



Climate Change Scenario Planning for Southeast Alaska Parks

Glacier Bay, Klondike, Sitka, and Wrangell-St. Elias

Natural Resource Report NPS/AKSO/NRR—2014/831



Scenarios Network
FOR ALASKA & ARCTIC PLANNING



ON THE COVER

Salmon, Glacier Bay National Park

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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, Southeast Alaska was the third area in Alaska to be examined by NPS through a scenarios workshop on February 21-24, 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 February 2012 workshop focused on Glacier Bay National Park and Preserve (GLBA), Klondike Gold Rush National Historic Park (KLGO), Sitka National Historic Park (SITK), and Wrangell-St. Elias National Park and Preserve (WRST).

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

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

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

General findings include the need for increased cooperation, trust-building, and information sharing among diverse groups; increased monitoring of resources, and improved emergency planning. More specifically, findings suggested building flexibility and cooperation by using traditional ecological knowledge (TEK) and co-management in planning, and hiring staff with multi-disciplinary skills. Workshop participants further suggested the need for specific monitoring programs, using the parks as living laboratories. Water monitoring and stream flow were at the top of the list. They also urged the importance of assessing vulnerability and risk for key resources and infrastructure. They admitted, however, that budget constraints might limit these efforts.

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 the National Park Service Scenario Planning Workshops were highly participatory, relying on input from every attendee. We would like to thank each of the individual 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

Driver	A climate variable that drives changes in weather, vegetation, habitat, wildlife, etc. Also referred to as a <i>critical force</i> and a <i>scenario driver</i> .
Climate effects	Existing or potential consequences, outcomes, or results of changes in climate. Can appear beneficial or deleterious, depending on perspective.
Critical force	A climate variable that drives changes in weather, vegetation, habitat, wildlife, etc. Also referred to as a <i>climate driver</i> or <i>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.
GLBA	Glacier Bay National Park & Preserve, SEAN Park
Impact	A forceful or particularly significant consequence. An effect that is likely to warrant a response.
KLGO	Klondike Gold Rush National Historical Park, SEAN 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.
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.
SEAN	Southeast Alaska Network, the National Park Service’s Inventory & Monitoring network of parks in southeast Alaska
Scenario	A projected course of events or situations, used to understand different ways that future events might unfold.
SITK	Sitka National Historical Park, SEAN Park
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 through fewer years or generations of experience.
WRST	Wrangell-St. Elias National Park & Preserve, SEAN Park

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

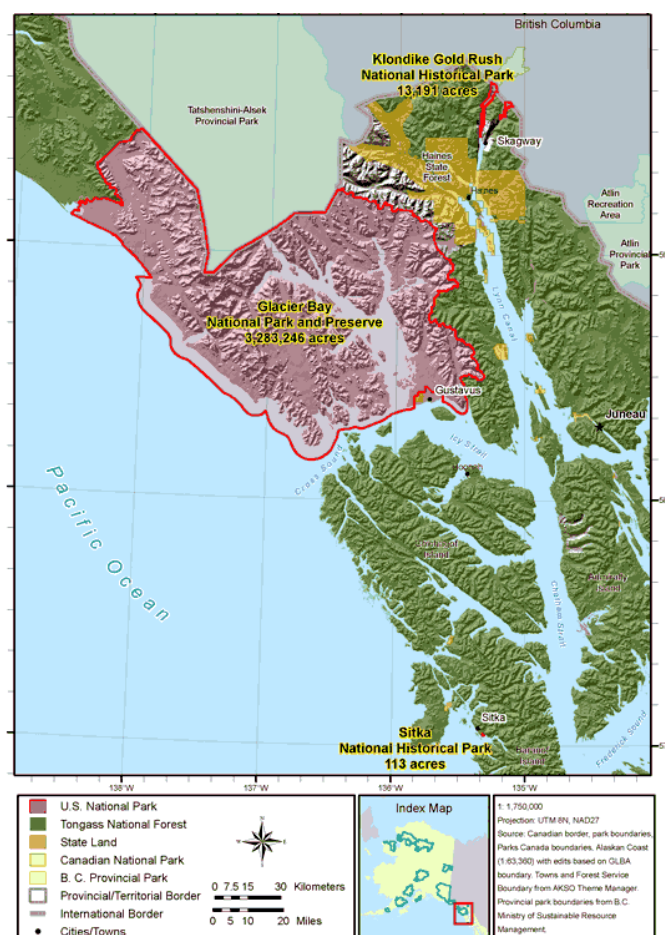


Figure 1: Southeast Alaska Network (SEAN) parks.

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

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

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

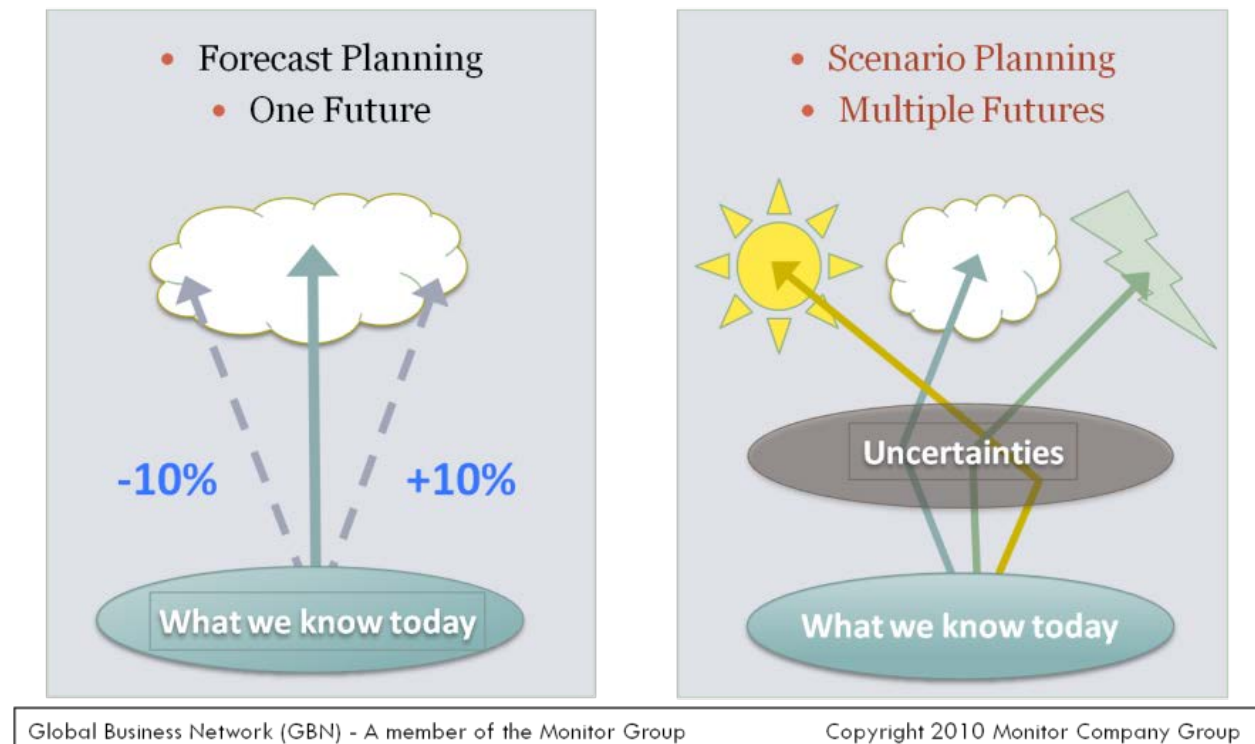


Figure 2. Difference between forecasting and scenario planning. Graphic courtesy of GBN.

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

Scenario synthesis is dependent on a multi-step process in which participants select two key drivers of change that are both important (likely to cause multiple significant effects) and uncertain (in terms of the magnitude or direction of the change). These drivers, when intersected, yield four possible futures (Figure 4). By selecting the drivers with the greatest importance and uncertainty, workshop participants insure that these four futures represent highly divergent scenarios that approximate the full range of possibilities worth exploring in depth.

In this workshop, the primary drivers were biophysical drivers of climate change. Participants first fleshed out some of the details of the four outcomes suggested by these primary drivers, by creating bulleted lists of potential effects to humans, ecosystems, and infrastructure in and

around parks. They then took the scenarios process to a higher level by examining each possible future in a sociopolitical framework that incorporated a wide range of societal concern and an equally wide range of institutional support (Figure 5). Selected divergent scenarios from this framework were fully described in both summary and narrative forms, and management actions were suggested based upon each selected scenario.

Scenario planning offers participants the opportunity to search for actions that perform well under all scenarios (often called “no-regrets” or “robust” actions); current actions the park should continue doing, 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.

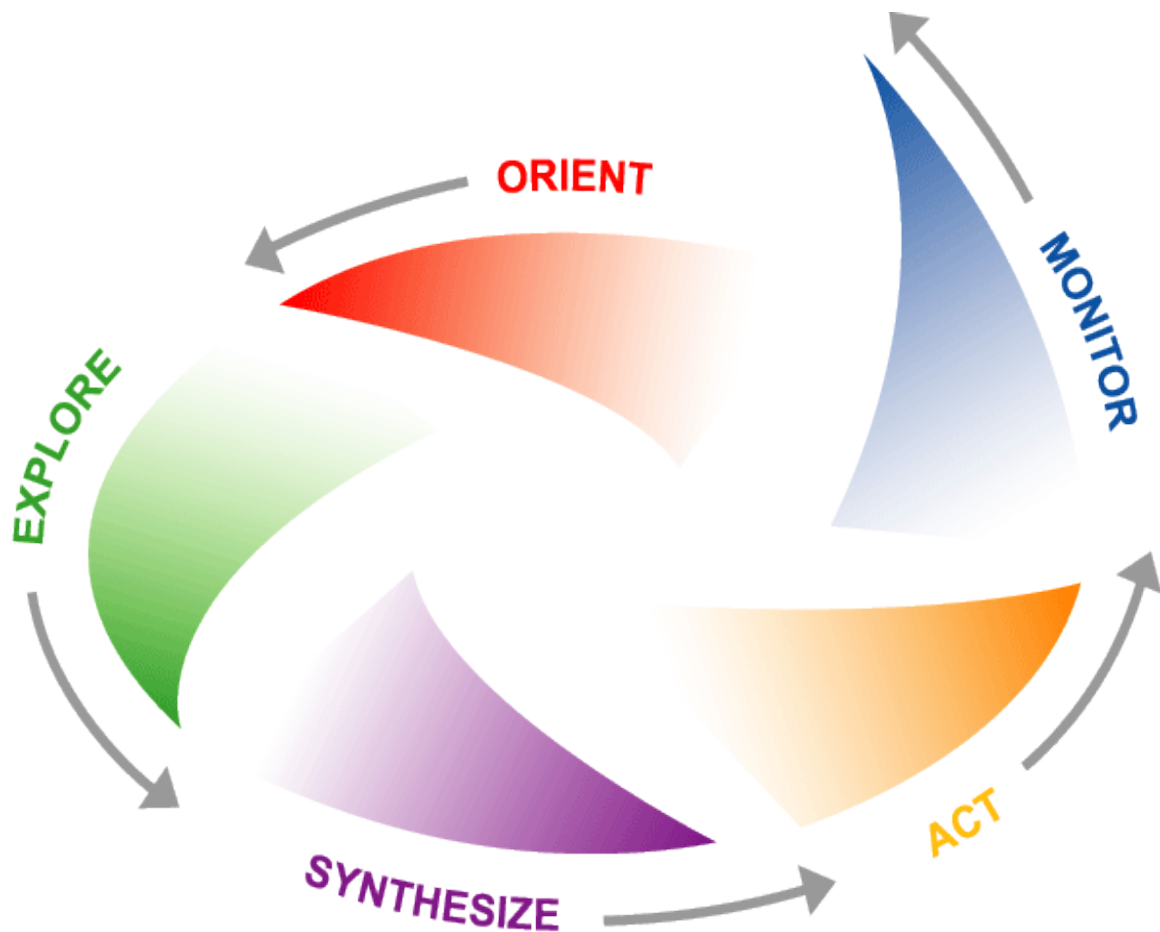


Figure 3. Stages in the scenarios building process. Diagram provided by Global Business Network (GBN).

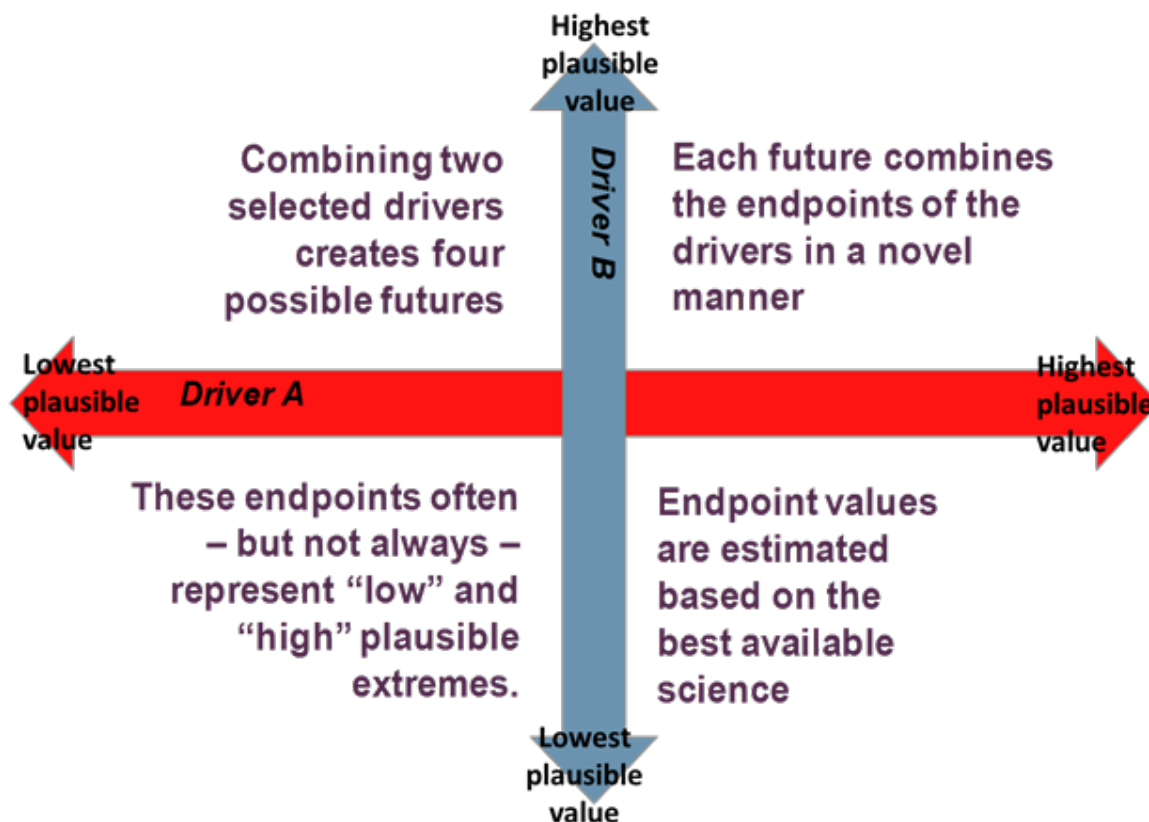


Figure 4: Creating a primary scenarios matrix. Two key climate-related drivers of change are crossed to create four possible futures.

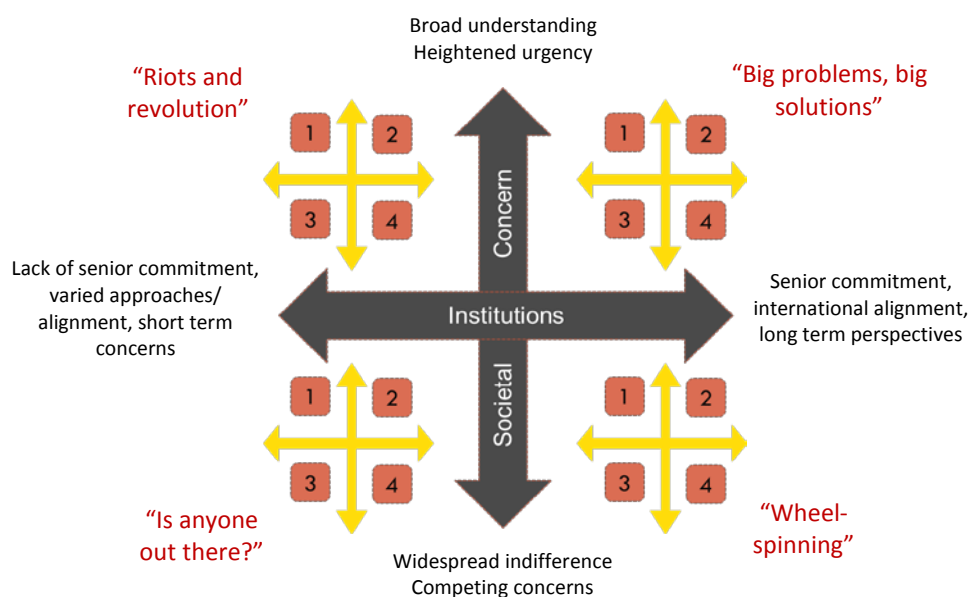
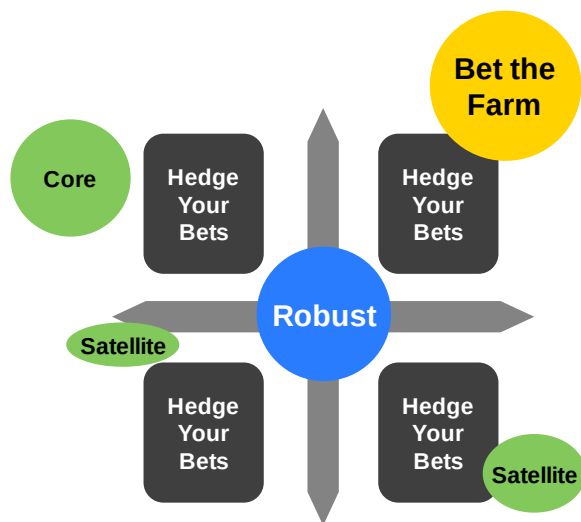


Figure 5: General design for a socio-political framework that incorporates the degree of societal concern in the future and the nature of future leadership. Adapted from GBN.



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 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 ecological, biophysical, or social change in the Southeast Alaska parks. (See Appendix F for a table of Northwest Alaska climate drivers). Webinar 3, led by Robert Winfree of NPS, was focused on climate change effects in the Southeast Alaska parks. Participants were asked to help rank the relative importance of these effects. (See Appendix G for the Southeast Alaska 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_Southeast_Alaska/

Models, Data, Maps, and Other Information

To help inform consideration of a range of possible futures, workshop participants were provided with data, maps, and summaries of climate projections specific to the Southeast Alaska region (Appendix D, Appendix E). Other climate change information, including drivers of change (Appendix F) and effects of those drivers (Appendix G), were shared prior to and during the webinars and workshop. This information was drawn from multiple sources. Prior to embarking on the project, NPS prepared regional summary documents on climate change impacts, including talking points on impacts to Alaska’s Maritime and Transitional regions: <http://www.nature.nps.gov/climatechange/docs/MaritimeTransitionalTalkingPoints.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_Southeast_Alaska/

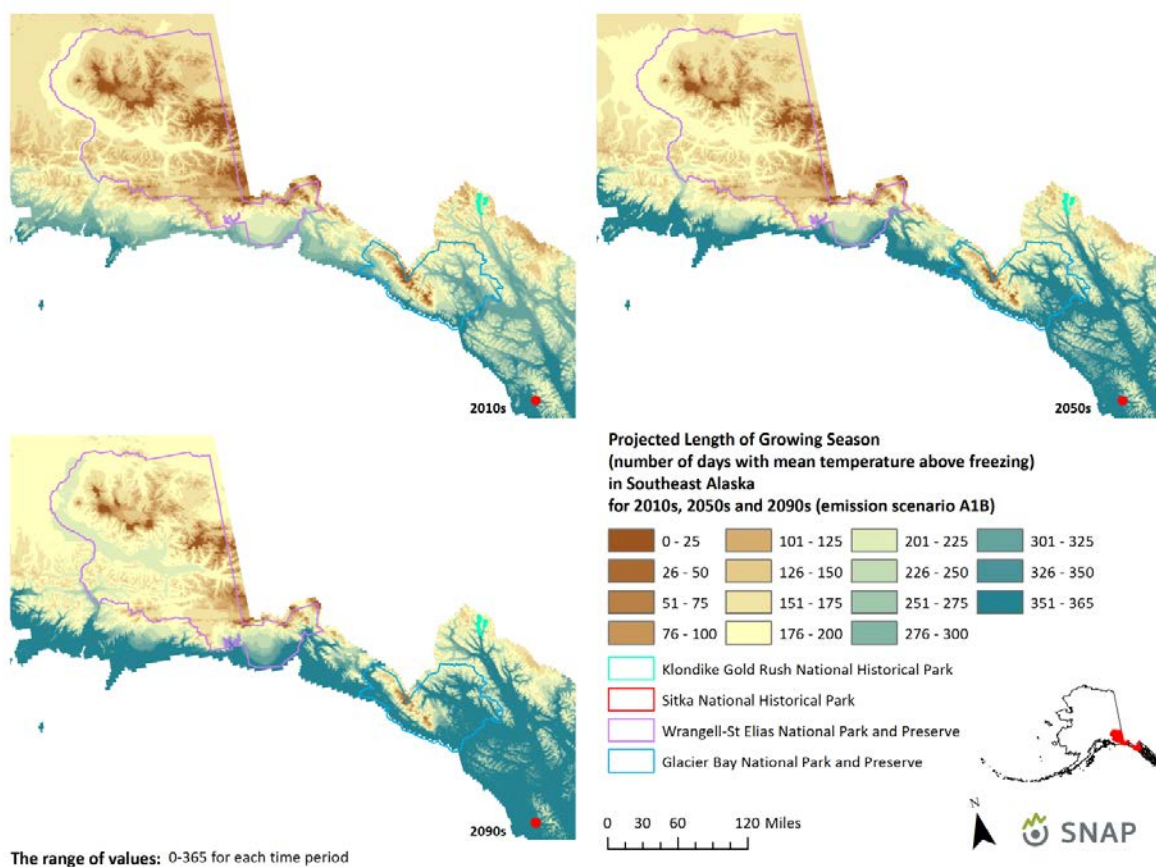


Figure 7: Mean summer season length. These maps show the projected number of days between the date the running mean temperature crosses the freezing point in the spring, and the date when that point is crossed again in the fall. Large areas of southeast Alaska are likely to be primarily unfrozen by the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

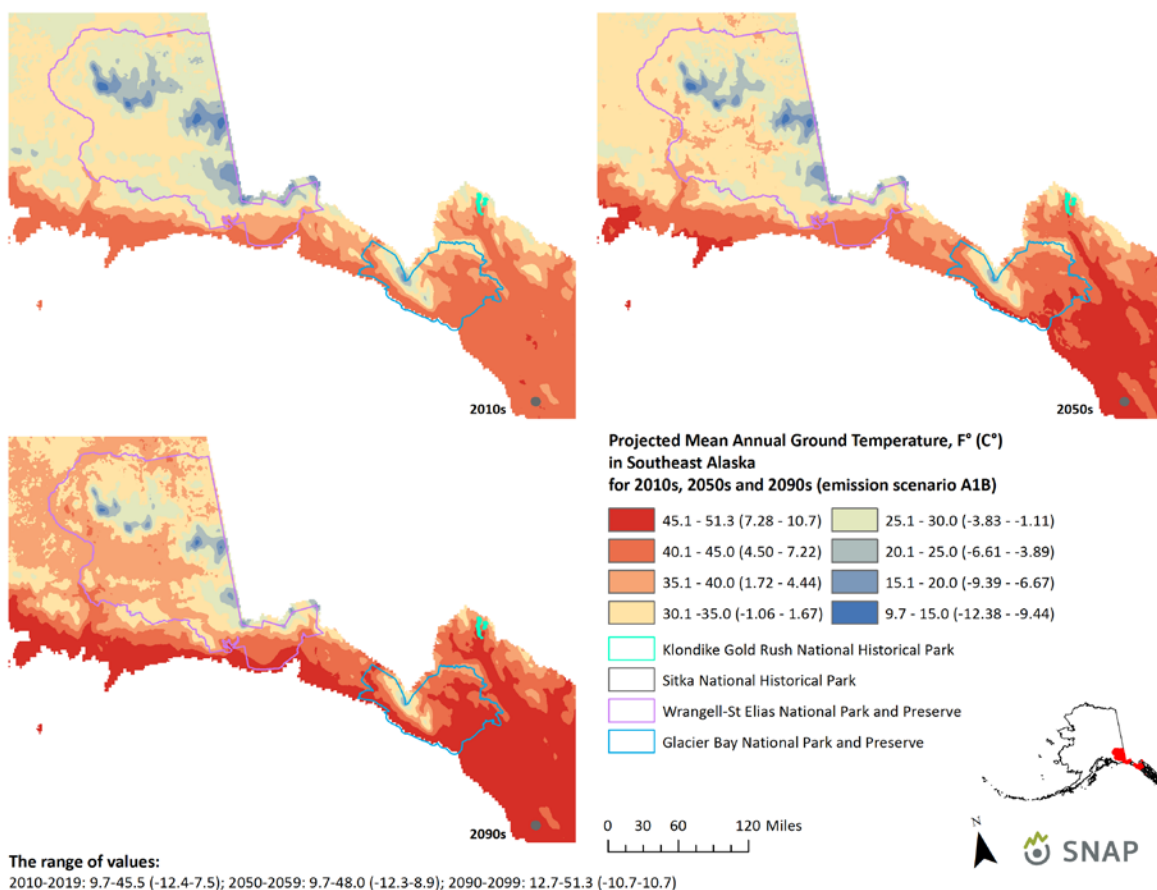


Figure 8: Mean annual ground temperature at one meter depth. Based on SNAP climate data and Geophysical Institute Permafrost Lab (GIPL) permafrost modeling, these maps depict projected ground temperature conditions. Extensive permafrost thaw is likely by the end of this century.

Additional Workshop Documents, Maps, & Reference Materials

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

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 by 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 review and elaboration for those who did.

Don Callaway of the National Park Service described the sociopolitical framework relevant to Alaska, and provided examples of nested scenarios and narratives derived from nested scenarios.

Jeff Mow of the National Park Service discussed park management implications, decisions and actions. Jeff presented various ways that park managers can use insights from scenario planning, as well as 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 southeast Alaska” folder at: http://www.snap.uaf.edu/webshared/NPS-CCSP/2012_Southeast_Alaska/.

Workshop Work Group Products

Workshop participants divided into two working groups for breakout sessions. Participants divided based on primary ecological zones to form a Marine group and a Terrestrial group. 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.

Marine Group

Marine Group Climate Driver Selection

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

Table 1: Rankings of climate drivers for the Marine work group. Group members discussed the impact and uncertainty of each potential driver.

	High Uncertainty	High Confidence	High Impact
Temperature		X	X
Form: rain & snow (changed)	X		X
Timing & magnitude of stream flow (added)	X		X
Freeze-up date		X	
Length of growing season		X	X
River/stream temperatures		X	X
Sea level rise		X	(isostatic rebound?)
Water availability (soil moisture)	X		
Relative humidity	X		
Wind speed		X	X
PDO	X		X
Extreme events: higher temperatures		X	X
Extreme events: precipitation	X		X
Extreme events: storms	X		X
Ocean temperature increasing (added)		X (but not degree)	X
Ocean acidification (added)		X	X

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

The Marine group discussed details of drivers at length, including the timing and magnitude of stream flow, ocean acidification, extreme storm events, the Pacific Decadal Oscillation (PDO), ocean temperature, extreme precipitation events, and ocean currents or upwellings. Points of discussion included how to define endpoints or extremes for each potential driver and how to define changes in timing and seasonality in terms of end points. The group tried several matrices of paired drivers, including stream flow crossed with ocean acidification, ocean acidification crossed with extreme storm events, and PDO crossed with ocean acidification.

Ultimately, the group decided that the most plausible, relevant, divergent, and challenging scenarios were created by crossing stream flow with ocean acidification, as shown in Figure 9.

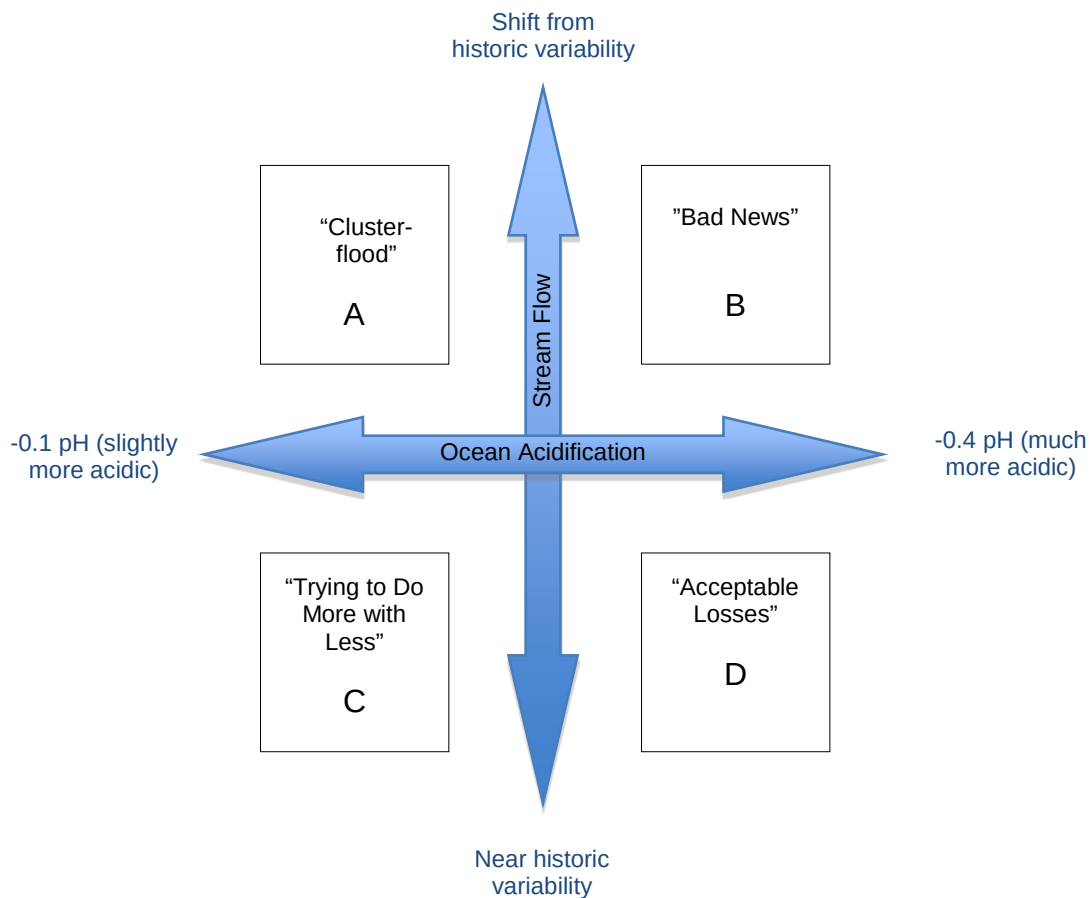


Figure 9: Primary matrix of climate drivers produced by the Marine group. Each quadrant represents a different combination of potential future temperature and extreme precipitation and storm events. Details of each quadrant are described in the text.

Marine Group 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 the Marine group were:

- A. "Cluster Flood," with low acidification and a high shift in natural stream flow,
- B. "Bad News," with high acidification and a high shift in natural stream flow,
- C. "Trying To Do More with Less," with low acidification and no change in natural stream flow, and
- D. "Acceptable Losses," with high acidification and no change in natural stream flow.

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

Marine Group Scenario A: “Cluster Flood”

The “Cluster Flood” scenario envisions a future in which ocean acidification is low (higher pH), but there is a high shift in natural stream flow. Potential effects of such conditions include:

- Biological
 - Mismatch with life stage events (recruitment/spawning)
 - Different volumes of water/different times
 - Salmon coming up, smolts missing bloom
 - Decrease in overall productivity
- Social/Cultural
 - Cannot assume same fishing patterns, possible increase in turbidity
 - People may move to cities because they cannot depend on resources
 - Potential for higher flooding-safety issue
 - Loss of cultural resources
 - Impact on rafting companies
- Infrastructure
 - Need to build new bridges
 - Erosion of trails
 - Less stable hydropower potential
- Glaciated:
 - Glacial dams bursting = increase in flash floods
 - Broaden the flow—more spring and fall—whole magnitude may raise in the middle
 - Longer periods of turbid water-decrease the productivity
 - More flow later in the year
- Non-glaciated:
 - Less high peak in the spring
 - Lower summer stream flow
 - Higher fall stream flow because of greater rains
 - Flow later in the year
- Temperature (cool/warm) has a huge impact. Warm: lots of different animals, cool: snowpack to protect plants.
- Freshwater: stratification patterns; reduction in melt = lower plankton blooms
- Herring, and other fish—more variability—can’t recover from a crash
- Most of SE parks are heavily glaciated: do we need to focus on this?
- PDO off for A (masking acidification-dampen variability), on for C (high acidification): look at compounding events
- PDO
 - Greater impact on temperature than precipitation
 - Cold PDO: masking, more similar to historical, moderated stream flow, higher salmon, more snow, more productive
 - Warm PDO: less advantage for productivity, more rain, more flashy events, drying of system, increase in fire frequency

- Another thing to toggle: uncertainty/variability—simplifying habitat
- Defining stream flow end points:
 - Change about the mean of peak flow
 - Higher or lower variability from the current hydrograph
 - Difference between glacial/non-glacial systems

Marine Group Scenario B: “Bad News”

The “Bad News” scenario envisions a future in which ocean acidification is high (lower pH), and there is a high shift in natural stream flow. Potential effects of such conditions include:

- Increase in invasive species
- Reduction in salmon and fish
- Loss of food web diversity
- Decrease in land/marine mammals, birds
- Loss in habitat structure
- Increase in disease
- Cultural losses
- Social pathology increase (commercial, tax base, culture, tourism decrease)
- Stranding of marine mammals

Marine Group Scenario C: “Trying To Do More with Less”

The “Trying To Do More with Less” scenario envisions a future in which ocean acidification is high (lower pH), and there is no change in natural stream flow (maintains the status quo). Potential effects of such conditions include:

- Higher acidification is driving the scenario
- Lower ocean productivity
- Less fish available
- More competition for fewer resources
- Decrease in sound absorption (noisier)
 - Change management of cruise ships
 - Larger impact on marine mammals
- Decrease in large mammals
- Increase in desire for subsistence in NPS
- Gradual and difficult to see = lack of awareness/delayed perception
- Change in bird populations
- Loss in habitat complexity—shellfish impact
- Visitation might be stable—bigger cruise ships

Marine Group Scenario D: “Acceptable Losses”

The “Acceptable Losses” scenario envisions a future in which ocean acidification is low (higher pH), and there is no change in natural stream flow (maintains the status quo). Potential effects of such conditions include:

- Moderate reduction in salmon and smaller biomass

- More variable in effects—less predictable
- Shift in available food—all marine populations
- Lower carrying capacity for all life forms—less life

Marine Group Scenarios Nested in a Socio-political Matrix

The Marine group nested the four 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 two nested scenarios to explore further. This narrowing of the field is in keeping with the scenarios planning methods outlined by GBN; the goal is to avoid redundancy and unnecessary use of time and effort, while maximizing the range of possibilities under consideration.

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

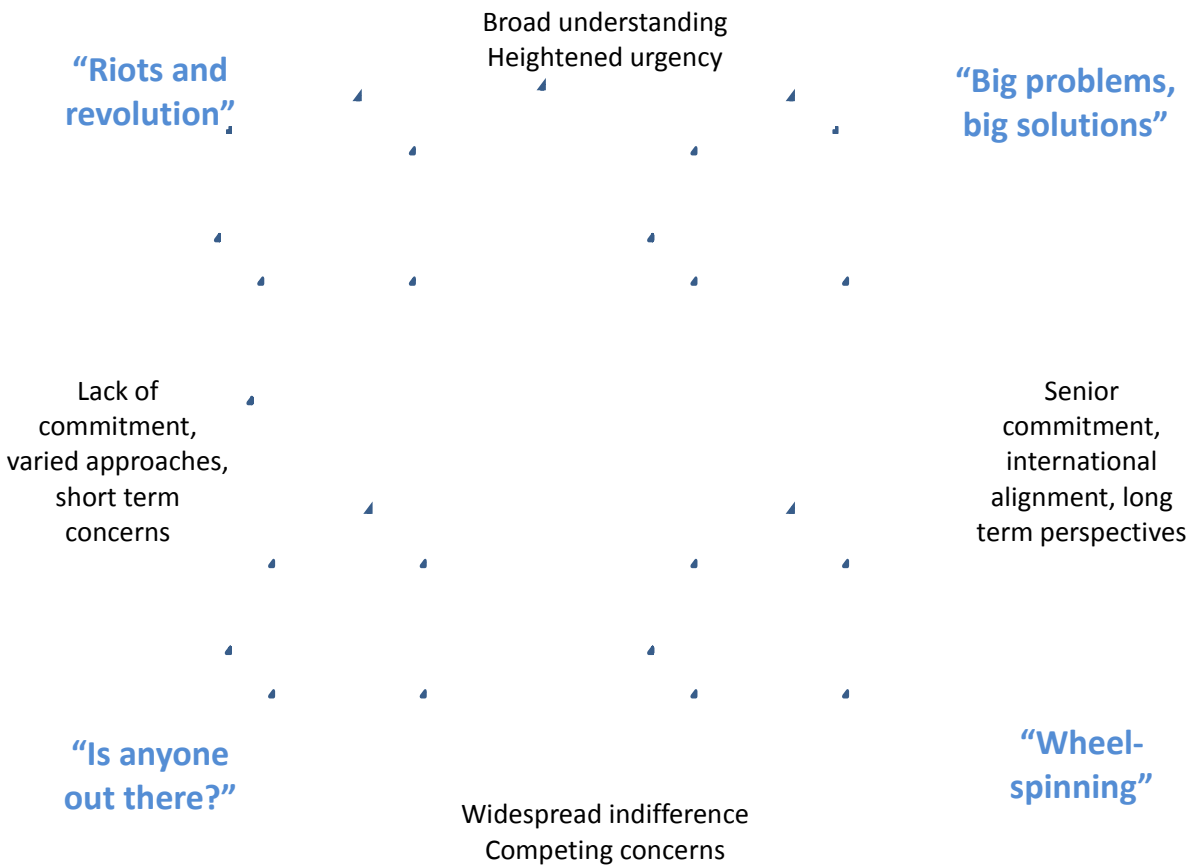


Figure 10: Nested scenarios selected by the Marine group. The selected scenarios are indicated by blue stars. The implications, management actions, research needs, and narrative associated with these two scenarios are elaborated upon below.

First Marine Nested Scenario: “Bad News” in “Big Problems/Big Solutions”

The following effects, issues, implications, and suggested needs and actions were identified by the Marine Group in the event that the “Bad News” scenario (with high ocean acidification paired with high shift in natural stream flow) was to occur under the conditions described for the “Big Problems/Big Solutions” quadrant (which describes a future in which both local and institutional commitment regarding climate is high) (Figure 10).

Implications

- High effort to green operations—green certification
- Climate-tours increase
- Federal capacity focused on FDR approach—restore fish habitat/aquaculture
- Increase outreach programs with personal perspective—build awareness and take advantage.
- Collaborative efforts are the status quo—more efficient and landscape scale management
- High focus on community participation
- Increase hydropower efforts

Management Actions

- Setting up co-management structures for harvested/non-harvested species (protocol, plan, set thresholds, allocation issues). Working group—what are local challenges? Need to think about transaction costs
- Exploring invasive management options and prioritizing actions
- Proactive planning around aquaculture planning
- Consider designated wilderness in planning
- Increased coordination between agencies/communities/local governments/federal government/state
- Proactive park-level leadership in coordination at a local level

Issues Facing Management

Cultural:

- Increased outreach and education to communities
- Risk assessment for vulnerable cultural resources & recovery plan
- Document oral histories and make accessible
- Assessment and management of newly recovered cultural resources

Facilities:

- Designing more energy efficient and adaptable infrastructure
- Utilizing renewable energy resources
- Address climate change in new infrastructure development
- Risk assessment of existing infrastructure
- Promoting telecommuting for reduced infrastructure footprint
- Reducing fixed costs for the park

Social & Economic:

- Proactive water rights planning
- Participation in the travel industry/travel planning (also research need)
- Explore ongoing value-based decision making or co-learning processes

Interpretation and Education:

- Redevelopment of interpretation and education programs
- Need to bring youth, the future, to the table
- Interpret changed conditions and values (loss of glaciers)

Visitor Protection:

- Increased need for visitor protection resources and communications
- Increased concerns about liability and how to respond (new technology)
- Protecting new cultural/natural resources that are exposed

Research Needs:

- River gauging data
- Long term acidification monitoring

- Comprehensive baseline social surveys of skills bank, household income, sharing networks and subsistence with economic indicators (baseline economic and social surveys with focus on subsistence)
- Infrastructure risk/vulnerability assessment
- TEK in defensible framework
- Monitor either harvest or escapement and ecosystem diversity
- Monitoring primary/secondary productivity
- Presence and distribution of invasive species
- Robust atmospheric monitoring in usable form for Park management
- Revisit the vital signs for the park

Other Issues:

- Prioritization with budget constraints
- Increased lawsuit costs
- New risks for visitors and employees

Second Marine Nested Scenario: “Cluster Flood” in “Riots & Revolution”

The following effects, issues, implications, and suggested needs and actions were identified by the Marine Group in the event that the “Cluster Flood” scenario (with low acidification and a high shift in natural stream flow) were to occur under the conditions described for the “Riots & Revolution” quadrant (which describes a future in which local government/institutional commitment regarding climate is low, but local concerns are high) (Figure 10).

Implications

- Development pressure in bigger cities—loss of rural community membership, higher gas prices
- More competition for fishing resources
- Boom and bust of resources (unpredictable resources)
- Increase in restricted areas—more critical habitats
- Reliance on outside imports—increase food costs
- Creating more marine protected areas
- Pursuit of alternative energy (tide/air power)
- Loss of identity, self-reliance and sense of intact community
- Increase in restoration efforts
- Increase demand for co-management
- Global water demand is up
- Potential coastal management plan
- Increased mineral/energy development
- Increase in invasive species

Major Impacts to the Bioregion

- Loss of history and sense of pride/tradition
- Loss of communities in general
- Decreased habitat quality
- Seasonal tourism less predictable (change in traditional recreation opportunities)

- Flooding and erosion increase—may influence habitat

Implications for Management

- Need for restoration
- Increase in hatcheries/aquaculture = potential loss of income (not wild caught)
- Increase in lawsuits
- Increase in demand for adaptive co-management
- Planning needs to account for threat to infrastructure
- Conflict in mandates
- Increase in maintenance costs = how to prioritize limited resources
- Dated policy and mandates-increased rigidity
- Need for increased landscape and international management
- Need for coordinating agency
- Subsistence vs. tourism-increased visitation
- Increase in resource extraction management
- Increased visitation
- Increase in civil disobedience
- Increase in emergency response
- How to assign value and prioritize?
- How to keep up with research needs? Scenario planning needs continual updating/revision.
- New technologies: access/use/etc...
- Funding to respond
- Monitoring needs, but no funding

Terrestrial Group

Terrestrial Group Climate Driver Selection

The methods and procedures for the Terrestrial group were nearly identical to those described for the Coastal group. However, the group's preferences and discussions resulted in a few differences. The Terrestrial group assessed the drivers as shown in Table 2.

The group also added a new driver to those previously presented: seasonality of water flow, which was judged to be highly uncertain and important. Next, the group selected the top three drivers, which were concluded to be seasonality of water flow, PDO, and precipitation and storms.

Ultimately, the Terrestrial group opted to consider PDO an amplifier instead of a driver, thus choosing as the two primary drivers Extreme Weather Events (storms/precipitation), ranging from a 20% decrease to a 20% increase; and Seasonality of Water Flow, ranging from historical flow/timing to “abnormal” flow/timing.

Table 2: Climate driver assessment by the Terrestrial group.

	High Uncertainty	Important
Extreme events –precipitation	Yes	Yes
Extreme events – storms	Yes	Yes
Precipitation	Yes	No
Water availability – changed to “seasonality of water flow”	Yes	Yes
PDO – certain that it does occur, but timing is highly uncertain	Yes	No
Increased temperature	No	Yes
Increased growing season length	No	Yes
Increased length of ice-free season	No	Yes
Extreme events - storms	No	Yes

Terrestrial Group Biophysical Scenarios Developed from Selected Drivers

Each quadrant resulting from the selected drivers represents a different scenario of potential future temperature and extreme storm events (Figure 11). General assumptions/certainties for all quadrants included the fact that the climate would be expected to be warmer, although the magnitude of the warming may be either dampened or amplified by the PDO. A slight increase in precipitation (5-16% based on SNAP projections) was also assumed.

Other considerations included the fact that river and stream temperatures may increase, but glacial feeding could make temperatures decrease. This could also affect nutrient influx.

As glaciers retreat, new species (vegetation and animals) would move into newly vacated areas

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

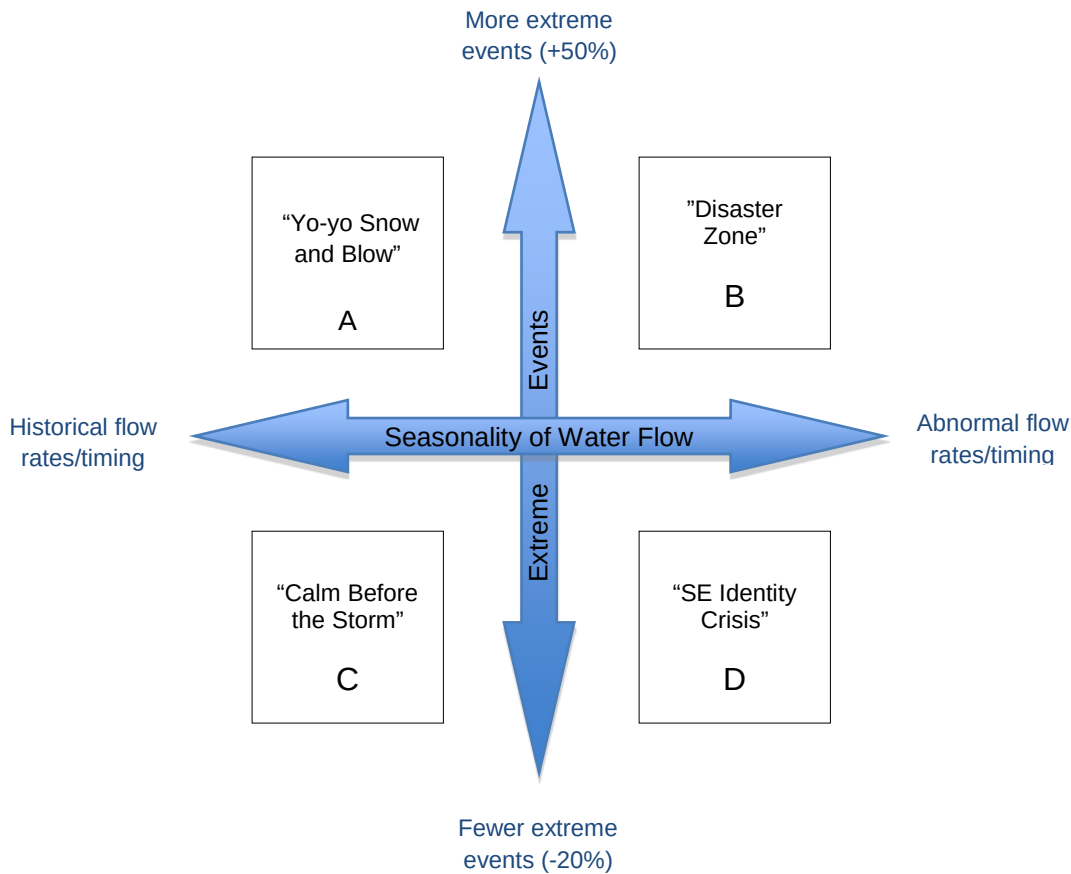


Figure 11: Primary drivers selected by the Terrestrial group. When crossed, these drivers create four divergent biophysical scenarios.

The resulting scenarios for the Terrestrial group were:

- A. "Yo-yo Snow & Blow," with historical flow rates/timing and more extreme events,
- B. "Disaster Zone," with abnormal flow rates/timing and far more extreme events,
- C. "Calm Before the Storm," with historical flow rates/timing and low extreme events, and
- D. "SE Identity Crisis," with abnormal flow rates/timing and low extreme events.

Terrestrial Group Scenario A: "Yo-yo Snow & Blow"

- The "Yo-yo Snow & Blow" scenario envisions a future in which stream flow rates and timing are on par with historical rates and timing, but extreme events are more frequent. Potential effects of such conditions include: episodic events and reduced resources
- Floods
- Forest blowdown
- Extreme fluctuation in fisheries/wildlife – depends on species = which are able to adapt? Some might flourish or become more stable? (Fluctuation vs destruction)
- More snow = deer die off, but then recover in subsequent years
- Big flood = wipes out salmon, invertebrates, but then recover in subsequent years
- Structural damage to facilities/infrastructure (historical/cultural)

- Transportation disruptions
- Heavier snowfall events (=avalanches) – large snow loads & blizzards
- Heavier rainfall events (=floods)
- More snow = grows glaciers at higher elevations? – not really “stable,” rather continued retreat of lower elevation glaciers while upper elevation glaciers get thicker (as temperatures increase, warmer air masses bring more moisture = more snow at higher elevation, more rain at lower elevations)
- More snow = more successful small rodents (subnivian = animals who live under snow)
- Slight increases in river and stream temps
- Salmon population unaffected
- Little opportunity for human adaptation (too yo-yo)
- Less focus on preservation and health because people too focused on responding to immediate disasters (compared with “ID crisis”)

Terrestrial Group Scenario B: “Disaster Zone”

- The “Disaster Zone” scenario envisions a future in which stream flow rates and timing are abnormal, and extreme events are much more frequent. Potential effects of such conditions include: natural disasters/catastrophic events more frequent
- Floods
- Fire – highest fire risk of the 4 quadrants
- Drought
- Glacial dams fail or develop
- Landslides
- Avalanches
- Blizzards
- Earthquakes
- Forest pests
- Forest blowout
- Riverbank erosion (with trees getting cut down)
- Water availability affected
- Tourism affected
- Movement or loss of species/migration affected
- Berries affected, which in turn affects bears
- River and stream temps
- Drastic loss of salmon – local extinction

Terrestrial Group Scenario C: “Calm Before the Storm”

- The “Calm Before the Storm” scenario envisions a future in which stream flow rates and timing are on par with historical rates and timing, and extreme events are less frequent. Potential effects of such conditions include: calm/moderate weather
- People attracted to area = more visitors/tourism
- Increase in invasive species (species move north and up in altitude)
- Glacial retreat continues
- More conflicts for use of resources

- Increased tourism = economic boost
- Slight increases in river and stream temps
- Salmon population unaffected
- More opportunity for human adaptation as changes happen at a more steady pace

Terrestrial Group Scenario D: “SE Identity Crisis”

- The “SE Identity Crisis” scenario envisions a future in which stream flow rates and timing are abnormal, but extreme events are less frequent. Potential effects of such conditions include: flooding
- Drought
- Disrupted fisheries
- Glacial loss/gone at lower elevations
- Coastal salinity issues
- Habitat change, food availability
- Increased coastal access, more fjords
- Vegetation and wildlife changes --- changes may be slow and steady ---habitat shifts of *mobile* species
- Shift in species composition
- Yellow cedar die
- Subnivian (underneath the snow) animals decline
- More fire
- Vegetation migration from south
- Wetlands impacted
- Riverbank erosion, houses lost
- Watershed loss -> cisterns, small ponds
- Insects and disease
- Ecological tipping point
- Decreased tourism or shift to Hubbard?
- Different marketing?
- Change is more predictable

Terrestrial Group Nested Scenarios and Implications

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

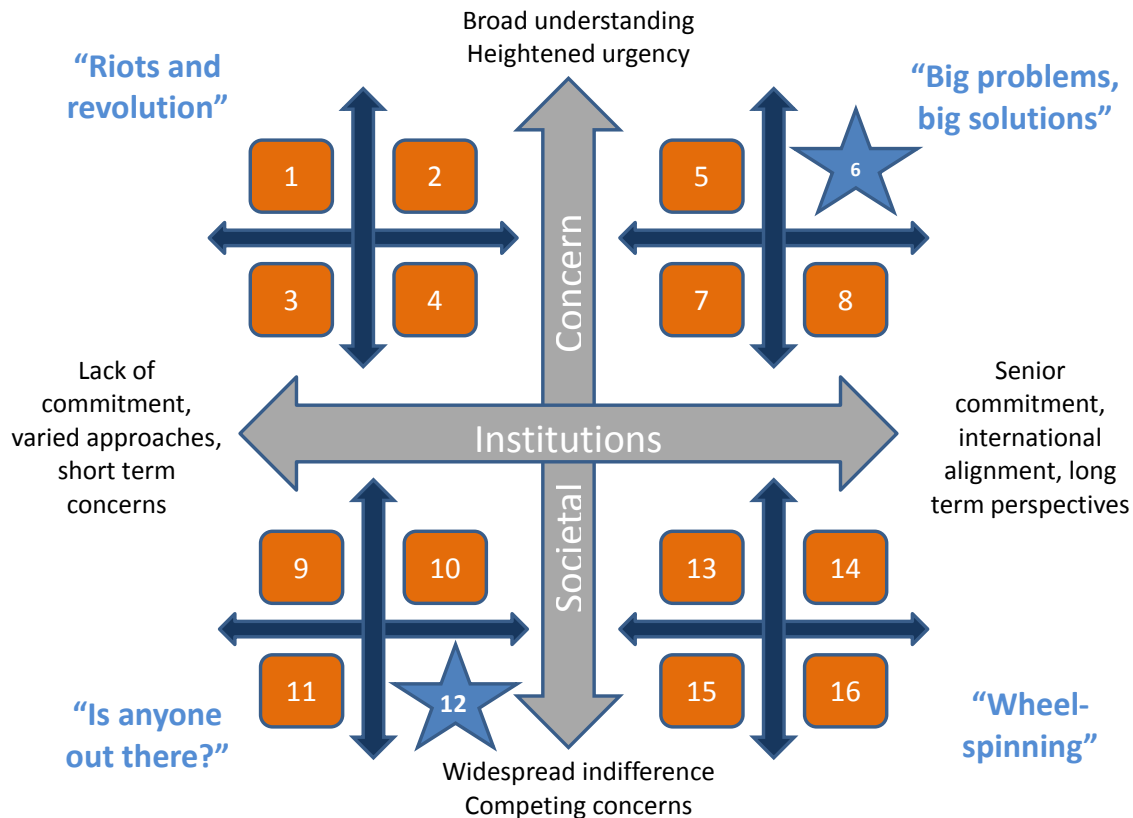


Figure 12: Terrestrial Nested Scenarios. The two nested scenarios selected by the Terrestrial group are marked by blue stars.

First Terrestrial nested scenario: "Southeast Identity Crisis" in "Is Anyone Out There?"

The following effects, issues, implications, and suggested needs and actions were identified by the Terrestrial Group in the event that the "Southeast Identity" scenario (with abnormal flow rates/timing and low extreme events) was 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) of the socio-political matrix (Figure 12).

Political/Social/Economic Implications

- What's happening now will continue. No major disasters, and no one can directly link these changes to climate change. Our political atmosphere will continue, i.e. competing concerns.
- Big economic drivers could make climate change drop out of the picture... other political concerns overshadow concerns of climate change.
- Thrust for smaller government continues. Agencies are not funded to deal with issues lower than national security. Some agencies dissolved.
- Increased corporate control. Corporate influence increases. Multinational corporations are the dominant interest in local communities.
- With great corporation influence and less federal influence, communities will be more responsible for social services (including environmental issues)?

- Corporations in SEAN specifically = logging (biofuels), tourism, fisheries, mining.
- Adaptation is not happening (Is Anyone Out There?)
- Higher fuel costs and less ability to supply

Major Impacts on the Bioregion

- Increasing temperatures
- Reduced flows
- Retreating glaciers
- Hibernation for bears shorter
- Salmon and fish = low productivity
- Vegetation shifts – including yellow cedars which advance north and up
- Habitat loss – changes in habitat – more disturbance to younger
- Habitat loss forces wildlife populations to adapt or move.
- Reduced habitats include wetlands, riparian zones, alpine & old growth forests.
- Areas vacated by de-glaciation creates habitat for deer and new vegetation.
- Potential wildfires
- Wetlands and muskegs (35-40% of landscape is wetlands) – lower water tables
- Increased incidence of peat fires = affects habitat, berries
- Changes in wildlife populations, habitat, fisheries
- Tree die off in riparian areas (around streams) from disease, pests, etc., exposes streams to sun, results in warmer stream temperatures = affects fish
- Dying forests create poor salmon and other fish productivity
- Deer population shifts
- Loss of glaciers – in 20 years, Tracy Arm will not have glaciers, but Glacier Bay will still have the tidewater glaciers. Example: Portage Glacier = huge visitor's center built, but now you can't see the glacier from the visitor's center!
- Biomass productivity? (logging?)

Issues Facing Management

- Pressure to reduce the size of federal government will force consolidation of agencies and less capacity overall (what they refer to as “streamlining”). Also, as agencies merge, potential for merging disparate interests = institutional chaos, inability to manage climate change.
- Administrative distraction:
 - e.g. fisheries: US Fish & Wildlife Service, National Oceanic and Atmospheric Administration (NOAA)
 - e.g. climate: US Geological Survey (USGS), National Weather Service (NWS)
- Competition for fish resources between commercial fishing, sport fishing, and subsistence needs intensifies
- Agencies and communities need to adapt to changing tourism patterns/demands. Shifting tourism ... NPS is a tourism agency
- Lack of education about science, environment, climate change
- Impacts of loss of subsistence means, TEK, and native culture
- Fuel costs and economic conditions produce challenges for Alaska ferry system. (SE transportation plan).

Second Terrestrial nested scenario: “Disaster Zone” in “Big Problems, Big Solutions”

The following effects, issues, implications, and suggested needs and actions were identified by the Terrestrial Group in the event that the “Disaster Zone” scenario (with abnormal flow rates/timing and far more extreme events) was to occur under the conditions described for the “Big Problems, Big Solutions” quadrant (which describes a future in which both local and institutional commitment regarding climate are high) of the socio-political matrix (Figure 12).

Political/Social/Economic Implications

- More and more annual disasters are striking SE AK, and government and people are working together to deal with major issues and to find and coordinate responses.
- Community health and economic health are both emphasized, meaning not just solutions such as starting a hatchery, but also finding holistic solutions to maintain ways of life.
- If fisheries and forestry are lost, what is replacing them? Sustainable tourism? Selective logging? Renewable energy, Biomass? Tidal? Wind? Geothermal? Hydro? All these resources are so close together, it is unusual.
- Individuals all feel interdependence and feel their important role in the communities.
- A combination of fire and floods destroy the cultural resources in Skagway and it becomes a ghost town and a more remotely managed park
- 50% of the small communities have to evacuate due to natural disasters, and are reabsorbed into other communities.
- Reduced potable water availability
- Loss of life – or shifting from death from social ills to death via disaster.
- Transportation disruptions with ferries, airports.
- Energy, buildings, waste disposal, social health networks, communications
- Willingness and ability to create and pay for engineered solutions, e.g. hatcheries
- Mariculture?
- Logging out the dead trees, but planting something that matches new ecosystem conditions
- More flightseeing to see reduced glaciers

Major Impacts on the Bioregion

- Major shifts in habitats, species, and tourism. Recolonization by willow in de-glaciated areas attracts moose and deer. Forest becomes grassland of engineered forests. Might attract elk, bison, and grouse. Mountain goats and other species move higher.
- Reduction in timber productivity
- Invasive species that may wipe out local species, in addition to more benign range shift.
- Seasonal crop failures balanced by other crops – shifting resources rather than eliminated.
- Collapse of commercial fishery

Issues Facing Management

- Decide how to switch from wilderness to more managed areas mixed with areas of dynamic change
- Parks are now managed for different resources. There used to be glaciers in Yosemite, but people still go there. Different visitor experience is being managed in different parks

- to see new energy sources, to see glaciers in Wrangell St Elias., from soft adventure to extreme adventure.
- Management faces infrastructure upgrades, need to be more disaster resistant
- Health emergencies help spark adaptations and change.

Management Actions and Research 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.

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's narrative took the form of the agenda for a climate change planning workshop for southeast Alaska in the year 2030; another group told the story of a future world through a series of Facebook posts; a third group wrote a story using the Raven character common to traditional Alaska Native stories; and the fourth narrative is a transcript of a conversation between a teenager and a legislator.

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

Management actions and research needs identified by both work groups and common to all four nested scenarios selected for this planning workshop are outlined below. They are grouped into three categories, reflecting recommendations for cooperation and information sharing, increased monitoring efforts, and planning for emergencies and disaster. However, some recommendations cross over between these categories. Many of the recommendations reflect the need for greater adaptability 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 work groups also stressed the need for assessing future needs, through any or all of several avenues, such as information-sharing, monitoring, and vulnerability assessment. In other words, part of the route to successfully managing future needs is to repeatedly assess both current and future needs.

Cooperation and Information Sharing

- TEK in planning
- Co-management
- Management of invasive species
- Cooperation at local level
- Collaborative process: bring communities to the table
- Need to develop deep relationships and build trust
- Bring in other groups, e.g. tourism industries, fisheries, logging, other landowners in AK (SeaAlaska, tribal groups, etc.), Parks Canada
- Importance of place-based education and collaboration between groups
- Value-based management

- o How to make hard decisions?
- o Values are changing—need a transparent decision process

Increased Monitoring

- Many types of monitoring
- Importance of water monitoring and stream flow
- Parks as living laboratories
- Potential problems within wilderness areas

Planning for emergencies and disasters

- Vulnerability and risk assessments (cultural resources/infrastructure)
- Emergency preparedness teams
- Staff with multi-interdisciplinary skills
- Budget issues
- No regrets actions might not be enough if trending in one direction

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

Two important factors enriched and strengthened the process. First, the group that came together – first via teleconference and later in the workshop itself – represented a broad range of interests, experiences, and knowledge. Not only was NPS represented at the Park and regional level, but these experts were joined by modelers and climate researchers from SNAP; representatives of Alaska Native subsistence and other local interests; representatives from nonprofit conservation organizations; and experts from other government agencies. Participants were engaged in the process, and contributed to the inputs, 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_Southeast_Alaska/).

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

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

Climate change impacts of particular concern in Southeast Alaska, as identified via this process, include changes in marine habitat and stream flow and their effects on cultural and historical resources, natural resource, communities, marine life, and subsistence food sources. These potential effects are primarily driven by increased air and ocean temperatures, and accompanying changes in glaciers, storms, vegetation, and wildlife. Increased variability in weather patterns can cause the timing of migration and food abundance to longer be in synchrony. Melting glaciers can significantly affect the landscape and water availability, affecting vegetation and wildlife downstream. Ecosystem shifts can drastically alter human experience for both visitors and residents – in particular, impacts to native species such as fish, berries and yellow cedar trees could have profound effects on the long-standing traditions of local Alaska Native populations. Shifts in the economies associated with changes to terrestrial and marine ecosystems 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 Southeast Alaska scenario planning 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 storms are a near certainty. “Wait and see” may be the preferred approach (and consistent with NPS policy) for dealing with effects of ocean acidification. 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>



Southeastern Alaska National Parks
Climate Change Scenario Planning Workshop
Mendenhall Glacier Visitor Center, Juneau AK
February 21-24, 2012
FINAL AGENDA



Tuesday February 21st

12:30 pm		ARRIVAL and COFFEE
1:00 pm	Plenary	➤ Welcome: Include: restrooms, snacks, coffee, eateries, group dinner, vehicles/transportation, lodging etc. ➤ Introductions & Participant Expectations ➤ Workshop Objectives, Agenda, Ground Rules
1:30 pm	Plenary	➤ Explain Scenario Planning, Review Scenario Process, and Introduce the Focal Question(s) (<i>Address scale: park & bioregion</i>) Feedback from group on how to narrow the focal question
2:00 pm	Plenary	➤ Present science information / overview / present a case study to illustrate scenario process ○ General insights ○ Climate drivers / uncertainties → handouts and input from group ○ Potential effects/impacts → handouts and input from group ○ How to create scenarios using uncertainties, drivers, and effects table (examples from other CC Scenario Workshops)
3:00 pm		BREAK
3:15 pm	Plenary Groups	➤ Video of CC Scenario, break into 2 groups ➤ Identify key climate drivers with “high uncertainty” but “high impact and importance” leading to challenging, plausible, relevant, and divergent futures. Keep in mind the effects tables when identifying “high impact.” Also identify relatively certain climate drivers.
4:45 pm	Plenary	ADJOURN – Final thoughts for the day

Wednesday February 22nd

8:00 am		ARRIVAL, COFFEE and LIGHT BREAKFAST
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	
		➤ Select climate drivers and test matrix combinations. Draw from impacts table to detail implications for each scenario (e.g. natural & cultural resources, facilities, interpretation)
10:00 am		BREAK
10:15 am	Groups	➤ Continue to detail implications for each scenario
11:30	Plenary	➤ Report-out: Groups share draft climate driver frameworks with key characteristics of scenarios
12:00 pm		LUNCH
1:00 pm	Plenary	➤ Describe Socio-Political Framework relevant to Alaska
1:30 pm	Groups	➤ Explain nested scenarios ➤ 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.
3:00 pm		BREAK
3:15 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) ➤ 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
4:15 pm		
4:45 pm	Plenary	FINAL THOUGHTS / QUESTIONS/ADJOURN for Day

Thursday February 23rd

8:00 am		ARRIVAL, COFFEE, and LIGHT BREAKFAST
8:15 am	Plenary	➤ Video of Climate Change Scenario
		➤ Overnight Insights
8:30 am	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)
10:00 am		BREAK
10:15 am	Plenary	➤ Explain management implications & actions
10:30 am		➤ 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
10:45 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.
12:00 pm		LUNCH
1:00 pm	Groups	➤ Continue to identify potential actions. Consider the best way to communicate the issues.
3:00 pm		BREAK
3:15 pm	Groups	➤ Groups finalize management implications, and if time permits, work on scenario narratives
3:45 pm	Plenary	➤ Groups present management implications to the larger group, and discuss.
4:45 pm	Plenary	FINAL THOUGHTS / THANKS/ADJOURN

Friday, February 24th

8:00 a.m.		ARRIVAL, COFFEE, and LIGHT BREAKFAST
8:15 p.m.	Plenary	➤ Overnight insights – additional thoughts on management implications
8:30 a.m.	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.
10:15 a.m.	Plenary	FINAL THOUGHTS / THANKS/ADJOURN

Appendix B: Participant List

Lead team

Bob Winfree	National Park Service, Alaska Regional Office, Regional Science Advisor
Bud Rice	National Park Service, Alaska Regional Office, Environmental Protection Specialist
John Morris	National Park Service, Alaska Regional Office, Interpretive Specialist
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
Don Callaway	National Park Service, Cultural Anthropologist (retired)
Don Weeks	National Park Service, Colorado, Climate change resource coordinator

Participants

Susan Boudreau	National Park Service, Glacier Bay NP, Superintendent
Lisa Etherington	National Park Service, Glacier Bay NP, Chief of Resources
Mike Goldstein	U.S. Forest Service, Alaska Coastal Rainforest Center, Vulnerability
Steve Gray	U.S. Geological Survey, Climate Science Center, Director
Cassie Hauser	University of Tennessee, MS Student
Tahzay Jones	National Park Service, Alaska Regional Office, Coastal Resources
Susan Kasinger	Wrangell Cooperative Association (WCA) Tribe
Greg Killinger	U.S. Forest Service, Tongass National Forest, Staff Office for Fish, Watershed, and Soils
Corrie Knapp	University of Alaska Fairbanks, PhD Student
Leilani Knight-McQueen	Central Council Tlingit Haida Indian Tribes of Alaska, Environmental Coordinator
Randy Larson	National Park Service, Sitka NHP, Superintendent
Amanda McCutcheon	National Park Service, Klondike Gold Rush NHP
Brendon Moynahan	National Park Service, Southeast Alaska Network, Inventory and Monitoring Program
Kris Nemeth	National Park Service, Glacier Bay NP, Chief of Interpretation
Raymond Paddock	Central Council Tlingit Haida Indian Tribes of Alaska, Education and Youth Outreach
MaryAnn Porter	Yakutat Tlingit Tribe, Environmental Director
Chris Sargeant	National Park Service, Southeast Alaska Network, Ecologist
Barbara Schrader	U.S. Forest Service, Regional Ecologist
Craig Smith	National Park Service, Sitka NHP, Park Biologist
Kelly Smitherman	National Park Service, Sitka NHP, Education Specialist
Miranda Terwilliger	National Park Service, Wrangell-St Elias National Park, Park Ecologist
Jim Thomas	U.S. Forest Service, Juneau, Regional Planner
Eric Veach	National Park Service, Wrangell-St Elias NP, Chief of Resources
Pat Warren	Chilkat Indian Village, Environmental Planner
Jessica Wilbarger	National Park Service, Klondike Gold Rush NHP

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?

IPPC Global Climate Models

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

Model Selection

- » SNAP investigator Dr. John Walsh and colleagues analyzed how well each model predicted monthly mean values for three different climate variables (surface air temperature, precipitation, and sea level air pressure) over four overlapping northern regions (Alaska, Greenland, latitude 60-90°N 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



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

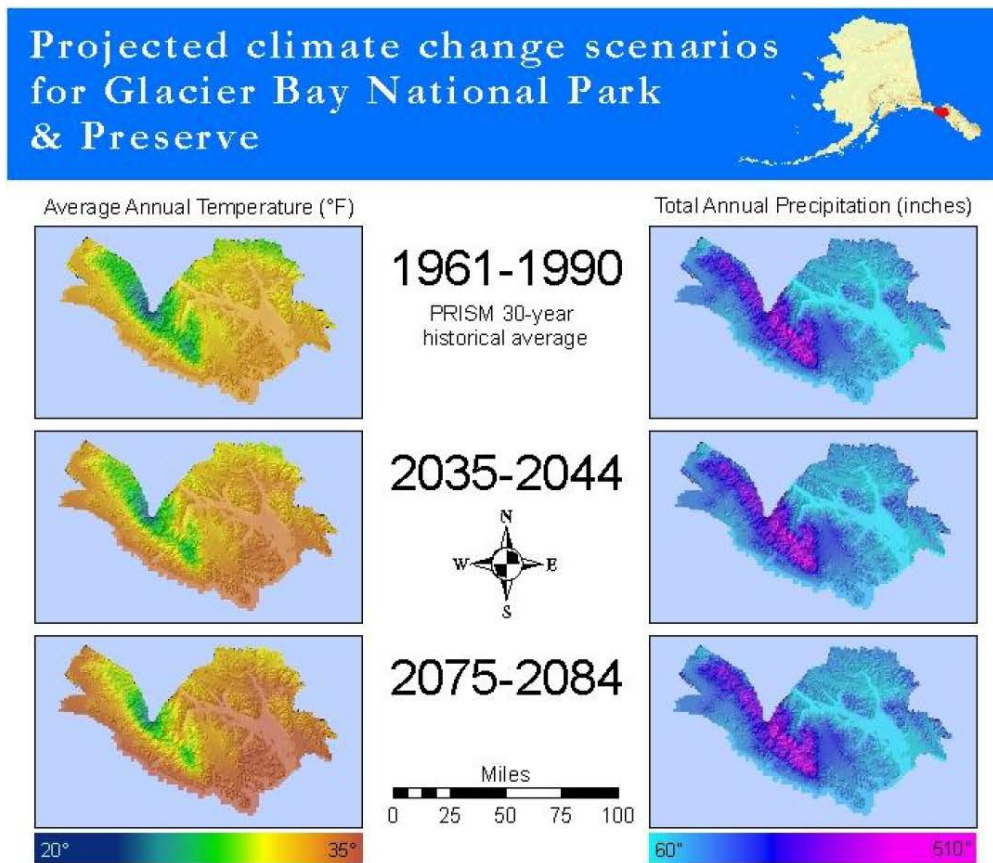
Estimating future air temperature, rainfall, and snowfall are just the first steps towards planning for change. Stakeholders who want more detailed information can create collaborative agreements with SNAP in order to work on projects that link climate data to variables such as permafrost thaw; timing 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.



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Appendix D: Climate Summary Reports



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*
Annual	Hist.	35.4 ± 1.9	NA	Annual	Hist.	159.4 ± 29.2	NA
	2040	38.7 ± 1.9	3.2		2040	166.4 ± 29.2	4%
	2080	41.5 ± 1.9	6.1		2080	170.4 ± 29.2	7%
Summer	Hist.	47.3 ± 1.6	NA	Summer	Hist.	52.0 ± 8.1	NA
	2040	49.6 ± 1.6	2.3		2040	54.6 ± 8.2	5%
	2080	52.1 ± 1.6	4.8		2080	55.4 ± 8.1	7%
Winter	Hist.	27.0 ± 2.2	NA	Winter	Hist.	107.4 ± 21.3	NA
	2040	30.9 ± 2.2	3.9		2040	111.9 ± 21.3	4%
	2080	34.0 ± 2.2	7.0		2080	115.1 ± 21.3	7%

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

For more information:

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

01/09

Climate Change Implications for Glacier Bay 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 Glacier Bay 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 3°F by 2040 and as much as 6°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 near the freezing point (~35°F), to temperatures well above the freezing point (~42°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 34°F by 2080, a figure that represents an impressive 7°F rise from the historical 27°F average. Average summer temperatures are projected to rise by almost 5°F by 2080 (from ~47°F to ~52°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 Glacier Bay 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 7%, 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 7% 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

Glacier Bay 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.

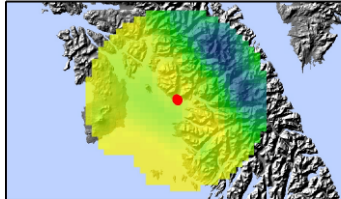
¹ This emissions outlook is the "A1B" scenario from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment, published in 2007. The models used in this analysis included ECHAM5, GFDL2.1, MIROC3.2MR, HadCM3, and CGCM3.1.

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 Sitka National Historic Park & surrounding area

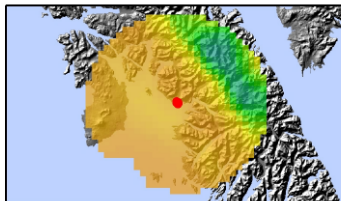


Average Annual Temperature (°F)

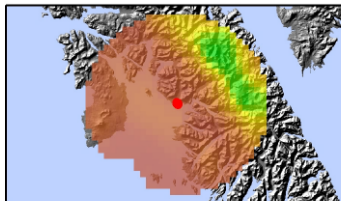


1961-1990

PRISM 30-year
historical average



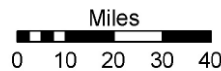
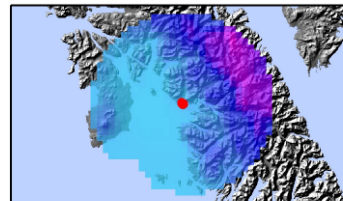
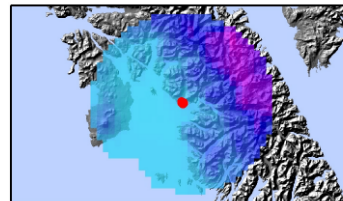
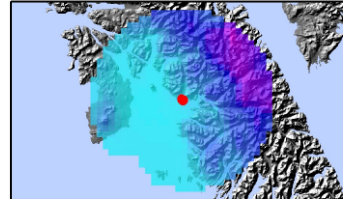
2035-2044



2075-2084



Total Annual Precipitation (inches)



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.	42.2 ± 0.8	NA	Annual	Hist.	122.6 ± 10.8	NA	NA
	2040	45.1 ± 0.7	2.9		2040	130.1 ± 10.8	7.4	6%
	2080	47.8 ± 0.7	5.6		2080	133.7 ± 10.8	11.1	9%
Summer	Hist.	50.9 ± 0.6	NA	Summer	Hist.	37.9 ± 2.7	NA	NA
	2040	53.3 ± 0.6	2.3		2040	40.1 ± 2.7	2.1	6%
	2080	55.6 ± 0.6	4.7		2080	41.0 ± 2.7	3.0	8%
Winter	Hist.	35.9 ± 0.9	NA	Winter	Hist.	84.7 ± 8.3	NA	NA
	2040	39.2 ± 0.9	3.3		2040	90.0 ± 8.3	5.3	6%
	2080	42.2 ± 0.9	6.3		2080	92.8 ± 8.3	8.1	10%

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

For more information:

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01/09

Climate Change Implications for Sitka National Historic Park & Surrounding Area



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 Sitka National Historic Park & surrounding area

Temperatures are projected to increase over the coming decades at an average rate of about 0.6°F per decade. Average annual temperature is expected to rise by about 3°F by 2040 and almost 6°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 near 42°F to temperatures approaching 48°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 42°F by 2080, a figure that represents more than a 6°F rise from the historical 36°F average. Average summer temperatures are projected to rise by almost 5°F by 2080 (from ~51°F to ~56°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 Sitka National Historic Park & surrounding area

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. Although summer rainfall is expected to rise by 8%, 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 10% and is likely to fall in the form of 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

Sitka National Historic Park & surrounding area 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.

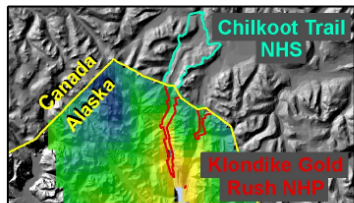
¹ This emissions outlook is the "A1B" scenario from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment, published in 2007. The models used in this analysis included Echam5, Gfdl2.1, Miroc3.2MR, HadCM3, and CGCM3.1.

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 Klondike Gold Rush National Historic Park & surrounding area



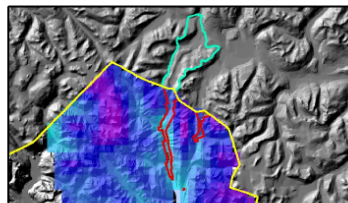
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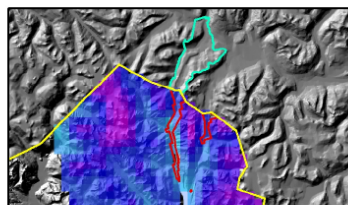
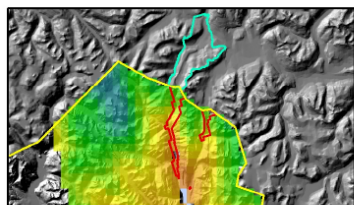
1961-1990

PRISM 30-year
historical average

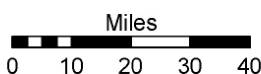
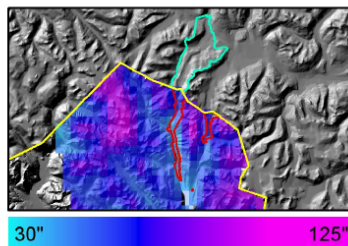
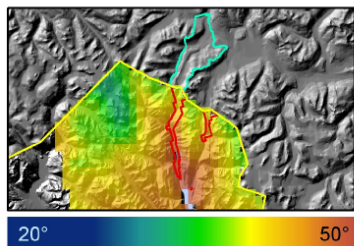
Total Annual Precipitation (inches)



2035-2044



2075-2084



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.	33.9 ± 1.2	NA	Annual	Hist.	65.2 ± 5.0	NA	NA
	2040	37.3 ± 1.2	3.5		2040	71.2 ± 5.0	6.0	9%
	2080	40.4 ± 1.2	6.5		2080	74.9 ± 5.0	9.7	15%
Summer	Hist.	47.6 ± 1.2	NA	Summer	Hist.	22.9 ± 2.1	NA	NA
	2040	50.2 ± 1.1	2.6		2040	25.2 ± 2.1	2.3	10%
	2080	52.9 ± 1.1	5.4		2080	25.9 ± 2.1	3.1	13%
Winter	Hist.	24.0 ± 1.3	NA	Winter	Hist.	42.3 ± 3.4	NA	NA
	2040	28.1 ± 1.3	4.1		2040	46.0 ± 3.4	3.7	9%
	2080	31.4 ± 1.2	7.4		2080	48.9 ± 3.4	6.6	16%

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

For more information:

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

01/09

Climate Change Implications for Klondike Gold Rush National Historic Park & Surrounding Area



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 Klondike Gold Rush National Historic Park & surrounding area

Temperatures are projected to increase over the coming decades at an average rate of about 1°F per decade.

Average annual temperature is expected to rise by about 4°F by 2040 and as much as 7°F by 2080.

Considering the natural variation in temperatures across the study area, this is likely to result in a transition from average annual temperatures very near the freezing point (~34°F), to temperatures well above the freezing point (~40°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 31°F by 2080, a figure that represents more than an 7°F rise from the historical 24°F average. Average summer temperatures are projected to rise by more than 5°F by 2080 (from ~48°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 Klondike Gold Rush National Historic Park & surrounding area

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 13%, 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 16% 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

Klondike Gold Rush National Historic Park & surrounding area 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, GISS2.1, 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 Wrangell-Saint Elias National Park & Preserve



Average Annual Temperature (°F)



1961-1990

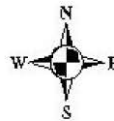
PRISM 30-year
historical average



2035-2044



2075-2084



Miles
0 60 120 180 240

0° 45°

Total Annual Precipitation (inches)



10" 400"

Magnitude of climatic change

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

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

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01/09

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



Climate Change in Alaska

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

In order to understand what these changes may be like, data from a composite of five down-scaled global circulation models was used to estimate decadal averages of future temperature and precipitation values within the preserve. These models assume a steady increase in carbon dioxide (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 Wrangell-Saint Elias National Park & Preserve

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

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

A likely outcome of these changes is a lengthening of the growing season, a change that could have profound 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 19°F by 2080, a figure that represents an impressive 8°F rise from the historical 11°F average. Average summer temperatures are projected to rise by slightly more than 5°F by 2080 (from ~42°F to ~47°F). Some species may benefit from these changes, while others may not be able to adapt or find suitable habitat conditions to sustain their populations.

Precipitation changes in Wrangell-Saint Elias National Park & Preserve

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

Summary of findings

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

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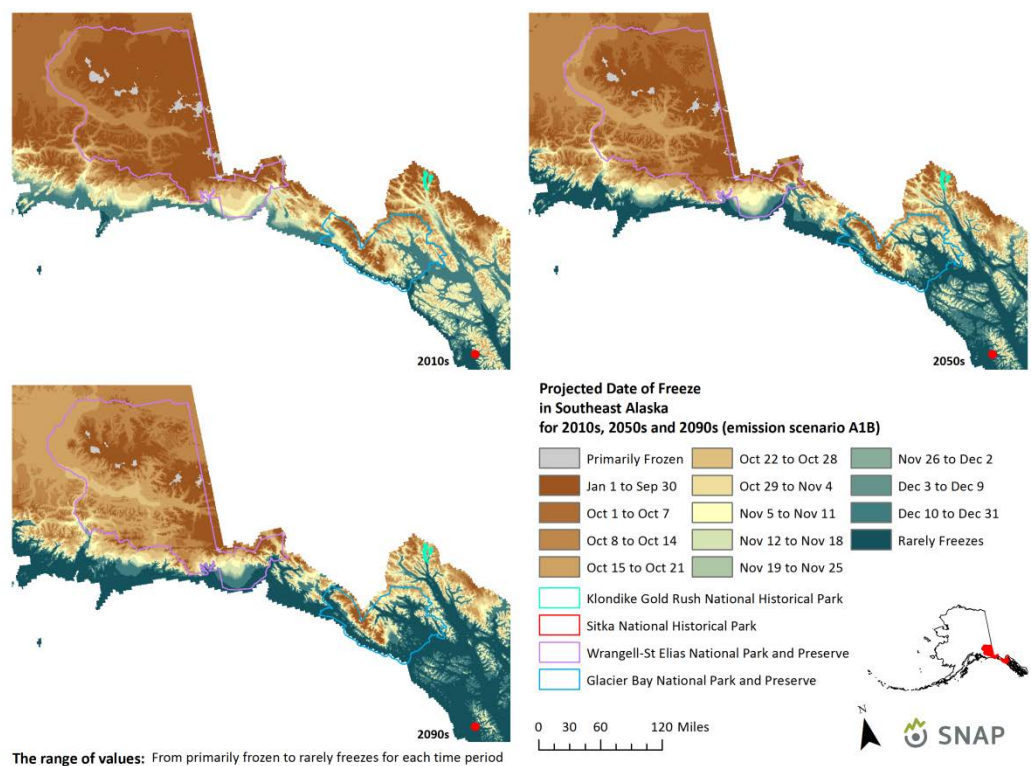
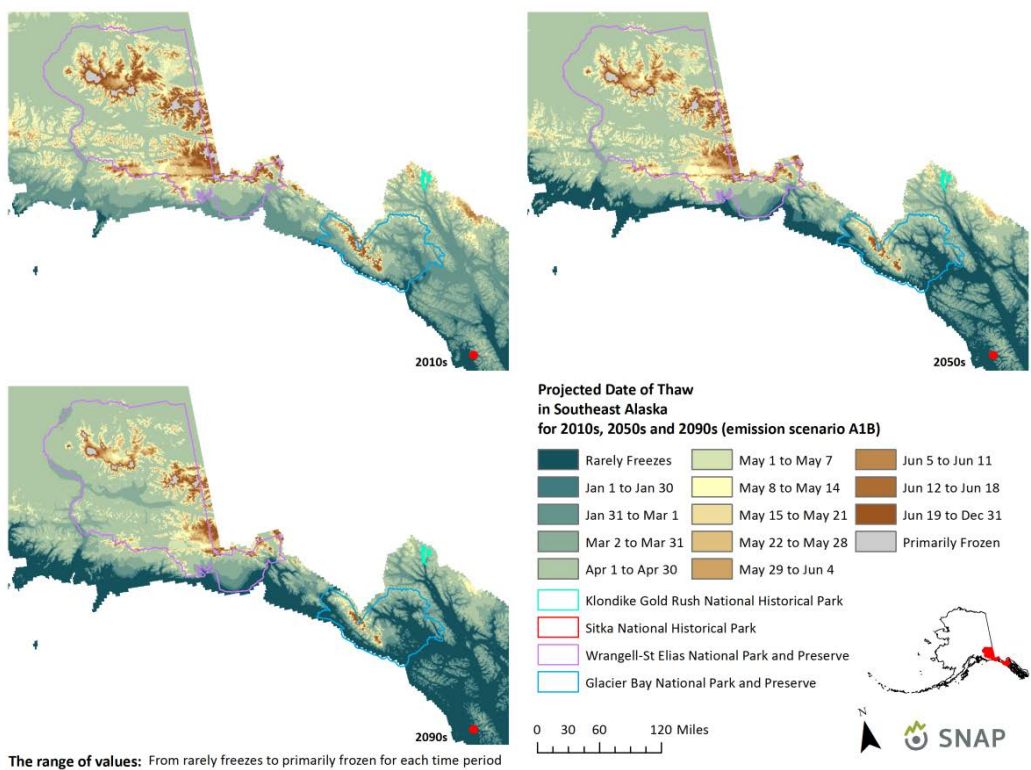
² Recent rates of global CO₂ emissions can be found on the Carbon Dioxide Information Analysis Center website (www.cdiac.esd.ornl.gov).

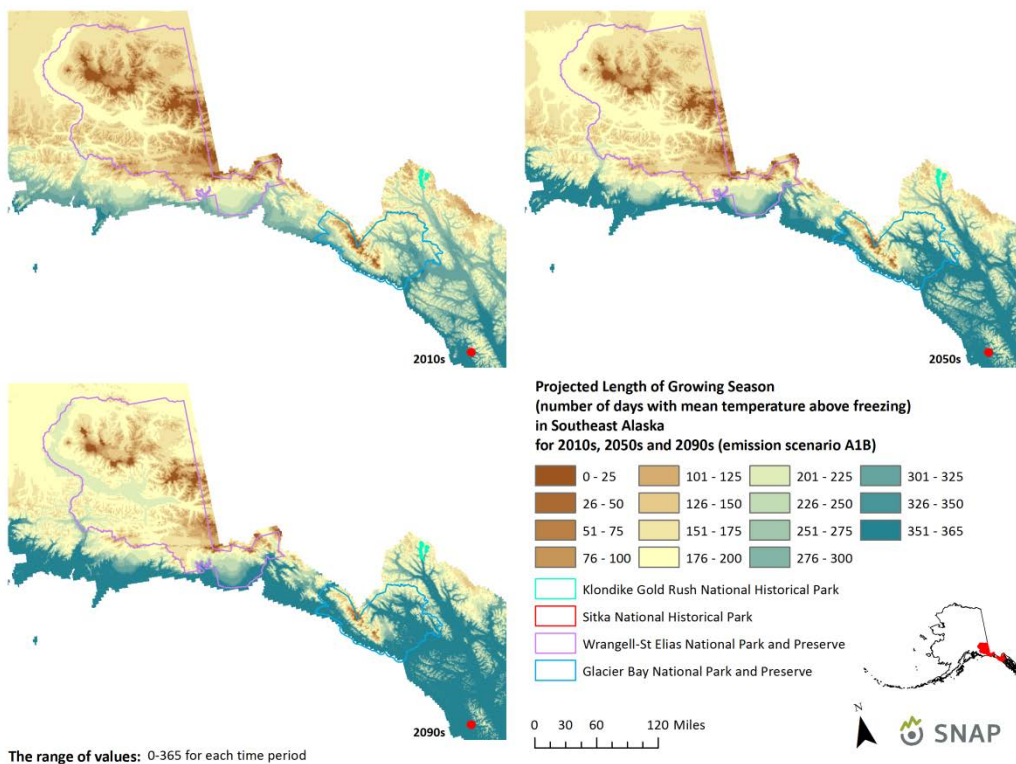
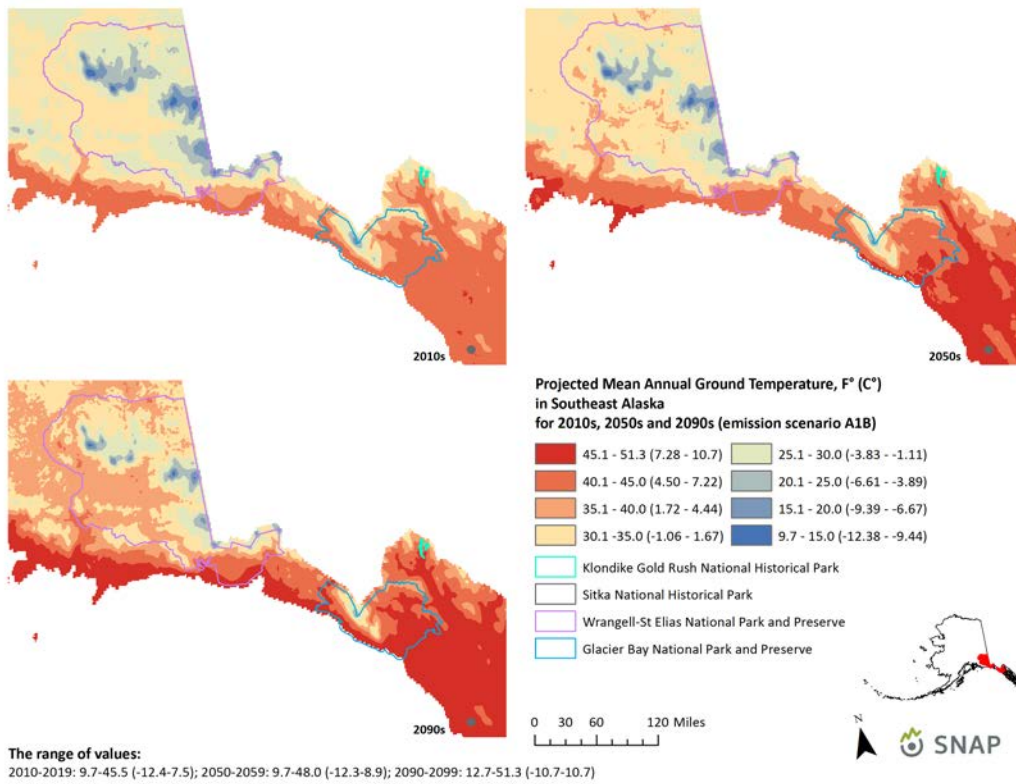
Appendix E: Southeast Alaska Modeled Climate Variables

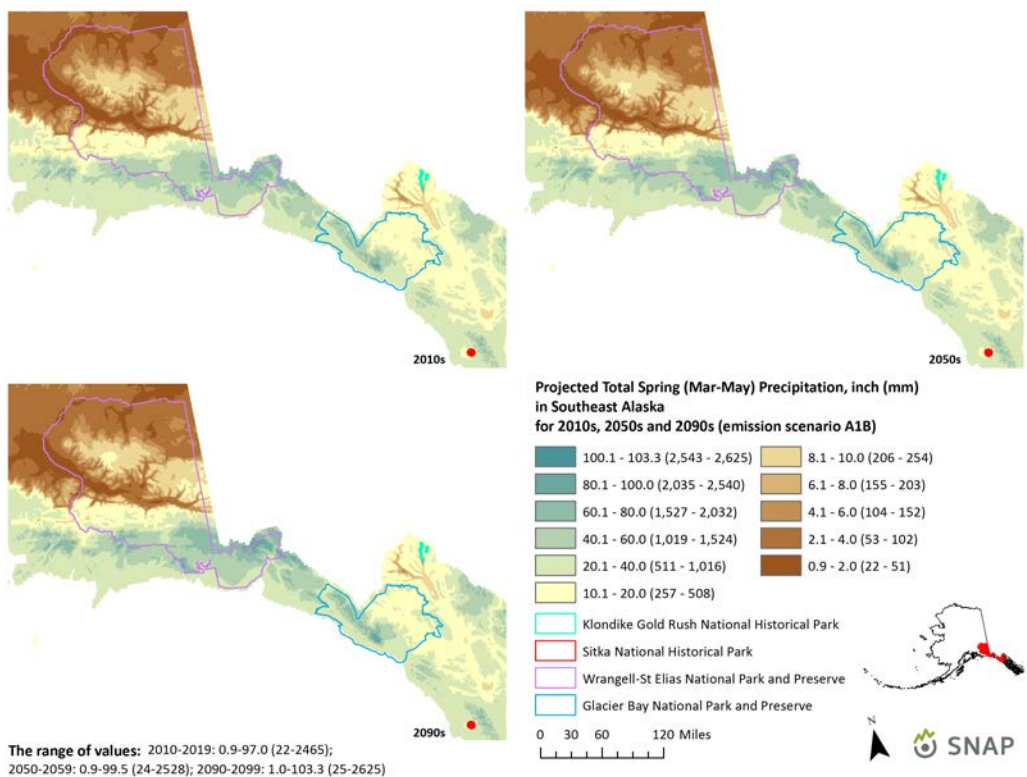
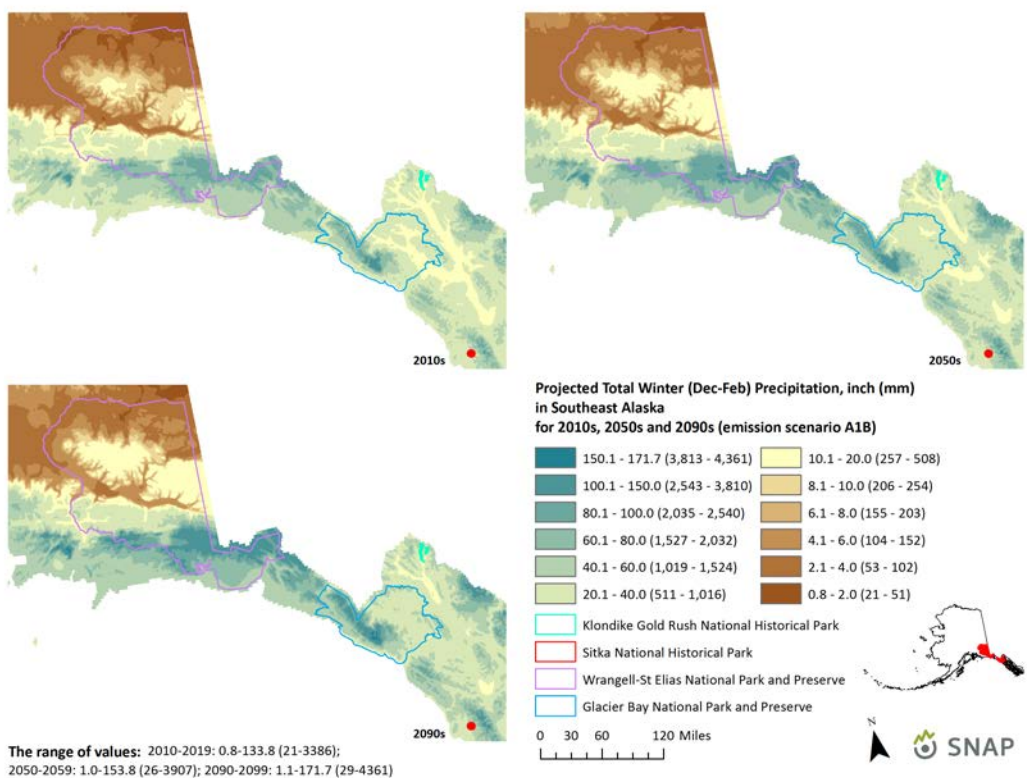
The set of maps included in this appendix were produced by SNAP. All maps represent projected data averaged across five downscaled GCMs and additionally averaged across decades (the 2010s, 2050s, and 2090s), in order to represent long-term trends. For a full description of SNAPs methods, see www.snap.uaf.edu.

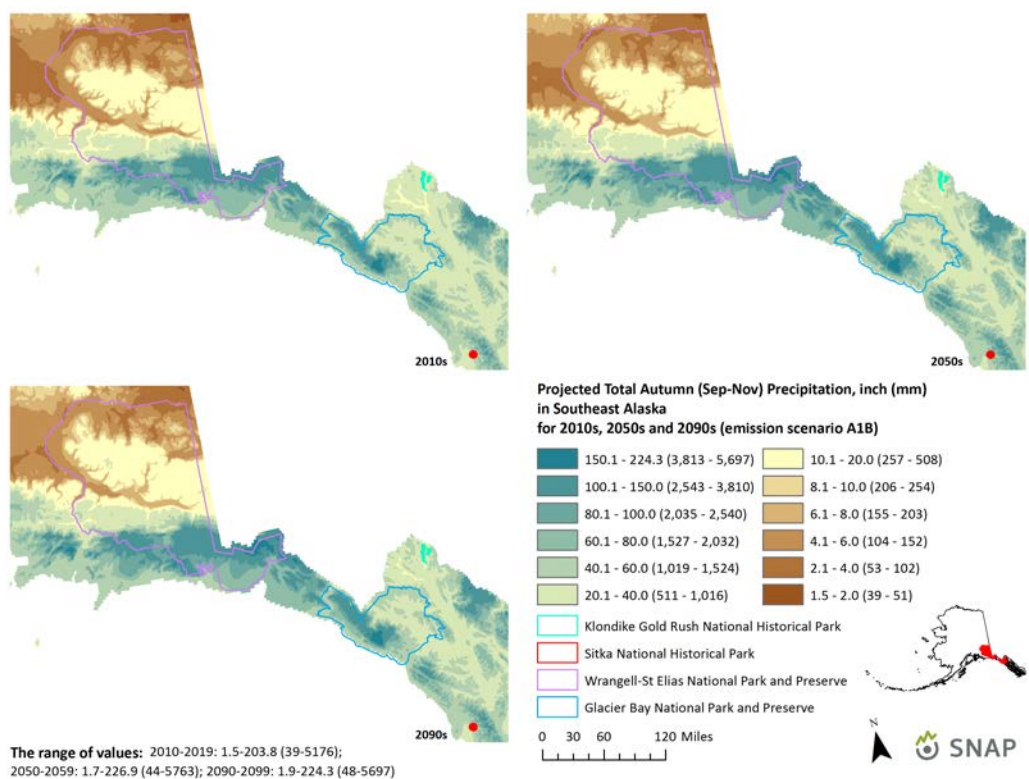
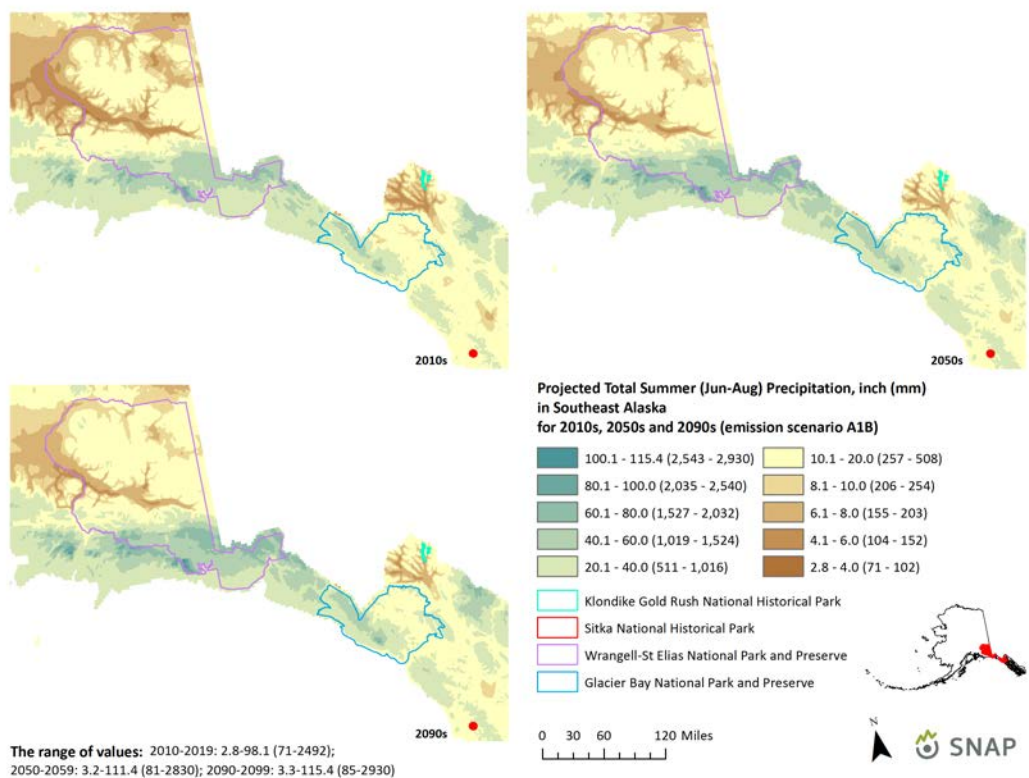
Maps included in this set include seasonal maps (three-month averages) for precipitation, as well as several temperature-linked maps, including projections for date of freeze, date of thaw, length of summer season, and ground temperature at once meter depth.

These maps show all 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-CCSP/2012_Southeast_Alaska/.









Appendix F: Climate Drivers Table

<i>Southeastern Park Units</i>				
Climate Variable	Projected Change by 2050	Projected Change by 2100	Confidence	Source
Temperature	+2°C ±1.5°C	+4°C ±2°C	>95% chance of increase	IPCC (2007); SNAP/UAF
Precipitation (rain and snow)	Increased precip (10%-20%), possible decrease in winter snow	Increased precip (20%-40%), possible decrease in winter snow	High uncertainty in timing of snowmelt	AMAP/SWIPA; SNAP/UAF
Freeze-up Date	5-10 days inland; freezeup may not regularly occur in coastal areas	10-20 days inland; freezeup may not regularly occur in coastal areas	>90%	SNAP/UAF
Length of Ice-free Season (rivers, lakes)	7-10 days inland; freezeup may not regularly occur in coastal areas	14-21 days; freezeup may not regularly occur in coastal areas	>90%	IPCC (2007); SNAP/UAF
River and Stream Temps	1–3°C	2–4°C	>90%	Kyle & Brabets (2001)
Length of Growing Season	increase of 10–20 days	increase of 20–40 days	>90%	IPCC (2007); SNAP/UAF
Sea Level	3–24 inches	7–72 inches	>90% chance of increase	IPCC (2007)
Water Availability (soil moisture = precip minus PET)	decrease of 0–20+%	decrease of 10–40+%	>66%; varies by region	SNAP/UAF; Wilderness Society
Relative Humidity	0% ±10% increase or decrease	0% ±15% increase or decrease	50% = <i>as likely as not</i>	SNAP/UAF
Wind Speed	2–4% increase	4–8% increase	>90% chance of increase	Abatzoglou & Brown
Pacific Decadal Oscillation (PDO)	Uncertain effect of atm circulation anomalies on Alaska's climate	Uncertain effect of atm circulation anomalies on Alaska's climate	High degree of natural variation	Hartmann & Wendler (2005)
Extreme Events: Temperature	3-6 times more warm events; 3-5 times fewer cold events	5-8.5 times more warm events; 8-12 times fewer cold events	>95%	Abatzoglou & Brown; Timlin & Walsh (2007)
Extreme Events: Precipitation	Change of –20% to +50%	Change of –20% to +50%	<i>Uncertain</i>	Abatzoglou & Brown
Extreme Events: Storms	Increase in frequency/intensity	Increase in frequency/intensity	>66%	Field et al. (2007)

Climate Drivers Table Citations

Abatzoglou, J.T., and T.J. Brown. 2011. A comparison of statistical downscaling methods suited for wildfire applications. *International Journal of Climatology* 32 (5): 772-780.

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Appendix G: Climate Effects Table

The table below outlines some of the possible effects of climate change in Southeast Alaska. These effects are drawn from model data, expert observations, and the existing literature, and were one of the primary references during upcoming workshop. In addition, prior to the workshop, participants were invited to take some time to answer a survey regarding the potential effects of climate change in the area. Results of this survey can be found in the Webinar 3 folder here: http://www.snap.uaf.edu/webshared/NPS-CCSP/2012_Southeast_Alaska/

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 annual 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.
	Sea ice	Less sea ice complicates travel, impacts ecosystems, and adds energy to storm surges. Seasonal reductions in sea ice increase the risk of spills contaminating coastal resources.
	Ice roads	Reduced winter transportation affects opportunities for travel and subsistence.
	Permafrost	Mercury & other pollutants are released into aquatic environments as permafrost thaws.
HYDROSPHERE	Sea level	Global average sea level is predicted to rise 1-6 feet by the end of the 21 st Century. Increased storm surges and permafrost erosion compound effects of change in sea level. Some coastal villages rapidly lose ground from storms, erosion and subsidence.
	Marine	Increasing sea surface temperature affects fish, seabird, and wildlife populations. Falling global phytoplankton could reduce ocean productivity and CO ₂ sequestration. Freshwater influx from thawing glaciers dilutes marine waters, stressing animals. Toxic marine algae & shellfish poisoning attributed to changes in water conditions. Ocean acidification affects food sources of fish, marine mammals and birds in the Arctic. Ocean acidification reduces sound absorption (by 40% by mid-century?)
	Estuarine	Coastal erosion and sea level rise increase the frequency of saltwater flooding. Some shallow water areas convert to terrestrial ecosystems with post-glacial rebound.
	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 level	Ground level rises in recently de-glaciated areas because of isostatic rebound.
	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 Earthquake activity increases in recently deglaciated areas due to isostatic rebound. Large and small tsunamis could result from collapse of unstable slopes in fjords. Coastal erosion claims both natural and cultural resources and constructed assets. 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.

Sector	Subsector	Potential Effects to Resources, Operations, and People
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	Average number of frost-free days for the Arctic could increase 20-40 days by 2100. 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. Mature yellow cedars decline across southeast Alaska, possibly due to lack of insulating snow.
	Fire	Models show a warmer climate leads to larger, more frequent and intense fires. Wildland fire hazards increase, affecting communities and isolated property owners. Fire-related landcover and soil changes result in vegetation shifts, permafrost thaw, etc.
BIOSPHERE - wildlife	Wildlife	Changes to terrestrial and aquatic species occur as ranges shift, contract, or expand, affecting visitor experience and subsistence Parks and refuges may not be able to protect current species within their boundaries. Animals and plants expand into landscapes vacated by glacial ice. Some species will suffer severe losses. So far, the greatest losses across all parks have been rodents, bats, and carnivores. Predator-prey relationships may change in unexpected ways. Migratory routes and destinations will change (e.g., wetlands, open tundra, snow patches).
	Birds	Arctic and alpine birds' breeding habitats reduced as trees and shrubs encroach on tundra. Kittlitz's murrelet populations decline with loss of important nesting and foraging habitat. Waterfowl shifts occur as coastal ponds become more salty. Productivity of nesting shorebirds may increase if schedules change to coincide w/ insects. Predation on ground nesting birds could increase if prey (lemming) abundance declines. Coastal seabirds (e.g. Ivory Gull and Aleutian Tern) are vulnerable to climate change. Population cycles of birds and their prey could be out of sync due to higher temperatures.
	Marine Mammals	Arctic marine mammals (e.g. seals, walrus and whales) are affected by sea ice decline. Less sound absorption (ocean acidification) affects marine mammals that rely on echolocation. Polar bears may have increasing difficulty accessing prey and finding shelter.
	Caribou/ Reindeer	Caribou and reindeer health are affected by changes in weather, forage, and insects and pests. Earlier green-up could improve caribou calf survival because of more available forage. Caribou may suffer heavy losses if rain events prevent successful feeding during cold weather.
	Moose	Shifts in forests could mean less habitat for caribou, but more habitat for moose. Climate change could hinder moose calf birth success and moose calf survival.
	Small Mammals	Fire may create new burrowing habitat and forage growth to help vole populations. Less snow cover reduces survival of subnival species, due to increased predation & cold stress.
	Fisheries	Commercial fisheries are affected by changes to ocean communities in the Bering Sea. Some marine plant and animal populations may decline with ocean acidification. New stream habitats become available for fish and wildlife as glaciers decline. Some salmon waters may become unsuitable for migration, spawning and incubation. Fish diseases increase with rising stream temperatures. Fish habitats in permafrost areas are degraded by slumps and sediment input into rivers.
	Invertebrates	Ice worm populations decline locally as glacier habitats melt. Marine intertidal environments change, may become more susceptible to exotic marine species. Exotic pests expand from warmer areas, and endemic pests expand as host species are stressed.
	Subsistence	Altered animal migration patterns make subsistence hunting more challenging. Sea ice changes make hunting for marine mammals less predictable & more dangerous. Managing new species and intensified management of native species may be needed.
OTHER	Tourism	Longer summer seasons increase tourism. Some visitor activities increase, others decline. Landscape-level changes affect visitor experiences and access, visitor use patterns shift.
	Wilderness	Large-scale physical and biological changes across broad landscapes affect abundance and condition of wilderness-associated resources (e.g., glaciers, wildlife, access routes, ..) Changing biophysical landscape affect key wilderness values such as naturalness, wild-untamed areas without permanent opportunities for solitude, etc.
	TEK	Uses of traditional ecological knowledge become less predictive and less reliable.
	Devpmt	More natural resource development in Alaska with increasing global demand. Fuel and energy prices increase substantially with carbon mitigation measures. Transporting fuels to remote locations becomes more challenging and costly.

Appendix H: Narratives

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

Narrative 1: “Scenario Workshop, 2030”

The following narrative was developed by the Marine Group based on the “Bad News” scenario (high ocean acidification paired with high shift in natural stream flow) nested in the “Big Problems/Big Solutions” quadrant (which describes a future in which both local and institutional commitment regarding climate is high) of the socio-political matrix (Figure 10). This narrative takes the form of the agenda for a climate change planning workshop for southeast Alaska in the year 2030.

Feb. 2030 – 4th Regional Climate Change Scenario Planning Workshop for SE AK
Juneau, AK Centennial Hall – 255 attendees (Public Welcome)
(Notes from the First Day Proceedings)

Theme for Day One: “You Look Lost – We Can Help”

8:00am: Keynote Panel discussion: “The Next Big Thing”

Panelists: James Balog, First Director, US Department of Reason
Melinda Nelson, Honorable Governor of Alaska,
Ray Wilson, Andy Gambel, and Ed Kuntz, Village elders

This spirited discussion outlined the current plans about to be finalized for an innovative regional distribution network serving all of SE Alaska. This multi-partner collaboration should provide transportation and delivery of food, fuel and supplies to communities through the region at lower cost and twice the frequency as present practices. A prime example of the benefits this new agency (analogous to the Homeland Security) is enabling through coordination of federal, state, local gov’t, businesses and NGOs.

10:30am: Progress update – Habitat Restoration Projects

Presenters: Regional Subcommittee for Habitat Integrity

As you know, salmon fisheries and other fish stock are in decline, and in recent years, there has been significant loss in habitat structure. Amongst other things, this subcommittee has been tasked with helping the region’s communities develop new economic and subsistence alternatives. We’re happy to report that 90% of the backlog of young growth clearing has been accomplished as of this Spring. Project manager Seth Anderson says that all of the crews have made excellent progress. In addition to providing funding support, agencies have actively engaged the youth in these communities as active agents in increasing and maintaining browse for deer and moose populations – reaping expanded harvests. Seth, who started his career in 2010 as a YCC work leader, noted that agencies have enjoyed high retention of enrollees (many becoming permanent staff) and they are also experiencing a boom of interest in citizen science research activities associated with this project. (Looks like the CCC is alive and well for a new generation.)

12:00 pm: Lunch

1:30pm: Special event - The 2030 “Fireside Chat for Climate”

Live Video chat presenting community and tribal leaders from communities across the region – including:

Kake, Hydaberg, Klawock, Angoon, Petersburg, Wrangell, Haines, Klukwan, Gustavus, Craig, and many others.

This multimedia event was developed to discuss recent shifts occurring in the region's tourism patterns as a result of changing climate. Recent growth in the package-tour market, coupled with the new larger cruise ships serving the region, provide opportunity to collaborate on new climate-inspired strategies for eco-tourism as well as for interpretive and education products and services. The focus of discussion included a wide range of options: sharing traditional ecological knowledge and expanding opportunities for eco-tourism by villages, embracing newer technologies and mobile devices by growing our products and services around a "personalized" perspective, and addressing the need to raise awareness about the current extreme conditions with key climate-related messages about adaptation strategies and concerns. The session concluded with a region-wide multi-venue rendition of "Alaska's Flag" – the first time ever, we believe!

3:30pm: Progress update – Energy Development and "Greening" Projects

Presenters: Regional Subcommittee for Energy Conservation

Several energy-related efforts have made good progress through this partnership over the past few years. Most notably, significant strides in bringing together communities via the grid have seen completion. Funding has been secured for installation of salt water transmission cables, the Thayer Lake hydro project has been operational since 2020, and there has been a concerted effort to reduce demand while increasing availability during peak periods. All the region's national parks have completed their Climate Friendly Parks Action plans and are making progress towards their reduction targets. Several partners have invested in plug-in hybrids for their fleets, and LEED certification standards are the standards for all new construction.

Finally – The Highlight from the Evening Reception – the 10th annual "Big Black Boot" award presentation to Hoonah for excellence in reducing their community's carbon footprint. The trophy is accompanied by a generous cash incentive, so competition has been fierce for this prize – congratulations to all the nominees!

Narrative 2: "Facebook Update"

The following narrative was developed by the Marine Group based on the "Cluster Flood" scenario (low acidification and a high shift in natural stream flow) nested in the "Riots & Revolution" quadrant (which describes a future in which local government/institutional commitment regarding climate is low, but local concerns are high) of the socio-political matrix (Figure 10).

This group chose to tell the story through a series of Facebook posts. In the story, a marine reserve was established and new technologies (jetpacks) were used. There was an additional post about aquaculture in waters adjoining the park and responses from community members. Another post discussed ice harvest and its impact on seals, emergency response and safety. To view the narrative, see http://www.nps.gov/akso/nature/documents/SEAK_Narratives.pdf

Narrative 3: "Ranger Ray and the Raven"

The following narrative was developed by the Terrestrial Group based on the "Southeast Identity" scenario (with abnormal flow rates/timing and low extreme events) nested 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) of the socio-political matrix (Figure 12). This narrative is written in the form of a traditional story using the Raven character common to such tales.

The novice Ranger Ray proudly dressed in his new agency uniform of the National Parks and Forests and prepared for his first day on the job. While on his walk to work he begins to ponder why some things he sees don't add up. The sights, sounds, and people surrounding the park do not seem to match what the National Geographic TV specials and Imax movies had portrayed about Southeast Alaska. He stops to take in the surroundings and sips his coffee along the river, or what is now more like a creek.

Lost in thought he was suddenly startled by a raven that fluttered close to him and landed on a branch just inches away from his shoulder. Ray looks into the Raven's eye and contemplated what the Raven and his ancestors knew about Alaska. He had an urge to ask the Raven what had happened to Southeast Alaska? Where were the famous salmon he had heard about, why did the glaciers seem smaller? Why were the evergreens trees so bare? If only ravens could talk he thought.....and with a strange squawk he was startled again. Had the Raven heard him? "Raven will you tell me more about what happened to Southeast Alaska and its people?"

Raven nodded and hopped excitedly.

"No one is talking about it. The other rangers at work didn't even mention the receding glaciers, the infested forest, the burning muskeg, or the missing salmon. Where did they go?"

Raven makes a motion, a sweeping away with his wing, as to say, "They are just gone."

Ranger Ray looks baffled by the response and ponders the response. How could these changes have happened and the world missed it? It is as if they were distracted with the national reorganization of natural resource agencies, deficit problems, downsizing of the federal government. The people were consumed with daily life, basic needs, and in the end they just ignored it.

"But Raven what will the native cultures, fishermen, bears and whales do with so few fish? Won't the people argue about the salmon and who gets how many?"

Raven nods in agreement and cocks his eye in concern.

"Who will decide? The new agencies are in chaos right now. The local governments and tribes have so much to worry about now, with the floods from the glacial dams breaking and muskeg fires."

Raven shrugs his wings as to say "Who knows?"

Ray asks, "What about the Tlingit people Raven? They cared for the land for so long and they know it so well. Can they help?"

Again Raven makes his sad sweeping motion towards the big city of Juneau. The indigenous people are suffering as well.

Many have been displaced by floods, lack of salmon and limited subsistence opportunities and some have even relocated to the cities. Tribal communities are a trying to cope with a disruption of cultural practices and take of their families. Ray is bewildered and again thinks how this could have gone unnoticed.

Ranger Ray is in denial and is dazed when he suddenly notices the time and realizes that he is almost late to board the newly developed Princess/ Holland America ferry that transports visitors to the park for a fee. "Raven I have to go, but I thank you for your ancient insight. Can we meet again?"

Narrative 4: "Jennie in D.C."

The following narrative was developed by the Terrestrial Group based on the "Disaster Zone" scenario (with abnormal flow rates/timing and far more extreme events) nested in the "Big

Problems, Big Solutions” quadrant (which describes a future in which both local and institutional commitment regarding climate are high) of the socio-political matrix (Figure 12). This narrative is in the form of a transcript of a conversation between a teenager and a legislator.

The year is 2030. Young Jennie, aged 16, a resident of a Southeast Alaska village, has travelled to Washington D.C. as part of the well-known Closeup program. There she is meeting with Representative B. Gladd, Senator I. M. Responsive, and Senator U. R. Adaptive. Below is her conversation with B. Gladd.

B. Gladd: I'm so pleased to be meeting a young lady from your community. The Senators and I have been hearing so much about the efforts you've been making to welcome the folks who had to evacuate when the village of [x] washed away after the last series of river floods. I hope the funding from the Relocation Bill is helping.

Jennie: Thank you, it is – although moving was so hard for a lot of people from [x]. Still, we all knew it was coming. We made plans, built homes, found ways to reconnect with distant family from [x] and to make new connections – so it's not all bad. Besides, a lot of people from [x] helped us out, in the big fire three summers ago, and in the blizzard year, when I was in fourth grade. So it's nice to be able to do something in return.

B. Gladd:

Yes -- you've certainly had a lot of fires, and what with that and the pest outbreaks, we all know the forest industry can't last. Senator Adaptive and I have been talking to the village councils from your area about adaptation strategies.

Jennie:

Oh, I know. I've been taking part in some of those initiatives in school, as part of the Hands-On-Learning program. I'm a tidal energy specialist now! And my cousin Susie is a hydro-power technician. Also, she's teaching me to cure bison hides. We never had bison until grasslands started coming in after the fires. It's pretty tasty. I do miss salmon, though.

B. Gladd:

A hatchery is still a possibility – but only if the local people agree to it, of course. The funding could be channeled to other initiatives as well, such as the redwood plantations.

Jennie:

I don't know. The Councils have been meeting to talk these ideas over. My friends and I go to the meetings – it's part of our school, and the elders like having us there. They say that if we are to plan for the future, we need the future to be in the room. I know everyone worries about jobs, and about traditions. We've had to change pretty quickly, and that can be hard on people, but we're doing it together, and that helps. There are still some good jobs. My uncle is an interpretive ranger, in the Park.

B. Gladd:

You know, there were people who said the visitors would stop coming, now that the glacier has almost disappeared, but it seems like the Dynamic Change Program that Senator Responsive championed is really working.

Jennie:

Yeah. Visitors used to come to see things that hadn't changed in millennia. Now they come to see things that are disappearing, and new things that are showing up – like the bison, and all the wildflowers, and our combined Geothermal and Wind plant. Pretty soon we'll start selling energy to British Columbia.

B. Gladd:

That's wonderful. I was proud to sponsor the International Intertie to make that power marketable.

Jennie:

It's not the same as the old ways, and sometimes I really wish things hadn't changed so fast. The older people talk a lot about everything they've lost – but they look to the future, too. I guess my people have always adapted, and always will.

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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