48.1 ± 9.9	7.2	17%
Summer	Hist	44.6 ± 2.4	NA	**Summer**	Hist	23.6 ± 4.9	NA	NA
	2040	47.1 ± 2.4	2.5		2040	25.7 ± 4.9	2.1	9%
	2080	50.2 ± 2.4	5.6		2080	26.4 ± 4.9	2.8	12%
Winter	Hist	9.2 ± 1.2	NA	**Winter**	Hist	17.3 ± 4.9	NA	NA
	2040	15.3 ± 1.2	6.1		2040	19.5 ± 4.9	2.2	13%
	2080	19.4 ± 1.2	10.2		2080	21.6 ± 5.0	4.3	25%

* Δ PRCP/TEMP: change in decadal precipitation/temperature average from historic value

For more information:

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Dr. Wendy Loya, Ecologist, The Wilderness Society, Alaska Region, 907-272-9453; wendy_loya@tws.org

01/09

Climate Change Implications for Denali National Park & Preserve

Climate Change in Alaska

Many areas in Alaska are already showing signs of climate change. Scientists have reported observations of wetland drying, glacial and polar sea ice recession, spruce-bark beetle infestations, and an increase in fire frequency and intensity throughout the state. A better understanding of where and when such changes could continue to occur is needed to help decision makers identify how Alaska's ecosystems may respond in the future.

In order to understand what these changes may be like, data from a composite of five down-scaled global circulation models was used to estimate decadal averages of future temperature and precipitation values within the preserve. These models assume a steady increase in carbon dioxide (CO_2) emissions from fossil fuel combustion over the first several decades of the 21st century, followed by a gradual decline in emissions as several kinds of low-emission energy alternatives become more prevalent. This emissions regime is considered a "moderate" estimate[1]. Several other scenarios have predicted higher emission rates, and scientists have since determined current levels[2] are significantly greater than even the most extreme concentrations analyzed by the Intergovernmental Panel on Climate Change. Higher emissions rates will likely accelerate changes in climate and lead to more severe ecosystem impacts.

Temperature changes in Denali National Park & Preserve

Temperatures are projected to increase over the coming decades at an average rate of about 1°F per decade. Average annual temperature is expected to rise by about 5°F by 2040 and as much as 8°F by 2080.

Considering the natural variation in temperatures across the study area, this is likely to result in a transition from average annual temperatures below the freezing point (~24°F), to temperatures near or above the freezing point (~32°F).

A likely outcome of these changes is a lengthening of the growing season, a change that could have profound affects on wildlife mating cycles, plant growth and flowering, water availability in soil and rivers, and hunting and fishing.

Winter temperatures are projected to change the most dramatically. Mean winter temperatures could reach a high of 19°F by 2080, a figure that represents an impressive 10°F rise from the historical 9°F average. Average summer temperatures are projected to rise by almost 6°F by 2080 (from ~45°F to ~50°F). Some species may benefit from these changes, while others may not be able to adapt or find suitable habitat conditions to sustain their populations.

Precipitation changes in Denali National Park & Preserve

Precipitation is predicted to increase across the study area. Despite this area-wide increase, conditions are expected to become substantially drier in the summer and fall and potentially icier in winter. Although summer rainfall is expected to rise by 12%, this increase is unlikely to be enough to offset an increase in evapotranspiration caused by warmer temperatures and a longer growing season. Winter precipitation may increase by as much as 25% and could fall in the form of snow, ice, or rain, depending on the temperature. Ultimately, the timing and intensity of precipitation will determine how these changes affect the landscape and hydrology of the Preserve.

Summary of findings

Denali National Park & Preserve is projected to become warmer and drier over the next century. Warmer temperatures and a longer growing season are expected to increase evapotranspiration enough to outweigh a regional increase in precipitation. Seasonal changes in climate will have profound impacts on the condition and health of wildlife habitat, lead to increased fire risk, and contribute to the likelihood of wetlands, steams, and lakes drying.

It is important to note that predicting changes in environmental variables is difficult, especially in Alaska where historical climate monitoring data is sparse. Increasing the scope of precipitation, temperature, and ecological monitoring throughout Alaska is one of the best strategies for improving our understanding of changes in climate and the response of ecosystems.

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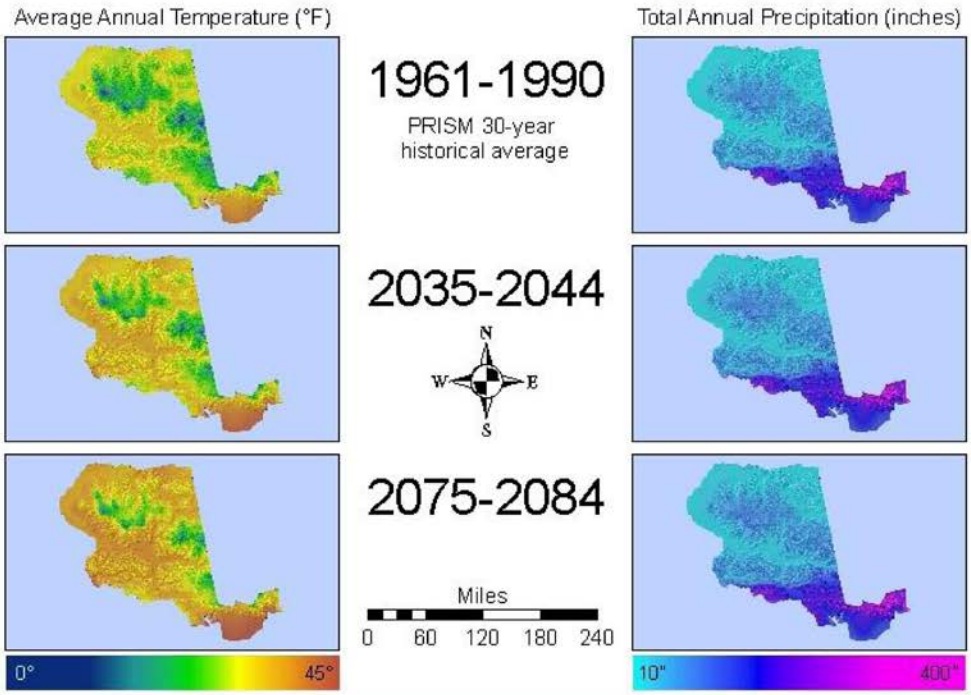
[1] *This emissions outlook is the "A1B" scenario from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment, published in 2007. The models used in this analysis included Echam5, Gfdl2.1, Miroc3.2MR, HadCM3, and CGCM3.1.*

[2] *Recent rates of global CO_2 emissions can be found on the Carbon Dioxide Information Analysis Center website (www.cdiac.esd.ornl.gov).*

01/09

Projected climate change scenarios for Wrangell-Saint Elias National Park & Preserve



Magnitude of climatic change

Projected Temperature (TEMP) Change (°F)				Projected Precipitation (PRCP) Change (in.)				
Season	Time	Avg. TEMP	Δ TEMP*	Season	Time	Total PRCP	Δ PRCP*	% Δ PRCP*
Annual	Hist.	23.6 ± 2.0	NA	**Annual**	Hist.	85.2 ± 25.8	NA	NA
	2040	27.5 ± 2.0	3.8		2040	90.5 ± 26.0	5.3	6%
	2080	30.7 ± 1.9	7.1		2080	93.6 ± 26.0	8.4	10%
Summer	Hist.	41.6 ± 2.4	NA	**Summer**	Hist.	36.2 ± 8.9	NA	NA
	2040	44.1 ± 2.5	2.5		2040	38.7 ± 9.0	2.5	7%
	2080	47.2 ± 2.4	5.5		2080	39.6 ± 9.0	3.4	9%
Winter	Hist.	10.8 ± 1.9	NA	**Winter**	Hist.	48.9 ± 17.1	NA	NA
	2040	15.6 ± 1.9	4.8		2040	51.8 ± 17.2	2.9	6%
	2080	18.9 ± 1.9	8.2		2080	54.0 ± 17.3	5.1	10%

* Δ PRCP/TEMP: change in decadal precipitation/temperature average from historic value

For more information:
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01/09

Climate Change Implications for Wrangell-Saint Elias National Park & Preserve

Climate Change in Alaska

Many areas in Alaska are already showing signs of climate change. Scientists have reported observations of wetland drying, glacial and polar sea ice recession, spruce-bark beetle infestations, and an increase in fire frequency and intensity throughout the state. A better understanding of where and when such changes could continue to occur is needed to help decision makers identify how Alaska's ecosystems may respond in the future.

In order to understand what these changes may be like, data from a composite of five down-scaled global circulation models was used to estimate decadal averages of future temperature and precipitation values within the preserve. These models assume a steady increase in carbon dioxide (CO_2) emissions from fossil fuel combustion over the first several decades of the 21st century, followed by a gradual decline in emissions as several kinds of low-emission energy alternatives become more prevalent. This emissions regime is considered a "moderate" estimate[1]. Several other scenarios have predicted higher emission rates, and scientists have since determined current levels[2] are significantly greater than even the most extreme concentrations analyzed by the Intergovernmental Panel on Climate Change. Higher emissions rates will likely accelerate changes in climate and lead to more severe ecosystem impacts.

Temperature changes in Wrangell-Saint Elias National Park & Preserve

Temperatures are projected to increase over the coming decades at an average rate of about 1°F per decade. Average annual temperature is expected to rise by about 4°F by 2040 and as much as 7°F by 2080.

Considering the natural variation in temperatures across the study area, this is likely to result in a transition from average annual temperatures well below the freezing point (~24°F), to temperatures approaching the freezing point (~31°F).

A likely outcome of these changes is a lengthening of the growing season, a change that could have profound affects on wildlife mating cycles, plant growth and flowering, water availability in soil and rivers, and hunting and fishing.

Winter temperatures are projected to change the most dramatically. Mean winter temperatures could reach a high of 19°F by 2080, a figure that represents an impressive 8°F rise from the historical 11°F average. Average summer temperatures are projected to rise by slightly more than 5°F by 2080 (from ~42°F to ~47°F). Some species may benefit from these changes, while others may not be able to adapt or find suitable habitat conditions to sustain their populations.

Precipitation changes in Wrangell-Saint Elias National Park & Preserve

Precipitation is predicted to increase across the study area. Despite this area-wide increase, conditions are expected to become substantially drier in the summer and fall and potentially icier in winter. Although summer rainfall is expected to rise by 9%, this increase is unlikely to be enough to offset an increase in evapotranspiration caused by warmer temperatures and a longer growing season. Winter precipitation may also increase by as much as 10% and could fall in the form of snow, ice, or rain, depending on the temperature. Ultimately, the timing and intensity of precipitation will determine how these changes affect the landscape and hydrology of the Preserve.

Summary of findings

Wrangell-Saint Elias National Park & Preserve is projected to become warmer and drier over the next century. Warmer temperatures and a longer growing season are expected to increase evapotranspiration enough to outweigh a regional increase in precipitation. Seasonal changes in climate will have profound impacts on the condition and health of wildlife habitat, lead to increased fire risk, and contribute to the likelihood of wetlands, steams, and lakes drying.

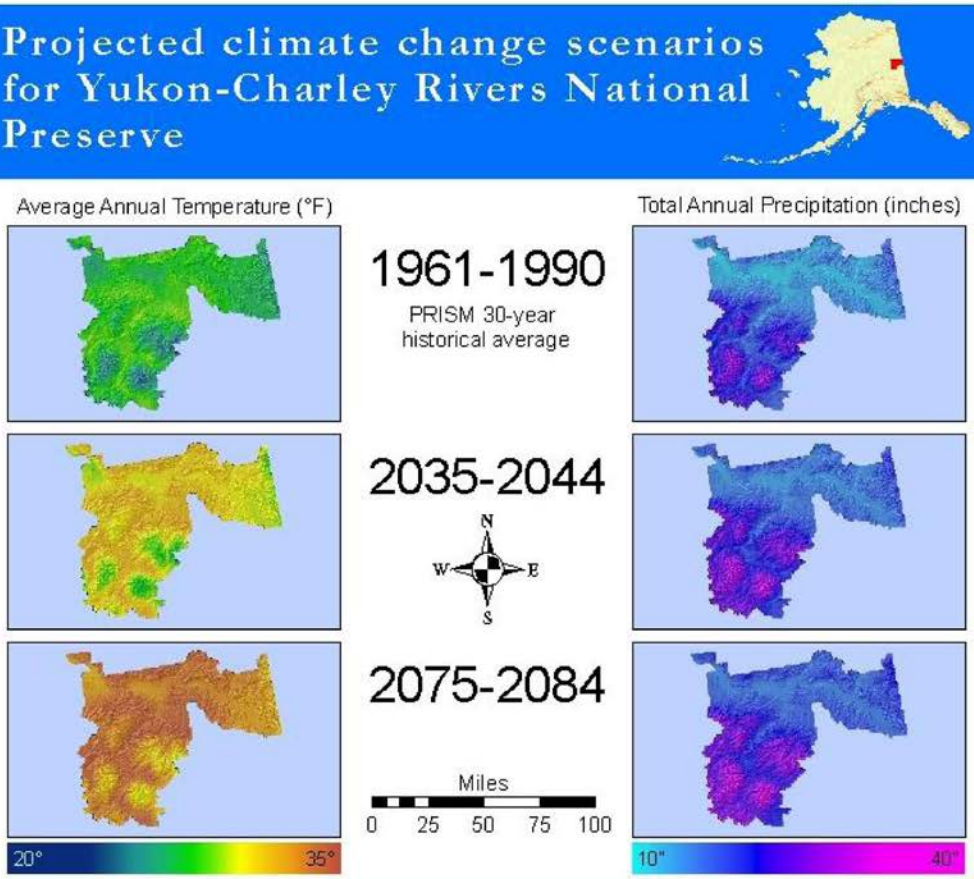
It is important to note that predicting changes in environmental variables is difficult, especially in Alaska where historical climate monitoring data is sparse. Increasing the scope of precipitation, temperature, and ecological monitoring throughout Alaska is one of the best strategies for improving our understanding of changes in climate and the response of ecosystems.

[1] *This emissions outlook is the "A1B" scenario from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment, published in 2007. The models used in this analysis included Echam5, Gfdl2.1, Miroc3.2MR, HadCM3, and CGCM3.1.*

[2] *Recent rates of global CO_2 emissions can be found on the Carbon Dioxide Information Analysis Center website (www.cdiac.esd.ornl.gov).*

01/09

Projected climate change scenarios for Yukon-Charley Rivers National Preserve



Magnitude of climatic change

Projected Temperature (TEMP) Change (°F)				Projected Precipitation (PRCP) Change (in.)				
Season	Time	Avg. TEMP	Δ TEMP*	Season	Time	Total PRCP	Δ PRCP*	% Δ PRCP*
Annual	Hist	24.7 ± 0.4	NA	**Annual**	Hist	17.0 ± 1.7	NA	NA
	2040	29.4 ± 0.4	4.6		2040	19.9 ± 1.7	2.9	17%
	2080	33.2 ± 0.4	8.4		2080	21.6 ± 1.7	4.6	27%
Summer	Hist	49.2 ± 1.2	NA	**Summer**	Hist	10.9 ± 1.1	NA	NA
	2040	51.8 ± 1.2	2.5		2040	12.4 ± 1.1	1.5	14%
	2080	54.9 ± 1.2	5.6		2080	13.1 ± 1.1	2.2	20%
Winter	Hist	7.3 ± 0.8	NA	**Winter**	Hist	6.1 ± 0.6	NA	NA
	2040	13.4 ± 0.8	6.2		2040	7.5 ± 0.6	1.4	23%
	2080	17.6 ± 0.8	10.4		2080	8.6 ± 0.6	2.5	40%

* Δ PRCP/TEMP: change in decadal precipitation/temperature average from historic value

For more information:
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Dr. Wendy Loya, Ecologist, The Wilderness Society, Alaska Region, 907-272-9453; wendy_loya@tws.org

01/09

Climate Change Implications for Yukon-Charley Rivers National Preserve

Climate Change in Alaska

Many areas in Alaska are already showing signs of climate change. Scientists have reported observations of wetland drying, glacial and polar sea ice recession, spruce-bark beetle infestations, and an increase in fire frequency and intensity throughout the state. A better understanding of where and when such changes could continue to occur is needed to help decision makers identify how Alaska's ecosystems may respond in the future.

In order to understand what these changes may be like, data from a composite of five down-scaled global circulation models was used to estimate decadal averages of future temperature and precipitation values within the preserve. These models assume a steady increase in carbon dioxide (CO_2) emissions from fossil fuel combustion over the first several decades of the 21st century, followed by a gradual decline in emissions as several kinds of low-emission energy alternatives become more prevalent. This emissions regime is considered a "moderate" estimate[1]. Several other scenarios have predicted higher emission rates, and scientists have since determined current levels[2] are significantly greater than even the most extreme concentrations analyzed by the Intergovernmental Panel on Climate Change. Higher emissions rates will likely accelerate changes in climate and lead to more severe ecosystem impacts.

Temperature changes in Yukon-Charley Rivers National Preserve

Temperatures are projected to increase over the coming decades at an average rate of about 1°F per decade. Average annual temperature is expected to rise by about 5°F by 2040 and as much as 8°F by 2080.

Considering the natural variation in temperatures across the study area, this is likely to result in a transition from average annual temperatures well below the freezing point (~25°F), to temperatures near or above the freezing point (~33°F).

A likely outcome of these changes is a lengthening of the growing season, a change that could have profound affects on wildlife mating cycles, plant growth and flowering, water availability in soil and rivers, and hunting and fishing.

Winter temperatures are projected to change the most dramatically. Mean winter temperatures could reach a high of more than 17°F by 2080, a figure that represents an impressive 10°F rise from the historical 7°F average. Average summer temperatures are projected to rise by about 6°F by 2080 (from ~49°F to ~55°F). Some species may benefit from these changes, while others may not be able to adapt or find suitable habitat conditions to sustain their populations.

Precipitation changes in Yukon-Charley Rivers National Preserve

Precipitation is predicted to increase across the study area. Despite this area-wide increase, conditions are expected to become substantially drier in the summer and fall and potentially icier in winter. Although summer rainfall is expected to rise by 20%, this increase is unlikely to be enough to offset an increase in evapotranspiration caused by warmer temperatures and a longer growing season. Winter precipitation may also increase by as much as 40% and could fall in the form of snow, ice, or rain, depending on the temperature. Ultimately, the timing and intensity of precipitation will determine how these changes affect the landscape and hydrology of the Preserve.

Summary of findings

Yukon-Charley Rivers National Preserve is projected to become warmer and drier over the next century. Warmer temperatures and a longer growing season are expected to increase evapotranspiration enough to outweigh a regional increase in precipitation. Seasonal changes in climate will have profound impacts on the condition and health of wildlife habitat, lead to increased fire risk, and contribute to the likelihood of wetlands, steams, and lakes drying.

It is important to note that predicting changes in environmental variables is difficult, especially in Alaska where historical climate monitoring data is sparse. Increasing the scope of precipitation, temperature, and ecological monitoring throughout Alaska is one of the best strategies for improving our understanding of changes in climate and the response of ecosystems.

[1] *This emissions outlook is the "A1B" scenario from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment, published in 2007. The models used in this analysis included Echam5, Gfdl2.1, Miroc3.2MR, HadCM3, and CGCM3.1.*

[2] *Recent rates of global CO_2 emissions can be found on the Carbon Dioxide Information Analysis Center website (www.cdiac.esd.ornl.gov).*

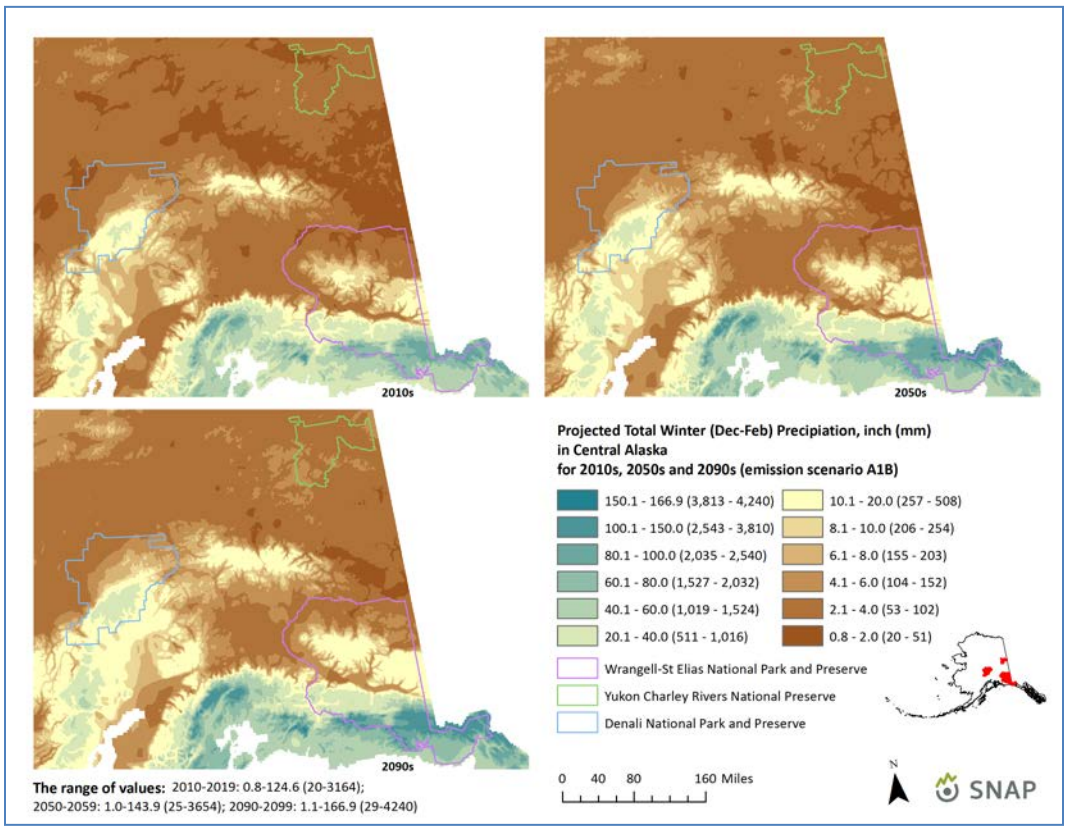
01/09

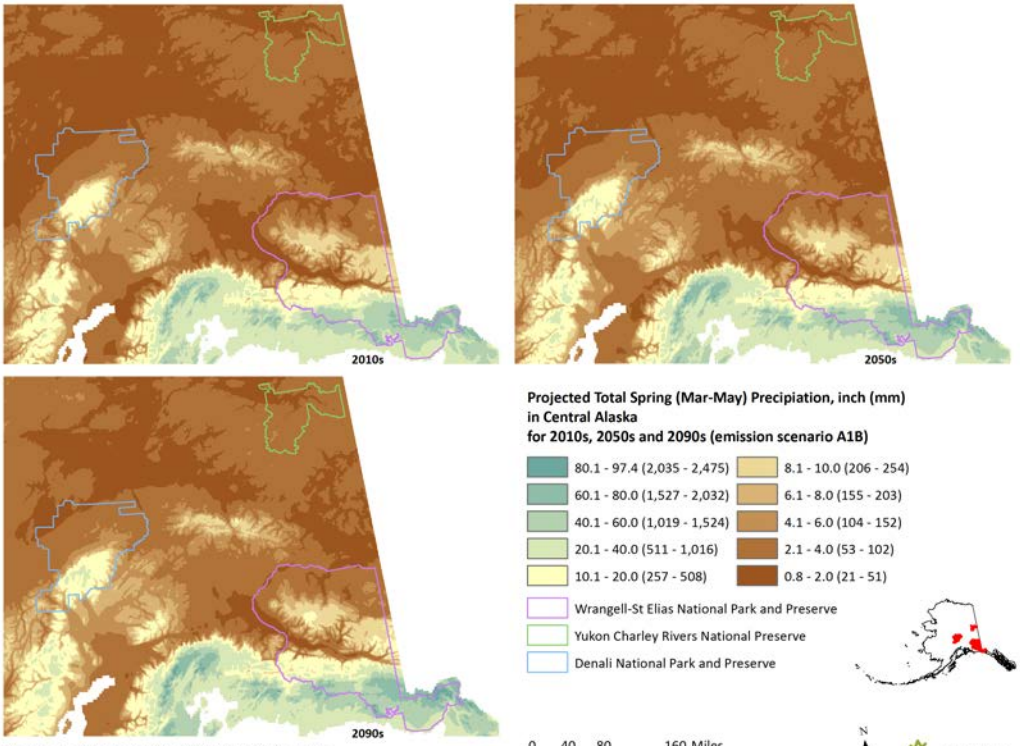
Appendix E: Central Alaska Modeled Climate Variables

The set of maps included in this appendix were produced by SNAP. All maps represent projected data averaged across five downscaled GCMs and additionally averaged across decades (the 2010s, 2050s, and 2090s), in order to represent long-term trends. For a full description of SNAPs methods, see www.snap.uaf.edu.

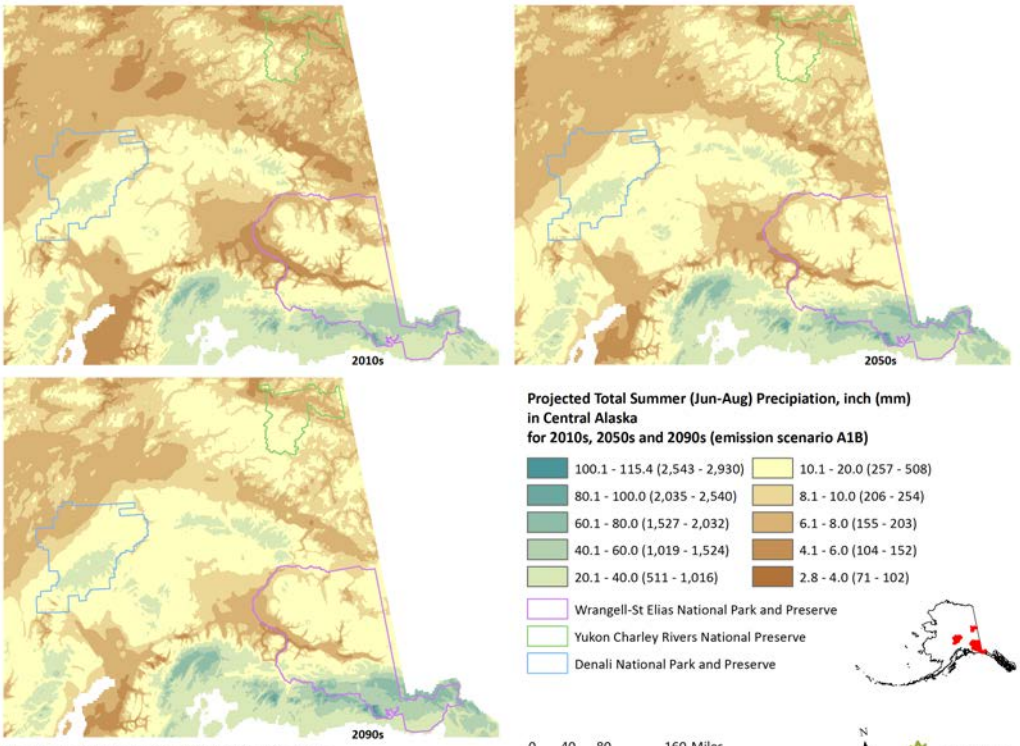
Maps included in this set include seasonal maps (three-month averages) for precipitation, as well as several temperature-linked maps, including projections for date of freeze, date of thaw, length of summer season, and ground temperature at once meter depth.

These maps show all Central Alaska Network Parks. They rely on a midrange (A1B) emissions scenario, as defined by the IPCC. For maps of individual parks, as well as maps depicting the more severe A2 climate change scenario, see http://www.snap.uaf.edu/webshared/NPS-CCSP/2012_Central_Alaska/

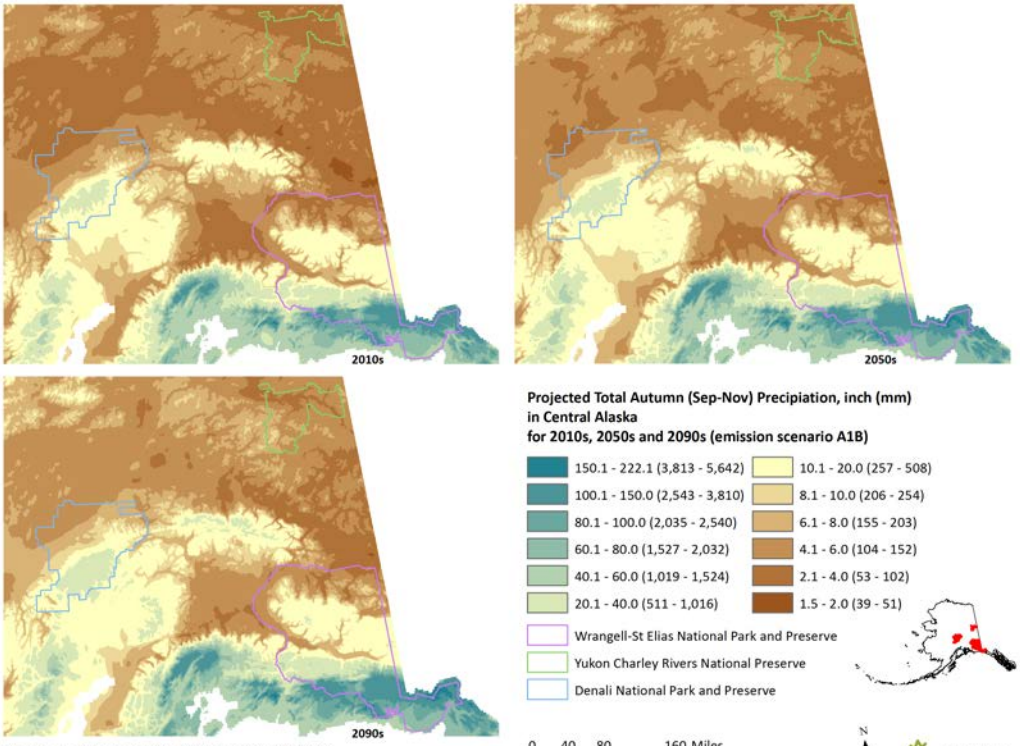




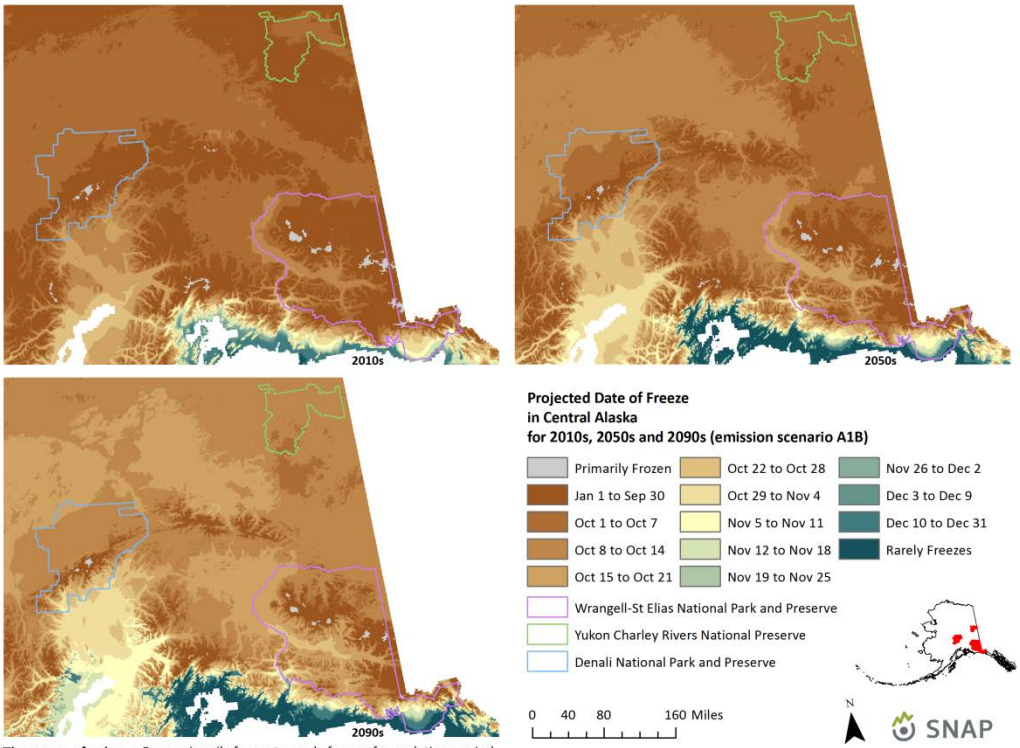
The range of values: 2010-2019: 0.8-83.0 (21-2107); 2050-2059: 0.9-89.4 (22-2272); 2090-2099: 0.9-97.4 (23-2475)



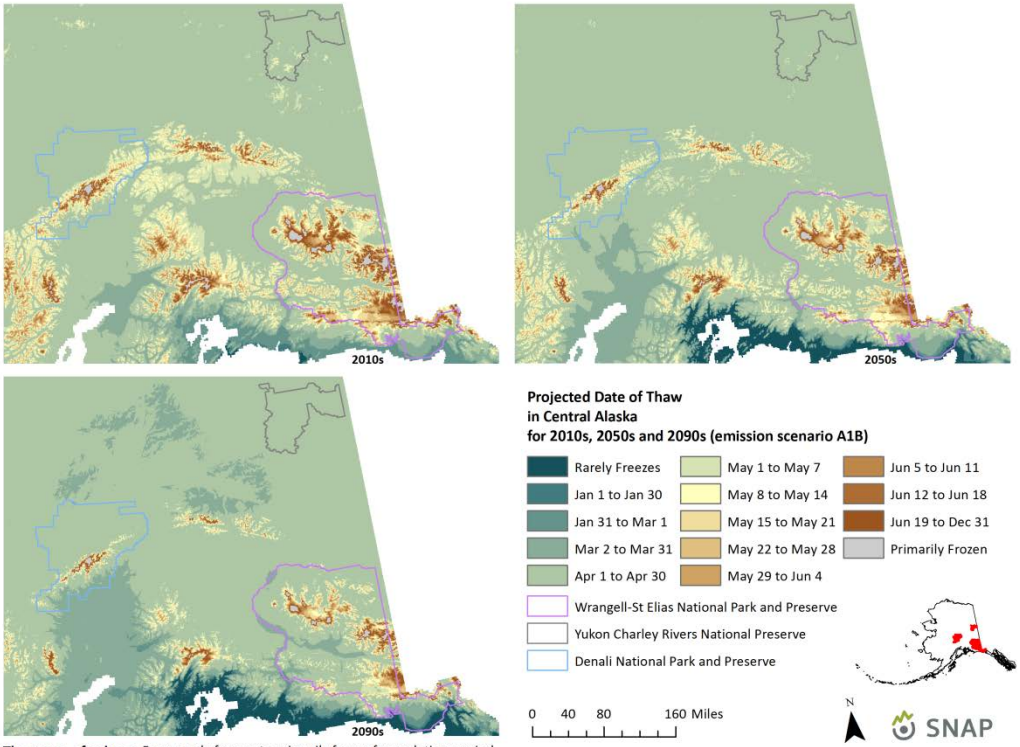
The range of values: 2010-2019: 2.8-98.1 (71-2492); 2050-2059: 3.2-111.4 (81-2830); 2090-2099: 3.3-115.4 (85-2930)



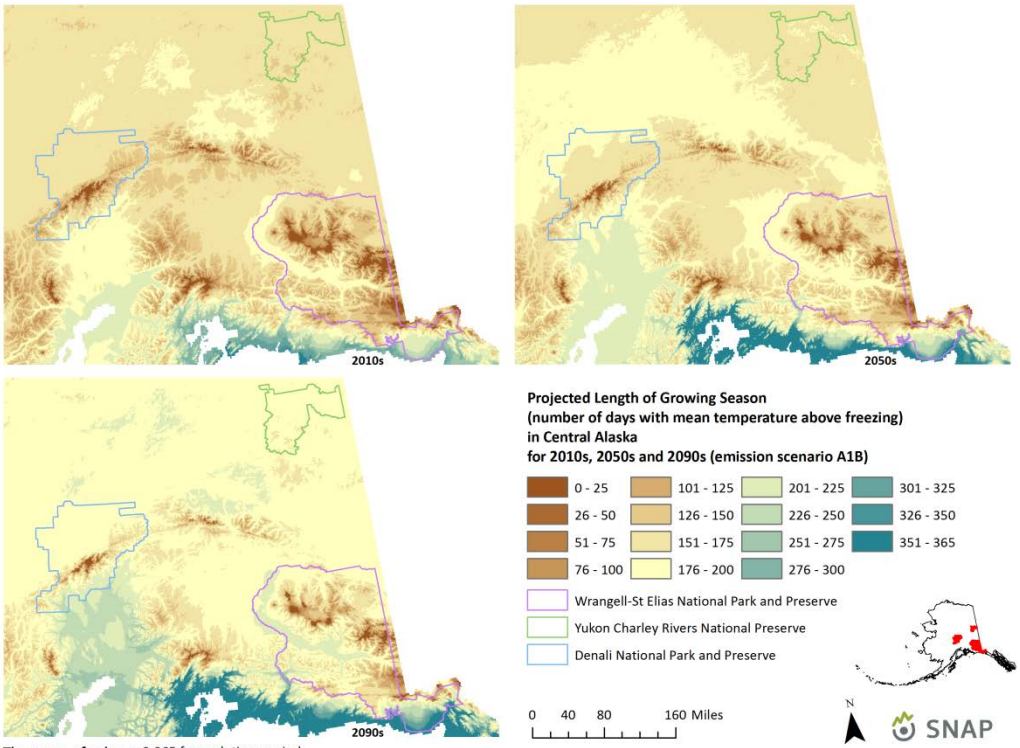
The range of values: 2010-2019: 1.5-190.5 (39-4839); 2050-2059: 1.7-209.0 (44-5309); 2090-2099: 1.9-222.1 (48-5642)



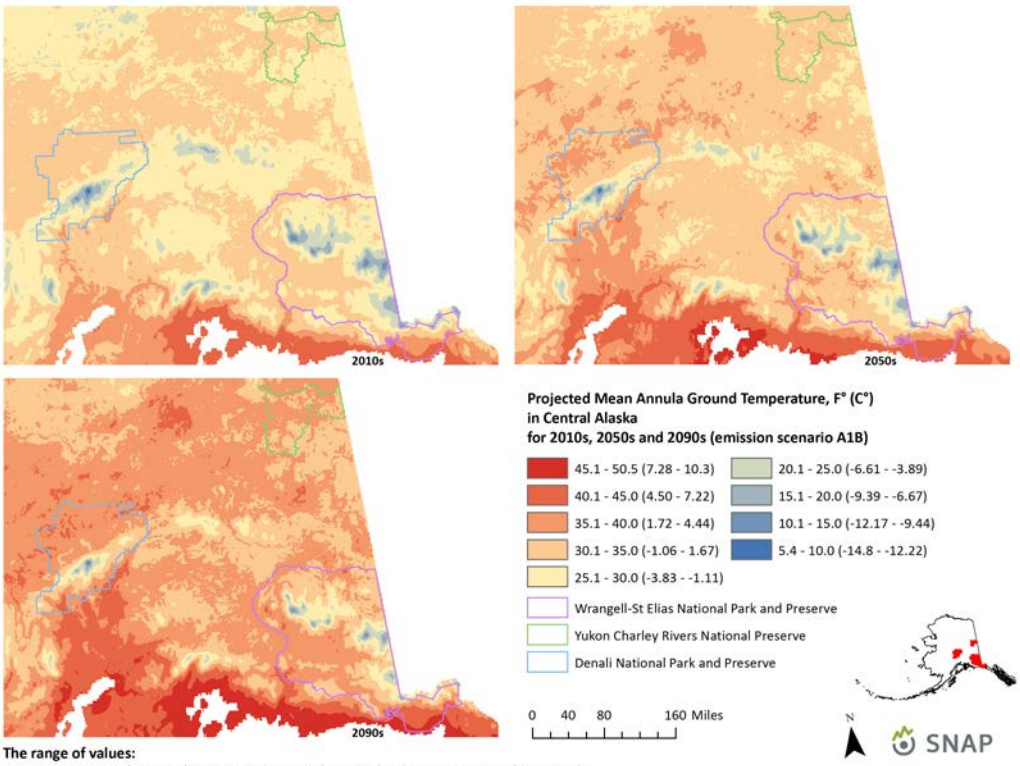
The range of values: From primarily frozen to rarely freezes for each time period



The range of values: From rarely freezes to primarily frozen for each time period



The range of values: 0-365 for each time period



The range of values:
2010-2019: 5.4-43.9 (-14.8-6.6); 2050-2059: 6.3-46.8 (-14.3-8.2); 2090-2099: 9.3-50.5 (-12.6-10.3)

Appendix F: Climate Drivers Table

Central Alaska Network Park Units – Climate Drivers Table

Climate Variable	Projected Change by 2050	Projected Change by 2100	Patterns of Change	Confidence	Source
Temperature	+1.9°C ± 0.5°C	+3.7°C ± 0.8°C	More pronounced in N & in autumn-winter	>95% for increase	IPCC (2007); SNAP/UAF
Precipitation (rain and snow)	↑ 33-109 mm	↑ 64-220 mm	Increased % falls as rain in shoulder seasons	High uncertainty in timing of snow onset and melt	AMAP/SWIPA; SNAP/UAF
Freeze-up Date	4-11 days later	9-26 days later	Largest change near coasts	>90%	SNAP/UAF
Length of season with average temps > freezing	↑ 7-13 days	↑ 18-35 days	Largest change near coasts	>90%	IPCC (2007); SNAP/UAF
River and Stream Temps	↑ 1–3°C	↑ 2–4°C	Earlier breakup, higher summer temps	>90%	Kyle & Brabets (2001)
Water Availability	↓ 0–20%	↓ 10–40%	Longer summer, thicker active layer	>66% varies by region	SNAP/UAF; Wilderness Society
Relative Humidity	0% ±10% ↑ or ↓	0% ±15% ↑ or ↓	Absolute humidity increases	50% *as likely as not*	SNAP/UAF
Wind Speed	↑ 2–4%	↑ 4–8%	More pronounced in winter & spring	>90% for increase	Abatzoglou & Brown
PDO	Uncertain	Uncertain	Major effect on Alaska temps in cold season	High degree of natural variation	Hartmann & Wendler (2005)
Extreme Events: Temperature	3-6x more warm events; 3-5x fewer cold events	5-8x more warm events; 8-12x fewer cold events	↑ warm events, ↓ cold events	>95% likely	Abatzoglou & Brown; Timlin & Walsh (2007)
Extreme Events: Precipitation	Change of –20% to +50%	Change of –20% to +50%	↑ winter ↓ spring	*Uncertain*	Abatzoglou & Brown
Extreme Events: Storms	↑ frequency/intensity	↑ frequency/intensity	Increase	>66%	Field et al. (2007)

Climate Drivers Table Citations

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Appendix G: Climate Effects Table

The table below outlines some of the possible effects of climate change in Central Alaska. These effects are drawn from model data, expert observations, and the existing literature, and were one of the primary references during upcoming workshop. In addition, prior to the workshop, participants were invited to take some time to answer a survey regarding the potential effects of climate change in the area. Results of this survey can be found in the Webinar 2 folder here: http://www.snap.uaf.edu/webshared/NPS-CCSP/2012_Central_Alaska/

Sector	Subsector	Potential Effects to Resources, Operations, and People
ATMOSPHERE	Air Temperature	Air temperature increases ~1°F per decade; greatest change in the north and in winter. Average spring/fall temps shift from below freezing to above freezing, changing freeze/thaw balance.
	Precipitation	Average annual precipitation increases. Relative amounts of snow, ice or rain change. Many areas experience drying conditions despite increased precipitation.
	Storms	Lightning and lightning-ignited fires continue to increase.
	Air quality	More smoke from longer and more intense fire seasons.
	Contaminants	Increased contaminants and shifting contaminant distribution.
CRYOSPHERE	Snow/ice	Later onset of freeze-up and snowfall + earlier spring snowmelt and break-up. Arctic snow cover declines with higher air temperatures and earlier spring thaw. Lack of snow cover leads to deeper freezing of water in the ground or rivers. Cultural resources are exposed as snow and ice patches melt and recede.
	Ice roads	Reduced winter transportation affects opportunities for travel and subsistence.
	Permafrost	Mercury & other pollutants are released into aquatic environments as permafrost thaws.
HYDROS-PHERE	Freshwater	Stream flows from melting glaciers increase and then decrease over time. Ponds shrink as ground ice thaws or thermokarst drainage occurs in permafrost areas. Drainage from thawing waste and sewage dumps contaminates rural water supplies.
BIOSPHERE - vegetation and fire	General	Ecological "tipping points" are likely to result in rapid change, when conditions exceed physical or physiological thresholds (e.g., thaw, drought, water temperature).
	Vegetation	Increased agricultural production in Alaska because of longer growing season. Potential large-scale shift of tundra to shrubs, to conifers, to deciduous forests or grass. Atypical outbreaks of pests and diseases affect native species and increase fire hazards. Invasive exotic plant species and native species from other areas expand their ranges. Vegetation expands into deglaciated coastal areas, less into higher elevation areas. Tree species and vegetation classes shift as species of lower latitudes and altitudes expand.
	Forests	Mature forests and “old growth” decline because of drought, insects, disease, and fire.
	Fire	Models show a warmer climate leads to larger, more frequent and intense fires. Wildland fire hazards increase, affecting communities and isolated property owners. Fire-related landcover and soil changes result in vegetation shifts, permafrost thaw, etc.

BIOSPHERE - wildlife	Wildlife	Changes to terrestrial and aquatic species occur as ranges shift, contract, or expand, affecting visitor experience and subsistence throughout the parks. Parks and refuges may not be able to protect current species within their boundaries. Some species will suffer severe loses. So far, the greatest losses across all parks have been rodents, bats, and carnivores. Predator-prey relationships may change in unexpected ways. Migratory routes and destinations change (e.g., wetlands, open tundra, snow patches).
	Birds	Arctic and alpine birds' breeding habitats reduced as shrubs encroach on tundra. Geese could lose almost half of their breeding habitat due to change from tundra to taiga and boreal forest. Predation on ground nesting birds could increase if prey (lemming) abundance declines. Population cycles of birds and their prey could be out of sync due to higher temperatures.
	Caribou/ Reindeer	Caribou and reindeer health are affected by changes in weather, forage, and insects and pests. Earlier green-up could improve caribou calf survival because of more available forage. Caribou may suffer heavy losses iin rain-on-snow events.
	Moose	Shifts in forests could mean less habitat for caribou, but more habitat for moose. Climate change could hinder moose calf birth success and moose calf survival.
	Small Mammals	Fire may create new burrowing habitat and forage growth to help vole populations. Less snow cover reduces survival of subnivian species, due to increased predation & cold stress.
	Fisheries	New stream habitats become available for fish and wildlife as glaciers decline. Some salmon waters may become unsuitable for migration, spawning and incubation. Fish diseases increase with rising stream temperatures. Fish habitats in permafrost areas are degraded by slumps and sediment input into rivers.
	Invertebrates	Exotic pests expand from warmer areas, and endemic pests expand as host species are stressed.
	Subsistence	Altered animal migration patterns make subsistence hunting more challenging. Managing new species and intensified management of native species may be needed.
OTHER	Tourism	Longer summer seasons increase tourism. Some visitor activities increase, others decline. Landscape-level changes affect visitor experiences and access, visitor use patterns shift.
	Wilderness	Large-scale physical and biological changes across broad landscapes affect abundance and condition of wilderness-associated resources (e.g., glaciers, wildlife, access routes). Changing biophysical landscape affect key wilderness values such as naturalness, wild-untamed areas wtihout permanent opportunities for solitude, etc.
	TEK	Uses of traditional ecological knowledge become less predictive and less reliable.
	Development	More natural resource development in Alaska with increasing global demand. Fuel and energy prices increase substantially with carbon mitigation measures. Transporting fuels to remote locations becomes more challenging and costly.

Appendix H: Narratives

As noted in the body of this report, creatively framed narratives were an important outcome of the intensive group brainstorming efforts that went into this CCSP workshop. The following imaginative narratives were created to synthesize these climate change scenarios and to bring them to life in a manner intended to engage diverse audiences.

Narrative 1: "Denali, not Denial"

The following narrative (in the form of a map) was developed by the Denali group based on the "Steambath" scenario (major increases in season length and precipitation) nested in "Big Problems, Big Solutions" (strong and coordinated support for climate change at the local and institutional levels) of the socio-political matrix (Figure 10).

Interactive Map

- Text associated with static Google image
- Could be part of an Environmental Impact Statement (EIS
- Meets the need to show what the changes are, how management actions to meet those changes can be meaningful andproactive.
- New vignettes and information can be added to the map over time.

http://www.snap.uaf.edu/webshared/NPS-CCSP/2012_Central_Alaska/Workshop%20Documents%20Central%20AK/CAKN_Narrative_MapofDenali.ppt

Narrative 2: "Arctic Safari: Saunas & Sunsets"

The following narrative (in the form of a monologue by "Gaia", i.e. "Mother Earth") was developed by the Denali group based on the "Better Sunsets" scenario (a future with a much longer summer season but little increase in precipitation) under the conditions described for the "Is Anybody Out There?" quadrant (low societal concern and poorly integrated institutions) of the socio-political matrix (Figure 10).

Gaia's Story

Look at that sunset . Pretty ain't it ...
Damn! Sometimes I wish I were not so beautiful.
Sometimes people just see the beauty, but they don't really see me.
Name's Gaia ... People call me Mother Earth ... or you can call me "The land."
(Waves dismissively) Whatever ...
Whatever ... That would sum up my life today: "Whatever"

Let me tell you:
I've always tried to take care of myself. I had a lot of self-control. (Straightens up)
Sure, I'd go through phases - doesn't everybody - but I kept it together.
But now, I'm not so sure. I'm starting to feel out of balance.
(aside) Whew, it's hot in here. Are you hot?

Used to be I felt I had plants on all the right places.
Tall trees, willows, beautiful little tundra flowers of all different colors ...

And berries - oo-oo Baby! I was fecund!
But then things started to change. It's like my soul just dried up.
All of a sudden I've got shrubs squeezing out my grasses and flowers.

And the fires!
I used to lo-o-o-ve a good fire to stir the pot!
But now they're happening all the time.
I can't send out a lightning bolt without burning down the house.
After a fire, I don't mess putting up trees anymore. I just replace 'em with grass.
Sure, a grassland is pretty ... esp. when you don't know what used to be there.

* cough * sorry about the smoke ... * cough *
I need a drink. But I am clean out of little ponds.
I'd drink out of my rivers, but, have you seen my sediment loads?

Oh, what used to be there ... my animals, my animals ...
I used to be crawling with all sort of things:
Grizzly bears, black bears, caribou, moose, sheep, wolves ...
They found what they needed to live, and I didn't worry about them too much.
But I didn't realize how all my vegetation changes were taking a toll.
First my pika ... gone ...
Then my caribou .. not gone, but hard to find - almost the same thing.
Then my bears - going, going ...
Then - oh, hello! - I got wood bison. Where'd you come from?

My timing is off.
My birds show up. My insects have hatched and gone.
I'm ... just ... off ...

Oh, people come. They travel that road.
They still see wildlife. They think I'm fine.
But believe me: It just ain't the same.

And that road: Everybody worries about that road.
"Oh Gaia, don't let that permafrost go! We'll lose that road."
But I ask you: What's in it for me?

I used to be decked out in blue ice and white snow.
But hemlines have moved up, if you know what I mean, and I'm not too comfortable with that.

You look at me and - if you ignore those fire scars - I look pretty and green and I know what you're thinking: you want to hike all over me ...
That's fine, but I'm NOT the same.
And no one seems to notice.
Hey, Green and Gray (waves) Hey, HEY, hey!
(Shrugs) Nothing ...

I used to feel connected with people.
All of them.
I fed them and they paid attention. But now there were so many ...
8 billion ... oops, 8 billion and one.

Even with so many, there were a few - those special few - who still paid attention.
I looked at them and they looked at me and it was like we were in love ... but was more than that: we understood each other ...

But this world - it's so hustling and bustling ...
They move away. It's like they said to me: It's over.
I'm lonely ...

Bright side * cough * all this smoke makes for beautiful sunsets.
I look at them and feel despair.
Makes me want to climb to the highest mountain and shout:
Is anyone out there ... who cares?

Narrative 3: "Bogged Down"

The following narrative (in the form of Park superintendent's annual report) was developed by the WRST/YUCH group based on the "Sponge Cake" scenario (a wetter future with a slightly longer summer season) under the conditions described for the "Is Anyone Out There?" quadrant (low societal concern and poorly integrated institutions) of the socio-political matrix (Figure 12).

SUPERINTERDENT'S ANNUAL REPORT for WRST & YUCH = WRYCH
Superintendent Emily McCarthy

Funding Changes
As Congress expects, Park operations will be funded 100% through various fees.
Park facilities will continue to be carried out by concessionaires and cooperators including Alaska Native Corporations

Subsistence
Due to the lack of a year round economic base, remaining subsistence users rely even more heavily on local subsistence resources.
Due to changes in federal and state legislation spurred by lawsuits, the Federal and State Subsistence programs have merged.
This has increased competition between local and urban subsistence users.
Also we are challenged to manage the expanding ORV trail networks due to increased subsistence activities.
On a positive note, we had a celebration for Charley Baker who caught the first Yukon River chum seen in the last 5 years.
The fish was so rare and unusual that instead of eating the salmon, the fish has been stuffed and is on display at the post office.

Management of Kennicott
What visitation we have is focused on the new and improved McCarthy Road to Kennecott.
Visitation continues to be affluent visitors who request guided hunting and special tours to Kennecott. The McCarthy-WorldWideTours Air Strip has been enlarged to accommodate jets.
Lodge development continues to occur at the end of the McCarthy Road.
Renovation of the Kennecott historic mining buildings have been completed with funding from WorldWideTours.

Permitting and Mineral Activity
A co-management agreement was used to build roads to logging grounds and mineral deposits.
Metal prices continue to go up, which has driven demand to develop mines in Woodchopper Creek in the Yukon Charley region.
This year we saw the extraction of over 1000 ounces of gold from Woodchopper Creek and we continue to facilitate river access to oil and gas leases on Nation River.
The challenges associated with the permitting and monitoring requirements for in-situ extraction methods in frozen soils will be used to mine all resources in both areas associated with these new methods.

Degradation of and Increasing Wetlands
Heavier rainstorms in recent years have caused slumping erosion, damaged roads and trails and have taxed our ability to maintain access (especially to in-holders) and prevent resource damage.
Visitation in wilderness has reduced almost to nothing, except for consumptive uses, and resource development.
We need monitoring for resource issues but have minimal funding and staff.
Contracting for resource monitoring is focused on mandates to preserve charismatic mega fauna as reflected in park enabling legislation.
Control of invasive species which are concentrated along the roads, trails, and river corridors remains focused on reed canary grass, white sweet clover, bird vetch, and a newly discovered Asiatic species.
On a positive note, locals are selling dandelion wine.
Also, biomass generators in the local community fed by invasive species help control efforts but have had an unexpected consequence of further degrading the ORV trails.

Narrative 4: "The Northland is a Changin' "

The following narrative, in the form of a song to be sung to the tune of Bob Dylan's classic "The Times They are A-Changin'," was developed by the WRST/YUCH group based on the "Smoked Salmon Riots" scenario: the "Alberta on Fire scenario nested in "Riots & Revolution" of the socio-political matrix (Figure 12).

Come gather round people
Wherever you roam
And admit that the waters
Around you have gone
And accept it that soon
You'll be dry to the bone
If your salmon to you
Are worth savin'
Then start takin' a stand
Or the fish will be gone
For the rivers they are a changin'

Come smokejumpers and tankers
Who fight fires to no end
And watch the land change
The spruce won't come again
And don't speak too soon
While the smoke's in the wind
There's no tellin' which
Of the species will win
For the caribou now
Have no lichen to chow
For the fires they are a ragin'

Come senators, congressman
Please heed the call
Don't stand in the doorway
Don't block up the hall
For folks are on edge
And the food stores are small
There's a riot outside
And it's ragin'
Your mandates will crumble

And we'll clog up your halls
For the lawsuits they're a comin'

Come hikers and paddlers
And give us a hand
While the last of the glaciers
Are still on the land
Your sons and your daughters
Won't see them firsthand
The old road is
Rapidly sinkin'
Your access is limited
With less frozen land
For the North it is a thawin'

Come hunters and gatherers
It's time to unite
Across northern nations
For C&T rights
The moose and the berries
Have vanished from sight
Expenses are
Rapidly risin'
Can traditions survive
When the land doesn't thrive?
For subsistence it is a changin'

The rivers don't freeze
The heat is here now
The mule deer and cougars
And bison now prowl
In a land lacking wetlands
And most waterfowl
The landscape is
A rapidly changin'
And the native species
Have thrown in the towel
For phenology it is a changin'

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

NPS 191/125235, 190/125235, 184/125235, July 2014

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
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