



Climate Change Scenario Planning for Interior Arctic Alaska Parks

Noatak – Gates of the Arctic – Kobuk Valley

Natural Resource Report NPS/AKSO/NRR—2014/833



Scenarios Network
FOR ALASKA & ARCTIC PLANNING



ON THE COVER

Arrigetch Peaks Glacier
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Robert Winfree, Bud Rice, John Morris, Nancy Swanton, and Don Callaway (retired)
National Park Service Alaska Region
240 West 5th Avenue
Anchorage, AK 99501

Jeff Mow
Superintendent
Glacier National Park
PO Box 128
West Glacier, MT 59936

Nancy Fresco and Lena Krutikov
Scenarios Network for Alaska & Arctic Planning
3352 College Road
Fairbanks, AK 99709-3707

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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, the Interior Arctic was the fourth area in Alaska to be examined by NPS through a scenarios workshop on March 27-29, 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 March 2012 workshop focused on three interior parks in the Arctic Network (ARCN): Noatak National Preserve (NOAT), Kobuk Valley National Park (KOVA), and Gates of the Arctic National Park and Preserve (GAAR). The other ARCN parks (Cape Krusenstern National Monument and Bering Land Bridge National Preserve) were addressed in a separate workshop ("Western Arctic") in 2012.

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 ecosystem shifts, changes in climate during the shoulder seasons, and ecological tipping points. More specifically, future scenarios focused on potential impacts to caribou and marine mammals; infrastructure, travel and development on the tundra; and associated changes in subsistence.

General findings and recommendations to managers include the need to strengthen collaboration via partnerships with other agencies, coordinated data collection, collaborative scenario planning in local communities, and creation of enterprise teams composed of local, state & federal personnel. The group also saw the need for increased staffing – particularly with local hire -- in fire suppression and technology innovation, and increased education efforts focused on Native life, science-based climate change information, and community presentations. Increased infrastructure would also be needed for tourism, with more attention to energy efficiency. Finally, the focus and mandates of Park management might need to be amended, in order to make them more relevant in a changing climate. Such changes might include tracking and allowing movement of new species into the area.

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 participants (affiliations and positions listed in Appendix B), as well as the organizations and communities that made it possible for them to attend.

List of Terms & Acronyms

ARCN	Arctic Network, the National Park Service’s Inventory & Monitoring network of parks in northern Alaska
Climate driver	A climate variable that drives changes in weather, vegetation, habitat, wildlife, etc. Also referred to as a <i>critical force and a scenario driver</i> .
Climate effects	Existing or potential consequences, outcomes, or results of changes in climate. Can appear beneficial or deleterious, depending on perspectives.
Critical force	A climate variable that drives changes in weather, vegetation, habitat, wildlife, etc. Also referred to as a <i>climate driver or scenario driver</i> .
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.
GAAR	Gates of the Arctic National Park & Preserve, ARCN Park
Impact	A forceful or particularly significant consequence. An effect that is likely to warrant a response.
KOVA	Kobuk Valley National Park, ARCN Park
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.
NOAT	Noatak National Preserve, ARCN Park
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 that future events 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.

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 interior Arctic 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.

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 single predictive forecasts 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

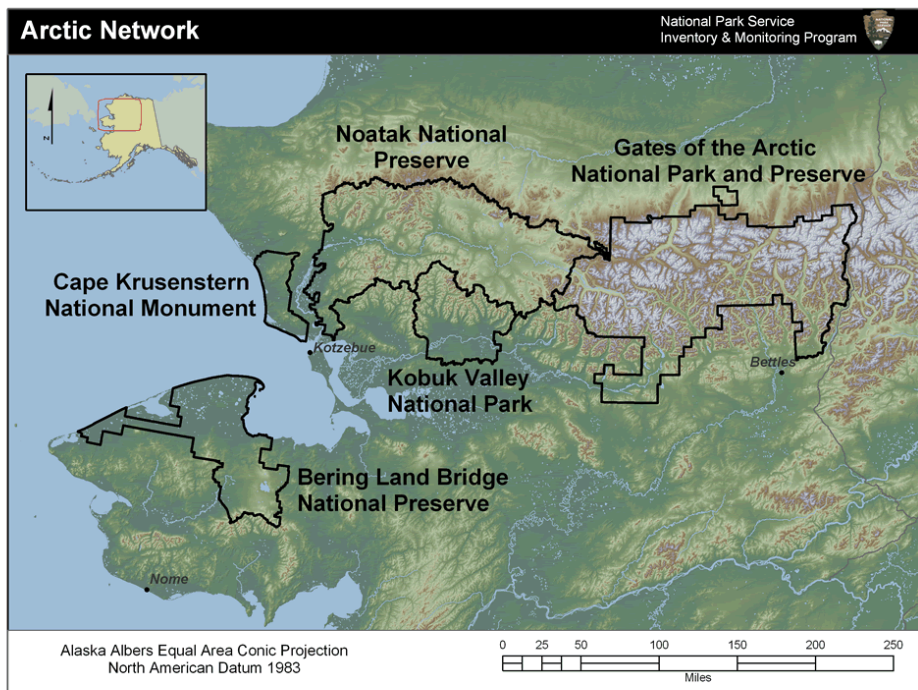


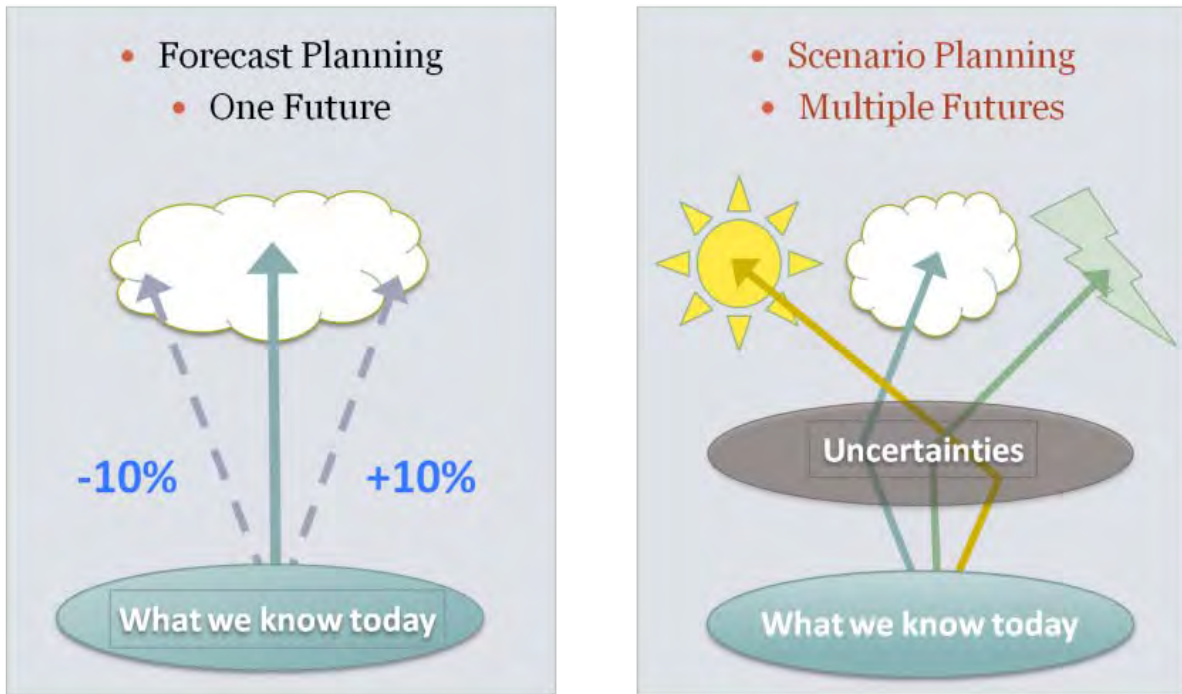
Figure 1: Arctic Network (ARCEN) parks. For the purposes of this project, the Arctic Network was divided into coastal and interior regions. Thus, the interior Arctic workshop was focused on Noatak, Kobuk Valley, and Gates of the Arctic park areas.

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.



Global Business Network (GBN) - A member of the Monitor Group

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Figure 2. Difference between forecasting and scenario planning.

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.

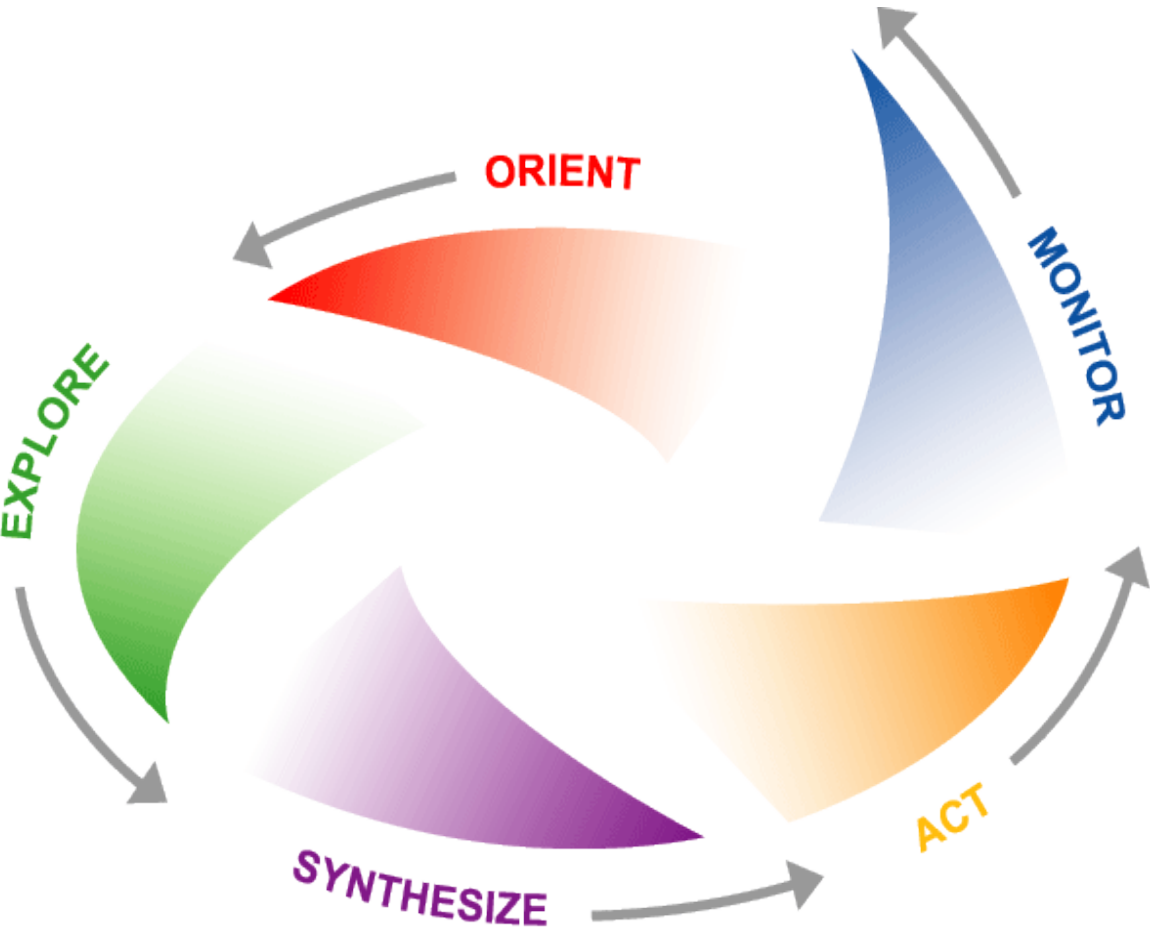


Figure 3. Stages in the scenarios building process. Diagram provided by the Global Business Network (GBN).

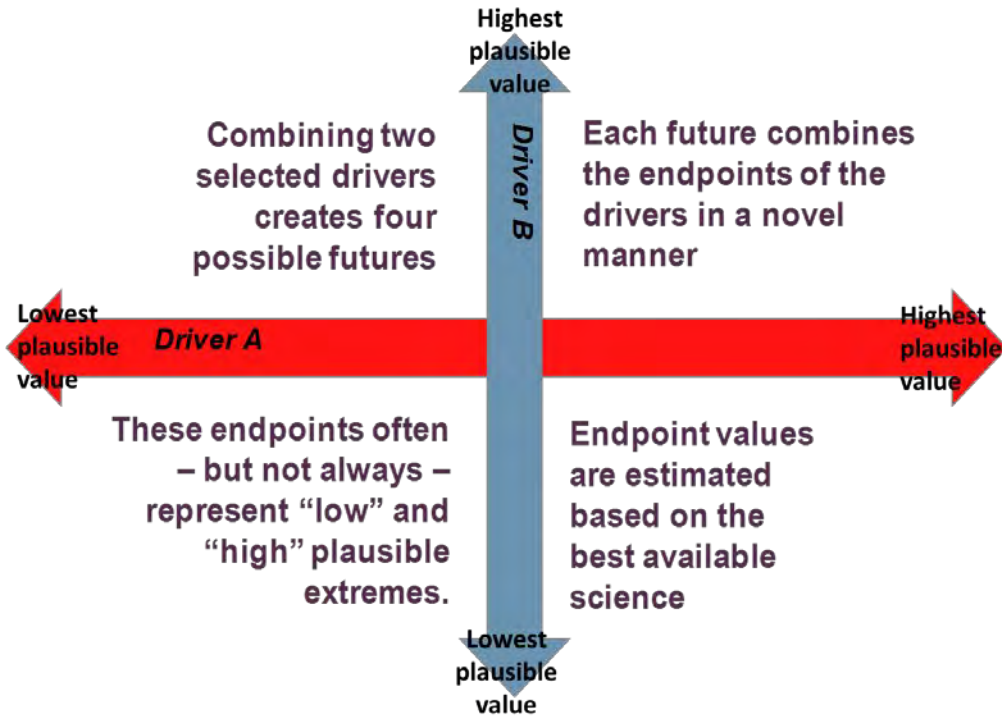


Figure 4: Creating a primary scenarios matrix. Two key climate-related drivers of change are crossed to create four possible futures.

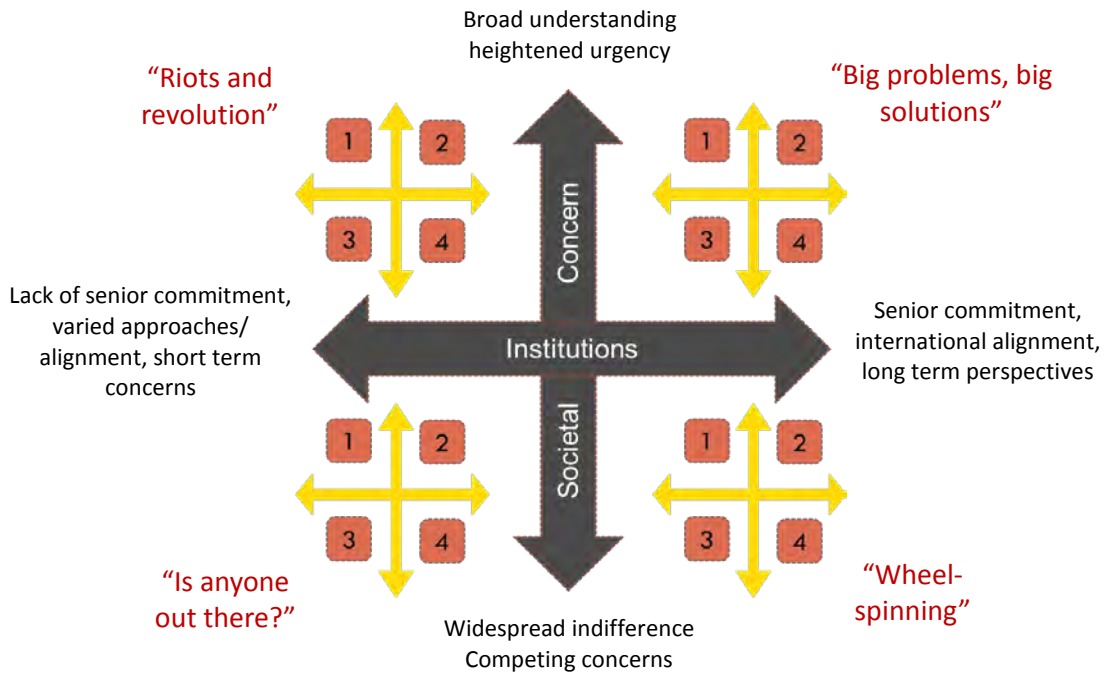
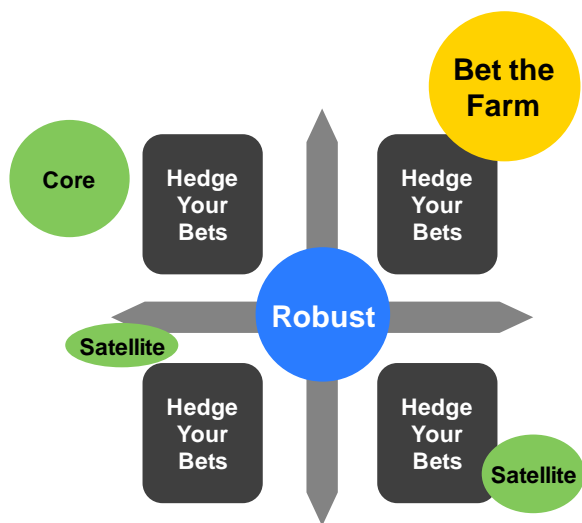


Figure 5: General design for a socio-political framework. This framework incorporates the degree of societal concern in the future and the nature of future leadership. Adapted from the Global Business Network (GBN).



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 three 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. Webinar 2, also led by Nancy Fresco, focused on climate drivers (key forces driving climate change) in the interior Arctic parks. (See Appendix F for a table of region-specific climate drivers). Webinar 3, led by Robert Winfree of NPS, was focused on climate change effects in the Northwest Alaska parks. Participants were asked to help rank the relative importance of these effects. (See Appendix G for the climate change effects table.) PowerPoint presentations and recordings of each webinar are available in the “Webinar 1,” “Webinar 2” and “Webinar 3” folders at: http://www.snap.uaf.edu/webshared/NPS-CCSP/2012_Interior_Arctic/

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 (Appendix D), including talking points on impacts to Alaska’s boreal and Arctic regions (<http://www.nature.nps.gov/climatechange/docs/BorealarcticTalkingPoints.pdf>). 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_Interior_Arctic/

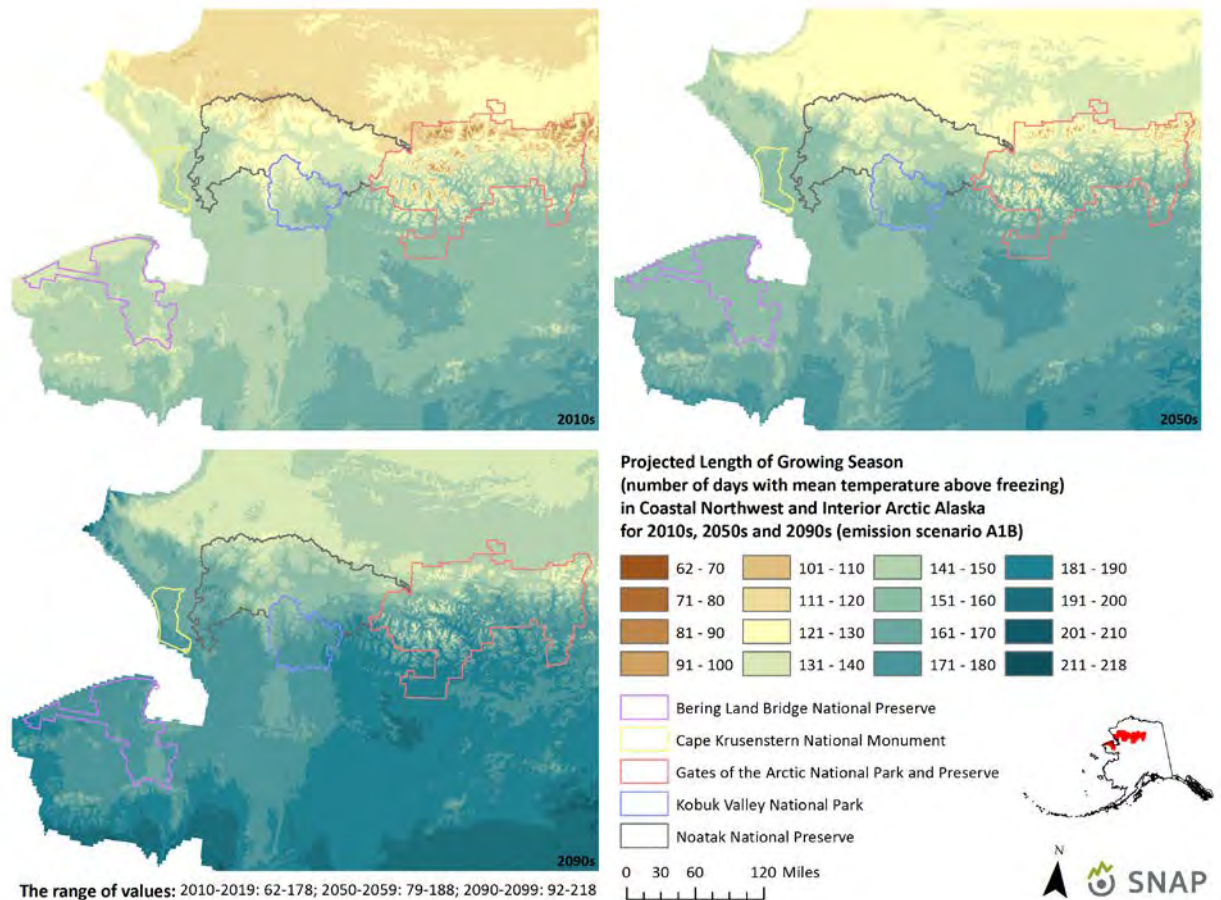


Figure 7: Mean summer season length. These maps show the projected number of days between the date on which the running mean temperature crosses the freezing point in the spring, and date on which when that point is crossed again in the fall. The above-freezing season is likely to be up to 40 days longer by the end of this century. See Appendix E for additional maps of projected thaw and freeze dates, ground temperature, growing season, and precipitation by season.

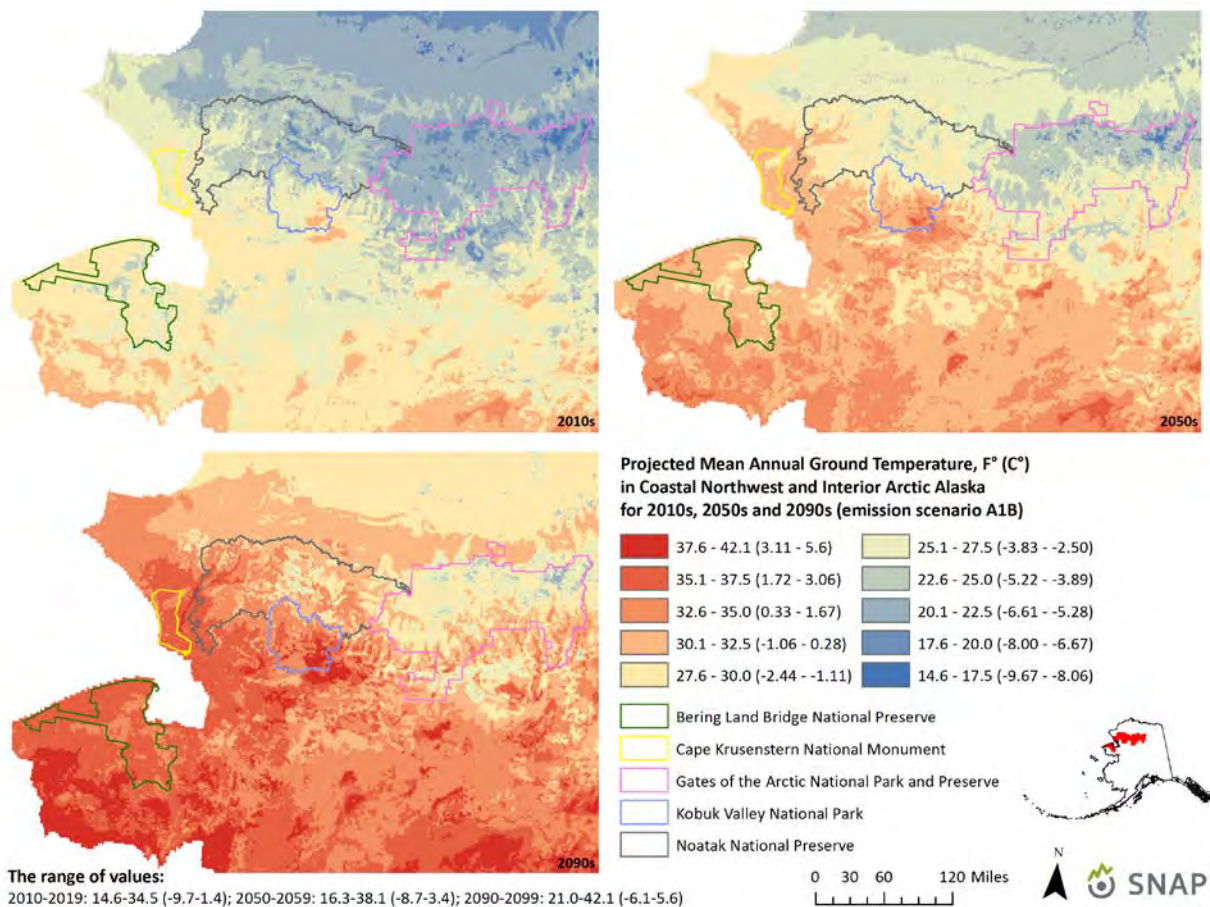


Figure 8: Mean annual ground temperature at one meter depth. Based on SNAP climate data and GIPL permafrost modeling, these maps depict likely ground temperature conditions. Regions of discontinuous permafrost thaw are likely in interior Arctic parks by the end of this century, particularly in Kobuk Valley.

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 “Interior Arctic Climate Scenarios,” available in the Reports and Products folder at http://www.snap.uaf.edu/webshared/NPS-CCSP/2012_Interior_Arctic/. Workshop 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. John Walsh of UAF's International Arctic Research Center discussed climate drivers and uncertainty, including an explanation of the effects of the Pacific Decadal Oscillation (PDO). Rick Thoman of the National Weather Service talked about climate variability and added more information regarding the 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 interior Arctic" folder at: http://www.snap.uaf.edu/webshared/NPS-CCSP/2012_Interior_Arctic/.

Workshop Work Group Products

Participants divided into two working groups for breakout sessions based on area of expertise, attempting to create groups that were as internally diverse as possible. Work 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.

Group One

Group One Climate Driver Selection

Group 1 first assessed the relative importance and uncertainty of climate-related scenario drivers. These drivers had been presented and discussed during the pre-workshop webinars, were reintroduced in workshop plenary sessions, and were reorganized, expanded upon, or tweaked in focus during this small-group discussion (see Appendix F). For the purposes of scenario planning, the goal was to select two drivers with high importance and high uncertainty.

Importance has multiple dimensions. A driver can be important because it causes effects across a broad area (lowlands, rivers, uplands); because it affects multiple sectors (tourism, subsistence, cultural sites) or because the effects in any one sector could be potentially catastrophic. In selecting drivers, Group 1 considered not only the effects that were discussed in the webinars and in the workshop plenary, but also the purposes for which the network parks were established.

A discussion of uncertainty included – with input from team leaders –the clarification that there are two distinct forms of uncertainty at work: threshold uncertainty and uncertainty of degree. The former refers to the confidence regarding some type of change occurring, e.g. 95% (high certainty) vs. only 50% (uncertain). The latter refers to the range within which that change might

be expressed, e.g. temperature increase of 1-5°C. A broad range reflects higher uncertainty than a narrow one. Since both types of uncertainty yield the divergence in potential futures that works best for scenario planning, both were taken into account in selecting climate drivers.

Group One discussed the following drivers:

- Temperature
- Snow depth
- Freeze/thaw rate (amplitude, duration and timing)
- Drought and water availability
- Length of growing season
- Fire season
- Permafrost thaw (rate)
- Asynchrony between climate and day length
- Erosion/disruption of land: river margins, hill slope failures, etc.
- Water (amount, nature, intensity of events)
- Peak spring flow
- Seasonal timing—capturing freeze/thaw, length of growing season
- Extreme events: ice events, rain/snow events, late winter storms

Discussion included the question of whether to select fundamental drivers (temperature and precipitation), given that these encompass many of the others. On the other hand, the group agreed that the derived drivers were more nuanced, and that, at least in some cases, they might be more pertinent for the local area.

Ultimately, Group 1 chose to pursue the intersection of the following two drivers, as shown in Figure 9:

- 1) frequency of extreme events, including everything from dry lightning to snow/ice/rain storm events; and
- 2) seasonal timing, including freeze/thaw dates, ice in/out dates, etc., and potential associated geophysical and biological asynchronies.

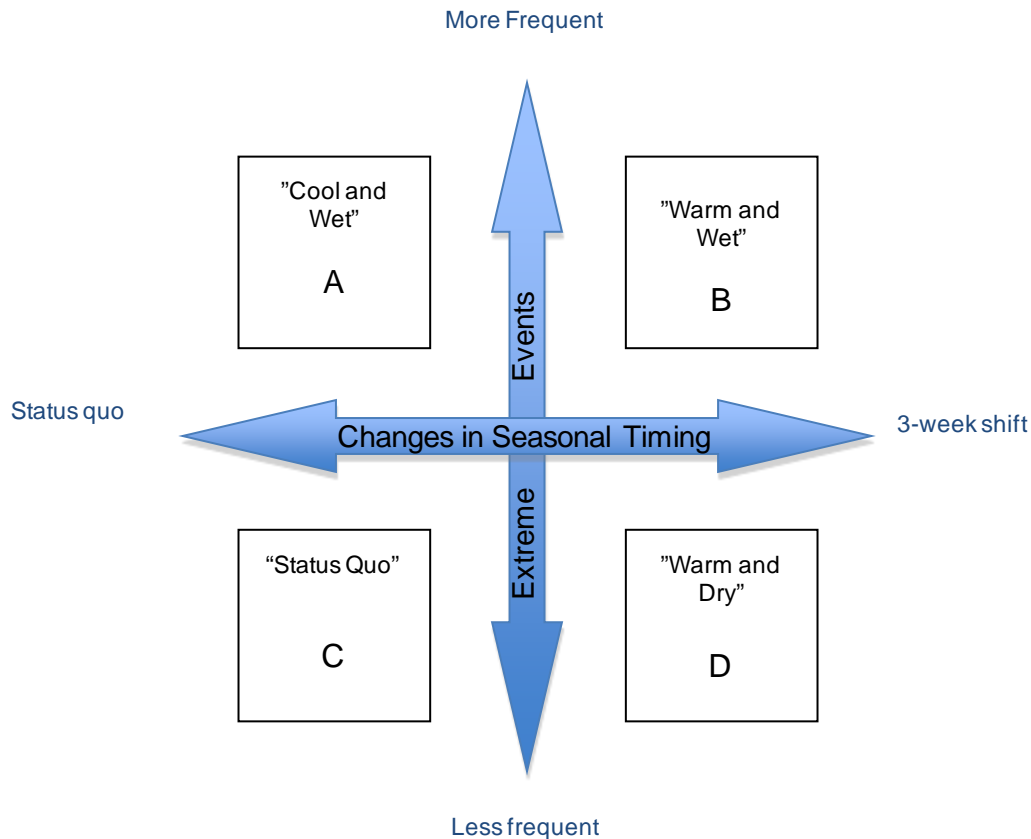


Figure 9: Primary matrix of climate drivers produced by Group 1. Each quadrant represents a different combination of potential future seasonal timing and extreme events. Details of each quadrant are described in the text.

Group One Bio-physical Scenarios Developed from Selected Drivers

Each quadrant resulting from selected drivers represents a different scenario of potential future temperature and storm/precipitation conditions (Figure 9). In order to flesh out each of these scenarios, participants referred back to the effects tables (Appendix G) derived during the pre-workshop webinars, as well as the scientific literature, maps, and other information shared during both the webinars and 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 resulting scenarios for Group 1 were:

- A. “Cool and Wet,” with unchanged seasonality and more frequent extreme events,
- B. “Warm and Wet,” with a large shift in seasonality and more frequent storms,
- C. “Status Quo,” with unchanged seasonality and less frequent extreme events, and
- D. “Warm and Dry,” with a large shift in seasonality and less frequent extreme events.

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

Group 1 Scenario A: “Cool and Wet”

The “Cool and Wet” scenario envisions a future in which seasonal change, as driven by temperature, has not changed much, but more frequent extreme events have increased total precipitation, storms, and flooding. Potential effects of such conditions include:

- Nest flooding
- Tree mortality
- Increased fire frequency/intensity
- Spring flooding/runoff
- Starving caribou
- Small mammal populations down
- Increased turbidity
- Warmer water, changes in thermostratification
- Change in energy budget of lakes
- Some erosion increase
- More thermokarst

Group 1 Scenario B: “Warm and Wet”

This scenario envisions future that is hotter and stormier, as compared to the early 21st century, with associated seasonal shifts. Potential effects of such conditions include:

- Early river breakup & late freeze-up
- Easier river/harder snow-machine travel
- Deep snow & ice storms-starving caribou (large increase)
- Shorter duration of duck occupancy
- Impacts to ground nesting conditions
- Increased fire frequency/intensity (large increase)
- High erosion increase

Group 1 Scenario C: “Status Quo”

This scenario envisions a future with little or no change from existing conditions. Thus, the group did not elaborate on the possible effects.

Group 1 Scenario D: “Warm and Dry”

This scenario envisions seasonal shifts of up to three weeks, but less frequent storms, major precipitation events, and flooding. Potential effects of such conditions include:

- Change in productivity of shore birds and water fowl
- Decreased water levels—difficult summer transportation on rivers
- Shift in peak flow—visitor season changing with hydrograph
- Impact for spring spawning fish populations
- Decrease in ability to successfully store food during winter
- Increased active layer depth and decreased flow in some areas
- Decreased connectivity—impact fish migration during late summer.
- Increased fire activity

Group One Scenarios Nested in a Socio-political Matrix

Group One nested the four climate scenarios described 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 three 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.

Both groups discussed the use of the nested matrices and noted that the biophysical and sociopolitical matrices are not truly independent of one another; significant change on the landscape could inspire more institutional support and societal change. In addition, although the degree of engagement described by “Big problems, big solutions” may seem implausible now, we could see a major change in the next 20 years. Furthermore, although this effort took global, widespread conditions into account, participants were primarily focused on the specific bioregion in question. At the village level, it was hypothesized that agency inaction could lead to “Riots and revolution” at a local level but not on a global level.

After the two groups separated once again, Group 1 independently discussed the nature of the new matrix, as well as the ramifications and plausibility of various combinations. The group ultimately opted to explore the two nested scenarios shown as blue stars in Figure 10 and described below.

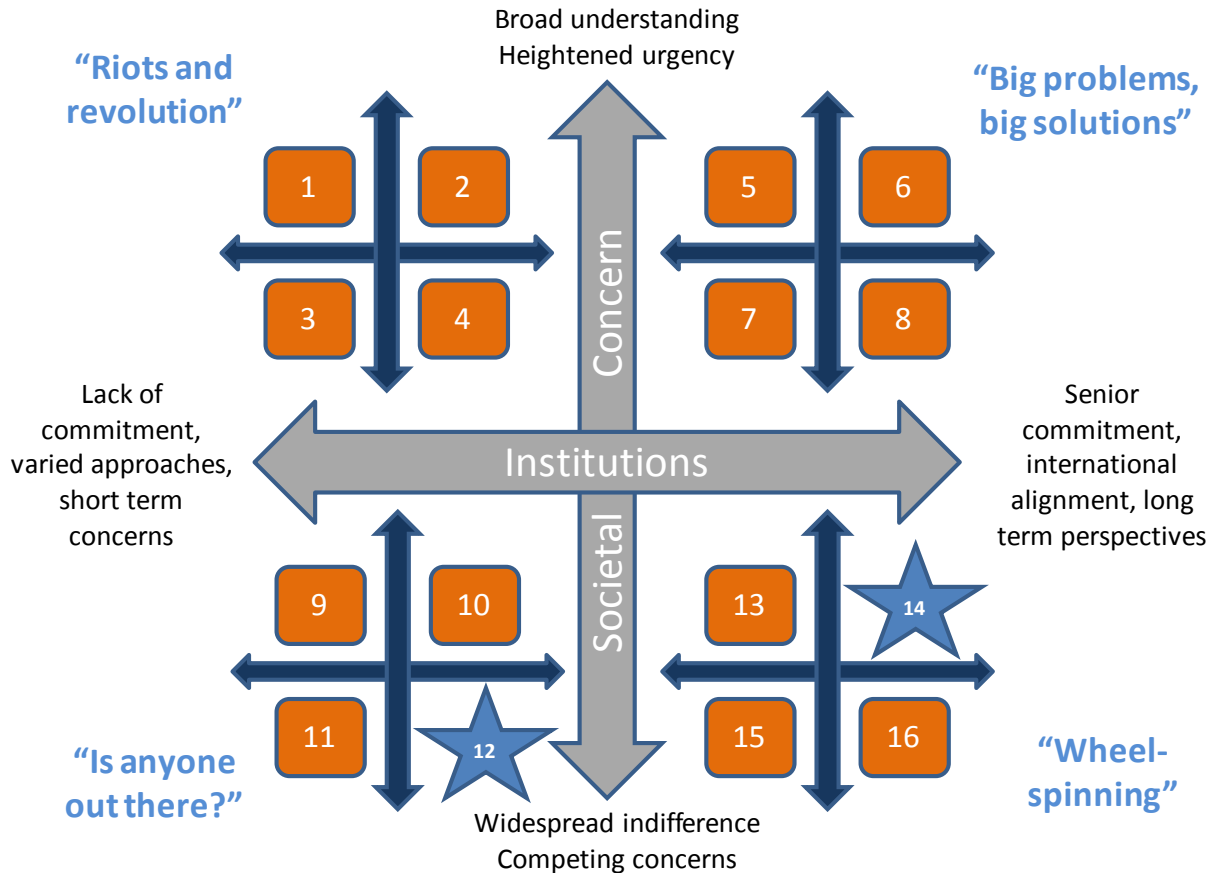


Figure 10: Group 1 nested scenarios. The two nested scenarios selected by Group 1 are marked by blue stars. The “Warm and dry” scenario (major changes in seasonal timing and reduced extreme events) is nested in “Is anyone out there?” (little social or institutional support for climate change adaptation efforts). The “Warm and Wet” scenario (major changes in both extreme events and seasonal timing) is nested in “Wheelspinning” (little local support and coordination, but significant support at the institutional level). The implications, management actions, research needs, and narrative associated with these two scenarios are elaborated upon below.

First Group 1 Nested Scenario: “Gussaq the Tussock”

The following effects, issues, implications, and suggested needs and actions were identified by Group 1 in the event that the “Warm and Dry” scenario (with shifted seasonality, but lower storm, precipitation, and extreme event frequency) were to occur under the conditions described for the “Is Anyone Out There” quadrant (which describes a future in which both local and institutional commitment and focus regarding climate change are low) (Figure 5). Group 1 named this nested scenario “Gussaq the Tussock” based on the narrative that was ultimately derived from it.

Describe this world in 2030/Major impacts to bioregion:

Fire

- More fire is expected on the landscape, with more caribou habitat burned
- Land takes a long time to recover – 60 to 70 years -- and might not come back at all

- Shrubs might take over, or it might burn again before lichens can come back. Post fire, more moose habitat is expected
- Call for fire suppression and call to change fire management plan, but that's resisted based on budget concerns
- Little strategic planning, more spending on response. Status quo is "let it burn," and lack of pre-planning will tend to leave it in that category

Subsistence

- People prefer caribou over moose for eating, but might be willing to switch
- Moose are currently much less numerous, by an order of magnitude
- "Cabelas hunter" (non-local) might stick around longer in the fall if it's warmer
- Increased conflict between indigenous hunters and other hunters
- Shorter time period in which to get caribou if they migrate later
- Current way of determining the hunting season would hold up ok, but the management system wouldn't deal well with the new competition in hunting
- Berries reduced

Permafrost

- Active layer gets deeper due to burning off insulation, permafrost loss
- More degradation, more thermokarst, infrastructure compromised on communities, villages, water sources affected, loss of safe water.
- Slope failure due to thermokarst, mass waste, sloughing and slumping

Fish/Rivers/Lakes

- Spawning affected due to water contamination
- More insects in water
- Some overwintering fish may do better with increased temperature, but salmon likely to suffer
- Beavers make more dams, stop water from flowing freely
- Northward migration of invasive species
- Salmon shark washed up in Kotzebue
- Higher siltation, salmon species moving farther north
- Sheefish negatively impacted
- More southern salmon might benefit as they shift north
- Less access to harvest areas due to not being able to go up rivers in boats, reduced harvest of sheefish, chum salmon, whitefish, also less access for hunting
- Increased nutrients going into lakes
- Oxygen concentration in lakes decreasing, so fish kills occurring.

Ice

- Loss of what's left of the glaciers
- Thinner ice – winter travel hazardous with snowmachine, for caribou hunting, ice fishing, geese hunting
- Might get thicker ice due to less snow

Tourism/business

- Longer summer season makes tourism more cost effective
- Visitor use for non-hunters goes up, enhancing the value of the park
- More birdwatching, sightseeing, river floating

- Some river floating may be curtailed by lower flow, but that affect would be minimal
- Economic opportunities to make money from these tourists
- Poor planning for new infrastructure to deal with increased visitor use
- More ice free days equals more mining activity, e.g. Noble Gold
- Passing caribou should take precedence over mining, but little management might lead to conflict between subsistence hunters and miners, diversion of caribou migration
- Less season for oil exploration due to limited ice roads
- Lack of monitoring of air strips, land use, hunting
- Unregulated development, unregulated transport. People may not bother to get permits for access.
- More visitors might mean more support for the park, more pressure to get funding to protect it, more TV time.
- Fewer bugs means better park experience for visitors
- Extended climbing season for Arrigetch Peaks

Food and food security

- Spoiled foods, greater dependence on groceries, less on soul food. Fatter kids, fewer teeth, health problems
- Underground freezers are melting—ice cellars – increased costs and energy use from switching to electrical freezers
- Aboveground caches useful for a shorter season
- Contaminated food supplies
- A transition to gardening wouldn't occur systematically via education in the schools, because of lack of cohesiveness

Wildness

- Its perception would be in danger, due to absence of a planned response
- Wildness is dependent on human intent – or lack thereof. More trash, garbage left by outside visitors, landfills filling up, outsiders deciding to stay because there was no one to tell them not to. “Range expansion” of Caucasian males
- Loss of sense of Park mission – gap between agency tradition and where it finds itself going. Park is still trying to preserve things unimpaired, and is failing at that. Agency culture would lack resilience

Contamination

- Smoke from fires – impacts on health and on access. Air quality impacted by too many vessels
- Potential for gold, copper, jade mining – contamination
- New road across from Fairbanks to Bettles, across Kobuk.
- Decreased wetland extent, decreased bird numbers, fewer migratory birds. Ducks and geese would be hit hard. More predator access. Less geese soup, ptarmigan soup etc.
- Increased river erosion – Ambler already has a problem with erosion, might impact water supply line. Sewage lagoons might be compromised. Vacuum system might not work as connections shift, and communities might have to resort to honey buckets.

Second Group 1 Nested Scenario: “Strange Bedfellows”

The following effects, issues, implications, and suggested needs and actions, and narratives were identified by Group 1 in the event that the “Warm and Wet” scenario (with shifted seasonality

plus increased storm, precipitation, and extreme event frequency) were to occur under the conditions described for the “Wheel-spinning” quadrant (which describes a future in which government/institutional commitment regarding climate is high, but local concerns are focused elsewhere) (Figure 5). Group 1 named this nested scenario “Strange Bedfellows.”

Describe this world in 2030/Major impacts to bioregion

Tourism

- Parks nearby are going to attract more people because it’s expensive to go far
- Crowded villages won’t attract the climbers and backpackers anymore

Vegetation

- Shrubs are going to be fine
- Treeline will probably be pushed back

Communication

- How to make people listen the message about climate change and the effects? How to make kids involved, how to educate, how to motivate?
- How to take advantage of new technologies: should hire people who are interested in using new technology in education
- Possibility of using public speakers
- Wilderness shouldn’t be sacrificed for development

Fire

- Increased fire: the increased need for more fire ecology researchers was mentioned, and also the question of burn permit enforcement.
- The group predicted increased human caused fires (e.g. from cigarette butts).
- Fire control: increased need for inventorying, monitoring, and knowing how to analyze information about fires

Pollutants

- More regulations needed on pollutants like mercury and methane
- More information needed about which resources are in threat, e.g. fish
- How to adapt to more pollutants?

Subsistence

- The consensus was that the subsistence opportunities have to be secured for communities, although it is up to the people whether they want to harvest or not
- One village resident also questioned whether children are learning how to harvest and live in communities; if the children aren’t interested in continuing there isn’t much that managers can do
- Ways to support managers?
- Communities have tried to incorporate new teachers with new skills and new technology to make children interested.
- Additional regulations needed to help to maintain subsistence.
- Educators to help represent the message from these climate change workshops to people, locally and regionally

Group Two

Group Two Climate Driver Selection

Group Two's assessment of the importance and uncertainty of selected drivers is shown in Table 1.

Table 1: Summary of Group Two's assessment of the uncertainty (vs. predictability) and importance of selected climate-related scenario drivers. Variables selected for matrices are highlighted.

Climate driver	High uncertainty	Impact Importance	Predictable
Temperature Increase		X	X
PDO	X	X	
Extreme Events (Temperature)		X	X
Precipitation (duration & extent of snow)	X	X	
Extreme Precipitation (rain & icing)	X	X	
Length of ice-free season	X	X	

The group discussed details of drivers, including the following:

- Snow cover as a potential new driver
 - Duration of snow cover, i.e. time between first snowfall and snowmelt
 - How much land the snow covers; extent
 - Depth of snow; less snow results in deeper freeze, which affects permafrost, archeological sites, travel, transportation, etc.
 - Is snow cover encapsulated by “length of ice-free season”?
- Extreme events
 - Important because they cause the greatest sociological effects
- Precipitation
 - Which is more important, extreme events or timing of precipitation?
 - More precipitation does not necessarily equal more snow cover; warmer temperatures in the winter can cause rain-on-snow events.
- Temperature
 - Is this is a larger driver that encompasses ice-free season?
 - No, ice-free season is specific to temperature during the shoulder seasons
- Temperature and Precipitation
 - Since all of the drivers seem to be derivatives of these two drivers, why not just use the overarching temperature and precipitation?
 - Precipitation as an axis choice is unclear, because snowfall and rainfall are such different things and have such different effects
 - PDO could increase/amplify or decrease/dampen projected temperature rise globally

Ultimately Group 2 decided to cross the “high level” drivers, Temperature and Precipitation, as shown in Figure 11.

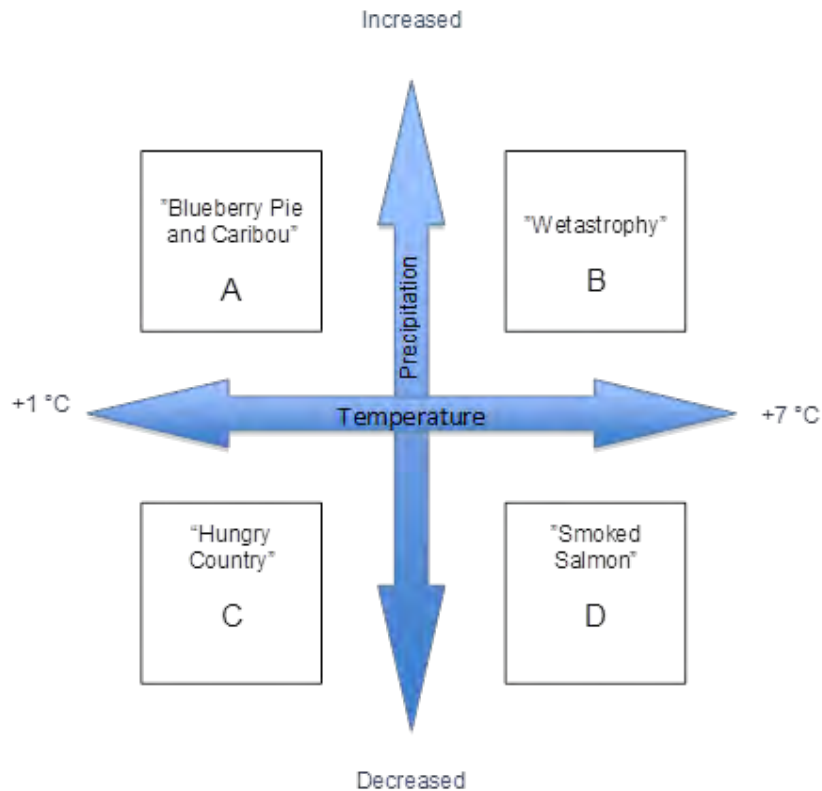


Figure 11: Primary matrix of climate drivers produced by Group 2. Each quadrant represents a different combination of potential future temperature and precipitation. Details of each quadrant are described in the text.

From this primary matrix, four scenarios emerged:

- A. “Blueberry Pie & Caribou”: +1°C and more precipitation and/or extreme events
- B. “Wetastrophy”: +7°C and more precipitation
- C. “Hungry Country”: drier, with only a slight increase in temperature
- D. “Smoked Salmon”: Temperature increase of 7°C and less precipitation and/or fewer extreme events

Group Two Bio-physical Scenarios Developed from Selected Drivers

Group 2 Scenario A: “Blueberry Pie & Caribou”

The “Blueberry Pie & Caribou” scenario envisions a slightly warmer future with increased precipitation and/or extreme events. Potential effects of such conditions include:

- Low to medium impact on cultural resources
- Flood events, bigger spring runoffs occur
- Big snow events, snow persists longer
- Short growing season
- Less fires

- More bugs, more disease (also human health issue). Distribution of yellow jackets changes
- Permafrost remains
- More and bigger wetlands. More biomass because more water
- Movements of big game (caribou, moose) may be curtailed by flooded rivers or deep snow
- Caribou like snowpack (helps to protect from insects)
- Wet conditions affect pollen conditions. If it's raining at the wrong time the pollen doesn't spread and if it's raining at a good time then the berries will be big and juicy.
- More fog and cloudiness?

Group 2 Scenario B: "Wetastrophy"

The "Wetastrophy" scenario envisions a much warmer future with increased precipitation and/or extreme events. Potential effects of such conditions include:

- Increased flooding/extreme events affect cultural resources
- People in communities have been forced to move because of flooding before
- Permafrost thawing
- Collapsing of food supplies (food security issue)
- Release of carbon dioxide (accelerating the changes?)
- According to climate researchers a 5°C increase in temperature is kind of a limit for ecosystems, so 7°C is very extreme and it is hard to imagine what might happen.
- Steep snow, more icing
- Vegetation changes, loss of tundra
- Lichen disappears, more shrubs, species migrating (happening already), more boreal forests (happening already in river valleys)
- Caribou suffer from deep snow, moose on the other hand succeeds
- Loss of lakes, but also forming of lakes could occur. Does warming compensate the increased precipitation?
- Dynamic changes in hydrology are probable, changes in river channels (less rivers, less ponds, lower level)
- Arctic water warms causing sediment flow changes and sea fish migrating to colder waters
- Pink salmon could move up to the north and new salmon species could replace it (in the arctic there are not so many salmon species there)
- More lightning due to more storms and more fuel (vegetation) thus more fires (if warming offsets the precipitation, then big fires)
- Loss of pollinators and phenology changes due to extreme weather conditions
- Dunes decreasing (stabilized) thus vegetation succession
- Expansion of active layer

Group 2 Scenario C: "Hungry Country"

The "Hungry Country" scenario envisions a slightly warmer future with decreased precipitation and/or extreme events. Potential effects of such conditions include:

Effects are described by season

Summer:

- Small permafrost loss
- Low river level
 - Affects boat transportation
 - Migration of fish affected, fish spawning decrease
- Higher fire events
 - Reduced shrubs

Fall:

- Permafrost stable
- River level: extreme low
- Low berry crop
- Longer fire season with fewer late summer rains

Winter:

- Small permafrost gain
- Low water freezes deeper – especially with reduced snow cover
- Less snowfall/less snow cover
 - Lower snow level kills off exposed tops of shrubs
 - Small mammal (subnivian) populations decreased
 - In turn affects owls, trappers
- Old berries aren't available through the winter – skinny caribou
- Drier wood for stove fires

Spring:

- Permafrost stable
- Reduced stream flow
- Breakup is later
- Lower small mammal birth with reduced snow cover

Group 2 Scenario D: Smoked Salmon

The “Smoked Salmon” scenario envisions a much warmer future with decreased precipitation and/or extreme events. Potential effects of such conditions include:

- Major increases in fire
 - Deeper burning, longer duration
 - cultural resource sites affected, as well as current structures
 - reduced shrubs and lichen
- More thermokarst development
- Ponds and streams dry out. Ephemeral streams may disappear.
 - Loss of fish habitat
 - In turn affects water fowl
 - Loss of food harvesting opportunities
 - Decreased subsistence leading to migration to cities
- Transportation
 - Earlier breakup

- Lack of snow cover for winter travel
- Significant permafrost loss/deepening of active layer
- Increase in riparian vegetation = Less favorable for caribou
- Potentially more moose
- Invasive plants/diseases/insect infestation
- Treeline moves north
- Fish dry better on racks

Group Two Scenarios Nested in a Socio-political Matrix

As with Group One, Group Two was given the opportunity to flesh out two scenarios from among the sixteen possible combinations available, when the four biophysical scenarios described above were nested in a sociopolitical framework. In an effort to pursue stories that most fully represented the full range of possible futures, the group voted on which scenarios to pursue, and ultimately chose the two nested scenarios indicated by blue stars in Figure 12 and described below.

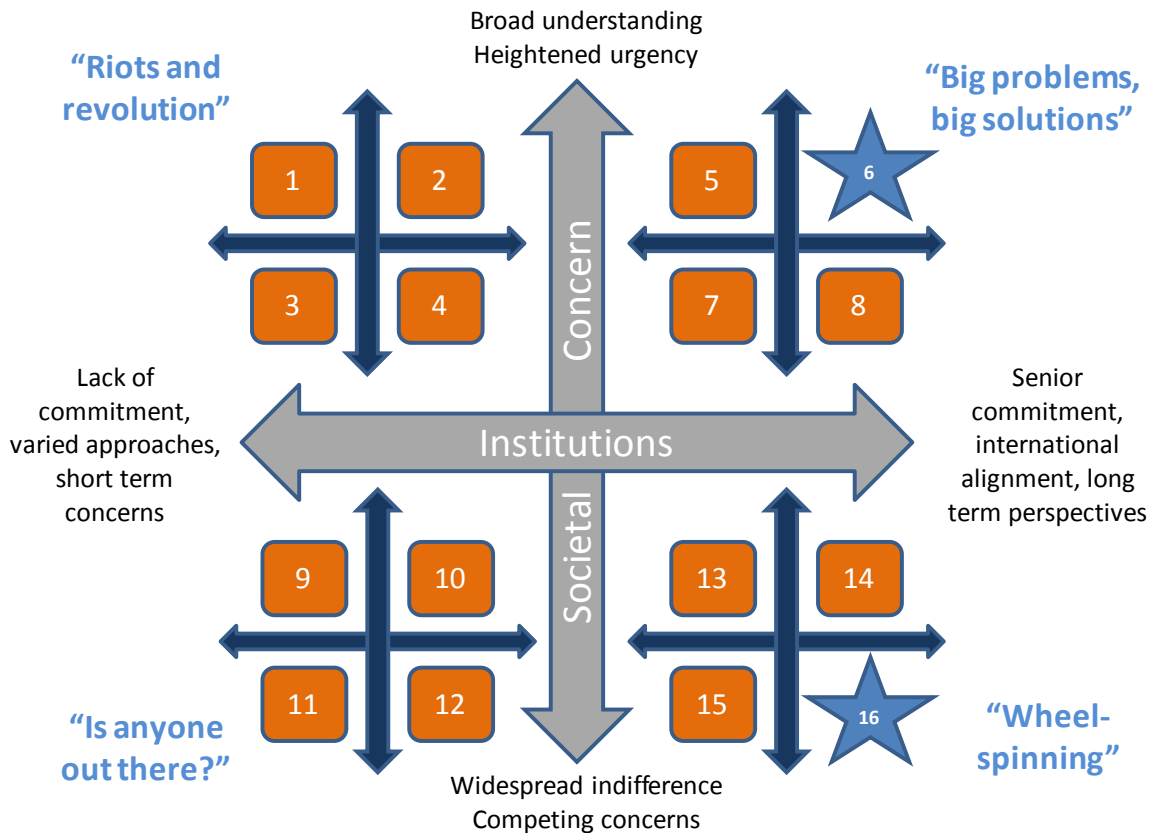


Figure 12: Group 2 nested scenarios. The two nested scenarios selected by Group 2 are marked by blue stars. The “Hot and dry” scenario (major changes in seasonal timing and reduced extreme events) is nested in “Is anyone out there?” (little social or institutional support for climate change adaptation efforts) The “Warm and Wet” scenario (major changes in both extreme events and seasonal timing) is nested in the “Wheel-spinning” scenario (senior institutional commitment but widespread public indifference and competing concerns). The implications, management actions, research needs, and narrative associated with these two scenarios are elaborated upon below.

First Group 2 Nested Scenario: “Sweatopia”

The following effects, issues, implications, and suggested needs and actions were identified by Group 2 in the event that the “Wetastrophy” scenario (with large increases in temperature and precipitation) were to occur under the conditions described for the “Big problems, big solutions” quadrant (which describes a future in which both local and institutional commitment and focus regarding climate change are high) (Figure 5). Group 2 named this nested scenario “Sweatopia.”

Describe the world in 2030

- All villages on rivers threatened by flooding
- Issues with permafrost thaw
 - High solutes in the water
 - Issues with food storage and preservation
- Subsistence concerns
 - Fish
 - Caribou
- Ice roads no longer feasible
- Enterprise teams of resource specialists to mitigate change, shadowed by interpretation team: PR
- Ample funding for mitigation/education

Major Impacts on the Bioregion

- More boreal forest
- Ecological succession
- Caribou habitat at risk – import woodland caribou from Canada?
- Replacement of traditional subsistence resources with:
 - More fisheries
 - More moose
- Fewer sheefish and whitefish, replaced with:
 - Innoko
 - Pike?
- Birds: major changes in migratory routes and duration that birds stay = some winners, some losers
- Tourism
 - Caribou around longer (“Red Dog Cruises”)
 - Demand for tourism increases
- TEK (traditional ecological knowledge) = now CEK (contemporary ecological knowledge)
- Increase in invasive species; NPS teams help prevent introduction of invasives

Issues Facing Management

- Increasing fuel load (and more lightning strikes), so if there is a dry year, could have massive fires
- Emergency response for floods, fires
- Minor infrastructure issues in the parks (ranger stations)
- Major issues in surrounding villages
- Resource extraction demands increase

- Ambler Mining district developed, operational
- Be able to compete with mining and oil companies
- More roads
- Adverse effects on cultural and natural resources
- Permafrost thaw
- Inventory and monitoring

Implications

Natural Resources:

- Wildlife species populations/compositions change
- Ecotype shifts
- Fisheries change
- Severe effects with heavy sediment, shifting river channels
- Permafrost degradation – thermokarsts, CO₂ & methane release, erosion
- Western Arctic Caribou Herd population and migration changes
- Disturbance corridors for invasive species to move in
- More insects and arthropods
- Precipitation – more snow in winter, shorter season

Socio-cultural Resources:

- Significant erosion and damage to cultural sites from floods/thermokarsts
- Subsistence foods & preserving/storing methods change: food security
- Disruption in TEK sharing, but new opportunities for sharing with new media (Facebook)
- Transportation = snow season shorter, boating seasons lengthens
- Increased tourism → increased demand for facilities, services
- Increased need for integrating local knowledge and scientific research

Facilities:

- New ‘green’ facilities
- Increased development: hatcheries, tourism, mining
- Village relocation

Education and Interpretation

- User conflicts increase
- Public demands for information
- Increased use of less acceptable

Management Actions

- Amend the Organic Act & other NPS policies
- Collaborative scenario planning with communities
- Establish effective method of gathering community input Enterprise teams
- Implement more research, interpretive outreach, resource protection, etc.
- Create enterprise teams
- Track & allow for range expansion, natural adaptation
- Cooperation with other large-scale climate change initiatives – reduce redundancy
- Increase local staff

Research & Information Needs

- Increased I&M, support/money for science-based data collection

- Needs assessment for ARCN Inventory and Monitoring investigate potential issues with new species introduction (e.g., woodland caribou, fish hatcheries)

Second Group 2 Nested Scenario: “EDO”

The following effects, issues, implications, and suggested needs and actions were identified by Group 2 in the event that the “Smoked Salmon” scenario (with severe temperature increase and decreased precipitation) were to occur under the conditions described for the “Wheelspinning” quadrant (which describes a future in which institutional/governmental commitment and funding regarding climate change are high, but local focus is lacking) (Figure 5). Group 2 named this nested scenario “EDO” or “Enoch Decadal Oscillation” in honor of one of the group members, a village resident and elder.

Describe the world in 2030

- Increased fire
- Low rivers, dried up ponds
- Decreased fish populations
- Early breakup, later snow
- New development mining
- Permafrost loss
- Lichen loss
- Increased predator control
- Increased insects & disease
- Increased shrub
- Reduced aquatic habitat

Major Impacts on the Bioregion

- Culture resource loss due to fire
- Pressure from outside on decision making: lobbyist, oil money
- Decline in tourism “because Russia blew up Red Dog mine”
- Greater need for assistance in villages
- Less berries, less caribous
- Transportation restrictions
- Decrease or changes in subsistence resources
- Subsistence camps in parks
- Cost in fuel increase leads in urbanizations
- Back to nomadic life ways
- More inter-village transportation for trading reindeer/ caribou

Issues Facing Management

- New roads
- New fish hatcheries
- Structure protection from fires
- New back-country ranger station & staff
- Enticing educational messages
- Partner with popular groups

- Use cutting edge virtual technology
- Cadre of educators shared by agencies
- Multi-lingual interpreters
- Restrictions on hunting, competition for hunting grounds
- Increased tourism
- Wilderness issues (air traffic)
- Fire management shift to suppression
- More airplanes + pilots for patrols

Management Actions

- Hard core facilitation training
- Hire/train technology innovators
- Partner with agencies (i.e. Head Start) for remote connectivity
- Well-funded meetings for all groups in an issue
- Increased fire staff for suppression
- More “fire wise” fuels reduction
- Infrastructure for tourism
- Technology & cultural resource surveys needed
- Greater need for fire ecology studies
- Coordinate data collection & analysis between groups

Research & Information Needs

- Produce education products from meetings for community presentation
- Native life education in classrooms
- Sustainability as a way of doing business-integrate into all parts of management
- Potential to start reindeer herding, woodland caribou/bison and introduce replacement fish
- Reality check with native people (what’s actually happening, are these scenarios possible?)
- Documentation from native people
- A need to provide compensation for traditional ecological knowledge, and to approach Native people appropriately

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 rhyming story reminiscent of a classic children’s tale; another group drafted an autobiographical piece as if written by a young girl; a third group

imagined a “State of the Arctic” address by a future US president; and the fourth dreamed up an interactive Google Earth map coupled with the life story of an Alaska Native elder.

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 in Table 2. They are grouped into four categories, reflecting recommendations for increased outreach, improved staffing, greater collaboration, and stronger funding and policy support. However, some recommendations cross over between these categories. Many of the recommendations reflect the need for greater flexibility in the face of an uncertain future; a more educated public, greater funding and staffing, and more effective information sharing would all bolster flexibility.

All four groups stressed the need for assessing future needs, through any or all of several avenues. These included GAP analysis, NPS Inventory and Monitoring efforts, or other new or existing monitoring programs. In other words, part of the route to successfully managing future needs is to repeatedly assess both current and future needs.

Table 2: Actions and needs common to all four scenarios. The actions outlined in this table are suggested as best practices regardless of which scenario proved more accurate, and are thus representative of robust strategies.

Outreach and Education	Staffing and Infrastructure	Collaboration and Information Sharing	Policy and Research Support
Produce education products from meeting for community presentations	Increased park staff & more local hire	Create cooperative enterprise teams composed of other local, state & federal personnel	Track & allow movement of new species expanding area
Native life education in classrooms	Hire/train technology innovators	Partner with agencies (NHSA) for remote connectivity	Amend NPS policies to address climate change: review, refine and make relevant
Collaborative scenario planning in area communities	Increased fire staff for suppression	Coordinate data collection and analysis between groups	Support for science based information to inform decisions

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 Interior Arctic 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 Interior Arctic 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, analysis, and 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 information 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 http://www.snap.uaf.edu/webshared/NPS-CCSP/2012_Interior_Arctic/).

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 Interior Arctic, as identified via this process, include projected shifts in ecosystems –with marine mammals and caribou herds being of primary concern to local subsistence users. The interplay between natural resource extraction, development, and climate change is highlighted in this area, and fire and invasive pests are new worries on the horizon. Changing seasonality and shifting local livelihoods are likely to complicate management choices, both inside and outside of National Parks.

As shown in Figure 3, the scenarios process is multi-step and iterative. The 2012 Interior Arctic 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. Discussions 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, while 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, these products 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 workshop outcomes are still necessary. Scenarios are a learning process, and new or unexpected information can make it important to revisit or repeat the process. The planning steps 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

For videos and presentations from the workshop,

see <http://www.nps.gov/akso/nature/climate/scenario.cfm>



Interior Arctic Alaska National Parks
 Climate Change Scenario Planning Workshop
 Wood Center, University of Alaska Fairbanks
 March 27-29, 2012
FINAL AGENDA



Tuesday March 27

10:00 a.m.		ARRIVAL and SIGN IN
10:30 am	Plenary	Welcome - Include: restrooms, snacks, coffee, eateries, group dinner, vehicles/transportation, lodging etc. Introductions & participant expectations
11:00 am	Plenary	Workshop objectives, agenda, ground rules
11:15 am	Plenary	<p>Explain Scenario Planning, Review Scenario Process, and Introduce the Focal Question(s) (<i>Address scale: park & bioregion</i>)</p> <p>Present scientific information on climate change</p> <p>John Walsh: General insights, climate drivers/uncertainties, PDO</p> <p>Rick Thoman: Climate, climate variability and climate change in and around Arctic parks</p> <p>Torre Jorgenson: Permafrost and ice dynamics</p> <p>Nancy Fresco: Linking potential effects/impacts to selection of scenario drivers</p>
12:30		LUNCH
1:15 pm	Plenary Groups	<p>Video of CC Scenario, break into groups</p> <p>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.</p> <p>Select climate drivers and test matrix combinations. Draw from impacts table to detail implications for each scenario (e.g. natural & cultural resources, facilities, interpretation)</p>
3:00 pm		BREAK
		<p>Continue to detail implications for each scenario</p> <p>Report-out: Groups share draft climate driver frameworks with key characteristics of scenarios</p>
4:45 pm	Plenary	FINAL THOUGHTS / QUESTIONS / ADJOURN for Day

Wednesday March 28

8:00 am		ARRIVAL
8:15 am	Plenary	CC Video Second thoughts and overnight insights Re-cap process (<i>what we did and where we are going, including the next step to build a matrix with climate drivers</i>)
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

Thursday March 29

8:00 am		ARRIVAL
8:15 am	Plenary	Video of Climate Change Scenario Overnight Insights
8:30 am	Plenary	Groups read/report on narratives
9:00 am	Plenary (Jeff Mow)	Explain management implications & actions Presentation: 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: Participant List

Lead Team

Bob Winfree	National Park Service, Alaska Regional Office, Regional Science Advisor
Don Callaway	National Park Service, Alaska Regional Office, Senior Cultural Anthropologist
Nancy Swanton	National Park Service, Alaska Regional Office, Subsistence/Planning
John Morris	National Park Service, Alaska Regional Office, Interpretive Specialist
Bud Rice	National Park Service, Alaska Regional Office, Environmental Protection Specialist
Jeff Mow	National Park Service, Glacier National Park, Superintendent
Nancy Fresco	University of Alaska Fairbanks, Scenarios Network for Alaska and Arctic Planning
Lena Krutikov	University of Alaska Fairbanks, Scenarios Network for Alaska and Arctic Planning
Corrie Knapp	University of Alaska Fairbanks, Scenarios Network for Alaska and Arctic Planning
John Walsh	University of Alaska Fairbanks, International Arctic Research Center

Participants

Sharon Alden	Alaska Interagency Coordination Center, Fire Specialist
Jennifer Barnes	National Park Service, Regional Fire Ecologist
Michael Brubaker	Alaska Native Tribal Health Consortium, Director
Greta Burkhart	US Fish & Wildlife Service, Arctic National Wildlife Refuge, Aquatic Ecologist
Jobe Chakuchin	National Park Service, NEPA Specialist/Park Planner
John Chase	Northwest Arctic Borough, Community Development and Flood Program Specialist
Jason Cheney	Alaska Department of Fish & Game, ANILCA Program
Lois Dalle-Molle	National Park Service, Research Coordinator
Greg Dudgeon	Gates of the Arctic, Superintendent
Melanie Flamme	National Park Service, Biologist
Steve Gray	US Geological Survey, Alaska Climate Science Center
Frank Hays	Western Arctic National Parklands, Superintendent
Michael Holt	National Park Service, Archeologist
Karrie Importi	DNR, Citizens' Advisory Commission on Federal Areas
Linda Jeschke	Education Specialist, Western Arctic Parklands NPP, AK
Torre Jorgensen	Alaska Biological Research, Inc., Ecological Land Survey Program
Roger Kaye	US Fish & Wildlife Service, Pilot/Wilderness specialist
Amy Larsen	National Park Service, Aquatic Ecologist
Jim Lawler	National Park Service, ARC/N, Program Manager, long-term ecological monitoring program
Tom Liebscher	National Park Service, Chief of Natural and Cultural Resources
Wendy Loya	The Wilderness Society, Lead Ecologist

Bruce Marcot	US Forest Service, Portland, OR
Enoch Mitchell	Noatak, Subsistence hunter
James Nageak	Anaktuvuk Pass, Subsistence Resource Commission for NPS
Peter Nietlich	National Park Service, ARCN
David Payer	US Fish & Wildlife Service
John Payne	Bureau of Land Management, North Slope Science Initiative
Jeff Rasic	National Park Service, Archaeologist
Pam Rice	National Park Service, Chief of Interpretation
Cheryl Rosa	US Arctic Research Commission, Deputy Director/Alaska Director
Laurie Smith	National Park Service
Pam Sousanes	National Park Service, ARCN, Physical Scientist
Heidi Strader	Bureau of Land Management, Fire Weather Forecaster
Bill Streever	British Petroleum, Environmental Studies Leader - BP Alaska
David Swanson	National Park Service, ARCN, Terrestrial Ecologist
Lee Swanson	National Park Service, ARCN, Terrestrial Ecologist
Douglas Vincent-Lang	State of Alaska, Division of Wildlife Conservation, Acting Director
Dan Warthin	National Park Service, Regional Fire Management Officer
Carole Wesley	Noatak Environmental Department, Environmental Assistant

Appendix C: SNAP Tools for Planners

SNAP Climate Projections: *tools for planners*

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?

IPCC 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 and 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



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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 4km² 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.



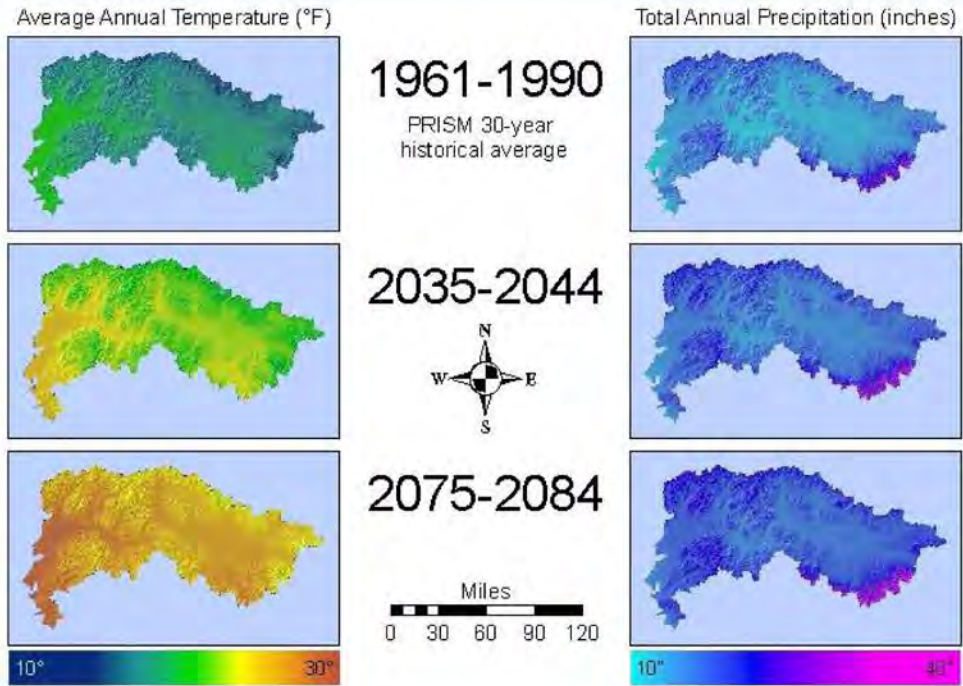
for more information contact Network Coordinator Dr. Nancy Fresco
nlfresco@alaska.edu • phone: 907-474-2405 • fax: 907-474-7151
University of Alaska Fairbanks, P.O. Box 757200, Fairbanks, AK 99775-7200

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Appendix D: Climate Summary Reports

Projected climate change scenarios for Noatak 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	16.6 ± 0.5	NA	Annual	Hist	17.4 ± 1.0	NA NA
	2040	22.4 ± 0.5	5.8		2040	20.1 ± 1.0	2.6 15%
	2080	26.9 ± 0.5	10.3		2080	21.9 ± 1.1	4.4 25%
Summer	Hist	44.6 ± 0.4	NA	Summer	Hist	10.6 ± 0.7	NA NA
	2040	47.0 ± 0.4	2.4		2040	11.8 ± 0.7	1.3 12%
	2080	49.7 ± 0.4	5.1		2080	12.4 ± 0.7	1.9 18%
Winter	Hist	-3.4 ± 0.6	NA	Winter	Hist	6.8 ± 0.4	NA NA
	2040	4.8 ± 0.6	8.2		2040	8.2 ± 0.4	1.4 20%
	2080	10.6 ± 0.6	14.0		2080	9.4 ± 0.4	2.6 38%

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

For more information:

Dr. Scott Rupp, Director, Scenarios Network for Alaska Planning, University of Alaska, 907-474-7535; ffsr@uaf.edu
 Dr. Wendy Loya, Ecologist, The Wilderness Society, Alaska Region, 907-272-9453; wendy_loya@tws.org

01/09

Climate Change Implications for Noatak 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 (CO₂) 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"¹ estimate¹. Several other scenarios have predicted higher emission rates, and scientists have since determined current levels² 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 Noatak 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 6°F by 2040 and as much as 10°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 (~-17°F), to temperatures approaching the freezing point (~-27°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 11°F by 2080, a figure that represents an impressive 14°F rise from the historical -3°F average. Average summer temperatures are projected to rise by about 5°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 Noatak 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 18%, 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 38% 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

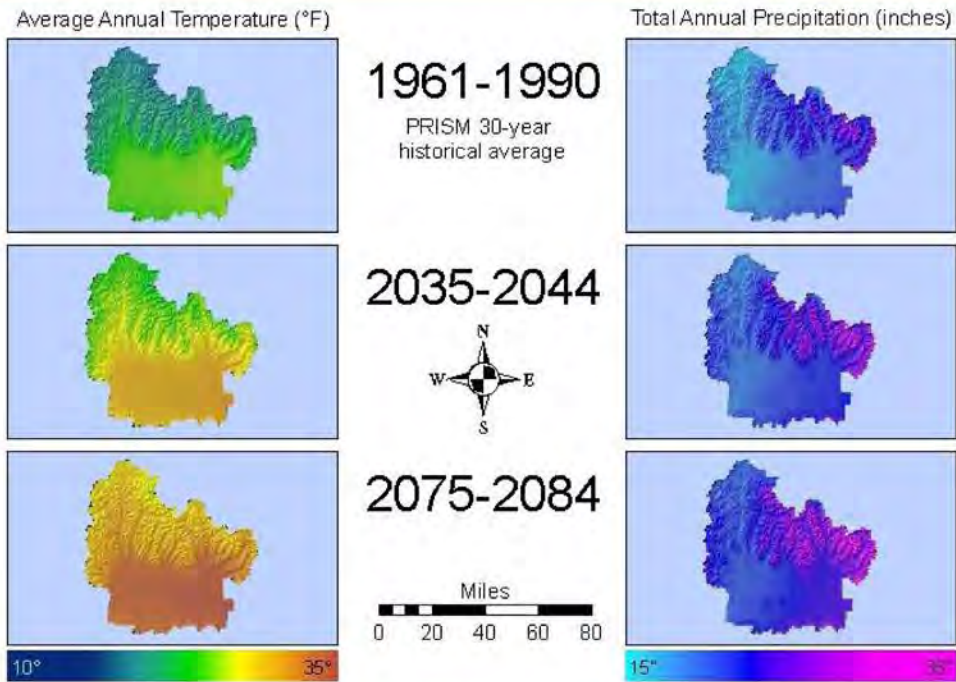
Noatak National Preserve is projected to become warmer and drier over the next century. Warmer temperatures and a longer growing season are expected to increase evapotranspiration enough to outweigh a regional increase in precipitation. Seasonal changes in climate will have profound impacts on the condition and health of wildlife habitat, lead to increased fire risk, and contribute to the likelihood of wetlands, streams, 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 CO₂ emissions can be found on the Carbon Dioxide Information Analysis Center website (www.cdiac.esd.ornl.gov).

Projected climate change scenarios for Kobuk Valley National Park



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	19.8 ± 0.8	NA	Annual	Hist	21.2 ± 1.1	NA	NA
	2040	25.5 ± 0.8	5.7		2040	24.2 ± 1.1	3.0	14%
	2080	29.9 ± 0.8	10.1		2080	26.2 ± 1.1	5.0	24%
Summer	Hist	47.3 ± 0.7	NA	Summer	Hist	13.2 ± 0.7	NA	NA
	2040	49.9 ± 0.7	2.5		2040	14.6 ± 0.7	1.5	11%
	2080	52.7 ± 0.7	5.4		2080	15.3 ± 0.7	2.1	16%
Winter	Hist	0.1 ± 0.9	NA	Winter	Hist	8.0 ± 0.4	NA	NA
	2040	8.1 ± 0.9	8.0		2040	9.6 ± 0.4	1.5	19%
	2080	13.6 ± 0.9	13.5		2080	10.9 ± 0.4	2.9	36%

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

For more information:

Dr. Scott Rupp, Director, Scenarios Network for Alaska Planning, University of Alaska, 907-474-7535; ffsr@uaf.edu
 Dr. Wendy Loya, Ecologist, The Wilderness Society, Alaska Region, 907-272-9453; wendy_loya@tws.org

01/09

Climate Change Implications for Kobuk Valley National Park



Climate Change in Alaska

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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 (CO₂) 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" estimate¹. Several other scenarios have predicted higher emission rates, and scientists have since determined current levels² 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 Kobuk Valley National Park

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 6°F by 2040 and as much as 10°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 (~20°F), to temperatures approaching the freezing point (~30°F).

A likely outcome of these changes is a lengthening of the growing season, a change that could have profound effects 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 14°F by 2080, a figure that represents an impressive 14°F rise from the historical 0°F average. Average summer temperatures are projected to rise by more than 5°F by 2080 (from ~47°F to ~53°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 Kobuk Valley National Park

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 16%, 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 36% 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

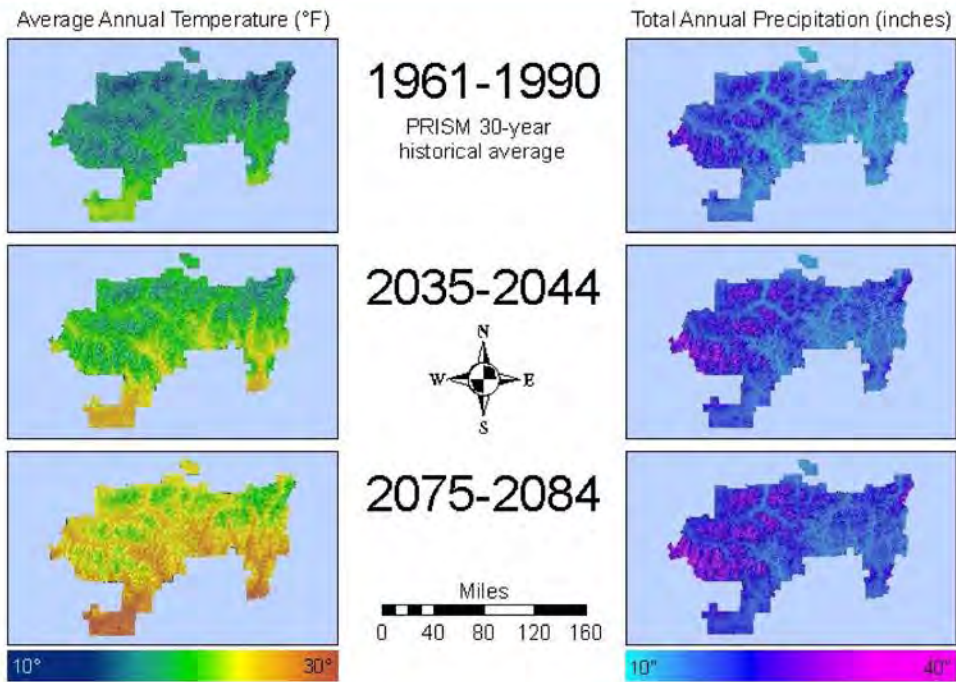
Kobuk Valley National Park is projected to become warmer and drier over the next century. Warmer temperatures and a longer growing season are expected to increase evapotranspiration enough to outweigh a regional increase in precipitation. Seasonal changes in climate will have profound impacts on the condition and health of wildlife habitat, lead to increased fire risk, and contribute to the likelihood of wetlands, streams, 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 CO₂ emissions can be found on the Carbon Dioxide Information Analysis Center website (www.cdiac.esd.ornl.gov).

Projected climate change scenarios for Gates of the Arctic 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	14.1 ± 0.9	NA	Annual	Hist	19.2 ± 1.5	NA	NA
	2040	19.6 ± 0.9	5.5		2040	22.1 ± 1.5	2.9	15%
	2080	24.1 ± 0.8	10.0		2080	23.9 ± 1.5	4.7	24%
Summer	Hist	41.5 ± 1.2	NA	Summer	Hist	11.0 ± 0.9	NA	NA
	2040	44.0 ± 1.2	2.5		2040	12.3 ± 0.9	1.3	12%
	2080	47.0 ± 1.2	5.5		2080	12.9 ± 0.9	1.9	18%
Winter	Hist	-5.4 ± 0.7	NA	Winter	Hist	8.2 ± 0.7	NA	NA
	2040	2.2 ± 0.6	7.6		2040	9.8 ± 0.7	1.6	19%
	2080	7.7 ± 0.6	13.1		2080	11.0 ± 0.7	2.7	33%

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

For more information:

Dr. Scott Rupp, Director, Scenarios Network for Alaska Planning, University of Alaska, 907-474-7535; flsr@ual.edu
 Dr. Wendy Loya, Ecologist, The Wilderness Society, Alaska Region, 907-272-9453; wendy_loya@tws.org

01/09

Climate Change Implications for Gates of the Arctic 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 (CO₂) 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" estimate¹. Several other scenarios have predicted higher emission rates, and scientists have since determined current levels² 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 Gates of the Arctic 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 6°F by 2040 and as much as 10°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 (~14°F), to temperatures approaching the freezing point (~24°F).

A likely outcome of these changes is a lengthening of the growing season, a change that could have profound effects 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 8°F by 2080, a figure that represents an impressive 13°F rise from the historical -5°F average. Average summer temperatures are projected to rise by almost 6°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 Gates of the Arctic 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 18%, 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 33% 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

Gates of the Arctic 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, streams, 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 Ecam5, Gfdl2.1, Miroc3.2MR, HadCM3, and CGCM3.1.

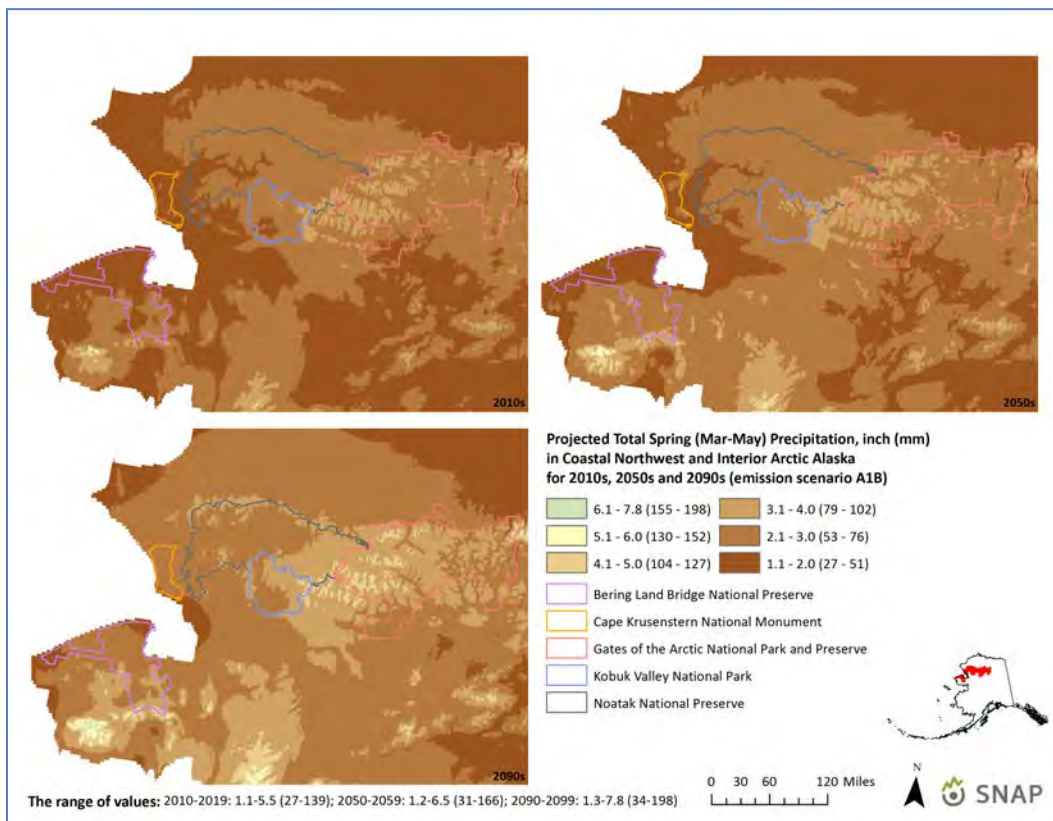
² Recent rates of global CO₂ emissions can be found on the Carbon Dioxide Information Analysis Center website (www.odiac.esd.ornl.gov).

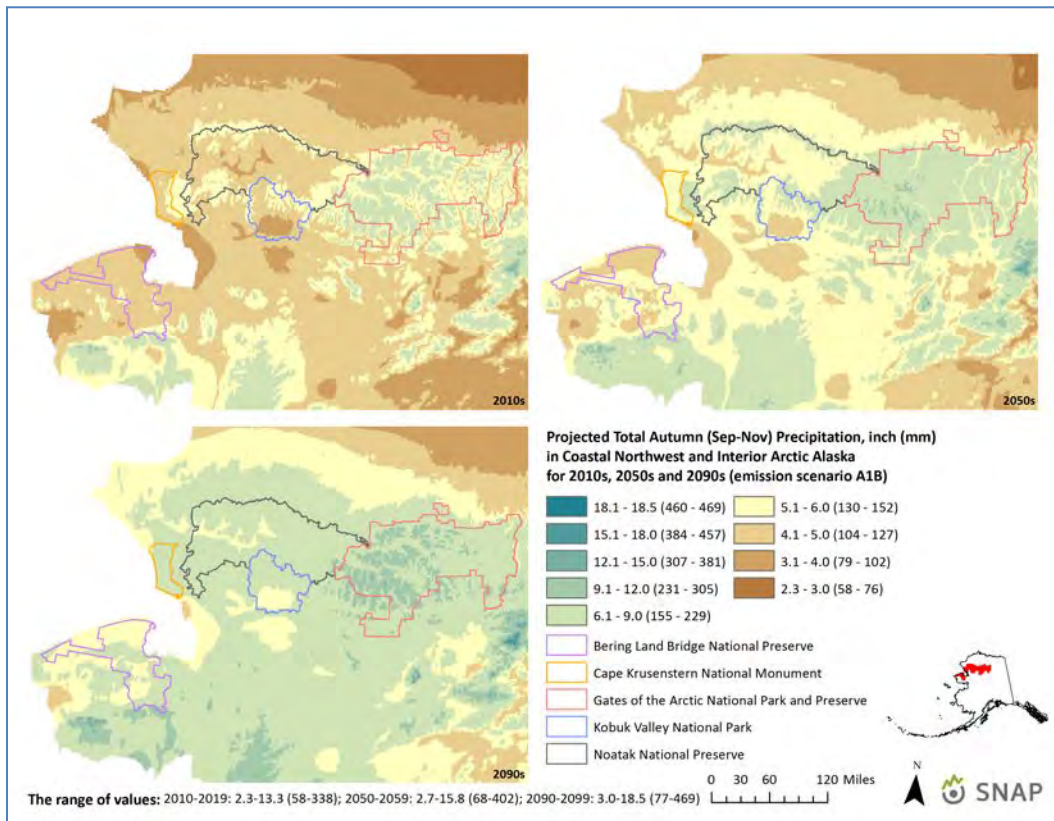
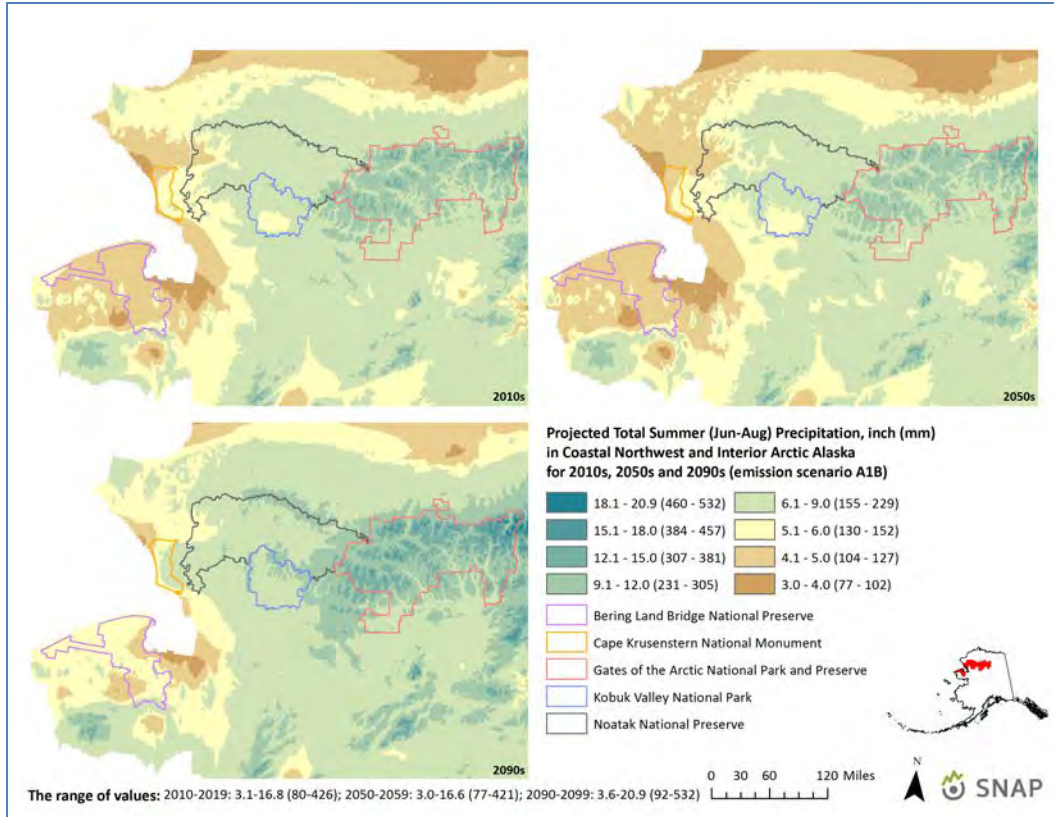
Appendix E: Interior Arctic Modeled Climate Variables

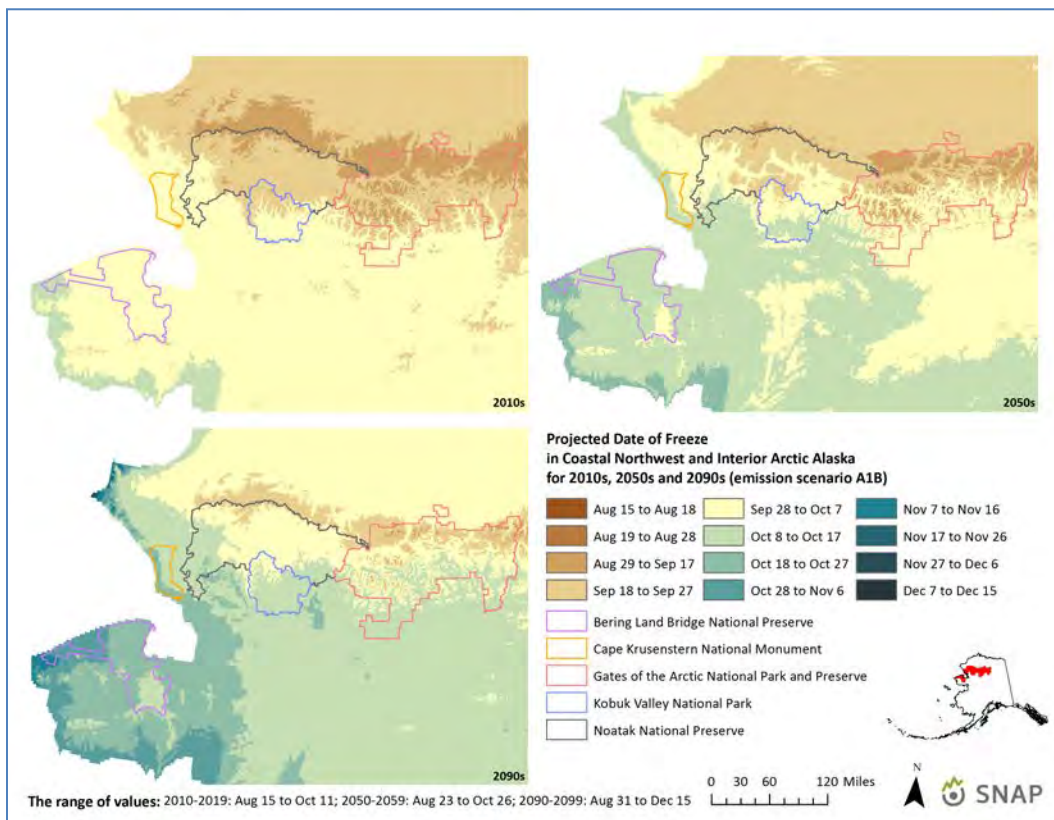
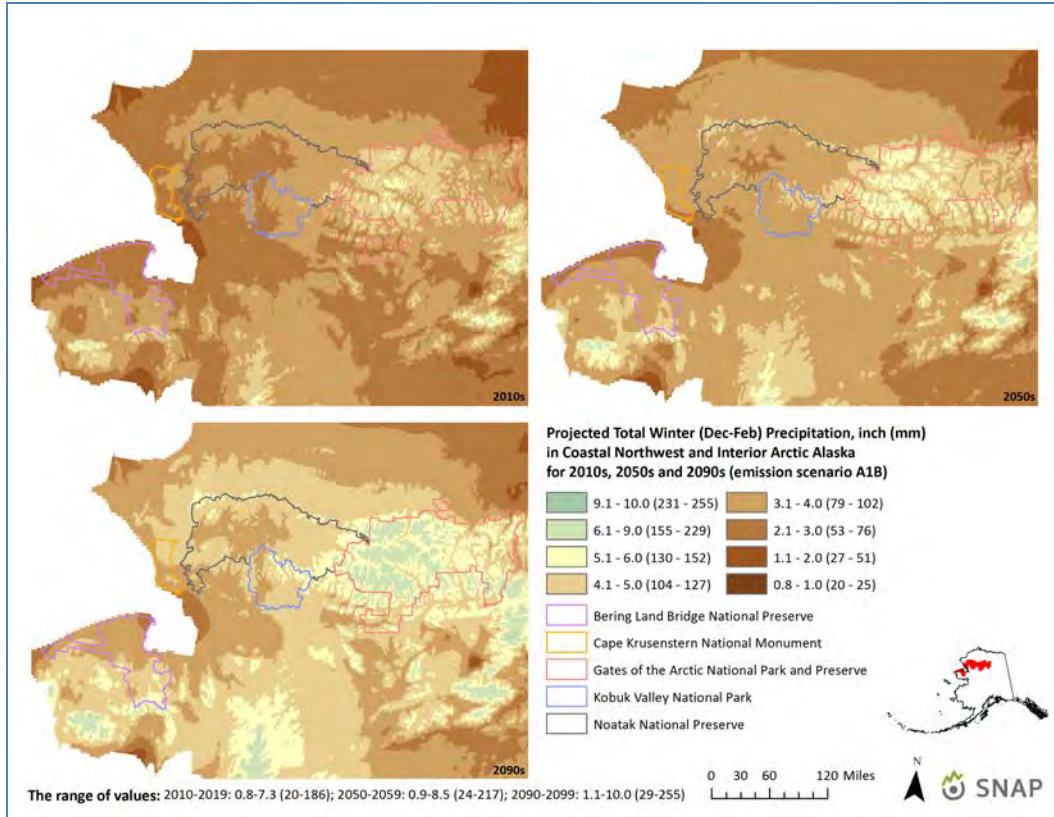
The set of maps included in this appendix were produced by SNAP. All maps represent projected data averaged across five downscaled GCMs and additionally averaged across decades (the 2010s, 2050s, and 2090s), in order to represent long-term trends. For a full description of SNAPs methods, see www.snap.uaf.edu.

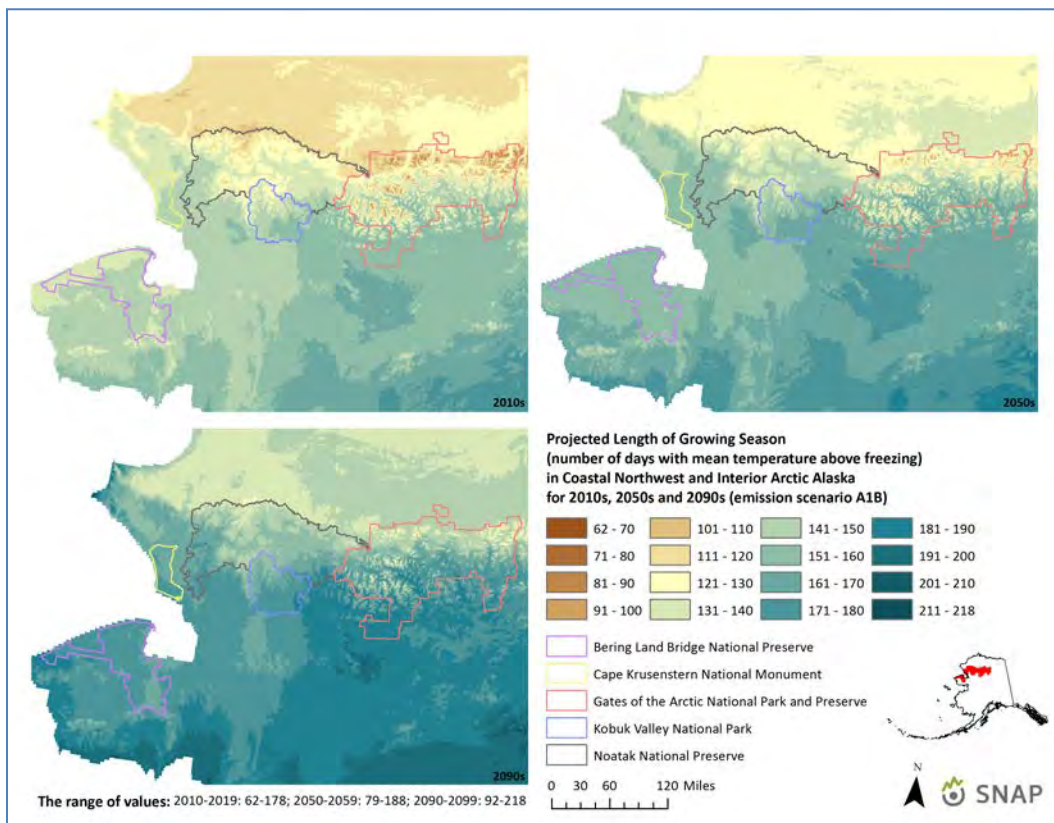
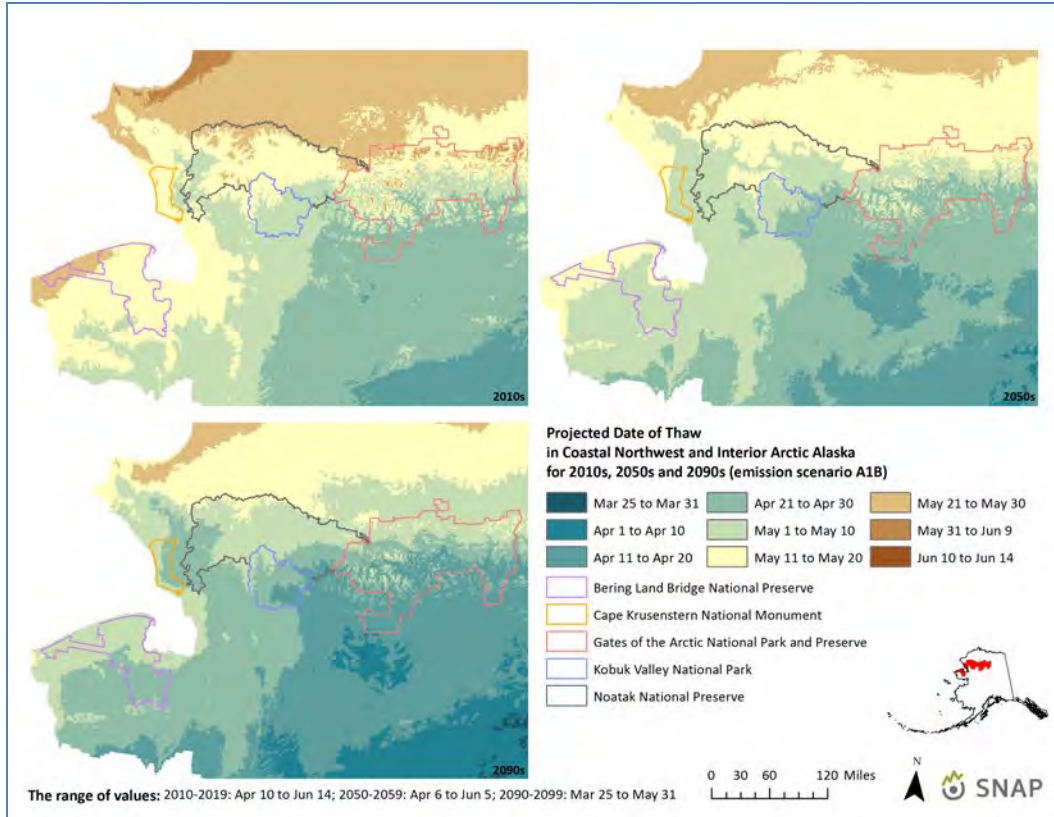
Maps included in this set include seasonal maps (three-month averages) for precipitation, as well as several temperature-linked maps, including projections for date of freeze, date of thaw, length of summer season, and ground temperature at once meter depth.

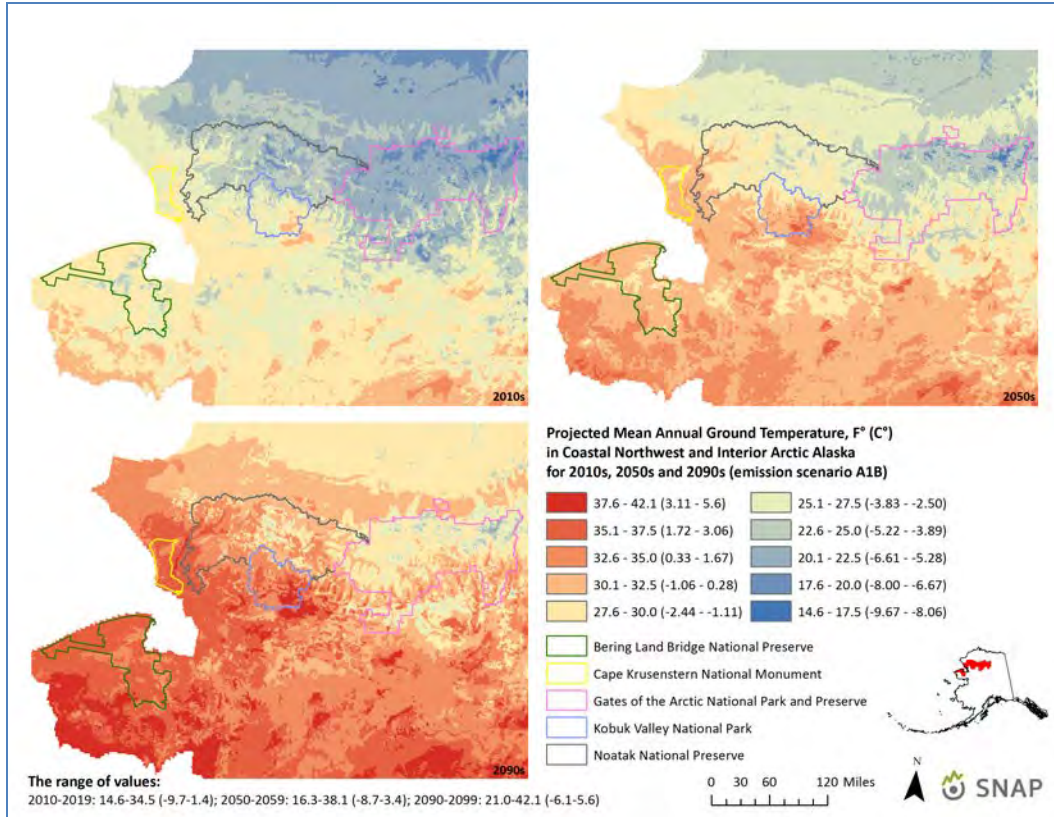
These maps show all Arctic Network Parks. They rely on a midrange (A1B) emissions scenario, as defined by the IPCC. For maps of individual parks, as well as maps depicting the more severe A2 climate change scenario, see [http://www.snap.uaf.edu/webshared/NPS-CCSP2012 Interior Arctic\Workshop documents Interior Arctic](http://www.snap.uaf.edu/webshared/NPS-CCSP2012%20Interior%20Arctic/Workshop%20documents%20Interior%20Arctic)












Appendix F: Climate Drivers Table

					
Climate Variable	Projected Change by 2050	Projected Change by 2100	Patterns of Change	Confidence	Source
Temperature	+2.5°C ±1.5°C	+5°C ±2°C	More pronounced in N and autumn-winter	>95% for increase	IPCC (2007); SNAP/UAF
Precipitation (rain and snow)	Winter snowfall Autumn rain and snow	Winter snowfall Autumn rain and snow	Increased % falls as rain in shoulder seasons	High uncertainty in timing of snow onset and melt	AMAP/SWIPA; SNAP/UAF
Freeze-up Date	5-10 days later	10-20 days later	Largest change near coast	>90%	SNAP/UAF
Length of Ice-free Season (rivers, lakes)	↑ 7-10 days	↑ 14-21 days	Largest change near coast	>90%	IPCC (2007); SNAP/UAF
Length of Growing Season	↑ 10–20 days	↑ 20–40 days	Largest change near coast	>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

Sector	Subsector	Potential Effects to Resources, Operations, and People
ATMOSPHERE	Greenhouse gases	Increased carbon storage where forests spread; decreased where drought causes loss of forest or where fire and permafrost release methane and CO ₂ . Shrub expansion into deglaciated areas and new vegetation = carbon sequestration
	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. More freezing rain events affect foraging success for wildlife, travel safety, etc. Avalanche hazards increase with rising precipitation and rising winter temps.
	Storms	Lightning and lightning-ignited fires continue to increase. Storm and wave impacts increase in northern Alaska where land-fast sea ice forms later.
	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.
	Glaciers	Most glaciers diminish as warming continues, though a few are still advancing. Glacial outwash affects aquatic productivity and forms deposits in shallow water. Glacial lakes fail more frequently, creating risk of flash floods and debris flows. Surging glaciers could block rivers and fjords, resulting in severe flooding.
	Ice roads	Reduced winter transportation affects opportunities for travel and subsistence.
	Permafrost	Mercury & other pollutants are released into aquatic environments as permafrost thaws.

HYDROSPHERE	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.
	Groundwater	Groundwater supplies dependent on seasonal glacial recharge become less predictable.
LITHOSPHERE	Ground stability	More roads and infrastructure fail or require repairs due to permafrost thaw. Landslides and mud flows increase on steep slopes. Rapid glacial retreat and permafrost thaw leave steep and unstable slopes in valleys and fjords. Burials and other remains are exposed as cultural sites thaw and erode.
	Soil	Soil moisture declines due to rising soil temperature, thawing permafrost, and drainage.
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	Ecological "tipping points" are likely to result in rapid change, when conditions exceed physical or physiological thresholds (e.g., thaw, drought, water temperature) 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	Black spruce may expand with warming – or contract as permafrost soils thaw and fires increase. 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	<p>Changes to terrestrial and aquatic species occur as ranges shift, contract, or expand, affecting visitor experience and subsistence throughout the parks.</p> <p>Parks and refuges may not be able to protect current species within their boundaries.</p> <p>Some species will suffer severe losses. So far, the greatest losses across all parks have been rodents, bats, and carnivores.</p> <p>Predator-prey relationships may change in unexpected ways.</p> <p>Migratory routes and destinations will change (e.g., wetlands, open tundra, snow patches).</p>
	Birds	Arctic and alpine birds' breeding habitats reduced as trees and shrubs encroach on tundra.
		Geese could lose almost half of their breeding habitat due to change from tundra to taiga and boreal forest.
		<p>Predation on ground nesting birds could increase if prey (lemming) abundance declines.</p> <p>Population cycles of birds and their prey could be out of sync due to higher temperatures.</p>
	Caribou/ Reindeer	<p>Caribou and reindeer health are affected by changes in weather, forage, and insects and pests.</p> <p>Earlier green-up could improve caribou calf survival because of more available forage.</p> <p>Caribou may suffer heavy losses if rain events prevent successful feeding during cold weather.</p>
	Moose	<p>Shifts in forests could mean less habitat for caribou, but more habitat for moose.</p> <p>Climate change could hinder moose calf birth success and moose calf survival.</p>
	Small Mammals	<p>Fire may create new burrowing habitat and forage growth to help vole populations.</p> <p>Less snow cover reduces survival of subnivian species, due to increased predation & cold stress.</p>
	Fisheries	<p>New stream habitats become available for fish and wildlife as glaciers decline.</p> <p>Some salmon waters may become unsuitable for migration, spawning and incubation.</p> <p>Fish diseases increase with rising stream temperatures.</p> <p>Fish habitats in permafrost areas are degraded by slumps and sediment input into rivers.</p>
	Invertebrates	<p>Ice worm populations decline locally as glacier habitats melt.</p> <p>Exotic pests expand from warmer areas, and endemic pests expand as host species are stressed.</p>
Subsistence	<p>Altered animal migration patterns make subsistence hunting more challenging.</p> <p>Sea ice changes make hunting for marine mammals less predictable & more dangerous.</p> <p>Managing new species and intensified management of native species may be needed.</p>	

OTHER	Tourism	<p>Longer summer seasons increase tourism. Some visitor activities increase, others decline.</p> <p>Landscape-level changes affect visitor experiences and access, visitor use patterns shift.</p>
	Wilderness	<p>Large-scale physical and biological changes across broad landscapes affect abundance and condition of wilderness-associated resources (e.g., glaciers, wildlife, access routes, ..)</p> <p>Changing biophysical landscape affect key wilderness values such as naturalness, wild-untamed areas wtihout permanent opportunities for solitude, etc.</p>
	TEK	Uses of traditional ecological knowledge become less predictive and less reliable.
	Devpmt	<p>More natural resource development in Alaska with increasing global demand.</p> <p>Fuel and energy prices increase substantially with carbon mitigation measures.</p> <p>Transporting fuels to remote locations becomes more challenging and costly.</p>

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: “Gussaq the Tussock”

The following narrative (in the form of a children’s poem) was developed by Group One, based on the “Warm and Dry” scenario (with shifted seasonality, but lower storm, precipitation, and extreme event frequency) nested in the “Is anyone out there” quadrant (which describes a future in which both local and institutional commitment and focus regarding climate change are low).

Far to the north, where the grasses still grow
Though the winds blow with smoke and soot when they blow
And the rivers are silty and slow when they flow
A young boy takes pause, ‘cause... he just needs to go.

“Hey!” growls a voice, “Don’t you pee on my head!”
The young Eskimo jumps and his face turns all red
He tugs at his pants and he swivels his head
“What’s that? Who are you? And what’s that you said?”

The words spring from where a small grassy mound
Competes with willows and shrubs on the ground.
“I am Gussuq the tussock, I speak for the land
For the birds, and the rivers, the bugs, beasts, and sand.

Sprout, you are young, and to you this seems strange
But I’ve weathered the years, and I’ve seen this land change
Once, winters were longer, and summers were shorter
And all of the north was much richer in water.”

The child considers. “My grandma says that.
She says that the berries were once ripe and fat.
And grandpa says once there was caribou meat
For every day, and not just for a treat.”

Grunts the tussock, “There are few caribou now.”
They are gone.” The Eskimo boy asks, “But how?
And why? Why did the caribou go?
And Gussaq the tussock replies, “Don’t you know?”

For seasons and decades and then decades more
The climate grew different from decades before
But all of you humans just couldn’t agree
And so you did nothing. Now what do you see?

The warm, early springs make the caribou late
But the ice is too thin and it won’t bear their weight
Pale hunters have come where there used to be few.
They rival and bitterly bicker with you.

The miners, I hear, have been doing the same
Digging and dredging and scaring the game
Our lake is all silty from sloughing and slumping
And my caribou friends say there's also been dumping."

Young Sprout is nodding, but asks the grass clump
"What of the guests who don't litter and dump?
My father – he works with the folks at the park
Who float and watch birds and don't leave a mark.

Gussaq still growls. "But what of the fish?"
Sprout is uncertain. "There are some... I wish
There were more in our cellar under the ground
But our cellar is thawing, and the trout aren't around.

There's not much goose soup, it's too dry for ducks
When Dad tries to go in his boat he gets stuck.
Other kids like Doritos and pop..."
Gussaq snaps, "When their teeth all fall out, they will stop."

"We tussocks are hardy," he goes on, with a groan,
"But you humans – you can't survive on your own.
Your air is all clouded with ashes and smoke
And the filth in your water supply makes you choke."

"Gussaq," the boy cries, "I know it is true.
Everything's changing -- but what can I do?
There's no money, no answers, no one will agree...
How can I get them to listen to me?"

"Tell this story," the tussock says, quick as a wink.
"Tell them to plan, and to hope, and to THINK.
Tell your people about all the changes I see
And next time... watch out where you pee."

Narrative 2: "Strange Bedfellows"

The following narrative (framed as a story by a young local girl) was developed by Group One and is based on the "Warm and Wet" scenario (with shifted seasonality plus increased storm, precipitation, and extreme event frequency under the conditions described for the "Wheel-spinning" quadrant (which describes a future in government/institutional commitment regarding climate is high, but local concerns are focused elsewhere).

"They used to call it breakup"

They call me Kalla – I grew up near there and have been running the Koyukuk/Kobuk road since I took over the trapline from my old man in the 60's – now I drive the route with mail, fuel, sourdoughs and cheechako's – it just ain't the same.

They used to call it break up, but now it's just mush. And I'm not talking about dog mushing. Spring's coming earlier; and it's not freezing as hard in the fall and winter as it used to. There's more open water longer; I've lost two snogos because I've gone through the thin ice twice. Stopped mushing dogs in the '60's and now I've given up on the iron dogs too.

Look at all the bushes and trees; they didn't used to be here like they are now. It used to be mostly tundra. And I mean frozen ground, not this mushy stuff you see now.

I never thought I'd see the day when I'd say this, but this road to the mines would not have been built this way if the feds hadn't done such a good job working with folks. They helped get this great road that runs to the prettiest country in the state. There are a few places where you can get supplies rather than a bunch of things thrown up. They even look like the old roadhouses that used to be here back when there was enough cold weather for the old winter sled roads. The locals are working these spots, along with a few campgrounds and guiding from the recreation points along the road. Many are working at the mines - I see 'em coming back to the village every now and again. Bring some money home...it's not caribou or fish but I guess it probably helps. The way I see it, it is a damn good thing that there are a couple of families in each village doing things the old ways. It's got to be tough as the only thing there is more of is berries and I think that is what holds it together. The village even had to move to more stable ground that ain't so wet, but it looks like this site will last a good long time.

When the powers to be decided that the road was going to happen, they decided to do it differently this time. In the old days, we would just take a cat out and push a road in - you can still see evidence of that now back next to the old camps- usually all mucked up with a bunch of junk and an old blue tarp to hide it a bit. They've been working to keep the fish running and helping to keep a subsistence lifestyle possible. I don't know - maybe it's working. I had my doubts with big old culverts that were big enough to be mucked out with cats, but the water runs through better and the road don't wash out like some of those old cat trails did. There ain't a bunch of crappy weeds, either, as the State and Feds used clean pits and clean vehicles. That just helped keep the old creatures around to eat what they always ate.

Most of the other village kids I drive are working in town and every so often they pack up to come see the family/elders. They don't get as much chance to hunt and trap the animals because there aren't as many and some of them don't do what they used to do. But - there seems to be more younger folks staying around as they have some livelihood and they aren't all heading south to Fairbanks or Anchorage. I don't think my kids, Kiana and Ruby, would be staying out in the bush if it was just running a trapline in wet snow and soggy ground. It ain't the same, but it seems to work.

I don't know what the future will bring but everyone worked together to get a way into the mines and they did it by working together rather than fighting each other every step of the way. Oh - that doesn't mean that there weren't fights, but the fights were over how to do it better rather than just on the short term cheap - that didn't seem the Alaskan way at the time, but it looks like the final result will help keep most of the bush lifestyle while allowing people a chance to make a living.

I never get tired of driving this road and talking with folks coming home.

Narrative 3: "The Last Pingo"

The following narrative developed by Group Two takes the form of a State of the Arctic address in New Noatak. President (Chelsea) Clinton visits Noatak for telecast/simulcast holograph of the speech, and for the signing of a treaty with "the Arctic 8" G50 nations narrative is based on the "Wetastrophy" scenario (with large increases in temperature and precipitation) under the conditions described for the "Big problems, big solutions" quadrant (which describes a future in which both local and institutional commitment and focus regarding climate change are high).

Introduction: James Nageak, Jr.

Welcome to the Enoch Mitchell Community center here in New Noatak. As you know, we've had to relocate. We want to thank the federal and state governments for their assistance with relocating our village and helping our community adapt to change while preserving cultural traditions. Together, we have managed to integrate thousands of years of Inupiaq knowledge with new technologies to build super-

insulated and efficient homes adapted to arctic conditions in areas that best meet the needs of our community while being as resilient as possible to the changing environment.

Adaption is not new to us. The Inupiat people have been adapting to their environment for thousands of years, an environment that is constantly in flux. We have fought hard to preserve as many of the traditional subsistence life ways as possible. I used to hunt caribou, but now the natural caribou migrations don't come here anymore. We've had to adapt. Reindeer meat is imported here from Fairbanks or Canada. We hunt and trade moose for caribou hunted by our neighbors on the North Slope. After much study, involving local input and multiple agencies, we have introduced woodland caribou from Canada which have proven to be much more resilient to the changes our local region is experiencing. Other animals have increased in the last couple of decades because it is warmer and wetter. We've had to adapt. We have more waterfowl, muskrat, coyotes, beaver, polar bear, and we've seen changes in the numbers and distribution of many other species. We have weaker wild runs of sheefish and whitefish, with new runs of silver and red salmon developing in our streams and rivers. To assist these newly developed fisheries, the Noatak hatchery has been revitalized augmenting an important food source, as well as providing jobs. We have concerns about our local foods – from both contaminants and disease. Mercury levels in northern pike have increased and are a threat to children and pregnant women. We have had difficulties preserving and drying our food by traditional methods. We have had to adapt. We have altered parts of traditional diet to allow consideration of health advisories and we have had to become more reliant upon several modern methods of storage. We are very proud of our part in these multifaceted efforts and our village is honored to be the site of today's announcement. It is my privilege to introduce President Clinton.

Speech: President Clinton

Thank you, James. The International Coalition of Arctic Nations (I-CAN) recognizes that there have been dramatic changes in the Arctic and the importance of preserving natural and cultural areas for future generations. Thank you for inviting me to New Noatak.

We are answering a call that is two decades old. In 2012, groundbreaking work started: the Arctic LCC and CCSP visionaries laid out the potential for dramatic climate related change and formulated a plan to move forward. At the time, the Arctic was on the frontline for climate change impacts, experiencing up to ten times the consequences felt in the lower 48. With increased awareness and understanding of the ramifications of continuing a carbon-based economy, Arctic state, local and federal governments got together with local stakeholders to address the challenges facing the planet. We acknowledged that problems were on the horizon and took proactive steps to adapt and mitigate the changes we saw. These efforts were widely accepted by international communities, and bring us together here today as we sign the ICAN Climate Agreement. Lessons learned in the past twenty years are being applied across the Arctic under this agreement.

The great visionaries of 2012 developed a model of change and plan for mitigation. Some of the key lessons learned earlier in the century are being used to guide our actions. We greatly appreciate the community participation and citizen science efforts of the last 20 years. The result has been improved data collection and, most importantly, education and engagement of the public. Interagency planning has led to the development of enterprise teams for inventory networks, risk analysis and implementation of mitigation efforts focused on the breadth of issues facing the ICAN. For example, in the face of diminishing subsistence opportunities, the teams augmented fish availability with hatcheries and introduced new species adapted to the changing conditions. A critical part of these teams were those you see around you. You have much to be proud of. We are here today to say that we stand unified and strong to address these challenges! Sensitive resources identified back in 2012 have been protected to the extent possible, and you have all contributed to the inventory and monitoring program of these resources.

Traditional ecological knowledge was the first "environmental monitoring"- during a time when the failure to monitor your environment could easily result in serious or fatal circumstances. There is no feasible way to reverse the biophysical and social effects of climate change. Management strategies have embraced

the spirit of preserving the wilderness. While preserving large, significant natural and cultural resource areas, we have been able to benefit local economies by supporting well-planned mineral and tourism developments.

Within the conservation units, natural processes have been allowed to dominate unfettered across the Arctic landscape for the past two decades. We have formulated a way, with effective stakeholder input, to balance conservation with some development. Economic opportunities from things such as tourism and resource development will not pass us by. We have found a path to success in “responsible development” that allows these opportunities to occur in a strong regulatory framework that prevents major impacts to subsistence resources and practices.

We visited the old townsite this morning by boat. We heard stories from elders about the storms and flooding that occurred, as well as tales of the vibrant community that existed there and now here. Your homes have had to be moved, but we have been proactive instead of reactive and anticipated these needs and their associated costs. You, the residents, have played a significant role in this process, thereby preserving local self-determination.

The new housing constructed has been given the utmost consideration by a group of engineers trained in innovative building solutions for cold climates. The net result, with input from stakeholders, is homes that are responsive to users’ needs while being highly energy efficient and resilient to the changes we are experiencing today and into the future. The use of alternative energy sources resulting in lowered fuel bills, ample supply of clean water for drinking and hygiene resulting in improved health outcomes and the selection of a protected site resulting in community security are all basic needs that have been filled. The transition from a reactive to a proactive mode was key in all of the approaches described above. Today, we are a global society, none more so than in the Arctic. As you are likely aware, carbon emissions are on the decline.

The public is the most informed in history as to how their actions have the potential to impact the world around them. By being party to this agreement, we are showing solidarity in this fight- a fight to retain our quality of life, our homes and the traditions we hope to pass down to our grandchildren’s grandchildren.

Thank you.

Narrative 4: “Enoch Decadal Oscillation”

This narrative developed by Group Two tells the story of how life has oscillated for Enoch [Mitchell] in 30 years. It includes an interactive Google Earth Map (shown as a screenshot in Figure 13). It is based on the “Smoked Salmon” scenario (with severe temperature increase and decreased precipitation) under the conditions described for the “Wheel-spinning” quadrant (which describes a future in which institutional/governmental commitment and funding regarding climate change are high, but local focus is lacking).

The climate has warmed substantially, but the rain and snow is low. Although the government is here to help people in the villages are fed up with bureaucracy. Life in the village has seen sweeping changes. We take a tour through a year of 2012 and take a quantum leap into the future of 2040.



Figure 13: Screenshot of interactive Google Map depicting locations from the EDO narrative

<i>Seasonal Activity</i>	2012	2040
<i>Summertime... Home is Where the Berries Are</i>	We pick blueberries and salmon berries near Noatak during July and do more fishing.	The blueberries are sparse because it is so dry, but there are abundant salmonberries due to the tundra fires. The berries go unpicked as everyone is away working in the mines when the berries are ripe.
<i>Fall Caribou Hunting</i>	We take boats up the river and find the caribou. We are able to bring back 8 caribou for our family.	The caribou are skinny due to loss of lichen in recent fires. Those that the hunters find have diseases that the people don't recognize. It is hard find them. Poor families have to pool their money to buy gas to get one boat up the river.
<i>Fall Moose Hunting</i>	Moose have been hunted near the village.	Enoch becomes a moose hunting guide and makes enough money to spend his winters in Hawai'i. Overhunting results in a dramatic decline in moose and Enoch returns to Noatak.
<i>Winter Trapping</i>	We set up a trapline from Noatak up to the Kelly River. We catch Lynx, wolf, wolverine, fox and marten.	The trapping is poor around Noatak as fuel prices are too high to travel far. Two trappers put their money together to run one snowmachine and only get one wolverine.

<i>Seasonal Activity</i>	2012	2040
<i>Winter Ice Fishing</i>	Winter ice fishing for trout, whitefish, grayling and evening mudsharks at traditional spots. One family can bring home 50 pounds of fish.	Ice on the river is thin and more dangerous and people fall through as they search for fish. One family only catches 10 fish, and there are no whitefish left.
<i>Winter Wood Cutting</i>	We collect wood near the village on either side of the river or up in the hills.	People are collecting dead wood from the recent burn. There is greater demand for wood now that fuel prices are higher.
<i>Spring Whaling</i>	We snowmachine to Point Hope to catch Beluga, bowhead, seal, polar bear, walrus and sea ducks.	The snow is gone and the rivers are thawing, so we need to fly to Point Hope. Now we can only afford to fly one person to Point Hope and there are no polar bears, walrus or seals in the area. Whaling was dangerous due to thin sea ice. The whales are covered in oil due to a spill under the sea ice.
<i>Summer Camp</i>	We head down the Noatak by boat to the summer camp to get more seals, beluga and fish. We dry fish on racks on the beach.	We drive the new gravel road down to the summer camp only to find that it washed away from a storm. In desperation we shoot a skinny caribou from the truck and head home. The Wildlife Troopers are there waiting for us.

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

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1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

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