Proceedings of a Workshop on Climate Change Scenario Planning for the Crown of the Continent Ecosystem, 9-10 March 2010, Whitefish, Montana

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Executive Summary

Resource management decisions must be based on future expectations. However, in an era of rapid climate change, the future will be characterized by highly consequential and unprecedented changes that are not completely predictable as they ultimately depend on global socioeconomic, technological, and political conditions that defy prediction. Since 2007, National Park Service (NPS) managers have been exploring scenario planning as one approach for science-based decision making in the face of a fundamentally uncertain future.

This report summarizes the processes and outcomes of the Crown of the Continent Climate Change Scenario Planning (C4SP) project, which culminated in a scenario planning workshop held in March 2010 in Whitefish, Montana. Key players in the project included Glacier National Park staff and other members of the Crown Managers Partnership, an international organization of land management entities in the Crown of the Continent ecosystem that comprises northwest Montana, southeast British Columbia, and southwest Alberta. This report describes two major elements of the C4SP project, (1) the process of integrating scientific research with expert judgment and local knowledge, leading to creation of scenario narratives prior to the workshop, and (2) the workshop results. It is intended to inform development of a structured process for scenario planning as a tool for NPS use, in collaboration with partners, to support climate change adaptation planning and natural and cultural resource management across large landscapes. It also provides feedback on scenario narratives developed for the Crown of the Continent region, and ideas for adaptation options, building adaptation capacity, and even changing management objectives.

Preparation for the workshop built upon experience from two previous scenario planning workshops, in 2007 and 2009, involving four NPS units. The previous NPS scenario planning efforts were focused within individual park units and culminated in outlines of scenarios, identification of several potential management options for specific scenarios, and general discussions about how scenario thinking could inform future considerations of climate change in NPS planning.

This project extended prior scenario planning efforts into new territories. The project scope was expanded outside NPS boundaries to include the larger Crown of the Continent region, involving many more agencies and a much larger workshop. The project tested whether scenarios developed by a small team prior to the workshop would be acceptable to a larger group with diverse perspectives, for use in discussions and planning. The consideration of adaptation options was extended to experiment with approaches for building on, rather than reinventing, the rapidly evolving array of adaptation actions being developed elsewhere. The project also explored methods for connecting scenario narratives with standard planning processes, and enabling management issues to drive research priorities. Finally, the entire process was designed and documented to provide a template for independent application to other NPS units.

Workshop preparations included a project website and a series of 10 Internet-based seminars (webinars) with assigned readings, invited presenters, and facilitated discussion conducted over a 6-week period, with a workshop held 10 days after the last webinar. The webinar materials, including the focus questions, readings, presentations, and recorded discussions, constitute key products of the project that proved useful for constructing the scenario narratives and that can be adapted for application elsewhere. Although workshop preparation was fast-paced with limited, informal participation, the approach was successful in developing scenario narratives that workshop participants

rated as relevant, creative, legitimate, and credible. Three scenarios were developed to challenge workshop participants' assumptions about the future of climate change and impacts in the Crown of the Continent region, as well as larger sociopolitical constraints or opportunities for adaptation. They are:

Climate Complacency – Is Anyone Out There? This scenario features local-scale climate volatility and ecosystem diversification, and increasing growth pressures due to climate change consequences occurring elsewhere. Lack of national leadership and inflexible policies, combined with public attention being focused on challenges elsewhere, severely restrict external assistance for the Crown of the Continent. The region must rely on its own creativity, flexibility, initiative and resources.

Colorado Creeps North – Wheel Spinning This scenario features steady regional trends toward dryness and increasing growth pressures due to severe climate change consequences occurring elsewhere. While national leadership and policies support a wide variety of options for adaptation, societal concern is focused elsewhere and the region must rely on its own initiative and internally generated resources.

Race to Refuge – Big Problems, Big Solutions The scenario features rapid climate change leading to transformative ecosystem changes in all parts of the Crown of the Continent region. However, society is focused on the region as the "last best place" and national leadership and policies support any innovations the region desires.

This project showed that the scenario planning process is practical for engaging with larger groups, provides opportunity to address climate change and its high level of irreducible uncertainty over multi-decadal time horizons, and has the potential for connecting with more formal planning processes and guiding other components within the NPS adaptive planning framework. However, additional innovation, application, and testing of scenario planning methods are recommended to: (1) connect regional scenarios to diverse field-level decisions in ways that explicitly incorporate the high uncertainties about key ecosystem processes , (2) use scenario narratives in evaluating combinations of alternative management objectives and adaptation options with standard planning procedures, and (3) develop explicit connections between the scenario planning process and other components of the NPS adaptive planning framework. NPS personnel should be encouraged to routinely apply the scenario planning process whenever they are faced with highly uncertain forces outside their control that have high impact on prospective management success.

1. Workshop Preparation

1.1 Scenario Planning and Prior National Park Service Case Studies

Resource management decisions must be based on future expectations. However, in an era of rapid climate change, the future will be characterized by highly consequential and unprecedented changes that are not completely predictable as they ultimately depend on global socioeconomic, technological, and political conditions that defy prediction. Climate change poses dilemmas for resource management that may not be solved, but must be managed with foresight and insight.

Scenario planning is a tool to support science-based decision making in the face of high uncertainty about the future and little ability to control its direction or rate of change. Scenario planning is used to create and assess alternate futures in a systematic fashion, and then envision management strategies and make decisions that are robust across a wide range of possible futures. The approach to scenario planning described in this report defines scenarios as narrative accounts that are not simply extensions of current conditions or trends, but imaginatively incorporate future possibilities, including surprises and outcomes from processes that are not currently seen as normal.

The National Park Service has been developing its approach to scenario planning since 2007, when a pilot scenario planning project was carried out for Kaloko-Honokohau National Historical Park in Hawaii and Joshua Tree National Park in California (National Park Service, 2008). The overall scenario planning approach for this pilot project generally followed the process identified by Petersen et al. (2003), but was adapted based on guidance from Ogilvy and Schwartz (2004) and Liu et al. (2008). First, a core interdisciplinary team of 3-5 investigators met several times via conference calls and web conferences to define the focal issues for each park, conduct research, adapt scenario planning concepts to the NPS context, and develop scenario planning tools. A time-varying mix of specialists joined the remote conversations, depending on the topic being discussed. The final step was a 15-person workshop held November 13-15, 2007, at the Joshua Tree National Park Headquarters. During this workshop, the actual scenarios were developed and several adaptation options identified for each of the two parks. Important outcomes of this process included (1) the use of tables from Snover et al. (2007) to organize and synthesize available information on the drivers of change ("Drivers Table") and their impacts ("Impacts Table"), (2) group development of flow diagrams of the relationships connecting the exogeneous drivers and impacts of change ("Influence Diagrams"), as a way to facilitate discussion of thresholds, feedbacks, and uncertainties within a Park system, and (3) use of systematic remote conversations about climate change topics prior to an in-person workshop.

In 2009, the NPS scenario planning process was refined in a project focused on Assateague Island National Seashore on the Atlantic coast and Wind Cave National Park in South Dakota (Global Business Network, 2009). The work was conducted over three months and used an initial 20-person meeting, assigned homework, and a final 40-person scenario workshop during which several scenarios were developed for each of the two parks. An important step taken during this process was the development of a high-level matrix differentiating future possibilities related to the nature of leadership and the degree of societal concern, two forces external to park management that are highly uncertain over decadal scales and that have high impact on the options available to meet park management objectives. Nesting the climate change scenarios specific to a given park within the high-level sociopolitical scenarios provided a consistent method for parks to consider national scale constraints for responding to local and regional scale challenges.

The prior NPS case studies demonstrated that scenario planning resonates with NPS managers and leads to identification of unique and creative ideas for proactively adapting to changes driven by climatic and

non-climatic forces, but they focused on management within a park unit. Recognizing that national parks exist within larger ecoregions managed by multiple jurisdictions with distinct missions and management goals, the NPS Climate Change Response Program (CCRP) sought a case study opportunity to test scenario planning at an ecoregional scale.

For the NPS Climate Change Response Program, this case study was intended to:
1. Test and document a formalized remote engagement process and structure for scenario planning workshop preparations. The process should allow consideration of broader issues affecting resource management, in addition to climate change, and allow for linking results from scientific research, expert judgment, and local knowledge.
2. Develop a scenario planning workshop structure to engage NPS staff and non-NPS land management organizations from the region, and scaled to include many more participants (>50 people) than prior NPS scenario planning workshops.
3. Extend prior scenario planning efforts into new areas by exploring approaches for rapidly advancing discussion of adaptation strategies, and for connecting scenario planning with formal planning procedures.

1.2 The Crown of the Continent Case Study

The NPS Climate Change Response Program selected Glacier National Park and the Crown of the Continent region as case study for testing scenario planning at a large regional scale, involving multiple jurisdictions outside Park boundaries. Glacier National Park has been the focus of substantial research on climate changes and impacts. It was one of the first US National Parks to participate in the NPS Climate Friendly Parks program and it integrated climate change components in their 2006 Environmental Management Plan (Glacier National Park, 2007). Glacier National Park had already set dates for a climate change workshop, on a timeline consistent with the CCRP schedule, in anticipation of developing adaptation strategies over the next couple years.

The Crown of the Continent ecosystem covers over 16,000 square miles within Montana, British Columbia, and Alberta. It is a largely intact ecosystem with two national parks at its core (Glacier in the US and Waterton Lakes National Park in Canada), each recognized by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as Biosphere Reserves, and as the combined Waterton-Glacier International Peace Park as a UNESCO World Heritage Site. However, the region is experiencing sustained pressures, including fragmentation and loss of wildlife habitat, degradation of ecosystem goods and services, invasive weeds, urban and rural residential development, and resource extraction.

Resource management for the Crown of the Continent ecosystem occurs across a complex mix of jurisdictions, including First Nation and Tribal Lands, Parks Canada, British Columbia Ministry of Environment, British Columbia Ministry of Forests, Alberta Community Development, Alberta Sustainable Resource Development, US National Park Service, US Forest Service, US Fish and Wildlife Service, US Bureau of Land Management, Montana Department of Natural Resources and Conservation, private land, counties, municipal and regional districts, cities, towns, and villages.

The Crown Managers Partnership (CMP) is a voluntary partnership of 22 agencies working together to foster transboundary approaches to environmental management (CMP, 2011a). They have agreed on a common vision for an ecologically healthy Crown of the Continent ecosystem, and initiate projects to build an understanding and awareness of the region's ecological health and build relationships and collaborations across jurisdictional boundaries. Recently, the CMP has been collaborating to define

ecological health in ways that can inform management by individual agencies, including identification of monitorable indicators that track the state of the region's ecosystem, e.g., biodiversity, water quality, air quality (CMP, 2011b).

Recognizing that climate change posed substantial risk to sustaining ecological health, the CMP selected climate change as the theme of their 2010 Annual Forum. Dates had already been set for a meeting, prior to the Annual Forum, on climate change. The CMP joined the NPS Climate Change Response Program's C4SP project, with funding from the Glacier National Park Fund.

For the CMP, the C4SP project objectives focused on the scenario planning experience. The project was not intended to train participants in leading scenario planning activities, or to produce a climate change adaptation action plan. Rather, the objectives were to:
1. Raise awareness and build capabilities in scenario thinking for CMP managers to enable them to better address climate change issues.
2. Extend scenario planning concepts developed in prior NPS case studies to the Crown of the Continent ecosystem and management concerns.
3. Facilitate interagency discussions about how Crown of the Continent resources should be managed given prospective changes in climate and other forces over the coming decades.

1.3 Steering Committee

A Steering Committee was organized to guide the project. In consultation with the project team at the University of Arizona, the Steering Committee made decisions about the project schedule, potential workshop participants, workshop parameters, the process for seeking and selecting workshop participants, the contents of letter of invitation and questionnaire to be sent to potential workshop registrants, topics to emphasize during pre-workshop webinars, the webinar schedule, potential webinar presenters and discussants, and use of a website to support project communication and collaboration. Steering Committee meetings were initially scheduled to occur every month throughout the project, but participation was sporadic and five meetings were cancelled at the request of members.

Table 1. Members of the Crown of the Continent Climate Change Scenario Planning Project Steering Committee.

Steering Committee	
Leigh Welling	Key Official, NPS Climate Change Response Program
Kathy Tonnessen	Rocky Mountain Cooperative Ecosystems Studies Unit
Jack Potter	Chief Scientist and Resource Manager, Glacier National Park
Tom Olliff	Resource Manager, Yellowstone National Park
Dennis Madsen	Resource Conservationist, Waterton Lakes National Park, Canada
Mary Riddle	Environmental Protection Specialist, Glacier National Park
Melanie Graham	Assistant, NPS Climate Change Response Program
Observer	
Stacey Ostermann-Kelm	Greater Yellowstone Inventory and Monitoring Network
University of Arizona Team	
Holly Hartmann	Project Investigator, University of Arizona

Lezlie Moriniere	University of Arizona, PhD student
Katherine Waser	University of Arizona, writer and editor

1.4 Project Schedule

The C4SP workshop preparations took place over a total of 11 weeks, with a break following the second week for federal holidays in the US and Canada. Selected tasks are described in more detail in other sections of this report.

Table 2. Schedule of pre-workshop activities.

Week	Activities
1	Establishment of project web site Begin posting materials Begin identifying candidates for "webinar" participants
2	Materials posted to web site Invitations from steering committee issued
3	Federal holidays in US and Canada. No project activity.
4	Experts identified for participation in pre-workshop webinars
5	Webinar 1: Scenario Planning
6	Webinar 2: Future Change in COC Webinar 3: Natural Resources, Terrestrial Impacts Webinar 4: Natural Resources, Aquatic Impacts
7	Webinar 5: Impacts on Cultural Resources Webinar 6: Impacts on Facilities and Services
8	Webinar 7: Feedbacks, Tipping points, and Cascades Small group meeting to review webinar process and project progress
9	Webinar 8: Building Scenarios
10	Webinar 9: Adaptation Options Webinar 10: Policy Screening Small group webinars to construct scenario narratives Small group workshop planning Steering Committee meeting
11	Workshop material preparation by University of Arizona team Scenario narrative construction by University of Arizona team Steering Committee meeting
12	2-Day Workshop in Whitefish, Montana

1.5 Project Website

The webinars were supported by a project website where participants could access material and pose questions. The NPS Sharepoint website was impractical because access is generally limited to NPS personnel. A minimalist website option was to use GoogleDocs, which allows registered members to share documents. A hosted website (e.g., within the Glacier National Park website or the University of Arizona Southwest Climate Change Network) was considered, but required substantial technological support with webpage changes restricted to NPS or University of Arizona. As a compromise, the Steering Committee approved use of BaseCamp (URL: basecamphq.com) an online project collaboration

tool offering an appealing website design, user-friendly structure, and project management features. The project website (URL: c4-sp.basecamphq.com) was maintained throughout the project.

The website provided a single place for people to access the collection of resources used in the project, including webinar agendas and readings, a link to recordings of each webinar, and presentations made at the workshop. It also enabled efficient management of project milestones and emailing webinar invitations. However, use of the website posed difficulties for some participants, e.g., registering, setting user preferences, receiving unwanted emails. The website did not provide enough storage capacity to host the large file size of the recorded webinars, so a separate dedicated server, hosted at the University of Arizona (URL: http://www.ua-alic.com/webinars/) was used to store the files and links were provided on the project website.

1.6 Webinars

A key element in the NPS climate change scenario planning approach is extensive interdisciplinary engagement prior to a face-to-face workshop, with a distinct orientation toward management-relevant concerns and responsibilities. The pre-workshop preparation process allows participants to explore the range of potential impacts to park resources and operations, share their management challenges and concerns, and begin thinking about viable management actions. However, individuals who contribute to scenario planning workshop preparation come from a variety of backgrounds and organizations; topic experts and personnel aligned with a specific park unit or region are typically located at great distance from each other. Even limited travel in preparation for a face-to-face workshop is too costly in time, money, and greenhouse gas impacts. Further, the topics that need to be addressed cross multiple disciplines and some topics challenge conventional thinking and agency approaches, requiring time to gather, process, and internalize new information and concepts.

In prior projects, the pre-workshop preparations were largely informal, exploratory, and internal to the NPS. Webinars had shown promise as a useful tool for remote collaboration. The Steering Committee requested a formal structure for a series of webinars, including a clear agenda for the entire series and for each individual webinar. While the webinars addressed topics and used tools and techniques that had been tested in the two prior NPS projects, two untested topics were added: a structured approach to adaptation, and formal connections to traditional planning procedures.

The webinars were designed to meet the following objectives:

- Remotely engage CMP members, NPS staff, and external specialists, as needed, to obtain sufficient background for developing relevant and credible scenarios.
- Provide a structure for shared learning across disciplines and candid discussion about climate change and other external forces driving regional change, their impacts and implications; agency vulnerabilities, management objectives and practices; and possible adaptation actions.
- Build scenario planning capacity of webinar participants. By participating in the webinars, it was intended that a subset of workshop participants would be comfortable with concepts related to uncertainty, exploratory scenarios, strategically thinking beyond standard practice and procedures, and abstractly considering multiple alternatives for managing resources.
- Explore two untested topics for development prior to the workshop. One, we wanted to experiment with having more comprehensive and nuanced discussion of adaptation options, because that area has advanced rapidly, with hundreds of adaptation options already generated (Climate Change Science Program, 2008; Heller and Zavalata, 2009). Simply restating ideas that have already been developed by others was not seen as sufficiently productive. Two, we wanted

to explore specific ways to connect scenario narratives and adaptation options to more traditional planning procedures.
- Formalize the remote engagement for scenario planning workshop preparations into a template that can be independently replicated by other NPS units.

Pre-workshop preparations were designed for different levels of participation. The Steering Committee specified that participation in the webinars would be entirely voluntary and self-determined. They expected that only about 20 people, in total, would be engaged through any of the webinars prior to the workshop, and there was no expectation that anyone would participate in all of the webinars. Ultimately, over 30 individuals participated in the webinars, including a small group of participants engaged in most or all of the webinars, presenters and discussants invited to participate in one or more specific webinars, individuals that engaged in only one or several webinars on a specific topic, and passive participants that listened to the webinar recordings posted online. We encouraged involvement through repeated webinar invitations and solicitation of presentations and discussants via email and phone. Selected webinar invitations are included in Attachment 1 as part of the workshop preparation template. Potential webinar presenters, discussants, and participants were identified by the Steering Committee and invited by the project lead; selected invitations to presenters are also included in Attachment 1. Webinar participants were invited to also participate in the project website, since it served as the repository for agendas, reading material, background resources, and collaborative documents.

We used Internet-based meeting technology to facilitate pre-workshop preparation. A variety of online meeting tools were available, but we chose GoToWebinar because the NPS had an existing account, and it had easy-to-use features useful for this project, including quick and reliable use by first-time webinar participants, easy transfer of the screen to presenters without requiring uploading of presentation files, no meeting charge for phone participants (they are responsible for their own phone costs, but face no added costs for webinar participation), no “per phone” connect charge or per meeting charge for the project, easy monitoring of webinar participants, multiple modes for participants to ask questions or engage in discussion (instant chat with the group or to specific individuals, telephone questions, graphically “raising a hand” for recognition by the facilitator), muting of participant telephones, and audiovisual recording of the webinar.

To join a webinar, potential participants received an email invitation, with the agenda, background reading, and prospective discussion questions. They also received an automated email reminder of the meeting and an invitation to register for the webinar. When registered, they received webinar connection information. To participate, individuals were required to log into the webinar meeting website and to also telephone a number provided by GoToWebinar. Using telephones allowed more reliable audio quality with less interference and the ability for facilitators to remotely mute individual phones to eliminate background distraction.

An initial schedule of 12 webinar topics was developed in December, with the webinars planned to occur between January 11 and March 2. However, the original schedule was shifted due to late CMP response to invitations and two webinars were designated as “contingency meetings” to revisit ideas or decisions, if the group required. Thus, the final schedule included 10 webinars conducted from January 21 – February 22. Agendas for individual webinars were developed by the UA project team shortly after presenters and discussants committed to participate and contributed background material or discussion questions. Each 1.5-2 hour webinar followed a general pattern: technology instructions and meeting logistics, introductions, review of the last webinar, introductory discussion, presentations, group discussion, and a preview of upcoming webinars. Because participation in each webinar was open-ended

and not known until the webinar began, the agendas included frequent review of project goals and scenario planning, discussions from prior webinars, and issues requiring clarification or decision prior to the workshop. Discussion questions served multiple objectives: to get people to think about specific topics, to extract discussion that would allow completion of drivers and impacts tables, and to solicit diverse perspectives. We also pushed discussions to move beyond statements of concern about impacts of change, to address implications for management within NPS and across the region.

The webinars were not intended to be classes or a presentation series, but a highly engaging, interactive, and focused exploration of topics selected to ensure that scenario planning in support of climate change adaptation would be relevant and useful to the CMP. Participants heard from regional specialists on a variety of topics, shared their expertise, and provided input about management challenges, local and regional systems and issues, data availability, and science and community activities. Thus, the webinars provided a way to link scientific literature, expert judgment, and local knowledge for many topics. A list of the panelists and discussants for each webinar, and the individuals participating in webinar discussions, in presented in Table 3.

Table 3. Panelists, discussants, and participants in pre-workshop preparation webinars.

Webinar	Panelists and Discussants	Participants*
1. Scenario Planning	Leigh Welling	Mike Britten, Tara Carolin, Stephanie DuBois, Joyce Lapp, Lon Johnson, Clint Muhlfield, Jack Potter, Matt Rose, Pei-lin Yu
2. Future Change	Steve Gray Dan Fagre	Tara Carolin, Shawn Carter, Chris Downs, Micheal Durglo, Jim Foster, Virginia Kelly, Lon Johnson, Dawn LaFleur, Joyce Lapp, Jack Potter, Kathy Tonnesson, John Waller, Pei-lin Yu
3. Terrestrial Impacts	Greg Pederson Dan Fagre George Malanson Kate Kendall	Mike Britten, Tara Carolin, Michael Durglo, Steve Gray, Virginia Kelly, Stacey Osetermann-Kelm, Lon Johnson, Joyce Lapp, Jack Potter, Dennis Divoky, Matt Rose, John Waller, Pei-lin Yu
4. Aquatic Impacts	Chris Muhlfield Tom Bansak	Mike Britton, Tara Carolin, Chris Downs, Micheal Durglo, Lon Johnson, Joyce Lapp, Stacey Ostermann-Kelm, Jack Potter, Kathy Tonnesson
5. Cultural Resources	Pei-lin Yu Sally Thompson Craig Lee Dan Odess	Tara Carolin, Chas Cartwright, Jim Foster, Micheal Durglo, Lon Johnson, Virginia Kelly, Joyce Lapp, Jack Potter, Matt Rose, Dierdre Shaw, John Waller, Leigh Welling

6. Facilities and Services	Matt Rose	Jim Foster, Cat Hawkins-Hoffman, Virginia Kelly, Lon Johnson, Linda Joyce, Joyce Lapp, Jack Potter, Glenn Smith, Don Weeks, Leigh Welling
7. Thresholds, Tipping Points and Cascades	Steve Running	Cat Hawkins-Hoffman, Jack Potter, Sally Thompson, Leigh Welling
8. Building Scenarios	None	Dennis Divoky, Stephanie DuBois, Cat Hawkins-Hoffman, Barb Johnston, Linda Joyce, Virgina Kelly, Dawn LaFleur, Joyce Lapp, Jeff Mow, Jack Potter, Matt Rose, Kathy Tonnessen, Leigh Welling, Pei-lin Yu
9. Adaptation Options	Jill Baron Linda Joyce	Dennis Divoky, Stephanie DuBois, Cat Hawkins Hoffman, Barb Johnston, Virginia Kelly, Dawn LaFleur, Joyce Lapp, Jeff Mow, Jack Potter, Matt Rose, Kathy Tonnessen, Leigh Welling, Pei-lin Yu
10. Policy Screening	Jeff Mow	Dan Fagre, Cat Hawkins Hoffman, Virginia Kelly, Jeff Mow, Jack Potter, Leigh Welling

*All webinars facilitated by Holly Hartmann.

**List constructed from notes and webinar recordings that may not reflect all participants.

Detailed agendas for each webinar, including their objectives, background reading, questions for discussion, and panelists and discussants, is presented in Attachment 2. The following text provides a short synopsis of each webinar.

The Scenario Planning Process. This webinar was intended to set the stage for scenario planning as a decision making tool. It also sought to determine the focal question for the project and the appropriate time horizon for climate change adaptation planning for the Crown of the Continent Ecosystem. The webinar also introduced the notion of exogenous drivers of change for the region, including both climate and non-climatic factors. Webinar participants tentatively agreed that planning should address potential change from the present to 2100, but preferred to focus on management options from the present to 2050, i.e., within the range of current NPS planning processes. A tentative focal question was modeled after versions used in prior case studies, “How will the CMP organizations need to manage the region in the face of prospective climate change impacts?” However, webinar participants raised the idea that management objectives may need to change, because some current objectives are unlikely to be met, given anticipated changes in climate and other forces. A new focal question emerged, “How do CMP management objectives need to change?” This focused managers on the possible need to shift management objectives rather than simply implement different actions to meet current objectives.

State of the Art: Future Change in the CoC. This webinar continued the discussion of exogenous drivers of change, including both climate and non-climatic forces. It explored future changes that would be beyond the ability of the CMP managers to control and that have a high level of irreducible uncertainty. The notion that the future offers increasing volatility, uncertainty, complexity, and ambiguity (VUCA) was introduced (Johansen, 2007), with the corollary that managers will be seeking to manage ongoing dilemmas rather than finding long-lasting solutions.

Impacts on Terrestrial Ecosystems. This webinar invited topic and regional specialists to help the group explore the sensitivities, vulnerabilities, and resiliency of terrestrial systems within the region, and their relationships to climatic and non-climatic stressors.

Impacts on Aquatic Ecosystems. This webinar invited topic and regional specialists to help the group explore the sensitivities, vulnerabilities, and resiliency of aquatic systems within the region, and their relationships to climatic and non-climatic stressors.

Impacts on Cultural Resources. This webinar invited topic and regional specialists to help the group explore the sensitivities, vulnerabilities, and resiliency of cultural resources and systems within the region, and their relationships to climatic and non-climatic stressors.

Impacts on Facilities and Services. This webinar invited topic and regional specialists to help the group explore the sensitivities, vulnerabilities, and resiliency of facilities and services within the region, and their relationships to climatic and non-climatic stressors.

Feedbacks, Thresholds, and Cascades. This webinar invited topic and regional specialists to identify key connections within the Crown of the Continent ecosystem and any feedbacks, both positive and negative. It also sought to identify thresholds and tipping points that, if exceeded, could initiate large or rapid change through cascading events. This session was important for allowing webinar participants to tie together impacts across sectors. For the JOTR and KAHO case studies, the group used CMAP (URL: http://cmap.ihmc.us/) an Internet-based tool to collaboratively draw conceptual model schematics (influence diagrams) and found the experience helpful. For C4SP, this approach proved redundant and not productive, because there were more topics and more diversity in the systems being addressed (e.g., East vs. West slope systems, terrestrial and aquatic ecosystems, more diverse mix of stressors), with less continuity in participation, and more group deference to presentations by invited speakers and prior work by outside experts. For the ecosystems, influence diagrams had already been prepared by the GNP Inventory and Monitoring team (Britten et al., 2007). A new conceptual diagram on social migration was contributed by P. Yu, a panelist for the Cultural Resources Impacts webinar. The group was comfortable in using these schematics to support discussions about feedbacks, thresholds, and cascades.

Building Scenarios. This webinar used focused discussion to facilitate participants in choosing basic elements of the scenario narratives that would be developed for the workshop. Participants finalized the focal question to be addressed in the workshop, ""How do CMP management objectives need to change?" That question was to be supplemented by the question, ""How will the CMP organizations need to manage the region in the face of prospective climate change impacts?" for workshop participants who might have difficulty related to the more abstract question about management objectives. Based on a synthesis of earlier webinars, the group identified key climate variables and characteristics of leadership and societal concern from the high-level sociopolitical matrix that should be highlighted in the scenarios, implications of emerging trends likely to have large impacts on the region over the next decade, and possible scenario narrative plot lines. This webinar was not intended to

develop the scenario narratives, but to provide the structure around which relevant, creative and credible stories could be constructed.

Adaptation. This webinar explored options for climate change adaptation within the Crown of the Continent ecosystem. The agenda and format for this webinar was largely exploratory. Hundreds of adaptation options have been identified through a variety of processes, within and outside NPS (Climate Change Science Program, 2008; Heller and Zavalata, 2009). The challenge for the C4SP workshop, compared to the JOTR and KAHO case studies, was that people would spend time re-creating existing ideas, or sorting through existing ideas instead of making space for brainstorming new ideas. For this webinar, we wanted to have a higher level discussion about adaptation options. The need was to organize adaptation options into several categories, with an emphasis on options related to changes in management objectives rather than actions to meet current objectives, or actions to build capacity to address adaptation. This emphasis resonated with high-level managers, but was more frustrating for field staff who wanted to focus on specific adaptation strategies and actions.

Policy Screening. This webinar explored how to evaluate and prioritize adaptation options within a planning framework, using a sophisticated water utility case study. It introduced concepts that were completely new to webinar participants, exploring whether participants would find this webinar understandable or relevant. Webinar participants considered the concepts important and understandable enough to include in the subsequent design of the workshop activities.

1.7 Creation of Scenario Narratives

In past NPS scenario planning workshops, the scenarios used to drive discussion of adaptation options were constructed as part of each workshop. However, for this project, the large number of workshop participants challenged the practicality of developing scenarios at the workshop. Further, past workshops were able to develop only simplistic scenarios that were little more than lists of impacts within one long time period. In order to better connect scenario narratives with planning processes that address different time periods, and to foster deeper discussion about adaptation options and time ordering or prioritization of potential responses, this project required more detailed scenario narratives.

The Steering Committee appreciated the tradeoffs between having workshop participants prepare their own scenarios versus having the scenario narratives prepared in advance. The former offered potential for greater ownership and acceptance of the scenarios, at the risk of individuals becoming so attached to their scenarios that the scenarios would take on an importance beyond use as a tool for strategic thinking, or the process would lead to conflict about sensitive topics. Constructing the scenarios in advance risked lesser “buy-in” from workshop participants, but the acceptance of prepared scenarios was a research question of this project; it also assured a selection of detailed scenario narratives that would pose specific types of climate and sociopolitical challenges to stretch the thinking of managers.

Scenarios can serve many different purposes, generally classified into three broad categories: education and public information, science and research, and decision support and strategic planning (Alcoma and Henrichs, 2008). For this project, the scenario narratives were designed to serve the following specific purposes, in the following order:

- Policy Making: To help managers “think big” about climate change and other stressors, taking into account the large scales of the challenges, and the connection across scales from global to regional to local.

- Long-term Planning: To provide several scenarios which would provide managers with a wide range of potential futures that can be used to evaluate the consequences of potential management choices. This use of scenarios would necessarily occur after the workshop, on a manager's own initiative.
- Exploration: To bring together information from different disciplines, including the natural and social sciences, to highlight the complexity and inter-connectedness of climate change challenges, especially for the long-term future.
- Scientific Assessment: To assess future developments of climate change and other stressors, combining qualitative and quantitative information about potential future events.
- Public Information: To raise awareness, inform, and consult managers and CMPs partners about climate change challenges and other stressors.

Earlier NPS scenario planning case studies confirmed the utility of the "four quadrant" approach (Ogilvy and Schwartz, 1998) for developing sets of scenarios having widely divergent characteristics that challenge people to think beyond routine perspectives and expectations. Scenario development for this project generally followed the same approach used in the prior case studies, but extending the process to produce narratives that provide dynamic change throughout the planning horizon. The basic steps for creation of scenario narratives are described below. Each scenario narrative is presented in Attachment 3, with supporting materials included in Attachments 4-5 as noted below.

Consideration of exogenous drivers of regional change. A modified form of Table 4.1 from Snover et al. (2007) provided the structure for constructing the climate change drivers table (Attachment 4); the modifications have remained consistent across the NPS scenario planning case studies. In prior case studies, NPS personnel completed the tables for climate changes and changes in park budgets and social expectations for park values. For this project, the webinar participants preferred to have a climatologist (S. Gray, University of Wyoming) prepare the climate change drivers table. No tables were prepared for the non-climatic drivers, because those drivers were represented in the high-level sociopolitical matrix developed in the ASIS and WICA case studies (Global Business Network, 2009) and vetted in this project's webinar discussions.

Assessment of potential regional impacts of changes in the exogenous drivers. Impacts tables (Attachment 4) were completed by the University of Arizona project team based on a literature review, invited webinar presentations and discussions by webinar participants. The impacts tables were limited to climate impacts on different NPS management sectors. Impacts of the sociopolitical drivers were discussed throughout webinars 2-8 and integrated directly into the scenario narratives.

Consideration of the linkages between drivers and impacts, with an emphasis on feedbacks, thresholds, and cascading effects. This step made use of conceptual model schematics, or influence diagrams, developed by P. Yu on human migration and the Rocky Mountain Inventory and Modeling Network (Britten et al., 2007) for terrestrial landscapes, alpine systems, wetlands, and streams (Attachment 4).

Selection of climate variables for constructing the climate scenario quadrants. After the formal webinar series, several informal webinars were held, involving a small number of webinar participants selected by Steering Committee members and outside topic specialists familiar with scenario planning, in order to make choices required for the development of scenario narratives prior to the C4SP workshop. Webinar participants selected the two climate variables they considered to have the greatest impact on regional conditions and also the highest uncertainty over the planning period. Webinar

participants, as a group, ordered several climate variables and some intermediate variables (in Attachment 5). These two climate variables formed the axes for differentiating the "four-quad" climate scenarios (Attachment 5). The ordering and selecting of climate axes was iterative, with the group testing their choices by developing some simple climate scenario outlines and then evaluating which quadrants produced scenarios with the greatest diversity of conditions. With the final selection of the two dominant climate axes, the group outlined the key characteristics of each of the four climate scenarios and gave them short, memorable names that encapsulated the essential nature of the scenarios. The scenarios selected were: Climate Complacency, Colorado Creeps North, Race to Refuge, and Volatile Surprise. The discussions for this step and the next were key for some participants to fully synthesize prior discussions and finally appreciate the difference between a climate sensitivity analysis using scenarios and a scenario planning assessment.

Placement of climate change scenarios into the high-level sociopolitical matrix (Attachment 5), and prioritization of which combined scenarios to develop into detailed scenario narratives. This process was iterative, with the group identifying which scenarios would stretch the thinking of management. The group chose three scenarios to use (Attachment 3): Climate Complacency/Is Anyone Out There?, Colorado Creeps North/Wheel-Spinning, and Race to Refuge/Big Problems, Big Solutions.

Developing detailed outlines of the time evolution of scenarios. The University of Arizona team combined the literature reviews and webinar-based tables of climate drivers and impacts into a matrix (Attachment 5) contrasting each scenario and subdividing the drivers and impacts into specific time periods. The matrix helped ensure that each scenario differed in character, even though some elements were common across all three, as noted in the scenario quadrant figures.

Development of scenario narratives. This was fundamentally a creative process of story-telling that incorporated information within the drivers and impacts tables, and the management issues and larger sociopolitical concerns raised in the webinar discussions. The narratives (Attachment 3) were ultimately created by a single individual (H. Hartmann) and reviewed for consistency by other members of the University of Arizona project team.

Past NPS case studies did not formally evaluate the scenarios. As part of the workshop, we tested whether the scenario narratives were accepted by the workshop participants, even though the scenarios had been developed in advance. Criteria for evaluation of the scenarios, and their order of importance, were selected prior to the construction of the narratives, following the guidelines suggested by Alcamo and Henrichs (2008):

- Relevance: Are the scenarios relevant to the CMP managers? Do the scenarios address the concerns and needs of the CMP managers? Do they broaden the understanding of managers?
- Creativity: Do they scenarios provoke new, creative thinking? Do they challenge current views about the future? Do they inform managers about the implications of irreducible uncertainty?
- Legitimacy: Are the messages of the scenarios perceived to be fair, avoiding the promotion of specific beliefs or values? Are participants satisfied with the process used to develop and communicate the scenarios? Were enough of the right people involved in the scenario construction process?
- Credibility: Are the scenarios plausible? Is their content compatible with current understanding? Was the development process scientifically rigorous?

While all the criteria apply to any scenario, their relative importance depends on the purpose of the scenario, and some criteria (e.g., credibility and creativity), may conflict (Alcamo and Henrichs, 2008).

Credibility is a priority when the scenarios must conform to scientific practice in support of scientific research. However, for this project, creativity was considered a higher priority because the scenarios were intended to challenge the views of CMP members that the future of the Crown of the Continent ecosystem will generally look like the past, or that science can provide reliable predictability about future changes in climate or its impacts over the long term, and to provoke new thinking about evolving management objectives.

The C4-SP workshop was planned to involve a mix of agencies with different missions and management objectives, and many participants would not have been involved in the creation of the scenarios. Therefore, there was concern that prepared scenarios introduced at the workshop might not be seen as relevant or credible, or that participants would disagree with or challenge the scenarios for other reasons. The challenge was to develop scenarios that were creative enough to stretch the thinking of participants, yet credible enough for participants to be willing to engage with them during adaptation and planning breakout sessions. However, because the C4SP workshop was designed as a stand-alone event, with no connection or commitment to subsequent CMP activities, the level of scenario acceptance required was less than required if the scenarios supported a formal planning process.

To evaluate the scenarios, we administered a questionnaire at the end of the workshop asking participants to rate how well each scenario met each criteria, on a scale of 1 to 4 (1=not at all, 4 = very well). Table 4 shows that workshop participants rated each scenario most highly on its relevance, and that each scenario was rated as being nearly equally creative. Scores for each scenario are considered acceptable, although the Race to Refuge/Big Problems, Big Solution scenario was considered to rank lowest in credibility (2.3) and legitimacy (2.6). Comments from participants during the workshop indicated that the climate elements of the scenario were not the source of the lower ratings. Rather, the availability of financial resources, especially through reprioritization of federal budgets, was considered implausible, if not impossible. However, all participants, when asked, were willing to continue working with that scenario for the purposes of considering adaptation options and continuing the workshop exercises.

Table 4. Workshop participant (n=25) rating of how well each scenario met the criteria (1=not at all, 2=somewhat, 3=mostly, 4=very well). Criteria are listed in order of their priority.

Evaluation Criteria	Colorado Creeps North/Wheel Spinning	Climate Complacency/Is Anyone Out There?	Race to Refuge/Big Problems, Big Solutions
Relevant	3.5	3.6	3.1
Creative	3.3	3.3	3.2
Legitimate	3.1	3.1	2.6
Credible	3.3	3.2	2.3

1.8 Workshop Design

Workshop parameters were set by the Steering Committee, except for the dates, which were set prior to the initiation of the project. The Steering Committee increased the maximum workshop attendance from an original 35 participants, to 50, and then to 65 as interest in the workshop grew and the Committee desired to accommodate more NPS staff and other agency participation.

Workshop invitations were created, sent out, and managed by the CMP. Each CMP organization was asked to nominate a workshop participant. Nominated individuals completed a form outlining their areas of interest, expertise, and management roles. The Steering Committee used this information to

ensure diverse participation and identify potential conflicts during the workshop (e.g., from individuals known to be skeptical about climate change, individuals with history of cross-organizational conflict or poor workshop participation). The workshop invitation and background form are included in the Attachment 6. Workshop invitations were sent out December 18, with a workshop registration deadline of January 8, which was subsequently extended by nearly two weeks, due to the lack of response over the holidays. The invitations stressed that participants should be interested in exploring issues across several disciplines, considering both policy and management challenges, and connecting science and management, all through constructive dialog with others having diverse backgrounds and responsibilities. They also suggested that participation would be most meaningful to individuals comfortable with uncertainty, complexity, and ambiguity.

All participants were asked to prepare for the workshop, with preparation time estimated to require about five hours of reading or listening to webinar recordings. Informal evidence suggested that few people prepared for the workshop, although some participants did, e.g., reviewing the webinar recordings.

From the perspective of the NPS Climate Change Response Program and the CMP, the objectives for the workshop included:

- Within a 2-day workshop for up to 65 people, engage NPS staff and CMP managers in climate change scenario planning to raise awareness and build capabilities in scenario thinking to enable them to better manage climate change challenges.
- Extend scenario planning concepts developed in prior NPS case studies to the Crown of the Continent ecosystem and management concerns.
- Test approaches to engage people with scenarios and the scenario development process, even though they weren't involved in the initial development activities.
- Extend prior scenario planning efforts within the workshop to new areas, i.e., to explore approaches for rapidly advancing discussion of adaptation strategies, and connect scenario planning with formal planning procedures.

The workshop was not intended to train participants in leading scenario planning activities, or to produce a climate change adaptation action plan.

However, considering the workshop participants, other objectives (listed in Table 5) and issues were also considered in the workshop design. We assumed that participants would have a basic understanding of climate change as an issue. The 2-day workshop schedule would not accommodate debate about whether climate change is happening, what might be causing it, or the appropriateness of any mitigation policies. We also understood the workshop was occurring within the larger context of CMP collaboration and coordination, involving many organizations and individuals that would not be present at the workshop, focused on resource management issues and ecological health rather than climate change adaptation. By project design, workshop participants were not going to be developing the scenarios at the workshop. One principle in scenario planning for environmental decision making (Alcamo and Henrichs, 2008) is that if stakeholders are not fully involved in development of the scenarios, the process used for creating the scenarios should be transparent. Further, it was considered important for workshop participants to understand the scenario development process and consider it legitimate. Thus, the workshop allotted significant time for explaining the process of developing scenario narratives and presenting information used in their construction.

Table 5. Additional objectives for design of workshop sessions and participatory exercises.

Primary Workshop Goals
Participation: Fun, engaging, leading to new perspectives useful for further climate change-related planning and adaptation processes.
Strategic Planning: Help CMPs 'think big' about climate change over large time, space, and organizational scales, and about the interconnectedness of climate change with other forces of change. Use scenarios as a device to explore the role of policies and management objectives in preparing for climate change challenges.
Decision Support: Identify and evaluate options for adaptation that can accommodate diverse futures, with a focus on the roles of scale and management objectives.
Secondary Workshop Goals
Exploration: Bring together information from different disciplines and sectors to highlight the complexity and interconnectedness of climate change with other problems.
Scientific Assessment: Combine qualitative and quantitative information about the future evolution of management challenges in the Crown of the Continent ecosystem. Help bridge scientific and political aspects of management challenges
Tertiary Workshop Goals
Information: Inform and consult with CMP managers about climate change and its challenges.

After the formal pre-workshop preparation webinars, a small group selected by Steering Committee members used informal webinars and teleconferences to develop the workshop agenda and facilitated breakout exercises. The workshop design process required multiple iterations to accommodate a mix of the types of presentations and exercises that had been field-tested in prior NPS scenario planning workshops and experimental breakout sessions.

A practical challenge related to the workshop was simply managing the larger number of participants that had been invited and registered for the workshop. Past NPS scenario planning workshops involved one-third to one-half as many individuals, almost all from the NPS, and in a clearly experimental effort with low expectations for the usability of results. A larger workshop would require simultaneous breakout groups and multiple facilitators, and a more formal agenda with relevant outcomes.

Workshop participants represented a variety of perspectives about climate change, relationships with the NPS and other CMP members, and expectations for their participation and workshop outcomes. The Steering Committee was concerned, in particular, that participants would be drawn into possible 'traps', including fundamental disagreement with climate change background, difficulty understanding scenario planning concepts, disagreement with choice of scenarios, too much concentration and anchoring of discussion on the provided scenario narratives and their details, and an overemphasis on "right answers" for the scenarios.

Both simplified and annotated workshop agendas are provided in Attachment 7. The annotated agenda provides explanations about the design and expectations for each component of the agenda, and was made available to workshop facilitators. The basic agenda was more simplistic and was made available to workshop participants.

The first day of the workshop was focused on ensuring that participants understood and accepted the process used to create the scenarios. However, an introductory activity asked participants to write down the fundamental purpose and mission of their organization, to highlight the commonalities and differences among CMP organizations, which ultimately affect the range of management objectives and potential responses to changes in climate and other forces.

Presentations about the drivers and impacts of change in the Crown of the Continent region were condensed versions of the webinar discussions, provided by respected regional experts. After the presentations, participants were asked to contribute notecards listing any changes or impacts that had been missed or underdeveloped.

A small group exercise was then used to give participants experience in developing climate scenarios using the four quadrant approach. It was intended to provide transparency about the process of exploring combinations of external driving forces, resulting in scenarios that are useful, redundant, or of limited relevance. The exercise used an imaginary NPS unit in a different bioregion, to preclude the group from anchoring to the scenario outlines they developed. Instructions for the exercise are provided in Attachment 8.

The process of converting the drivers and impacts tables to scenario narratives was presented in a generic way, followed by presentation of the specific climate quadrants developed from the webinar-based preparations. This allowed workshop participants to be introduced to the scenarios, but without having the narratives to scrutinize overnight.

An important part of scenario assessment is placing the scenarios in a historical context (Mahmoud et al., 2009). An evening program was designed to incorporate tribal perspectives about climate, ecosystem, and socioeconomic variability in ways more flexible than in the necessarily highly structured workshop. Tribes have traditions and experience with large change and strong, uncertain external driving forces. The distinct evening program offered the opportunity to highlight those perspectives. The idea for the evening program emerged from the webinar discussions, and Dr. S. Thompson, University of Montana, was invaluable in organizing the program, inviting panelists, and moderating discussions.

While the first day of the workshop consisted mostly of presentations, the second day was largely organized into breakout sessions with directed activities. Two scenario assessment and adaptation breakout sessions were intended to provide a process for participants to review and vet the scenario narratives. Participants were asked to provide feedback about whether anything in the scenario narrative seemed not possible or plausible.

Then, participants were asked the focal question, *How do CMP management objectives need to change?*, in order to prompt consideration of new management objectives that might be more appropriate given the changes described in the narratives. The emphasis was on recognizing that some present-day management objectives may not be attainable, and considering that mandates and policies may be needed to give managers the flexibility, direction, or authorization they need.

Asking participants to focus on possible changes in management objectives posed a risk that the discussion would be too abstract or different from their thinking about adaptation options. So the exercise also included a component to consider adaptation options. Participants were asked, How will CMP managers need to manage the region in the face of prospective climate change impacts? This part of the exercise used an experimental method intended to allow rapid generation of a wide variety of

options targeted at different time periods, so that consideration of adaptation options could occur within a context relating to specific management objectives. The purpose of this portion of the session was to (1) quickly and productively build on the extensive generation of adaptation options already done by others, and (2) be able to consider a wide variety of adaptation options in the screening phase of the scenario planning.

Within these sessions, we attempted to focus discussion on long-term changes, their implications and adaptation challenges. To foster creative thinking, we asked participants to begin by thinking about conditions described by the scenario narratives for 2100, and then think of management objectives that needed to be in place by 2050 in order to prepare for 2100. Then they were asked to think of conditions described for 2050 and consider what management objectives needed to be in place by 2020. The entire breakout session exercise is described in Attachment 8.

Within each of the scenario assessment and adaptation breakout sessions, participants were asked to focus on a single scenario. Further, participants were presented with the scenario narratives only as needed for their use in the adaptation breakout sessions. Each person participated in two adaptation breakout groups, and so considered only two scenario narratives. However, to ensure that the full creativity of each participant was stretched to the fullest, every person participated in a breakout focused on adapting to the scenario, Race to Refuge/Big Problems, Big Solutions. Participants were divided into four groups, and each group engaged with two different scenarios over the two breakout sessions. Each group engaged with the Race to Refuge/Big Problems, Big Solutions scenario narrative and one other. Table 6 summarizes the number of breakout sessions that engaged with each scenario.

Table 6. Number of breakout groups that engaged with each scenario within the scenario planning and assessment breakout sessions.

	Colorado Creeps North/Wheel Spinning	Climate Complacency/Is Anyone Out There?	Race to Refuge/Big Problems, Big Solutions
Number of breakout groups	2	2	4

Results reported out from the scenario assessment and adaptation breakout groups were used as materials for the subsequent breakout sessions on policy screening. The policy screening breakouts were designed to allow participants to evaluate the adaptation options (Attachment 8), seeking to identify:

- commonalities across all scenarios and assessments,
- differences that cannot be accommodated across scenarios,
- what ordering of adaptation options over time increases the ability to accommodate different scenarios,
- what indicators might be important for determining when choices must be made about implementing specific options,
- whether policies must change to accommodate any adaptation options, and
- how results of the screening might connect with other planning processes.

The intended plenary report-outs from the policy screening breakout groups were replaced with a requested presentation about recent CMP activities from the CMP Steering Committee chair.

The C4SP workshop was held 9-10 March 2010 in Whitefish, MT. A list of workshop participants, and their affiliations, is included in Attachment 9. Each participant received a notebook with contextual information about the Crown of the Continent ecosystem, scenario planning, and the information used to create the scenario narratives. Contents of the workshop notebook are provided in Attachment 10.

2. **Workshop Results**

The C4SP workshop was held 9-10 March 2010 in Whitefish, MT. A list of workshop participants, and their affiliations, is included in Attachment 9. Each participant received a notebook with contextual information about the Crown of the Continent ecosystem, scenario planning, and the information used to create the scenario narratives. Selected contents of the workshop notebook are provided in Attachment 10.

The stated objectives of the workshop, included in each workshop packet, were to:

- Explore, assess and respond to alternative futures for the Crown of the Continent ecosystem, cultural resources and facilities, which managers can use to help inform decisions in light of potential climate change and impacts.
- Apply scenario planning as a tool to facilitate partners' management of the region.
- Assess how the scenario planning process might best be packaged and replicated for the NPS and others.

The purposes and missions of the participating CMP organizations, as contributed by workshop participants, are listed in Attachment 11. Participant identification of management concerns of CMP organizations and impacts of climate change for the Crown of the Continent ecosystem are listed in Attachment 11.

Detailed results from the scenario assessment and adaptation breakout groups are presented in Attachment 11. Changes in management objectives were generated through group discussion, while adaptation ideas were contributed through posting of notecards by individuals working independently. Over 300 individual notecards with adaptation ideas were contributed by breakout session participants. Post workshop, notecard content was systematically reviewed to extract unique messages. Some notecards contained multiple ideas (e.g., integrate climate change into fire management plans and flood mitigation plans; improve techniques and do more restoration); in other cases, multiple notecards contained similar messages (e.g., improve monitoring). Distinction was made between ideas that build capacity to adapt and ideas that actually implement adaptation. Table 7 summarizes the results for each type of adaptation idea, for each scenario and time period.

Two breakout groups screened a subset of adaptation ideas provided from the output of the scenario assessment and adaptation activities. Several ideas, related to the management of water and aquatic systems, were presented without identifying which scenario(s) had sparked them. Participants were asked to identify options that were suitable for all scenarios, or only two scenarios, or only a single scenario. The groups refined, expanded, and organized the options according to which scenario(s) each option was relevant (thus, their options differ from the earlier versions). Results were combined from the two breakout groups into the graphical depiction is presented in Figure 1. This figure illustrates that the sequential ordering of adaptation options can be used to maximize the flexibility of management decisions to be relevant for a wide range of possible futures. Lack of time remaining in the sessions

precluded identification of indicator variables that could be used to inform managers when choices must be made to implement options suitable for a narrower set of future conditions.

Table 7. Number of distinct ideas for climate change adaptation in the Crown of the Continent ecosystem, suggested for implementation by years 2020 and 2050 by workshop breakout groups in response to scenario narratives.

Year	Type of Idea for Climate Change Adaptation	Colorado Creeps North/Wheel Spinning (2 breakout groups)	Climate Complacency/Is Anyone Out There? (2 breakout groups)	Race to Refuge/Big Problems, Big Solutions (4 breakout groups)
2020	Changed management objectives	10	6	13
2020	Build capacity to adapt	60	55	76
2020	Adaptation actions	18	11	16
2050	Changed management objectives	10	6	4
2050	Build capacity to adapt	37	17	21
2050	Adaptation actions	17	11	8
	Grand Total = 396	152	106	138

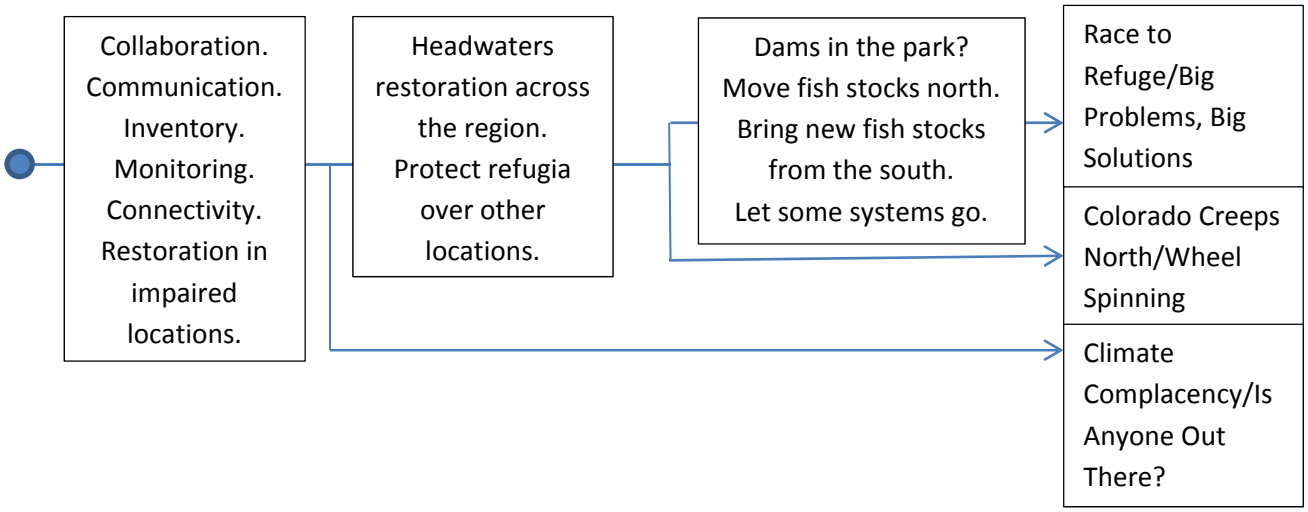

Figure 1. Schematic showing which selected climate change adaptation options were considered applicable to each scenario narratives. Options listed on the far left apply to all three scenarios, while options listed on the far right apply only to the Race to Refuge/Big Problems, Big Solutions scenario.

Using the same methodology, post-workshop evaluation of the 396 adaptation ideas generated by the scenario assessment and adaptation breakout groups reveals several options that were suggested for all scenarios. Table 8 highlights these “no regrets” options. Because each participant engaged with only two of the scenario narratives, agreement in ideas across all three scenarios reflects the perspective of more than a single individual.

Table 8. “No Regrets” ideas for climate change adaptation in the Crown of the Continent region, suggested for implementation by years 2020 and 2050 by workshop breakout groups in response to scenario narratives.

Year	Type of Idea for Climate Change Adaptation	“No Regrets” Ideas (suggested for all three scenarios)
2020	Changed management objectives	• None: No agreement across all scenarios
2020	Build capacity to adapt	• Increase/maintain general monitoring • In planning, identify trigger points for protection or moving of resources • Identify and lobby for general budget resources and funds
2020	Adaptation actions	• Water conservation
2050	Changed management objectives	• None: No agreement across all scenarios
2050	Build capacity to adapt	• None: No agreement across all scenarios
2050	Adaptation actions	• Acceptance of impacts and losses • Scheduled/active dam releases

Alternatively, Table 9 highlights some ideas suggested for only the Race to Refuge/Big Problems, Big Solutions scenario that represent significant departures from current policies or practice. They are not preferred or recommended options, but only ideas generated in “thinking outside the box” in response to that specific scenario narrative. While these options may be seen as quite different from current practice, risk management suggests preparation to implement these options, as conditions move towards those of the Race to Refuge/Big Problems, Big Solutions scenario.

Table 9. Selected ideas for climate change adaptation in the Crown of the Continent region for the Race to Refuge/Big Problems, Big Solutions scenario, suggested for implementation by years 2020 and 2050 by workshop breakout groups in response to scenario narratives. Note: Table contents are not preferred or recommended options, but only ideas generated in response to that specific scenario narrative.

Year	Type of Idea for Climate Change Adaptation	Race to Refuge/Big Problems, Big Solutions Scenario
2020	Changed management objectives	• Major water infrastructure • Rethink roles for public lands services
2020	Build capacity to adapt	• Develop protocols for creating plant collection areas for 1855 treaty tribes • Begin an endowment so that necessary actions can be funded after the “boom” in support has ended • Work with tribal communities to learn from their traditional “low-carbon footprint” lifeways
2020	Adaptation actions	• Aggressive logging on larger scales than previously done, primarily for human safety • Establish new cultural traditions

		• Close or remove infrastructure from areas at high risk from mass wasting
2050	Changed management objectives	• Triage
2050	Build capacity to adapt	• Enforce standards that prevent plant consumption for cultural uses • Restructure public lands agencies to create supportive social structures to ensure production for food, water and shelter • Plan to fight dam and irrigation plans for Park water • Restructure federal government so that management boundaries disappear
2050	Adaptation actions	• Triage the Going to the Sun Road and don't repair or rebuild • Scale down and reduce services

Twenty-five workshop participants submitted workshop evaluations, the scores of which were tallied and shown in Attachment 12. Overall, participants considered the C4SP workshop a success, with 17 of 25 respondents indicating that the workshop met the main objective, i.e., to explore, assess and respond to alternative futures for the Crown of the Continent ecosystem. Of the 25 respondents, 15 indicated that the workshop also met the secondary objective, i.e., to apply scenario planning as a management tool.

NPS staff also submitted verbal and written comments to the University of Arizona team to incorporate in an assessment of the workshop and breakout exercises. In addition to the workshop evaluations forms, feedback about the project and workshop was solicited using a variety of methods. During the workshop, efforts were made to ask participants for their perspective about different activities. After the workshop, comments were informally solicited from NPS participants remaining at the workshop venue. A debriefing session of selected Steering Committee members, NPS staff, and the University of Arizona team was held the morning after the workshop. Finally, NPS staff also submitted verbal and written comments to the University of Arizona team to incorporate in an assessment of the workshop and breakout exercises. Open-ended comments about the workshop and pre-workshop preparation process are listed in Attachment 12.

3. Lessons and Recommendations for CMP and CCRP

This section begins with topics related to specific elements of scenario planning projects. It moves to topics about scenario planning as a management tool, and finishes with recommendations for next steps for Glacier National Park and the CMP to move forward in their consideration of climate change, scenario planning, and adaptation planning.

3.1 Project Website

The project website was generally useful in supporting project objectives, although not all website capabilities were used by all participants. For the University of Arizona project team, the website provided an easy way to manage invitations, provide directions for webinar participation, and provide

controlled and structured access to webinar agendas, background reading material, webinar recordings, and workshop presentations. The social networking capabilities of the website allowed participants to communicate with the project team without having to identify who was most appropriate for a specific task (e.g., to request changes in email receipt). Feedback from project participants indicates the most useful contributions for the website were accessing the workshop presentations, the background readings, and the recorded webinars.

3.2 Pre-Workshop Webinars

Webinars are useful and key to the success of the workshops and ownership of the process.

The ambiguous, evolving nature of webinar participation was an exogenous project design parameter. It posed significant challenges of continuity in connecting concepts across webinar topics. Most webinars had several key participants joining for their first time in the series, requiring review of project and scenario planning goals, processes, and issues. Recurring reviews were frustrating to some regular webinar participants, yet was essential to give new participants context for the discussions and their respective contributions.

The webinar schedule was short, even before being compressed by two weeks due to the delayed response of CMP members to the workshop invitations. While the Steering Committee did not expect anyone to participate in all the webinars, one consistent participant commented that the rigorous schedule was problematic. Two webinars per week was too demanding of participants and difficult for organizers to adapt when presenters changed or calendars needed adjustment to accommodate key participants. Other participants suggested either fewer webinars or a longer schedule, or both.

Assessment of the appropriate number of webinars required to prepare for a scenario planning workshop is confounded by the many degrees of freedom inherent in a project. Scenario planning to support environmental decision making can occur productively within an afternoon or across several years (Mahmoud et al., 2009). For this project, a key requirement was that the scenario narratives would be developed prior to the workshop, by individuals familiar with the scenario planning process rather than with specific prospective changes and management challenges of the region. Other requirements were to introduce scenario planning requirements to key individuals in the CMP and to explore two new concepts related to scenario planning and climate change adaptation.

For these requirements, the number of webinars and their topics were appropriate. The webinars allowed a variety of issues to be discussed with more specificity and depth than prior NPS case studies or the C4SP workshop. Each of the webinars was useful in preparing for the C4SP workshop. Each webinar allowed participants to address, in depth, a topic key to project requirements and discuss how it related to management concerns and challenges in the Crown of the Continent ecosystem.

The webinars on scenario planning and change (Scenario Planning, Future Change) could be combined if participants are familiar with scenario planning methods or climate change science. However, in this case study there was sufficient discussion about scenario planning as a process, and the irreducible uncertainty inherent in climate change and long-term planning, to warrant keeping these topics as separate webinars. While the drivers table was prepared by a climatologist external to the project by slightly modifying a similar table already completed for the WICA case study, webinar 2 was needed to discuss the climate drivers and allow participants to collectively approve having the table prepared by the climatologist.

The webinars on system impacts and vulnerabilities, (Impacts on Terrestrial and Aquatic Ecosystem, Cultural Resources, and Facilities and Services; Feedbacks, Tipping Points and Cascades) could be combined. They allowed extraction of information sufficient for the project team to complete the impacts tables, with supplementary information from a literature review. A regional team could potentially prepare the impacts tables with fewer webinars. However, each webinar also included valuable discussion about management challenges related to the prospective impacts, providing important context for ensuring that scenario narratives and workshop were relevant.

The webinar on scenario construction (Building Scenarios) was essential for allowing the group to make choices about priorities for construction of the scenario narratives. If the scenarios are constructed using another process for making these choices, e.g., by a regional project team, the webinar may not be necessary, but may still be helpful to provide transparency about the process.

The webinars dealing with adaptation (Adaptation Options, Policy Screening) are not needed to prepare scenario narratives in advance of a workshop. While this case study confirmed the relevance of the topics, further innovation and testing are needed to improve their applicability for resource management.

The schedule included two "contingency" webinars where problematic issues or unfinished discussions could be addressed. While these webinars were ultimately not needed, it seems prudent to still include extra webinars in pre-workshop preparations.

The webinar recordings offer a rich resource for understanding details of CMP challenges. Collectively, they include over 18 hours of discussion. Based on informal feedback, people that listened to the webinar recordings as a substitute for participation found them useful. The ability to fast-forward past the logistics and technology discussions was important.

In retrospect, creation of 1-page summaries of webinar discussions would have provided an efficient way for people to connect with the webinars and conversations, and for emailing updates to the larger group. Such summaries could also have helped in promoting webinar or workshop participation.

3.3. Scenario Narrative Construction

After the webinars on climate change and impacts, some participants were eager to begin assessment of adaptation options. The process of identifying the climate scenario dimensions and prioritizing scenarios for construction of narratives, however, is an important step requiring reflection and synthesis of prior discussions, and requiring participants to seek maximum uncertainty and change rather than try to minimize it. The discussions were not easy, requiring several online meetings after the formal webinar series. It took this process for some participants to finally appreciate the scope and scale of the management challenge of climate change (e.g., that using positive and negative variants of a baseline temperature is not sufficient, that there is no "business as usual" or "no change" scenario).

The ranking process used to identify the primary scenario dimensions was important for ensuring that a wide range of possible future conditions was considered, based on an explicit and repeatable process that could be understood by and communicated to others. Focusing on the climate variables having the highest uncertainties and the highest impact on the region provided a structure to keep discussions from drifting to easier topics, being dominated by personal preferences of some participants, or attempting any "end run" of narrative development by shifting to ad hoc processes. In fact, when a

suggestion was made to avoid the need to prioritize the important variables and use an ad hoc process to develop narratives, other participants voiced strong disagreement; having a structure for considering uncertainty was considered too important.

Likewise, the process for prioritizing which scenarios to "build out" into narratives was important, requiring the group to seek out scenarios that would pose the most relevant and challenging situations for current managers to consider. Three frames seemed to offer the most potential to stretch managers' thinking about the future. (1) If there are low levels of societal concern and leadership, can managers meet the challenge of even small, slow change? (2) Even if managers are supported by the highest levels of leadership and societal concern, with concomitant resources and institutional flexibility, will that be enough to meet the challenges of abrupt change that will remake the regional landscape? (3) Would changes in policy offer enough flexibility to meet the challenges of inexorable climate change?

This case study confirms findings from prior NPS case studies that multidimensional scenario planning takes significant pressure off specific global climate model outputs and the details of down-scaled model projections. Participants were able to focus on management challenges, rather than the details of specific modeling and downscaling methods.

Discussion about the higher level framework was essential. It provoked extensive discussion about scale and the difference between external drivers and internal system responses. Drivers, system responses, and impacts proved to be difficult concepts for participants to grasp consistently, especially in distinguishing among different scales (e.g., from global and national perspectives, within a region, within a NPS unit, within a specific habitat). Likewise, some participants had difficulty distinguishing management options from external drivers or system responses, especially related to wildfire and invasive species issues.

The current nested scenario approach did not allow adequate consideration of the high impact and high uncertainty related to (1) understanding ecosystem and cultural processes, or (2) estimating the effectiveness of management actions. For example, the processes and controls on invasive species, regional economic development, and wildfire management practices are not understood with high certainty. Further innovation, experimentation, and testing to include these additional dimensions of uncertainty within the scenario planning process are recommended.

This case study confirmed prior experience that group discussion is essential for making choices and developing the skeleton of the scenarios. Past case studies developed the scenario outlines in their workshops, but this project attempted to use webinars, followed by several informal web meetings prior to the workshop. However, discussions proved too difficult for the group to agree on specific storylines (i.e., key uncertainties and system sensitivities), and not all individuals were comfortable with the creative aspect of writing scenario narratives. The scenario narratives were ultimately developed by the University of Arizona team.

There is typically tension between the creativity and credibility of scenarios developed for environmental decision making (Alcamo and Henrichs, 2008). For this workshop, creativity was considered more important due to the desire to challenge the perspectives of the CMP managers. Credibility may be more important in other applications if the scenarios are intended to support a public planning process.

Based on feedback from the workshop, participants found the scenario narratives to be relevant, creative, legitimate, and credible, with one exception. Participants were skeptical that societal upheaval could be concurrent with an abundance of resources for managing the Crown of the Continent ecosystem in the Race to Refuge/Big Problems, Big Solutions scenario. However, they were still were willing to use the scenario narrative to support discussion about adaptation options and planning processes.

The formal scenario development process is recommended for independent use by NPS units and their partners. Each step in the process is suitable for group interaction. While creation of the scenario narratives is fundamentally a creative writing effort uncomfortable to some people, selection of elements to include in the narratives can involve anyone, as can review of the narratives to ensure they incorporate the full range of information and concerns expressed throughout a project.

3.4 Workshop

As in prior case studies, the C4SP workshop was successful in using scenario planning to help managers develop insights about prospective regional climate changes and impacts; demonstrating methods for responding to evolving information about important, yet highly uncertain, forces outside their control; and strategically evaluating their management objectives and potential adaptation options. A scenario planning workshop provides a needed mechanism for strategic planning. In the words of one participant, “We have to make daily decisions on so many things. We don’t even have a chance to breathe and do strategic planning.”

The C4SP workshop also demonstrated that scenario planning is a useful method for engaging with partners outside of the NPS about climate change. However, additional innovation, applications, and testing are warranted to improve scenario planning methodologies, workshop design, and implementation.

Many participants were confused as to the real objectives of the workshop. While some expected to learn how to create scenarios (i.e., training, training of trainers), others expected to create scenarios themselves at the workshop (i.e., doing, without needing to master the process itself). Neither of these was the organizers’ intention; it is unclear how these expectations developed, since they were not included in any project communications.

There seemed to be 3 types of participants, with each having a different perspective about the workshop objectives. One group saw the workshop as a place for broad discussion about the future of the region; while they appreciated the opportunity to engage with the NPS in this workshop, they clearly desire continued discussion across many topics and felt limited by the narrow topic and format of this workshop. A second group sought specific actions to affect their work shortly after the workshop, an ‘action plan’ similar to the Climate Friendly Parks workshops’ mitigation action plans; this group seemed frustrated at the lack of closure and next-step actions as workshop outcomes. A third group saw this workshop’s primary goal as expanding perspectives about future possibilities, as only one piece of developing approaches for considering management responses to climate change; this group seemed most satisfied with the workshop.

Regarding objectives, one lesson learned is to give more thought a priori to the particular expression of the workshop objectives and to organize the schedule around them, to ensure they will be met. A more

appropriate set of workshop objectives that would be worth considering are those supporting decision making and long-term planning in Table 5.

In the workshop, some participants strongly wanted to share their perspectives on driving forces and change, for the past, present, and future. The workshop agenda didn't allow that sharing and it was frustrating to some, especially participants from other organizations that seemed not to have other avenues for communicating that with the NPS. Many of these same individuals found the early presentations on climate change and impacts to be useful, but felt that they didn't have the time to reflect on the material and integrate their own perspectives; they felt left behind as the workshop moved past discussion of impacts to identification and assessment of adaptation options.

Another challenge was trying to fit two new areas into the workshop schedule (adaptation options and screening). Each of these topics required a shift in participants' thinking from a focus on impacts to potential strategies. The workshop demonstrated that it is possible address these topics in a 2-day scenario planning workshop, although changes in workshop design are required to achieve an "action plan" of options. While the workshop also demonstrated methods to strengthening linkages between scenario planning, management actions, and standard planning practices, the top workshop area that participants identified as needing improvement was improving those linkages.

For developing potential adaptation options, the approach of going backward in time, beginning with potential conditions in 2100, was successful. It kept the emphasis of discussion away from near-term "no regrets" actions that have already been identified, and instead focused on the challenges posed by long-term changes that may require irreversible commitments and long lead-times in decision making. Subsequent movement of discussion to shorter-term needs provided opportunity to highlight management options that may have long-term or irreversible consequences.

Some participants in the day 2 breakout sessions were frustrated with the use of pre-defined adaptation options and wanted to come up with those same options in their own words. There was confusion in some breakout groups about the purpose of the whiteboards and the ready-made "answers" that needed to be placed on the boards. One facilitator felt that the participants could come up with those ideas for climate change adaptation, in their own words, without that part of the exercise.

There is no dearth of options; hundreds have been identified that can be applicable to resource management (e.g., Climate Change Science Program, 2008; Heller and Zavalata, 2009). The idea is not to repeat work that has already been done at different management levels, in other organizations, or in research, but to build on that work in ways that are specific to the NPS unit, region, and neighboring organizations. Development of adaptation case studies (e.g., the EcoAdapt Climate Change Adaptation Knowledge Exchange) is helpful, but as the number of proposed adaptation options grows, there is increasing need simply to navigate efficiently through the expanding milieu, to move the conversation beyond what's currently available, to focus on questions most appropriately addressed using scenario planning, and to connect a variety of adaptation options to planning processes. However, workshop participants were at very different stages in their thinking about adaptation options, with some being able to list many detailed options relevant to specific locations and management challenges, and others wanting to discuss basic concepts. This posed challenges in trying to productively engage with participants during the breakout sessions focused on adaptation and planning. High-level management was interested in focusing on changes needed in management objectives, but changes in actions are more concrete and approachable by field personnel.

An alternative perspective of many workshop participants was that the distinction between options that build adaptive capacity and those that actually implement an adaptation action was useful. Further, while some workshop participants wanted more group development of options, having some options pre-identified did allow for the planning-related exercises to proceed within the workshop schedule.

The topic of policy screening, whereby adaptation options are connected to a formal evaluation process, was a significant advance in the application of scenario planning. Managers particularly liked the session on analysis of adaptation options using policy screening as part of a planning process. Policy screening shows promise for making evaluation of options practical and consistent with evaluation practices and processes.

Methods to produce time-varying weighted portfolios of adaptation option investments that can accommodate potential changes in management objectives, however, are not yet developed enough, although methods demonstrated in this project show one way to proceed. The demonstrated approach can also be used to develop a management-driven research agenda, as management requires answers to questions such as:

- How will I know when important underlying driving forces are changing?
- Will decisions I make now have long-term consequences? Will they make my system more vulnerable to future change?
- For decisions that require long lead-times, how will I know when conditions are moving away from some scenarios and towards others? What information will I need to make my decision at that long lead-time?

Discussions in the policy screening breakout sessions progressed far enough to determine that these kinds of management questions resonated strongly with some participants, notably high-level management. However, the workshop didn't provide enough time to develop responses to these questions.

Participants generally wanted more time to work through the materials after getting through the basic information about scenario planning, drivers of change, and impacts. Management may consider adding a third day to future workshops or develop further engagement, especially if the goal is to bring the scenarios down to the level of daily management applications. A common suggestion was to minimize the focus on the SP process and allocate more time for participants to work through applications of scenarios. Workshop organizers may be tempted to shorten the first day because participants seemed to readily accept the scenario narratives. However, it's not clear that compressing the first day is appropriate. Did the acceptance of the scenario narratives derive from our transparency about the process? Further, the ability of participants to create their own scenarios for ongoing planning is important, as climate change and impacts science evolves, or to focus on more local scales.

Scenario planning workshops should occur at the regional scale with a diverse array of participants. A practical challenge for doing many local-scale workshops is the shortage of climate scientists that are available to participate. The process used in the C4SP project can accommodate many participants, including non-NPS personnel, while not exhausting the limited number of climate change scientists that are important for supporting the climate assessment. A practical approach is to have a regional 'kickoff' workshop that focuses on the scenario planning process using the high-level socio-political matrix and regional climate changes and impacts. If the pre-work team and workshop participation are large enough, subgroups could address field-scale issues. A suggestion is to begin with regional scenarios and then build out four quadrants that incorporate the high uncertainty and high impact dimensions within a specific decision context. While this would require more effort and commitment to ensure appropriate

participation of topic and regional experts, an alternative would be to have more pre-workshop effort to develop options for the sub-regional scenarios, which could then be supplemented at the workshop and worked through the evaluation process on the third day.

More care is also warranted in the organization of group members for activities, to ensure diversity and provide a safe setting for candid discussion of sensitive topics. While expert facilitation can foster the trust required to share perspectives, we observed deference of some participants to their chain-of-command supervisors when both participated in the same breakout group. We suggest organization of breakout group participation by level of management concern, especially a separation of higher level management and field operations. More presentations from other expertise are suggested, both at the workshop and for preparations, including from cultural, ethnographic, demographic, economic, and facilities disciplines.

Clear identification of a committed core group to support pre-workshop preparations would be tremendously helpful. A core group familiar with local issues and a commitment to scenario development activities would make the entire effort much more efficient, although an external perspective may still be helpful to ensure challenges to current perspectives rather than simply magnifying current challenges. Smaller teams that could manage specific topics for the webinars or workshop would provide a richer experience by enabling exploration of the diversity of situations within a large region and the diversity of experience and perspectives of the larger group.

However, this project demonstrates that a core group is not essential for developing useful scenario narratives that are acceptable for use in scenario planning workshops. While some NPS and CMP personnel were assigned to workshop preparation (e.g., logistics), the project design precluded asking them to review literature, construct drivers or impacts tables, develop the scenario outlines or narratives, or prepare workshop materials. Participation in the webinars was voluntary, rather than assigned as in earlier scenario planning case studies (L. Welling, personal communication, 2009). The lack of a formal commitment on the part of NPS personnel or CMP members challenged the continuity of discussions across the webinar series, and the advancement of conceptual thinking by some workshop participants. Yet, a key finding is that this lower level of participation was still sufficient for the rest of the project to proceed successfully. The process and scenario narratives were considered by workshop participants to be relevant, creative, and generally legitimate and credible, and preparations enabled the workshop to achieve its primary objectives.

Posting workshop presentations proved useful after the workshop. They were used to support presentations to other groups by NPS personnel who had attended the workshop. However, there should also be explicit arrangements made to continue discussions after the workshop. The risk is that the workshop seems like it was an interesting event, but ultimately proves irrelevant without some connection to ongoing discussions.

3.5 Next Steps for the Climate Change Response Program

Scenario planning focuses on what could happen and what is unlikely but possible, i.e., the circumstances under which resilience building and conservation are less likely to have sufficient impact to counteract climate change impacts (Wickel et al, 2009). The types of climate changes that scenario planning effectively encompasses includes shifts in climate envelopes, the occurrence of extremes beyond prior experience, total changes in the state of climate, and unforeseen climate regimes. Consistent with findings from earlier NPS case studies, participants generally see great value in scenario

planning. There is, however, inherent risk in creating an interest in this type of planning, without a path for producing a clear planning outcome. Linking scenario planning more concretely with dynamic ongoing management and planning of agency personnel is an important next step.

The NPS has many options for conducting scenario planning throughout the organization, each requiring very different levels of commitment for personnel and resources. One option is to continue using scenario planning largely for providing insight at the highest levels of park management. For this effort, the regional workshop approach described here seems sufficient and may be overkill. For example, for National Park Superintendents and Resource Managers to informally screen prospective decisions for robustness, it may be sufficient for the park managers to appreciate the concept of divergent scenarios and have some simple scenario outlines available with which to screen decision options.

However, as the NPS approach to considering climate change has become more nuanced, the role of scenario planning within a formal adaptive planning framework has become clearer. One of the stated goals of the C4SP workshop was to "document a structured process for assessing the impact of climate change". That goal more accurately reflects the role of vulnerability assessments; the unique role of scenario planning is to foster strategic thinking by management, by moving beyond the usual assumptions about management's ability to choose and achieve a desired future, given the prospects of climate change.

The NPS has committed to connecting the outcomes of scenario planning workshops with more formal planning processes. In 2010-2011, the NPS trained over 150 people, both within and outside the NPS, on the process of climate change scenario planning, and is currently developing an instructional handbook for managers who want to replicate the process. The NPS is also developing an internal website for NPS planners and managers that includes downscaled climate change projections for consideration in specific park planning efforts.

The NPS is currently revising its planning policies and framework to better address the challenges facing national parks, including climate change. Elements of the climate change scenario planning process will be incorporated into this new NPS planning framework (i.e., Foundation Documents, General Management Plans, Resource Stewardship Strategies, Comprehensive Interpretive Plans), and the NPS will apply the full-scale scenario planning process when warranted.

3.6 Next Steps for Glacier National Park and CMP

Highlights of the C4SP workshop, communicated via evaluation forms, included learning about the scenario planning process and hearing the climate science presentations. This finding confirms that there is a market for scenario planning as a tool for managers and that, in the words of one participant, "serving them the science" early on in such a workshop is a key component to achieving ownership and active participation. The simple act of bringing together participants representing many disciplines, professional roles, and encouraging healthy dialogue about pressing issues of concern was another highly rated workshop outcome that highlights an opportunity for Glacier National Park or CMP to organize more workshops related to climate change and adaptation planning.

After the workshop, we were asked to identify "no regrets" alternatives from workshop activities. In some conceptions, "no-regrets" actions increase resilience, which is the ability of a system to bounce back from stresses. In others, "no regrets" planning aims to avoid "locking in" vulnerabilities, which could lead to significant and potentially irreversible damage in the future. The scenario planning process, as implemented here, was not aimed at identifying these types of "no regrets" actions.

However, the scenario narratives developed under this project can be used to test any adaptation options using quantitative or qualitative models, to assess whether they lead to significant or potentially irreversible damage for any of the potential futures. This type of assessment was beyond the scope of this project or workshop, but can be conducted by others, independently (Mahmoud et al., 2009).

Another conception of 'no-regrets' strategies is that they begin to create some benefits in the short term, no matter how the climate changes in the future and even if the potential long-term benefits are never realized. The scenario planning process in this workshop did not seek to identify options that would create benefits in the short term, but it did seek to identify options that would be appropriate no matter how climate and other forces change.

Based strictly on the results of the scenario assessment and policy screening activities, the following emerged as "no regrets" actions, defined as being seen as appropriate for any of the possible futures considered in the workshop. To build capacity to adapt, "no regrets" actions include:

- collaboration,
- communication,
- inventories,
- increase general monitoring by 2020,
- identify and lobby for general budget resources and funds by 2020, and
- within planning identify trigger points for protecting or moving resources.

"No regrets" adaptation actions include provision of connectivity, restoration of impaired locations, implement water conservation by 2020, provide for active scheduling of dam releases by 2050, and acceptance of impacts and losses by 2050. There were no "no regrets" changes to management objectives for either 2020 or 2050 planning horizons.

While these "no regrets" actions may appear abstract, they can be transformed into more concrete options. For example, a recommendation would be to focus on ensuring connectivity and restoration of impaired locations within the North Fork of the Flathead River.

One potentially useful path forward that was supported at the workshop is to identify "connection points" or "layers of activities" that can unify or link CMP goals or plans at appropriate levels, i.e., where scenario planning can integrate with ongoing CMP activities, plans and goals. An example would be to focus on connecting workshop results with CMP efforts to define and take stock of ecological health in the Crown of the Continent ecosystem, e.g., by identifying triggers for protection or movement of resources within plans of CMP organizations.

A clear message, however, that pervades discussion in the webinars and workshop is that the Crown of the Continent ecosystem is a unique place, with values that do not exist elsewhere. While CMP organizations have different missions and objectives, all are threatened by changes in climate and other forces. By facing the challenges together, prospects for regionally successful adaptation are increased, if not assured.

In any subsequent scenario planning activities, several suggestions are offered to improve prospects for effective participation. Identification and invitation of workshop participants for the C4SP project was loose. Inviting people over the holidays proved difficult and may have led to some attendance issues. Interacting with potential participants through the CMPs created barriers in communication with the project team, with little ability to track the level of enthusiasm for workshop attendance or engage directly with prospective workshop participants. The low overall level of CMP commitment made it

difficult to ask workshop registrants to prepare for the workshop by participating in the webinar series or workshop planning meetings.

More one-on-one communication is suggested prior to future workshops to correctly set expectations of those who do not attend preparatory activities, as well as to assure the balanced presence of key participants (e.g., government, tribes). One Steering Committee member recommended assigning stewards or mentors from committed and enthusiastic participants (or the CMP Steering Committee) to repeatedly talk to prospective participants and encourage joining in the webinars, on the website, and at the workshop.

Within a 2-day workshop, some participants had to leave early due to long travel times. The dropoff in attendance affected the discussion at the end of the workshop. Conversely, many participants were within commuting distance of the workshop location. This made it difficult to ensure high participation for the evening program. Future workshop organizers should ask CMP members, or more broadly all prospective workshop participants, to suggest meeting structures that would foster participation throughout a workshop.

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Attachment 1: Webinar Invitations
- Selected webinar invitations
- Selected invitations to webinar presenters

Webinar 1: Scenario Planning
Tuesday, January 21, 2pm MST

As a registrant of the upcoming Crown of the Continent Climate Change Scenario Planning (C4-SP) Workshop, welcome! We look forward to seeing you in Whitefish, Montana, March 9-10, 2010!

We are developing a lot of information prior to the workshop, in addition to the usual workshop logistics (hotel information, location maps). We will be posting all preparation and support material on the C4-SP website at http://c4-sp.basecamphq.com. You have already been registered to access the website, using your email address.

Our C4-SP Workshop Webinar Series begins on January 21, 2010 at 2pm MST. This series of 12 to 13 online meetings is an important part of preparing for the March workshop. The webinars are not classes or a presentation series. They are a highly engaging, interactive, and focused exploration of topics, designed to ensure that scenario planning in support of climate change adaptation will be relevant and useful to your organization. We will hear from regional experts on a variety of topics, but together, we will also be synthesizing information and building a foundation for collaborative climate change adaptation planning that can continue long after the March workshop. We will be asking for, and incorporating, your expertise and input about management challenges, local and regional systems and issues, data availability, science and community activities, and more.

We strongly welcome and encourage your participation in the first webinar of the series: "Scenario Planning". The goal of this first webinar is to introduce scenario planning as a specific process and to get started by identifying a focal question and key external drivers that will guide the entire series and workshop. The complete webinar schedule, including the theme of each meeting, is posted at the C4-SP website.

Logistics: Webinar 1 starts at 2pm MST, Thursday, January 21. You will receive a separate email with the webinar link that is *unique to you*, which you should use on Thursday. We will also send a separate email for an optional practice session, with its own unique weblink just for you to use. If you have any logistical questions about using the webinar technology, please contact Melanie Graham at 970-267-2198.

Planned Meeting Agenda:
- Introduction to webinar procedures and functions
- Introduction of participants

- Introduction to overall project, webinar series, and March workshop
- Introduction to C4-SP project website
- Scenario Planning : Holly Hartmann and Leigh Welling
  What is scenario planning? How does it relate to other approaches for considering climate change and adaptation?
- Discussion: Developing a focal question
- Discussion: Considering "key external drivers"

To prepare for this Webinar, you are requested to:

1. Review three key documents (all attached).

- Peterson et al., 2003.
- A summary table comparing several approaches for decision support.
- Short directions on how to use the webinar technology.
- Note: These documents are posted on the C4-SP website as well, at: http://c4-sp.basecamphq.com

2. Think about the following questions.

- What are your concerns about the future of the Crown of the Continent region?
- What external factors (climatic and non-climatic) affect management within the Crown of the Continent region? Which of these external factors have both high impact and high uncertainty?

3. Prepare a list (short or long).

- Please list the management, policy, or decision approaches you use within your organization. These may be reports, processes, tools, or methods, e.g., general management plans, 10-year plans, vulnerability analysis, sensitivity studies, etc.

We look forward to your participation on Thursday.
Warm regards,
-- Holly, C4-SP Principal Investigator

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Webinar 1: Scenario Planning
Tuesday, January 19, 2pm MST

Invitation Letter
Dear participant:
Our Webinar Series begins on January 19, 2010 aiming to prepare the upcoming Crown of the Continent Climate Change Scenario Planning (C4-SP) Workshop in early March, 2010. We strongly welcome your participation in this first of the series, whose goal is to make all participants comfortable with the concept of Scenario Planning and to conclude on the focal question and key external drivers that will guide the entire series.

Logistics: The Webinar starts at 2pm MST and you can access it by clicking on this link: URL: c4-sp.basecamphq.com.

Proposed meeting agenda:

- Introduction of participants
- Introduction to overall project and March workshop
  - Objectives of webinar 1: Scenario Planning
  - 1. Presentation on Scenario Planning (as a decision support tool), Holly
    - Discussion, comparison with annual decision/policy docs managed by each participant
  - 2. Presentation of Focal Question (*How can Crown managers respond to climate change impacts?)*, Holly
    - Discussion, comparison
  - 3. Presentation of Key External Drivers (*Climate change, Governance / Leadership, Societal Concern*)
    - Discussion, comparison
  - Final debate, questions.

To prepare for this Webinar, you are requested to review two key documents:

- Peterson, 2003, attached
- A summary table comparing various Decision Support Mechanisms, Table 1 attached
- Please bring your questions and comments to the Webinar, as well as a quick list of the decision support tools you are required to update regularly in your work.

We look forward to your participation. Warm regards,
Dr. Holly Hartmann

From: Holly Hartmann <hollyoregon@juno.com>
To: dan_fagre@usgs.gov
Date: Mon, 25 Jan 2010 14:21:29 -0800
Subject: C4-SP: preparing for webinar 3: Terrestrial Impacts

Entered your email incorrectly the first time.... HH
hollyoregon@juno.com>
To: dan_fagre@ugs.gov
Cc: george-malanson@uiowa.edu,kkendall@usgs.gov,gpederson@usgs.gov, lezlie@email.arizona.edu
Date: Mon, 25 Jan 2010 14:09:13 -0800
Subject: C4-SP: preparing for webinar 3: Terrestrial Impacts

Hi Dan, George, Kate, and Greg,

First, thanks to each of you for agreeing to serve as panelists for webinar #3 (Natural Resources: Terrestrial Impacts) in preparation for the Crown of the Continent Scenario Planning workshop in early March. In the first 2 webinars, we have tried to establish a foundation for thinking beyond taking Global Climate Model projections, downscaling and pushing them through regional models (terrestrial, hydrologic, etc.), and then looking at potential impacts.

Our foundation includes the notions that (1) the future is increasingly volatile, uncertain, complex, and ambiguous, (2) climate is not the only external factor that has high impact on the CoC region and has high uncertainty, (3) our scenarios will not be predictions, but only internally consistent, plausible stories about how the future might unfold, (4) the scenarios need to have some context and connection with past change, (5) within CoC, responses to these external forces are not simply linear, with thresholds or tipping points, pinch points or bottlenecks, and then cascading effects when thresholds are crossed or bottlenecks are too tight, and (6) many aspects of the CoC may undergo change and have to respond to impacts.

My request to each of you is to help our group take a sufficiently broad view of the prospects for terrestrial ecosystems and management. In webinar #2, we began to frame our approach to considering change from multiple external driving forces having both high uncertainty and high impact. Steve Gray and Dan Fagre (thanks, Dan!) helped set the tone by highlighting climate considerations we need to be including in our scenarios (e.g., small changes can have big impacts, the need to consider natural variability as well as GHC-driven changes, evolving recognition of non-stationary climate and hydrology).

I'd appreciate your help in framing our approach to the terrestrial resources issues. How have approaches (that's ambiguous, I know)to terrestrial resources changed, and were any of those changes surprises? What kinds of forces (non-climate and climate) affect approaches to terrestrial resources? Do you see approaches for relating to terrestrial resources changing in the next 10 years? next 50 years? 100 years? How might the region be interested in terrestrial resources as any of our scenarios unfolds? (especially considering stakeholders have different levels of power and different interests related to these resources).

Certainly, please incorporate information about projected impacts on terrestrial resources in the CoC region, from non-climate and climate forces, to the extent you think appropriate, given that most participants have heard many talks on prospective impacts of climate change. I've attached a file, extracted from a report on the Joshua Tree and Kaloko-Honokuhau National Park case studies of scenario planning. We will be trying to develop similar tables, although the non-climate factors will

depend on what the group thinks is critical (the JOTR example used budgets and the role of the park to society), aligned with the non-climate dimensions mentioned in webinar 1 (i.e., the nature of leadership, and degree of societal concern). If there are aspects related to terrestrial resources that we should be sure to include, it would be great if you could address that, too.

Finally, if there are any slides or short readings that you think would be helpful for webinar participants to look at before the meeting, please send them to me and Lezlie Moriniere for including with the webinar invitation and posting to the C4-SP website. We'd be pleased to have any input about general resources that could inform our scenario development as well. (Greg, you've already sent me material for this.)

Well, that's a lot to ask of each of you. I've included all 4 of you on this email, in case you want to coordinate with each other. But even if you aren't able to coordinate, hearing your individual perspectives on these common questions will be immensely helpful to the group.

If you'd like to talk with me further, I'm in my office all this week. Please don't hesitate to call at your convenience. If you want to upload anything to the C4-SP website or would like to do a dryrun using the webinar technology, please contact Lezlie.

Thanks again for agreeing to serve as a panelist and for participating in the webinars. I look forward to hearing your comments!
Regards,
-- Holly
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Holly C. Hartmann
Director, Arid Lands Information Center
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Ph: 541-607-6722
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Hi Matt,

First, thank you for agreeing to serve as a panelist for webinar #6 (Impacts on Facilities and Services) in preparation for the Crown of the Continent Scenario Planning workshop in early March. In the first 2 webinars, we have tried to establish a foundation for thinking beyond taking Global Climate Model projections, downscaling and pushing them through regional models (terrestrial, hydrologic, etc.), and then looking at potential impacts.

Our foundation includes the notions that (1) the future is increasingly volatile, uncertain, complex, and ambiguous, (2) climate is not the only external factor that has high impact on the CoC region and has high uncertainty, (3) our scenarios will not be predictions, but only internally consistent, plausible stories about how the future might unfold, (4) the scenarios need to have some context and connection with past change, (5) within CoC, responses to these external forces are not simply linear, with thresholds or tipping points, pinch points or bottlenecks, and then cascading effects when thresholds are crossed or bottlenecks are too tight, and (6) many aspects of the CoC may undergo change and have to respond to impacts.

My request to you is to help our group take a sufficiently broad view of the prospects for facilities and services of the Crown Management Partners (CMPs) in the CoC region. In webinar #2, we began to frame our approach to considering change from multiple external driving forces having both high uncertainty and high impact. Steve Gray and Dan Fagre helped set the tone by highlighting climate considerations we need to be including in our scenarios (e.g., small changes can have big impacts, the need to consider natural variability as well as GHC-driven changes, evolving recognition of non-stationary climate and hydrology).

I'd appreciate your help in framing our approach to facilities and services issues. How have approaches (that's ambiguous, I know) to facilities and/or services changed, and were any of those changes surprises? What kinds of forces (non-climate and climate) affect approaches to facilities and services? Do you see approaches for relating to facilities or services changing in the next 10 years? next 50 years? 100 years? How might the region be interested in CMP facilities or services as any of our scenarios unfolds? (especially considering stakeholders have different levels of power and different interests related to various facilities and services).

Certainly, please incorporate information about projected impacts on facilities and services in the CoC region, from non-climate and climate forces, to the extent you think appropriate, given that most participants have heard talks on prospective impacts of climate change. I've attached a file, extracted from a report on the Joshua Tree and Kaloko-Honokuhau National Park case studies of scenario planning. We will be trying to develop similar tables, although the non-climate factors will depend on what the group thinks is critical (the JOTR example used budgets and the role of the park to society), aligned with the non-climate dimensions mentioned in webinar #1 (i.e., the nature of

leadership, and degree of societal concern). If there are aspects related to facilities and services that we should be sure to include, it would be great if you could address that, too.

Finally, if there are any slides or short readings that you think would be helpful for webinar participants to look at before the meeting, please send them to me and Lezlie Moriniere for including with the webinar invitation and posting to the C4-SP website. We'd be pleased to have any input about general resources that could inform our scenario development as well. [Note: Thanks for the material you have already sent. It will be especially useful for webinar #10 (Adaptation Options) on February 18.]

Well, that's a lot to ask of you! I've asked Tim Hudson and Jim Foster to be panelists as well, but I haven't heard from them. If you have any recommendations for someone that might provide a perspective somewhat different than your own, I'd appreciate the lead!

If you'd like to talk with me further, I'm in my office all this week. Please don't hesitate to call at your convenience. If you want to upload anything to the C4-SP website or would like to do a dry-run using the webinar technology, please contact Lezlie.

Thanks again for agreeing to serve as a panelist and for participating in the webinars. I look forward to hearing your comments!
Regards,
-- Holly
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Holly C. Hartmann
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Tucson, AZ 85721
Ph: 541-607-6722
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Hi Jill, Linda, and Leigh,

Thank you for agreeing to serve as panelists for Webinar #10: Adaptation Options in preparation for the Crown of the Continent (CoC) Climate Change Scenario Planning (C4-SP) Workshop in early March. Webinar #10 is scheduled for this Thursday, February 18, at 2pm MST.

In prior webinars, we have tried to establish a foundation for thinking beyond taking Global Climate Model projections, downscaling and pushing them through regional models and then looking at potential impacts. Our foundation includes the notions that (1) the future is increasingly volatile, uncertain, complex, and ambiguous, (2) climate is not the only external factor that has both high uncertainty and high impact on the CoC region, (3) our scenarios will not be predictions, but only internally consistent, plausible stories about how the future might unfold, (4) the scenarios need to have some context and connection with past change, (5) many aspects of the CoC may undergo changes and need to respond to impacts, and (6) within the CoC, responses to these external forces are not simply linear, but have thresholds or tipping points, pinch points or bottlenecks, and then cascading effects when thresholds are crossed or bottlenecks are too tight. We have discussed potential impacts across a variety of sectors, including terrestrial and aquatic ecosystems, cultural resources, facilities, and services.

At this stage in the webinar series and workshop preparation, we are beginning to look at how managers in the CoC region may respond to future changes imposed by outside forces. We will also be considering how adaptation options can be evaluated and arranged to maintain flexibility to accommodate a wide range of potential futures.

My request to each of you is to help move our group beyond first-effort brainstorming of adaptation options. Some webinar participants have been eager to offer adaptation options developed in other settings, most typically focused on things that can be implemented now. However, our scenario planning effort is looking at a long time horizon (the 21st century), where management objectives themselves may change, requiring an expanded consideration of adaptation options to include potential legal, policy, or even cultural changes (e.g., increased risk tolerance) that may require long lead-times to develop. How do you see management objectives changing (or needing to change) over the next 10 years? by 2050? by 2100? How would you recommend that managers consider adaptation options when some present-day management objectives may simply not be achievable?

If there are any slides or short readings that you think would be helpful for webinar participants to look at before the meeting, please send them to me and Lezlie Moriniere for including with the webinar invitations and posting to our C4-SP website. We would be pleased to have any input about general resources that could inform later discussions, post-workshop, as well. You will be receiving separate emails about how to access the webinar (using your computer and your telephone) and the C4-SP website.

Well, that's a lot to ask of each of you. I've included all 3 of you on this email, in case you want to coordinate with each other. But even if you aren't able to coordinate, hearing your individual perspectives on this topic will be immensely helpful to the group. The structure of the webinar is flexible enough to accommodate whatever you think most appropriate. You can each give a short presentation (10 minutes), with or without slides, and then participate in discussion, lead discussion, or simply participate in a discussion that I would lead…

If you would like to talk with me further, I'm on my cell phone all this week (541-543-5449). Please don't hesitate to call at your convenience. If you would like to do a dry-run using the webinar technology, please contact Lezlie (lezlie@email.arizona.edu).

Thanks again for agreeing to serve as a panelist and for participating in the webinars. I look forward to hearing your comments!

Regards,
Holly
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Holly C. Hartmann
Director, Arid Lands Information Center
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University of Arizona
Tucson, AZ 85721
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Hi Jeff,

Thank you for agreeing to serve as a panelist for Webinar #11: Policy Screening in preparation for the Crown of the Continent (CoC) Climate Change Scenario Planning (C4-SP) Workshop in early March. Webinar #11 is scheduled for Monday, February 22, at 9am MST.

In prior webinars, we have tried to establish a foundation for thinking beyond taking Global Climate Model projections, downscaling and pushing them through regional models and then looking at potential impacts. Our foundation includes the notions that (1) the future is increasingly volatile, uncertain, complex, and ambiguous, (2) climate is not the only external factor that has both high uncertainty and high impact on the CoC region, (3) our scenarios will not be predictions, but only internally consistent, plausible stories about how the future might unfold, (4) the scenarios need to have some context and connection with past change, (5) many aspects of the CoC may undergo changes and need to respond to impacts, and (6) within the CoC, responses to these external forces are not simply linear, but have thresholds or tipping points, pinch points or bottlenecks, and then cascading effects when thresholds are crossed or bottlenecks are too tight. We have discussed potential impacts across a variety of sectors, including terrestrial and aquatic ecosystems, cultural resources, facilities, and services.

At this stage in the webinar series and workshop preparation, we are beginning to look at how managers in the CoC region may respond to future changes imposed by outside forces. In webinar 10, we focused on consideration of adaptation options, including those that have long lead times for implementation, and options that may be implemented on shorter time-scales but with long-lived and potentially irreversible consequences.

My request to you is to help our group consider the perspective of NPS managers and their ability to deal with high irreducible uncertainty. How much uncertainty can be accommodated in current management and planning practices? What insights have you gained from your experience with scenario planning, especially for managing dilemmas that don't have easy solutions? Can managers use scenario planning for more than a 'mental stretching exercise'? How can scenario planning results mesh with ongoing NPS planning and management practices?

If there are any slides or short readings that you think would be helpful for webinar participants to look at before the meeting, please send them to me and Lezlie Moriniere for including with the webinar invitations and posting to our C4-SP website. We would be pleased to have any input about general resources that could inform later discussions, post-workshop, as well. You will be receiving separate emails about how to access the webinar (using your computer and your telephone) and the C4-SP website.

Well, that's a lot to ask of you. The structure of the webinar is flexible enough to accommodate whatever you think most appropriate. You can give a short presentation (10 minutes), with or without slides, and then participate in discussion, lead discussion, or simply participate in a discussion that I would lead…

If you would like to talk with me further, I'm on my cell phone all this week (541-543-5449). Please don't hesitate to call at your convenience. If you would like to do a dry-run using the webinar technology, please contact Lezlie (lezlie@email.arizona.edu).

Thanks again for agreeing to serve as a panelist and for participating in the webinars. I look forward to hearing your comments!

Regards,
Holly
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Holly C. Hartmann
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1955 E. Sixth St.
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Tucson, AZ 85721
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Attachment 2: Webinar Agendas
- Summary list
- Agenda for each webinar

Date and Time	Webinar and Topic
Jan. 21, Thursday, 2pm MST	1: Scenario Planning
Jan. 25, Monday, 9am MST	2: State of the Art: Future Change in CoC
Jan. 28, Thursday, 11am MST	3: Natural Resources: Terrestrial Impacts
Jan. 28, Thursday, 2pm MST	4: Natural Resources: Aquatic Impacts
Feb. 1, Monday, 9am MST	5: Impacts on Cultural Resources
Feb. 4, Thursday, 2pm MST	6: Impacts on Facilities and Services
Feb. 8, Monday, 9am MST	7: Contingency Meeting
Feb. 11, Thursday, 2pm MST	8: Feedbacks, Tipping Points, Cascades
Feb. 15, Monday, 9am MST	9: Building the Scenarios
Feb. 18, Thursday, 2pm MST	10: Adaptation Options
Feb. 23, Tuesday, 2pm MST	11: Policy Screening
Feb. 25, Thursday, 2pm MST	12: Workshop Preparation
Mar. 2, Monday, 9am MST	13: Contingency Meeting

Objectives of webinar 1: Scenario Planning

- Presentation on Scenario Planning (as a decision support tool), Holly
- Discussion, comparison with annual decision/policy docs managed by each participant
- Presentation of Focal Question (*How can Crown managers respond to climate change impacts?* Discussion, comparison
- Presentation of Key External Drivers (*Climate change, Governance / Leadership, Societal Concern*) Discussion, comparison

Annotated Agenda

- Introduction to webinar procedures and functions (5 minutes)
- Introduction of participants (10 minutes)
- Introduction to overall project, webinar series, and March workshop (10 minutes)
    - Climate change poses dilemmas for the Crown of the Continent that cannot be solved, but must be managed with foresight and insight. Scenario planning is especially appropriate for supporting management within a science-based decision-making framework, in situations where there is high uncertainty about the future and little ability to control its direction. Through this workshop and pre-workshop activities, you and others will develop the skills to support ongoing scenario planning efforts and link it with other decision support processes, such as vulnerability assessment, decision analysis, and official management plans. Prior to the workshop, an assessment of climate change projections and potential impacts will be completed with input from your agencies. After the workshop, you will have access to an adaptation planning toolkit, including a database of adaptation options.
    - Based on past scenario planning workshops, participation will be most meaningful with individuals that are comfortable with uncertainty, complexity, and ambiguity. You should be interested in exploring issues across several disciplines, considering both policy and management challenges, and connecting science and management, all through constructive dialog with others having diverse backgrounds and responsibilities.
    - The purpose of this workshop is to create, assess and respond to alternative futures for the *Crown of the Continent ecosystem*, *cultural resources, facilities, and services*, which managers can use to help inform their decisions about managing agency resources in light of potential changes due to climate change.
    - We have high expectations for the interactive and insightful exchanges required within such a Scenario Planning process. All participants will be asked to prepare for the workshop; it is expected that preparation time to participate constructively in the workshop debates will include roughly 5 hours of reading and listening to information from the workshop website prior to the event.
    - This series of 12 to 13 online meetings is an important part of preparing for the March workshop. The webinars are not classes or

a presentation series. They are a highly engaging, interactive, and focused exploration of topics, designed to ensure that scenario planning in support of climate change adaptation will be relevant and useful to your organization. We will hear from regional experts on a variety of topics, but together, we will also be synthesizing information and building a foundation for collaborative climate change adaptation planning that can continue long after the March workshop. We will be asking for, and incorporating, your expertise and input about management challenges, local and regional systems and issues, data availability, science and community activities, and more.

- Introduction to C4-SP project website (5 minutes)
  - Goal: allow the group to jointly work on documents, but with more structure than GoogleDocs provides. It's a compromise that's short of a full-blown website. We may provide a more typical type of website as we go along… We're open to suggestions.
- Scenario Planning : Holly Hartmann and Leigh Welling (30 minutes)
  What is scenario planning? How does it relate to other approaches for considering climate change and adaptation?
  What policy and management planning processes do the managers face?
- Discussion: Developing a focal question (10 minutes)
- Discussion: Considering "key external drivers" (15 minutes)
  - Where do they fit re: the nested hierarchy of GBN (Wind Cave and Assateague Nat. Seashore)?
- Feel free to submit questions to be addressed for the next webinar.
- Next webinar: State-of-the-art: Change in the Crown of the Continent region = Monday at 9am
  - Will send out a table to fill out over the next several sessions (by the Feedbacks webinar #8).
  - Will send 1-2 readings

1. Review three key documents (all attached).

- Peterson et al., 2003.
- A summary table comparing several approaches for decision support.
- Short directions on how to use the webinar technology.
- Note: These documents are posted on the C4-SP website as well, at: http://c4-sp.basecamphq.com

2. Think about the following questions.

- What are your concerns about the future of the Crown of the Continent region?

- What external factors (climatic and non-climatic) affect management within the Crown of the Continent region? Which of these external factors have both high impact and high uncertainty?

3. Prepare a list (short or long).

- Please list the management, policy, or decision approaches you use within your organization. These may be reports, processes, tools, or methods, e.g., general management plans, 10-year plans, vulnerability analysis, sensitivity studies, etc.

Here's what I'd like each of you to do:
- Via the Question or Chat window: Please list the management plans and/or planning processes that you use that you think may be need to include a climate change component.

Objectives of webinar 2: State of the Art: Future Change in the CoC region

- Introductions: webinar procedures, participants, C4-SP website
- Progress from last webinar (#1: Scenario Planning)
- Exploration of Future Change: VUCA as the "new normal"
- Non-climate Drivers and Stressors: global, national, regional
- Climate Drivers and Stressors
    - Steve Gray
    - Dan Fagre
- Introduction to drivers and impacts tables
- Next webinars: Terrestrial Impacts (Thursday, 11am) and Aquatic Impacts (Thursday, 2pm)

-
- forces and stressors - non-climate
    - Discussion: how do these non-climate factors affect CoC and/or your organization?
- Climate forces and stressors
    - Steve Gray
    - Dan Fagre
    - Discussion of uncertainty of climate forces/stresses (starting from the presentations and Schiermeier (2010)
- Introduction to Drivers Tables
- Discussion about information
- Discussion, comparison with annual decision/policy docs managed by each participant
- Presentation of Focal Question (*How can Crown managers respond to climate change impacts?* Discussion, comparison
- Presentation of Key External Drivers (*Climate change, Governance / Leadership, Societal Concern*) Discussion, comparison

Annotated Agenda

- Introductions: webinar procedures, participants, C4-SP website
- Updates to webinar schedule
- Progress from last webinar (#1: Scenario Planning)
- Thanks to People for Input, Questions, Comments
    - Last webinar, we brought up different planning requirements, decision support approaches. We will continue to build that table with your input. We will be posting the table under Webinar 1 material.
    - We also brought up focal questions and key drivers. Our discussions will still inform that. So we appreciate continued input.
    - We will be addressing some of that input during today's webinar.

    - We also appreciate, as we go along, any information that you think might be helpful for our process and the workshop.
    - We've updated the table referenced in the first webinar. We are posting it in the resources related to that webinar. Would like more input still…. Reiterate the type of input and what we will use it for.
- Exploration of Future Change:
    - What surprises have people had in their careers? Especially the managers… Anyone pre-date NEPA? Other NPS policies? Are there equivalents for Canada? Non-NPS folks?
    - Look at
- Discussion: Developing a focal question (10 minutes)
- Discussion: Considering "key external drivers" (15 minutes)
- Feel free to submit questions to be addressed for the next webinar.
- Next 2 webinars: Thursday, Jan. 28, 11am = Terrestrial Impacts, 2 pm = Aquatic Impacts
    - Will send out a table to fill out over the next several sessions (by the Feedbacks webinar #8).
    - Will send 1-2 readings

1. Review two key documents (attached).

- 2 slides from the scenario planning presentation of webinar 1.
- Schiermeier, 2010. The real holes in climate science. Nature 423: 284-287.
- Note: These documents are posted on the C4-SP website as well, at: http://c4-sp.basecamphq.com

2. Think about the following questions.

- What surprises have there been in the Crown of the Continent region over the past 100-200 years? For the Crown Management Partner organizations (50-100 years)? For you in your career (5-25 years)?
- What are your concerns about the future of the Crown of the Continent region? It might help to think about your concerns over the next 1-2 years, 10 years, 25 years, 50 years, 100 years.
- What external factors (climatic and non-climatic) affect the Crown of the Continent region? Which external factors affect the Crown Management Partner organizations? Which of these external factors have both high impact and high uncertainty?

Objectives of webinar 3: Natural Resources: Terrestrial Impacts
Explore sensitivities, vulnerabilities, and resiliency of terrestrial systems within CoC and their relationships to climatic and non-climate stressors.

Agenda

- Introductions: webinar procedures, participants, C4-SP website
- Progress from last webinar (#2: Future Change in CoC)
    - review of drivers and impacts tables
- Exploration of Change in Terrestrial Systems in CoC
- Group Discussion with panelists:
    - Greg Pederson
    - Dan Fagre
    - George Malanson
    - Kate Kendall
- Next webinars: Aquatic Impacts (Thursday, Jan. 28, 2pm MST), Impacts on Cultural Resources (Monday, Feb. 1, 9am MST), and Impacts on Facilities and Services (Thursday, Feb. 4, 2pm MST)

Review 3 key documents (one attached):

1. Chapter 4 from "Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments" by the Climate Impacts Group (CIG) at the University of Washington. We're asking that you only read the 12 pages in Ch. 4, not the whole guidebook! The entire guidebook is too big to attach, so please download it directly from CIG at: http://cses.washington.edu/cig/fpt/planning/guidebook/gateway.php
2. The recent report "Impacts of Climate Change on Forests of the Northern Rocky Mountains" by Dr. Steve Running, University of Montana. This is a 6-page report that is easy to read, but it is too large to attach to an email, so please download it from URL: http://www.bipartisanpolicy.org/library/research/impacts-climate-change-forests-northern-rocky-mountains
3. Sections 1 and 4 of Pederson et al. (2010) "A century of climate and ecosystem change in western Montana: what do temperature trends portend?" This article is provided here as an email attachment.

Please think about the following questions:

- What is different about climate change stresses compared to other stresses that CoC has faced in the past, now, and in the future?
- Are there gaps in understanding that preclude any discussion about potential impacts? Or that could make any discussion today seem pointless over the next few months or years?
- What changes to the drivers and impacts tables make sense for the CoC?

Objectives of webinar 4: Natural Resources: Aquatic Impacts
Explore sensitivities, vulnerabilities, and resiliency of aquatic systems within CoC and their relationships to climatic and non-climate stressors.

Agenda

- Introductions: webinar procedures, participants, C4-SP website
- Progress from last webinars
  - review of drivers and impacts tables
- Exploration of Change in Aquatic Systems in CoC
- Group Discussion with panelists:
  - Clint Muhlfeld (and friends)
- Next webinars: Impacts on Cultural Resources (Monday, Feb. 1, 9am MST), and Impacts on Facilities and Services (Thursday, Feb. 4, 2pm MST)

Review 3 key documents (2 attached):

1. Chapter 4 from "Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments" by the Climate Impacts Group (CIG) at the University of Washington. We're asking that you only read the 12 pages in Ch. 4, not the whole guidebook! The entire guidebook is too big to attach, so please download it directly from CIG at: http://cses.washington.edu/cig/fpt/planning/guidebook/gateway.php
2. Milly et al (2008) "Stationarity is dead: whither water management?"
3. "Aquatic ecosystems and global climate change" from the Pew Foundation. The relevant sections for this webinar: Section IIIA-C (pp. 7-23) and Section V (pp. 34-35). This is an older report that will lead us to questions about what level of information is "actionable".

Please think about the following questions:

- For aquatic systems, what is different about climate change stresses compared to other stresses that CoC has faced in the past, now, and in the future?
- For aquatic systems, are there gaps in understanding that preclude any discussion about potential impacts? Or that could make any discussion today seem pointless over the next few months or years?
- For aquatic systems, what changes to the drivers and impacts tables make sense for the CoC?

Objectives of webinar 5: Impacts on Cultural Resources
Explore sensitivities, vulnerabilities, and resiliency of cultural resources and systems within CoC and their relationships to climatic and non-climate stressors.

Agenda
- Introductions: webinar procedures, participants, C4-SP website
- Exploration of Change in Cultural Systems and Resources in CoC
- Group Discussion with panelists:
    - Pei-lin Yu
    - Sally Thompson
    - Craig Lee
- Next webinar: Impacts on Facilities and Services (Thursday, Feb. 4, 2pm MST)

Request for input prior to Monday's webinar.
There are no readings for this webinar! Instead, the panelists for webinar are asking you to provide them with some input before Monday's meeting. They would like you to please identify topics in cultural resources that you would find most immediately useful in the context of scenario planning (with regard to both research and stewardship). Please email your input to Lezlie Moriniere (lezlie@email.arizona.edu) and she will forward it to the team of panelists.

Please think about the following questions:
- For cultural systems and resources, what is different about climate change stresses compared to other stresses that CoC has faced in the past, now, and in the future?
- For cultural systems and resources, are there gaps in understanding that preclude any discussion about potential impacts? Or that could make any discussion today seem pointless over the next few months or years?
- For cultural systems and resources, what changes to the drivers and impacts tables make sense for the CoC?

Supplementary material
The panelists have provided 2 resources as preparation for the March workshop. They are:
1. The Mystic Lake Declaration, a declaration of an international consortium of indigenous peoples on the issue of climate change (attached and posted at the C4-SP website).
2. A National Geographic Television video that touches on the issues of melting ice patches as a cultural impact of climate change. URL: http://channel.nationalgeographic.com/series/naked-science/4233/Overview#tab-Overview.

Objectives of webinar 6: Impacts on Facilities and Services
Explore sensitivities, vulnerabilities, and resiliency of facilities and services within CoC and their relationships to climatic and non-climate stressors.

Agenda

- Introductions: webinar procedures, participants, C4-SP website
- Exploration of Change in Facilities and Services in CoC
- Group Discussion with panelists:
    - Matt Rose
- Next webinar: Returning to Scenario Planning Topics: Focal Issues, Tables of Drivers and Impacts, and More (Monday, Feb. 8, 9am MST)

Review two key documents (attached):

1. Milly et al (2008) "Stationarity is dead: whither water management?"
2. Hamlet and Lettenmaier (2007) "Effects of 20th century warming and climate variability on flood risk in the western US." If you don't want to read the entire article, please focus on the Introduction and Conclusions.

Please think about the following questions:

- For facilities and services of the Crown Management Partners (CMPs), what is different about climate change stresses compared to other stresses that CoC has faced in the past, now, and in the future?
- For facilities and services of CMPs and the CoC, are there gaps in understanding that preclude any discussion about potential impacts? Or that could make any discussion today seem pointless over the next few months or years?
- For facilities and services of CMPs, what changes to the drivers and impacts tables make sense for the CoC?

Supplementary material

1. Three detailed reports on the impacts of climate change in parts of the Pacific Northwest, produced by the University of Washington. The reports deal with water, stormwater, and energy supply and demand. They are too big to email, so they have been uploaded to the C4-SP website. The overall URL is: http://cses.washington.edu/cig/res/ia/waccia.shtml If you have any question about which files to get, please let me know.

Objectives of webinar 8: Feedbacks, Thresholds, Cascading Effects
Explore and identify key feedbacks, thresholds, and cascading effects important for the Crown of the Continent region over this century, related to climate and non-climate forces.

Agenda

- Introductions: webinar procedures, participants, C4-SP website
- Exploration of Feedbacks, Thresholds, Cascading Effects
- Group Discussion with panelists:
    - Steve Running
    - Dan Fagre
- Next webinar: Tuesday, February 12, 2pm MST. Building Scenarios

Review two sections of CCSP SAP 4.2: Thresholds of Climate Change in Ecosystems

1. Section 2.4: Ecologial Thresholds Defined (pp.24-25)
2. Section 4.3: Temperature Increases Are Pushing Ecosystems Towards Thresholds (pp.76-86)

Please think about the following questions:

- What are the key feedbacks within the CoC region that may amplify impacts of external change from climate or non-climate forces?
- What are thresholds or tipping points that may irrevocably change the character of conditions within the CoC region if they are crossed?
- If a threshold is crossed, would the effects cascade across the region and sectors (e.g., terrestrial systems, aquatic systems, cultural resources, facilities, services)? How?

Objectives of Webinar 9: Building Scenarios
Based on discussions in prior webinars, choose basic elements of the scenarios to be developed for the March 9-10 workshop.

Agenda

- Introductions: webinar procedures, participants, C4-SP website
- Review of principles in building scenarios
- Group discussion to choose specific elements of the scenarios (see questions about possibilities, below)
- Next webinar: Thursday, Feb. 18, 2pm MST. Webinar #10: Adaptation Options

Review two key documents (attached):
Ogilvy, J. and P. Schwartz, 1998. Plotting your scenarios. Global Business Network.
Slides 13-16 from Hartmann's presentation in Webinar #1

Please consider the following possibilities:

- Focal question:
    - How do our management objectives need to change over the next 50 years?
    - How will our organization need to manage
- What are the TWO most important and most uncertain climate forces for the CoC region? Possibilities:
    - water balance
    - shifted seasonality
    - rate of change
    - changes in extreme events
    - drought
    - others?
- Major elements of the theme "Nature of Leadership" (please refer to slides 13-16 of Hartmann's presentations in webinar 1 for a description of this theme)
    - budget levels
    - flexible vs. entrenched policies
    - degree of accountability
    - level of coordination among agencies
    - political-level support
    - long-term vs. short-term outlook
    - others?
- Major elements of the theme "Level of Societal Concern" (please refer to slides 13-16 of Hartmann's presentations in webinar 1 for a description of this theme)
    - regional population shifts

    - demands posed by other issues (economics, energy, crisis elsewhere, health)
    - degree that people are affected by or concerned about CoC region and conditions
    - perception of role of federal/public lands
    - sense of ability to make a difference
    - social and environmental movements
    - others?
- In getting from 2010 to 2100, what are the implications of emerging trends that are likely to have large impacts over the next decade?
    - Emerging trends: diasporas and emerging economies, commons and collaboration, food and water disruptions, integration of technology with human and environmental systems, intensifying rich/poor divide (from Johansen, 2009. Leaders Make the Future and the Institute for the Future)
- How might the following "Plot Lines" work for the CoC region?
    - Winners and losers, Crisis/response, Good news/Bad news, Evolutionary change vs. Revolution/Tectonic change vs. Perpetual chance, Wild cards, others?

Objectives of webinar 10: Adaptation Options
Explore options for climate change adaptation within the CoC region.

Agenda

- Introductions: webinar procedures, participants, C4-SP website
- Options for Adapting to Climate Change
- Group Discussion with panelists:
    - Jill Baron
    - Linda Joyce
    - Leigh Welling
- Next webinar: Policy Screening (Monday, Feb. 22, 9am MST). NOTE: This is a change from the earliest webinar schedules. Please make sure your calendar has the Feb. 22, 9am time for Webinar #11!

Review 2 key documents (attached)

1. Baron et al., 2009. Options for National Parks and Reserves for adapting to climate change. Environmental Management 44:1033-1042.
2. Joyce et al., 2009. Managing for multiple resources under climate change: National Forests. Environmental Management 44: 1022-1032.

Please think about the following questions:

- What resources describing adaptation options have you found particularly useful?
- In the last several years, the number of adaptation options mentioned in the literature, workshops, and meetings has expanded tremendously, posing challenges for managers in simply organizing adaptation option information. One product of this C4-SP project is a database of adaptation options, as part of a broader scenario planning toolkit. Do you have any suggestions for what would make an adaptation options database most useful for managers?
- From a manager's perspective, how much certainty is required to move from 'considering' an option to actually implementing it?
- How might adaptation options differ under different management objectives?

Supplementary material (#1 attached and #2 posted to the C4-SP website)

1. Craig, R., 2009. "Stationarity is dead" - long live transformation: five principles for climate change adaptation law. Harvard Environmental Law Review 34:1, 2010. This is a long article (57 pages), but it contains a good organization of legal principles to support climate change adaptation by resource managers.
2. Brekke et al., 2009. Climate Change and Water Resources Management: A Federal Perspective. USGS Circular 1331. This is fairly long, too, but it

captures adaptation principles and options related to water resources and facilities.

Objectives of webinar 11: Policy Screening
Explore how to consider adaptation options within a scenario planning framework, and their relevance to CoC managers.

Agenda

- Introductions: webinar procedures, participants, C4-SP website
- Policy Screening within Scenario Planning
- Meshing Scenario Planning Results with NPS Plans
- Group Discussion with panelist:
    - Jeff Mow
- Next webinar: Workshop Preparation (Thursday, Feb. 25, 2pm MST).

Review 2 key documents (attached)

1. Chapter 6 of Tucson, Arizona's "Water Plan: 2000-2050": The Planning Process.
2. Section 6 of the 2008 Update to Water Plan: 2000-2050. In particular, look at Figure 6.4 (Demand-Resource Scenario Summary).

Please think about the following questions:

- How can you apply the results of a scenario assessment and development of adaptation options?
- What 'end product' of scenario planning is most useful for different CoC planning processes?
- From a manager's perspective, how much certainty is required to move from 'considering' a set of options to actually implementing it?

Attachment 3: Scenario Narratives
- Colorado Creeps North/Wheel Spinning
- Climate Complacency/Is Anyone Out There?
- Race to Refuge/Big Problems, Big Solutions

Colorado Creeps North/Wheel Spinning

Short Synopsis: The CoC region gradually becomes warmer and drier. Although winter precipitation holds steady, lower non-winter precipitation and increased evapotranspiration demands create water balance stress for much of the year. Over the decades, local-scale changes coalesce into larger patterns comprised more of shrubs and grasslands. Elsewhere, society struggles to cope with problems along low-lying coasts, increasingly arid regions, and from oceanic food production losses. Governments are strapped for resources, but provide broad authority to implement policies, regulations, and procedures at local and regional levels. Can the CoC region use flexible policies to adapt effectively, even though external funds are unavailable? Can fire be managed? How will the extra stresses of drier and warmer conditions add to those from in-migration and increased pressure for food and fuel production as other regions become less productive and desirable? Can the CoC sustain viable populations of key 'wilderness' species, like wolverine and lynx, or key fisheries, like bull trout?

TimeSlice 2020: Climate change in the CoC region is experienced as a summation of many local-scale changes. There continues to be variability in precipitation and temperatures from year to year, but the trend is toward warmer temperatures and less non-winter precipitation. Extremely cold days are rare and occur in a smaller 'winter window', i.e., ending 3 weeks earlier than historically. Transitions between seasons become more variable; rain-on-snow events and cold snaps after warm spells are more frequent. Most glaciers are gone, although a handful persists in the coldest locations, with concurrent reductions from streamflows in glacier-fed streams.

Extremely hot days occur more than 3 times more often than historically and can occur over a window about a month longer, as well. Even increases in winter precipitation can't offset the effects of higher temperatures, especially the higher evapotranspiration demands of the atmosphere and plants, and earlier snowmelt and peak streamflows. Moisture stress is most serious in late summer, at levels similar to 1917-1941, with impacts most evident in sensitive locations: alpine areas, high-elevation streams historically glacier-fed, meadows, and dry-site forests. Aquatic systems are nearing temperature thresholds for sensitive species in the most vulnerable locations; higher water temperatures are favoring lake spawners and non-native species that can manage the earlier peak streamflows. Fire risks are increasing over a season that's more than 2 months longer than historically. While the severity and extent are mostly local, dependent on prior fire history, localized forest condition, and management impacts, the increasing occurrence of extremely hot days, even in September, mean than any fire poses risks of becoming severe. Environmental risks have increased, but the odds still are in favor of no extreme events occurring in any given year.

TimeSlice 2050: The CoC region continues to warm. The winter season is 2 weeks shorter than at the end of the 20th century, spring streamflow peaks are earlier as well. Transitions between seasons are still variable, but happen earlier and later in the year. Although there is still variability from year to year, average late-season snow depth is only 50% of what occurred at the end of the 20th century and flows are often 15% lower than at the turn of the century. Moisture stress is a more serious issue in more locations, becoming a general region-wide problem across all ecotypes. The growing seasons and fire seasons have gotten even longer, by more than another month, with late summer and early fall often being stressed in many areas. However, there is still climate variability. When conditions are wet, some

habitats 'perk up' and respond with higher productivity; overall, though, there's an increasingly strong trend toward drier conditions, with each 'dry streak' producing larger change. Soils are slowly drying, changing the chemical and nutrient cycles more regionally.

The effects of localized disturbance across the region over the past few decades are coalescing into landscape-scale changes. The effects of fire, disease, pests, exotic species, and differential environmental adaptation are turning the CoC region into a place more akin to Colorado, albeit with winters that are warmer and wetter than that state. While the mix of species is changing, overall, the region is becoming more simple. However, there is still potential for relict populations to persist in unique, spatially limited areas.

From an outsider's perspective, the CoC region is still the 'last of the best' for the continental US; other regions are under much more stress from sea level rise, water supply shortages, and global food production stress. People are moving from areas that are experiencing even greater stress, and see the CoC region as having more water, more amenities, and more opportunity than the arid Southwest, the southern Rocky Mountains, and low-lying coastal regions throughout the world. This brings an incredible variety of people to the CoC region, from many cultures and with many languages. From a federal perspective, there's always another region that needs more budget support because change in the CoC region is gradual. However, policies are flexible and managers are given high flexibility to meet their challenges.

TimeSlice 2100: Warming continues, as does the transition to more moisture-limited system, as non-winter precipitation continues to decline. The winter season is shorter still, with all snow generally melted by the end of March, and many days in the winter that are snow-free. Late summer streamflows are generally 25% lower than at the turn of the century.

Transitions between seasons continue to be volatile. With time, extreme events have occurred throughout the region; some locations have been hit repeatedly. Perversely, even with dry conditions, there can be extreme events, especially when the ground is bare after a disturbance, e.g., fire, which greatly increases the risks of highly erosive events and high sedimentation and nutrient loads in streams and lakes. However, for much of the time, there aren't any events, just a slow, inexorable transition to drier conditions – a lack of events.

The one exception is fire. Fire occurrence is still variable in time and space, depending on local conditions, prior fire history, and management. While fire risks have increased, the number of fire starts is tied to human-caused ignition rather than lightning. When fire does occur, it can be severe and escape control. Where conversion to shrublands and grasslands has been complete, fire has become much more common, with return intervals less than a decade.

The changes here have not kept people from moving to the CoC region. Kalispell is as big as Missoula at the turn of the century, while Missoula is as big as Denver in 2000.

Climate Complacency/Is Anyone Out There?

Short Synopsis: In the CoC region, impacts of global warming are offset for several decades by the Pacific Decadal Oscillation and, given continued campaigns to discount climate science, national governments focus on other issues. As the decades pass, society elsewhere struggles to cope with problems along low-lying coasts, increasingly arid regions, and from oceanic food production losses. They don't have time or money to pay attention to a region that seems, to them, to still be 'the last of the best'. Governments are focused on these 'bigger problems' and technological investments to provide large-scale mitigation. The CoC region is on its own, in terms of policies, budgets, and attention from general society. Will the CoC region use the relatively benign conditions early in the 21st century to plan for inevitable stresses? Can the CoC region take care of itself during times of increased stresses? How will the CoC deal with increased pressures from in-migration and the need for food production as other regions become less productive and desirable?

TimeSlice 2020: The Pacific Decadal Oscillation is a climate pattern that can bring 2-3 decades of cooler, wetter conditions to the Pacific Northwest, like from the 1970s to the mid-1990s. While the Earth continues to warm, the PNW doesn't warm as much as it did at the turn of the 21st century. There's climate variability and some continued warming of course, but it's hard to distinguish between the two.. For example, throughout the year seasonal precipitation is not much different than the past several decades–so what's the problem? Sure, there continue to be many stressors for the CoC region: population increases and attendant demands for water and space, a fire regime that continues to reflect historical forest density increases, and non-native species mixing with natives in disturbed, fragmented, or altered habitats. And sure, some changes extend worrisome trends: there are many fewer glaciers in GNP than last century, and snowmelt and peak runoff continue to occur earlier--but not at the pace feared a decade before. The risk of rain-on-snow events has increased, but over a decade, CoC has escaped without any serious events. And, some changes are even helpful: a shorter winter season, with longer 'shoulder seasons' for recreational opportunities, and increased tourism that extends historical trends.

Meanwhile, having done their own climate vulnerability and impact assessments, global investment firms see the CoC as providing key amenities that will be hard to find over the coming decades. They have interest in quietly acquiring extensive land holdings to be developed for maximum return.

TimeSlice 2050: The PDO moderation of climate change in the CoC region has ended… Overall, the CoC seems to be changing to a warmer and more dynamic climate, with more atmospheric moisture, more active frontal systems, more cloudiness, and increasing precipitation year-round, although more so in the non-winter seasons. The dynamic conditions mean that the risk of rain-on-snow events has gone up.Over the past decade, events have happened in a few localized places, causing damage to a handful of historic structures; however, the biggest threat to historic structures is deterioration due simply to the higher temperatures and overall moisture increase.

Most glaciers are gone, although a handful persist in the coldest locations. In some areas, increased precipitation can't offset the effects of higher temperatures, especially the higher evapotranspiration demands of plants and the atmosphere, and the earlier snowmelt and peak streamflows; however, effects are highly localized, variable from year to year, and generally short-lived (weeks or 1-2 seasons).

Aquatic systems are changing, with higher water temperatures favoring lake spawners and non-native species that can manage the earlier peak streamflows and flashflood-like storm runoff throughout the non-winter months.

Overall, the CoC seems to be on a trajectory of increased productivity. The effects of 20th century fire suppression and 21st century policies are strong, but in general, the wetter and more localized water balance stresses limit fire intensity and areal coverage--although fire frequency can be higher in areas favoring fine fuels, e.g., grasses. Of course, fire risks increase during seasons experiencing drought, but drought is infrequent. With the increasing temperatures, phenological mismatches are occurring, but in unpredictable ways--plants and insects, especially, have their own environmental thresholds. Alpine areas, especially, are changing, with endemic species clearly having trouble competing but not yet succumbing.

The CoC region is not experiencing these climate impacts in isolation from other pressures. Other regions are facing much more difficult problems: water supplies are stressed in many areas, especially low-lying coastal areas and the US Southwest. Food production is an increasing concern as ocean productivity declines. So, industry, agriculture, and people are moving to the region more than ever. Both society and governments are too distracted to provide much support to the CoC, either through policies or funding. The CoC region is left to manage itself.

TimeSlice 2100: An incredible global effort to control CO2 levels through new technology, including large-scale sequestration, is beginning to pay off. Emissions have slowed and are near stable at 450ppm. Globally, climate sensitivity has been on the low end of early 21st century projections, due to mediating feedbacks. The CoC region has escaped the worst of those early projections, although regional warming has still affected seasonal hydrology, moving peak streamflows about 1 month earlier than at the turn of the 21st century. As time passes, the increased risk of rain-on-snow events has been felt throughout the region, both at the local level, and during one melt event that caused widespread but moderate damage throughout the region. Increased non-winter precipitation, in good years, means aquatic systems remain connected, but several times each summer, water temperatures get high enough to cross the temperature thresholds of most native fishes.

Overall, the CoC continues to experience increased productivity, although moisture is more limiting in more places as higher precipitation can no longer compensate for increased evaporative demands. Alpine areas have lost half of their endemic species, including both plants and insects. Throughout the region, the mix of species in each habitat continues to evolve into new assemblages, including a mix of exotic species and the reduction of some native populations to relict populations within isolated patches that provide reliably cool conditions. Historic structures are increasingly under threat of rot and insect infestation, due to the warmer and more humid conditions. Termites have moved into the region.

Regardless, the CoC region continues to attract people, industry, and agriculture. Kalispell is as big as Missoula was in 2000, while Missoula is as big as Denver was then. This growth, however, has not brought with it the attention or support of national governments, which are still focused on massive infrastructure redevelopment (e.g., integrated water supply system), diasporas from coastal regions that cannot sustain in the face of sea level rise, and the rapid build-out of mitigation technologies over the past several decades. Once again, the CoC region is left to its own devices.

Race to Refuge/Big Problems, Big Solutions

Short Synopsis: Global warming has accelerated due to amplifying feedbacks. Warming and shifts in climate patterns are abrupt, with changes happening decades earlier than projected at the turn of the 21st century. The CoC cannot escape severe impacts and rapid transitions, including collapse of native aquatic systems, the emergence of fast-moving diseases and exotic species in sometimes unexpected settings, region-wide fires, and loss of infrastructure, which, together, pervasively diminish cultural values. Other regions are changing dramatically, too. Society and governments respond strongly both globally and nationally, even diverting military budgets to support policies and programs for coping with crises, adaptation, and large-scale mitigation. Can the CoC think big enough to address seemingly insurmountable problems? For some problems, there are no solutions, only choices. How does the CoC handle those dilemmas?

TimeSlice 2020: The climate models were wrong. Unfortunately, they were not bold enough. Amplifying feedbacks are releasing additional carbon into the atmosphere and warming is occurring faster, stronger, and with greater changes in climate patterns than projected a decade earlier. Average temperatures in the CoC region are nearly 4° F higher than during the last half of the 20th century. Impacts within the CoC region are severe and create feedback loops that further increase the rapidity and severity of impacts to local ecosystems.

In the CoC region, winter precipitation is holding steady, but the winter season is already 2 weeks shorter than only 2 decades ago; spring streamflow peaks are earlier as well. Average late-season snow depth is only 50% of what occurred at the turn of the century and flows are often 15% lower than only 2 decades ago. Because hydrologic changes have been so rapid, slope destabilization is severe and common, dramatically increasing sedimentation when the frequent rain-on-snow events occur throughout the winter. Non-winter precipitation is decreasing markedly, but given the pace of change, it's hard to discern whether the drought is only temporary.

Combined with the earlier end of winter and increased evapotransipiration demands, moisture stress is leading to ecosystem changes that are measurable, but in highly fragmented patterns. Some native species, as well as culturally important species and landscapes, experience rapid decline; however, which will be next is not yet predictable. Exotic species appear, but it's not clear which will become problems. Phenological mismatches are occurring, especially for species having critical periods during the winter, spring, and summer season transitions. The fire season is longer and more intense, now more than 3 months longer than in the mid-20th century, and a full month longer than only 2 decades ago. With each disturbance, the ecosystem becomes drier and favors revegetation by shrubs, grasses, and exotic species. However, the disturbance and transition is fragmented as the fire patterns are highly dependent on the local weather, prior fire history, and management. Tourism is largely affected by the fire season; severe fires early in the season can decimate the recreational economy for the rest of the season. Cold-water fish mortality is noticeable, with some significant mortality events due to water temperatures periodically exceeding 70°F for several days at a time, combined with low flows, and locally heavy sediment loads that can occur when rains follow intense fires.

The global economic scene is changing quickly as well; the intensifying Southwest US drought, loss of Arctic ice cover, and other evidence convinces both governments and the public that climate change is a

serious problem. Globally, funds are being diverted from military budgets to develop large-scale sequestration technology, but with only pilot projects planned so far. While societies in other regions are stressed, the CoC region is not yet 'on the radar' as a place of permanent retreat and ongoing stress in the financial markets don't support widespread mobility.

TimeSlice 2050: In the CoC region, average annual temperatures are 8°F higher than those at the turn of the century, continuing the pattern of regional increases being about double that experienced globally. High elevations are experiencing even greater increases. The winter season is generally over by the end of March, with many snow-free winter days. Average flow is 25% lower than at the turn of the century. Rain-on-snow events are common at any time during the winter, with significant risk of region-wide melt events and widespread flooding. The Going to the Sun Road has suffered major damage in several locations due to slope instabilities and rain-on-snow events, and the risks continue to escalate. Stream and lake sedimentation is widespread as well, in winter/spring and after fires.

CoC ecosystems and species are clearly under stress and undergoing transformative change. For example, up to 50% of lynx habitat has been lost. Alpine systems, especially, are under severe stress from loss of endemic species and the appearance of exotic species. Low lands are also undergoing a rapid conversion to shrublands and grasslands, with every disturbance that occurs. Forests are undergoing widespread transition from disease, insect infestation, and wildfire. By 2050, extensive and severe wildfires are a high risk, with potential for any fire to become as large and severe as those in Australia in the early 21st century. Wildfires continue to negatively impact tourism; severe fires early in the season can decimate the recreational economy for the rest of the season.

Permanent drought exists in Southwest US. Levels of aridity there are comparable to the 1930s Dust Bowl but with very hot temperatures, producing 'drought refugees' like in the 1930s. Globally, widespread human migration is occurring as well. But the CoC is not seen as a refuge. Instead, people are moving to other regions with more abundant water.

Globally and nationally, serious mitigation efforts against climate change are now under way. National attention in both US and Canada is focused on coastal areas where sea level rise is threatening infrastructure, and on areas where drought is now endemic. Worldwide, governments understand that getting climate change under control is a problem that overwhelms all others; they have embraced cooperation rather than aggression, freeing up funds from military budgets for adaptation and mitigation efforts. This means that agencies have almost unlimited flexibility to address regional problems through policy.

TimeSlice 2100: Climate changes at the turn of the 22nd century are difficult to fathom from early 21st century standards. Sea levels have risen about 5 feet since 2010. Temperatures across much of the US and Canada, especially interior areas, are 10-18°F higher than in 2010. In the CoC region, temperatures have increased similarly, transforming the regional water balance and ecosystems. Grasslands cover all the lower elevations within the CoC, with fire frequency return intervals of less than a decade. Juniper is common at mid-elevations and ponderosa pine at high elevations. Most, if not all, sensitive species that occurred within the CoC at the turn of the 21st century are no longer present. Some stream reaches have become ephemeral and most support only warm-water species. Cultural values tied to species and landscapes of the 20th century have been lost.

Attachment 4: Drivers and Impacts Tables, Influence Diagrams
- Climate Drivers Table
- Impacts Table
- Influence Diagram for Human Migration (contributed by Pei-lin Yu, NPS)
- Influence Diagram for Landscapes (from Britten et al., 2007)
- Influence Diagram for Alpine Systems (from Britten et al., 2007)
- Influence Diagram for Wetlands (from Britten et al., 2007)
- Influence Diagram for Streams (from Britten et al., 2007)

Table 1 – C4-SP CLIMATE DRIVERS[1]

SUMMARY OF PROJECTED CLIMATE CHANGES FOR THE CROWN OF THE CONTINENT ECOSYSTEM					
Climate Variable	**General Change Expected**	**Range of Change Expected & Reference Period***	**Expected Change Relative to 1990-2010**	**General Patterns of Seasonal Change**	**Confidence**
Temperature	Increase	1.5 to 2.1 °C (1.7 to 3.7 °F) increase by 2050	Moderate to Large	Projected increases are slightly greater in summer	Virtually certain that temperature will increase; models consistently call for an ecologically significant rise in temperature; the magnitude of this increase may be greater at higher elevations.
Precipitation	No change to small increase in total annual precipitation	2-5% increase in winter by 2050; no change to 4% decrease in summer by 2050	Small to Moderate; most changes within the bounds of the observed record	Increase in winter, decrease in summer	The majority of projections suggest small to moderate increases in winter precipitation; forecasts are generally inconsistent in their portrayal of summer precipitation.
Evaporation	Increase	Varies with temperature change (magnitude, seasonality and diurnal variatons)	Moderate to Large	Primary impacts in late spring, summer and early fall	Changes in evaporation are tied to increasing temperatures; therefore it is very likely that increased evaporation will occur; increasing transpiration is also likely.
Drought	Increased frequency and severity; possible increase in duration	Varies with magnitude of temperature change and evaporation change	Moderate to Large	Greatest impacts in summer; also potential for hydrologic drought related to changes in snowpack dynamics	Changes in regional drought are primarily a function of increasing temperatures, and potential increases in precipitation would not offset many of these impacts; therefore it is very likely that (relative to historical conditions) drought severity and frequency will increase.

[1] *This is a general summary of projected climatic changes for the Crown of the Continent region. This table was adapted by Stephen Gray from regional projections for Western North America contained in the Intergovernmental Panel on Climate Change's (http://www.ipcc.ch/) Fourth Assessment Report (IPCC 2007). Projections are based on output from 21 climate models run under the A1B emission scenario. Given that actual emissions are on track to surpass those in the A1B scenario, the summary below likely represents a conservative estimate for future climatic change in the Crown of the Continent region. Ranges for temperature and precipitation correspond to the 25th and 75th percentiles of projected changes from the model runs.*

Climate Variable	General Change Expected	Range of Change Expected & Reference Period*	Expected Change Relative to 1990-2010	General Patterns of Seasonal Change	Confidence
Snow cover	Increase in snow-free days; decreased snow accumulations	Could see >50% reduction in average late-spring snow-depths by 2050	Varies with magnitude of seasonal temperature change and elevation	Greatest potential impacts in fall, late-winter and early spring	Changes in snow cover are tied to increasing temperature; therefore it is very likely that snow cover will decline in spring and fall. Low to mid elevations (relative to current snowline) are most susceptible to change.
Streamflow	Some potential for increased total annual flow, but trends vary with season	Varies with changes in winter precipitation and summer temperatures and evaporation	Varies with changes in winter precipitation and summer temperatures and evaporation	Winter flows projected to increase; spring peak comes earlier; summer and fall flows diminished.	Winter flows and potential for winter flooding likely to increase because of warmer temperatures and increased precipitation, but there is significant uncertainty as to how this will impact mean annual flows; earlier spring peak and diminished summer/fall flows are strongly related to increased temperatures, and therefore very likely.
Length of growing season	Increase	Varies with magnitude of temperature change, but likely to be several weeks longer by 2050	Large	Spring-like temperatures arrive earlier; date of last frost becomes earlier; fall-like (vs. historical) temperatures and frost arrive later	Very likely
Extreme Events: Temperature	Warm Events Increase / Cold Events Decrease	Varies with magnitude of temperature change	Large	Increase in frequency and length of extreme hot events (summer); decrease in extreme cold events (winter)	Very Likely; even small changes in mean temperature would translate into ecologically significant changes in the distribution of extremes. Days above/below critical temperature thresholds (e.g., freezing or frost point) very likely to change.

Climate Variable	General Change Expected	Range of Change Expected & Reference Period*	Expected Change Relative to 1990-2010	General Patterns of Seasonal Change	Confidence
Extreme Events: Precipitation	Potential for decreased frequency of precipitation events coupled with increased intensity	Uncertain	Uncertain	Potential for more intense spring floods and flash floods during summer	Model forecasts are inconsistent, but summer warming may lead to more intense thunderstorms; warmer temperatures may also contribute to heavier snowstorms on windward (western) slopes; Potential for increased rain-on-snow flooding under certain circumstances.
Extreme Events: Storms	Increased intensity; possible decrease in frequency	Uncertain	Uncertain	Potential for more intense thunderstorms and storm-related impacts	Same as above

SECTORS AND POTENTIAL IMPACTS TO CROWN OF THE CONTINENT (CoC) ECOSYSTEM

Sector	Sub-Sector	Impacts (SOURCE: WEBINARS)	Impacts (SOURCE: LITERATURE)
Natural Resources	**Hydrology & Water Resources**	Over next 100 years, changes in **hydrology** may be more important than changes in temperatures	precipitation is projected to be 103.7% the 50 year normal for 2020 and 104.15% for 2030 (Hall and Fagre, 2003)
		2,000 m up: rapid *temperature* change; surface albedo changing; declines in peak SWE translates to about *14 more snow-free days …*; biggest drivers are the major global teleconnected features like PDO	mean temperatures (July to August) for 2020 are projected to be between 16.66 and 17.30; for 2030, 16.69 and 17.66 (Hall and Fagre, 2003)
		interaction between snowpack, temperature and stream flow is a crucial element of any future planning	
		increasing temperature in winter months over last 30 years means *more rain, more rain on snow, and increased early runoff*	daily temperature time series reveal that extremely cold days (≤ −17.8◦C) terminate on average 20 days earlier (Pederson et al, 2010)
		variability of precip, seasonal maximum SWE (snow water equivalent) is also increasing	
		1970-2008 data show earlier *winter runoff with declining summer flows*	
		more important than overall risk of flooding is that different *basins respond differently* to changes in precip; so mix of transient and high basins, west and eastside basins may all respond differently	
		risk of *drought* apparently greater east of divide, and risk of *floods* greater on west side	Though the late-19th C was marked by a series of >10 yr droughts, the single most severe dry event occurred in the early-twentieth century (A.D. 1917–41) (Pederson et al, 2006)
		Shifts in water balance: Models show April 1 snowpack in Northern Rockies is zero by 2070	
		GCMs for this region suggests that *winter/snowpack season by end of century will be a month shorter and summer a month longer*	extremely hot days (≥32◦C) show a three-fold increase in number and a 24-day increase in seasonal window during which they occur (Pederson et al, 2010
		→ increasing water withdrawals for local agriculture	
		→ decline in late summer water flows driven both by temp increase AND by increased water withdrawals in some areas → impacts on local aquatic systems, fish, etc (see below)	

SECTORS AND POTENTIAL IMPACTS TO CROWN OF THE CONTINENT (CoC) ECOSYSTEM

Sector	Sub-Sector	Impacts (SOURCE: WEBINARS)	Impacts (SOURCE: LITERATURE)
Natural Resources	**Hydrology & Water Resources**	Increased pressure on park to either conserve water (albeit with minor potential) or supply water to downstream states as the latter are more adversely affected by aridity driven by temp increases	
		Possible over allocation of water – and potential implications for jurisdictional cooperation and conflict	
		Policy change in definitions of "beneficial use" as water becomes over allocated	
	Aquatic Ecosystems	impact of loss of snow and glaciers on groundwater recharges in critical fish spawning areas. in general, surface-ground water interactions foster biodiversity so their loss could cause fish to become more concentrated where these interactions occur.	The influence of glaciers on aquatic ecosystems ranges from providing base flows during the hot, dry summers to moderating stream temperatures. In these remnant cold-water fisheries regulation of stream temperature is of key importance in controlling the distribution and abundance of invertebrates (Hauer et al. 1998) and fish (Keleher and Rahel 1996; Dunham et al. 2003) (Pederson et al, 2010)
		Potential for reservoirs and streams to dry up [esp. if driven by "perfect storm" of unusually hot summer, over allocated water rights leading to extreme withdrawals, lower summer water flow]	As the glaciers melt, streams will initially have greater summer flows but are likely to transport more sediment, which has implications for aquatic life; eventually, as the glaciers disappear, stream flow will decline. (Morris and Walls, 2009)
		→loss of crucial habitat for native fish	Global warming may ultimately be the greatest threat to the persistence of native fishes because it will exacerbate current negative effects of invasive aquatic species and habitat degradation while increasing water temperatures to unsuitable thresholds (Williams et al. 2007a).
		→possible species loss in all ecosystems	The distribution of plants and trees will change [as glaciers melt], as some species will grow on land formerly covered by ice. (Morris and Walls, 2009)
		Water pollution: while some mining developments are presently banned, impacts of any future activities would be magnified under low flows	In addition to the potential for damage to existing and proposed structures, high-magnitude rock fall avalanches in the area could adversely affect **aquatic habitats** through increased sediment loads, could reduce the quality of water used for downstream irrigation projects, and could increase siltation that could lead to overtopping of two reservoirs along the GNP/Blackfeet Indian Reservation boundary (Butler, 1986)
		→increased potential for diseases, pathogens, and aquatic nuisance species	
		FISH	
			Salmonids are often considered a keystone species for aquatic and terrestrial ecosystems, and may be an especially important indicator of ecosystem health in the face of climate change. (Pederson et al, 2010)

SECTORS AND POTENTIAL IMPACTS TO CROWN OF THE CONTINENT (CoC) ECOSYSTEM

Sector	Sub-Sector	Impacts (SOURCE: WEBINARS)	Impacts (SOURCE: LITERATURE)
Natural Resources	**Fish**	possible loss of population recruitment in native fish species (trout) with increased winter flooding destroying spawning beds, and higher temperatures and lower flows in the fall	
		two possible overall trends: species shifting northward in general, and species that deal well with lots of frequent disturbance of hydro regime (winter flooding etc) will do better. Favors lake spawners.	
		invasive species and diseases as climate change impacts increase.	
		Increased fish mortality if temps go over 70 degrees for a certain period [in Yellowstone they used 3 consecutive days as trigger for closing streams to fishing]	
		cutthroat trout: Hybridization largest threat and is more common in warm degraded streams. lots of overlap in spawning times. studies show hybridization rapidly reduces fitness.	
		bull trout: invasion of non-native Lake trout is biggest current problem ; possible future habitat loss could severely impact populations: some forms of bull trout are highly migratory, 250 km in native streams, all habitats from headwaters to main water to lakes are crucial to these fish.	the loss of glacial runoff, which has dried up streams and scenic waterfalls, has also jeopardized the park's aquatic life. At particular risk are Glacier's native bull trout, a threatened species, which spawn in the fall and therefore rely on strong late-season stream flow (Saunders et al, 2008)
		drier landscape causing changes in nutrient regime that could affect fish populations—difficult to model.	
	Vegetation	*Background: GNP contains numerous low to mid-elevation forests communities that vary in type and species. Dominant tree species in the Park include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta) in the lower subalpine forests and include Douglas-fir (Pseudotsuga menziesii), western larch (Larix occidentalis) in montane forests (Lesica 2002). Lying in a transition zone, GNP is unique in that it contains ecotypes more typical of the Pacific Northwest as well as those of the Northern Rocky Mountains west of the Continental Divide, and Northern Great Plains ecotypes to the east. (LcKenzie et al, 2009); Nearly one quarter of GNP can be classified as alpine, characteristically represented by talus slopes, snow-fields, sheer cliffs, fellfields, and wet meadows (Kes-sell 1979). It is in association with the fellfields where terrestrial lichens comprise a dominant component of the vegetation. The difference in precipitation and temperature [demarcated by the continental divide] is sharply reflected by the vegetation. (Debolt, 1993). Whitebark pine is considered a 'keystone' species due to its provision of food for more than 17 animal species (Arno and Hoff 1990; and Tomback et al. 2001, in Pederson et al, 2010).*	

SECTORS AND POTENTIAL IMPACTS TO CROWN OF THE CONTINENT (CoC) ECOSYSTEM

Sector	Sub-Sector	Impacts (SOURCE: WEBINARS)	Impacts (SOURCE: LITERATURE)
Natural Resources, con't.	**Vegetation, con't.**	Increased length of growing season (i.e. frost-free period)—currently on order of 2 weeks longer than 50 years ago; anticipated to be another 2 weeks longer by 2100	Increases in area and density of trees resulted in increased homogeneity, affecting snowpack distribution, microclimate, and forest fuel connectivity. (Klasner, 2002)
		Increased growing season length might be counter-balanced by other impacts, e.g., drought, disease	Assessment of widespread tree line response to climate change fundamentally depends on the inclusion of indirect responses, especially to changes in disturbances, as well as general shifts in climatic gradients (Beaudoin, 1989). (Allen, 1996)
			Mean minimum summer temperatures have increased by 1.5uC over the past century and, coupled with variations in the amount of early spring snow water equivalent, likely account for much of the increase in tree cover at the tree line ecotone. (Roush et al, 2007)
			...development in western forests recently linked to a changed climate is a rapid dieback of aspen trees that scientists have labeled "sudden aspen decline" which could put at risk the scenic aspen groves of Rocky Mountain, Grand teton, Yellowstone and Glacier NPs. .....generally changing plant communities above and at mountain tree lines…growing more upright and filling in gaps. (Saunders et al, 2009)
		loss of traditionally important plants [e.g. sweetgrass], etc due to invasions by non-native species	31- 65 % declines in abundance of seven tundra plants from 1989 through 2002. (Saunders et al, 2008);
		loss of wildlife habitat	The ecotone transition from alpine to subalpine (tundra to forest) became more abrupt from 1945 to 1991. (Klasner, 2002)
		loss of agricultural productivity, also due to invasives	The distribution of plants and trees will change [as glaciers melt], as some species will grow on land formerly covered by ice. (Morris and Walls, 2009)
		loss of sites that are traditionally used to gather native foods	
		within region: increasing population in urban/wildlife interface—retirees? Land values go up, landscapes/habitats become more fragmented	Fragmentation of krummholz surrounding areas of human activity (trails) was evident at fine spatial scales. (Klasner, 2002)
		Some evidence of increasing forest mortality around the West	Climate change is not likely to severely affect established forests, rather its affects will be seen in the earliest stages of stand development. (McKenzie, 2009) ...patterns suggest that existing trees facilitate leeward seedling establishment and survival, by depositing wind-blown snow. These seedlings in turn modify their leeward environment, thus allowing forest advancement in a linear pattern. (Bekker, 2005)

SECTORS AND POTENTIAL IMPACTS TO CROWN OF THE CONTINENT (CoC) ECOSYSTEM

Sector	Sub-Sector	Impacts (SOURCE: WEBINARS)	Impacts (SOURCE: LITERATURE)
Natural Resources, con't.	**Vegetation, con't.**	Carrying capacity of land for forests appears to be declining [driver: changes in water balance, decrease in summer precip]	
		Entire biome shift caused by replacement of forest by shrublands if /as big disturbances (see below) take out forests	distribution and cover type in futures with climate change (Hall and Fagre 2003). Beyond affecting species distribution, fire, coupled with climate change, will likely affect successional trajectories and fundamental patterns of tree establishment based, in part, on reproductive strategy. (McKenzie, 2009)
	Wildlife	**BEARS**	
		Changes in denning time and duration with rising temps; shorter denning time could mean bears out later in season so potential conflicts with hunting season/hunters	The recent depression in the reproductive rate of grizzly beats has been due to influences related to climate, and the closure of garbage dumps has little effect. The effect of climate on the survival of the yearling age class, however has not been defined (Picton, 1978)
		More avalanches could mean more disturbed habitat, potential plus for bears ; BUT habitat loss/fragmentation in region due to development a major overall concern for bears	The role of avalanche paths as vital habitat for animals such as the grizzly bear also warrants a thorough analysis of the geologic and topographic locational influences on their spatial distribution (Butler, 1990)
		Whitebark pine is functionally extinct for bears, not enough trees/cone production to support much wildlife food source or habitat. developing resistance to mt pine beetle/rust/repopulate trees would take hundreds of years	Since the seeds of the whitebark pine are an important source of food for the grizzly bear and other animals, the decline of the tree may have severe consequences for the wildlife in Glacier [National Park] (Vitousek et al, 1996); With the Mountain Pine Beetles expansion to higher elevations, novel species/host associations have occurred with the beetle infesting and killing whitebark pine (Pinus albicalus). This is disconcerting since whitebark pine is considered a 'keystone' species due to its provision of food for more than 17 animal species (Arno and Hoff 1990; and Tomback et al. 2001)(Pederson, 2010)
		If tree line rises could affect **army cutworm moth** migration/survival rate, negative for bears because moths are a food source for them	
		Loss of huckleberry sources due to habitat changes due to water balance changes→adverse effect on food sources for bears	
		Decreased ease of migration driven by vegetation change causing decrease in cover	

SECTORS AND POTENTIAL IMPACTS TO CROWN OF THE CONTINENT (CoC) ECOSYSTEM

Sector	Sub-Sector	Impacts (SOURCE: WEBINARS)	Impacts (SOURCE: LITERATURE)
Natural Resources, con't.	**Wildlife, Con't.**	**SPECIES LESS FLEXIBLE BEHAVIORALLY , e.g. pika, bighorn sheep**	
		loss of wildlife species [e.g. due to chronic wasting disease] For example, Loss of snowshoe hare from adaptation limits: color linked to daylength, not snow cover	**Lynx** habitats in peril: snow and temperature, up to 50% may be lost with rise to 7 degrees temperature increase (Saunders, 2009)
		loss of traditional migration routes due to vegetation change (e.g., less cover) leads to loss of ability to pioneer new habitat	
		Heat stress [esp. during "perfect storm" of unusually hot summer, water over allocation, low flows] →potential for populations to nosedive [NB: reference to moose populations affected by hot summer in Minnesota]	Outside of severe winters, **white-tailed deer, elk, and moose** (Alces alces) appeared to be equally vulnerable to wolf predation. Snow depth (r= 0.73, P= 0.03) and proportion of total kills by wolves that were deer (r = 0.66, P= 0.06) were negatively correlated with the annual variation in the total search distance of wolves. (Kunkel, 2004)
		Timing of migrations shifted, i.e., disruption of phenological patterns	**BIRDS/BUTTERFLIES:** Elevation, structural diversity of the site and moisture were the major factors explaining species distributions (Debinski/Brussard, 1994)
		Herps (reptiles, amphibians): Loss of habitat as wetlands and ponds dry up	**HERPETOFAUNA:** The area of Flathead and Glacier Counties in the Rocky Mountains of northwestern Montana, comprising GNP, is not noted for the variety of its herpetofauna. Ten species are represented by specimens collected within the Park. (Manfeld, 1957); Boreal toads (Bufo boreas boreas) in GNP increased in occurrence after fires in 2001 and 2003. (Guscio, 2007)
	Disturbance & Hazards (fire, pests, pathogens, avalanche)	**FIRE**	
		June—sept now have temps ranging over 90, when it used to be july-august. Also have more hot days. Both have effect on fire regimes, including fire season covering longer period of time each year.	Simulation results indicate that fire influences landscape pattern metrics more that climate alone by creating more diverse, fragmented, and disconnected landscapes. Fires were more frequent, larger, and more intense under a future climate regime (Keane, 1999).
		Increase in fires at high elevations	
		Increase in severity and intensity	
		Wildfire: 65% of flathead basin has burned since 1984; invasive species is a real and growing problem.	The forests of western Montana, and the northern Rockies have been found to have a fire regime strongly controlled by temperature and precipitation (i.e. water balance [Littell et al. 2009]), thus making the forests of western Montana highly vulnerable to increased temperatures (Westerling et al. 2006). (Pederson 2010)

Sector	Sub-Sector	Impacts (SOURCE: WEBINARS)	Impacts (SOURCE: LITERATURE)
Natural Resources, con't.	**Disturbance & Hazards con't.**	Changes in fire regime from 1986 to present: western fire season 78 days longer, 4x increase in fires > 1000 acres, 6x increase in acres burned; greatest increases in altitudes over 6500 ft (from Science article 2009)	
		DROUGHT	
			...reconstruction shows numerous decadal-scale shifts between persistent drought and wet events prior to the instrumental period (before A.D. 1900). Though the late-nineteenth century was marked by a series of >10 yr droughts, the single most severe dry event occurred in the early-twentieth century (A.D. 1917–41). These decadal-scale dry and wet events, in conjunction with periods of high and low snowpack, have served as a driver of ecosystem processes such as forest fires and glacial dynamics in the GNP region. (Perderson et al, 2006)
		ROCK & LAND SLIDE, DEBRIS FLOW	
			Alpine glacier retreat resulting from global warming since the close of the Little Ice Age in the 19th and 20th centuries has increased the risk and incidence of some geologic and hydrologic hazards in mountainous alpine regions of North America. Abundant loose debris in recently deglaciated areas at the toe of alpine glaciers provides a ready source of sediment during rainstorms or outburst floods. This sediment can cause debris flows and sedimentation problems in downstream areas. Moraines built during the Little Ice Age can trap and store large volumes of water. These natural dams have no controlled outlets and can fail without warning. Many glacier-dammed lakes have grown in size, while ice dams have shrunk, resulting in greater risks of ice-dam failure. The retreat and thinning of glacier ice has left oversteepened, unstable valley walls and has led to increased incidence of rock and debris avalanches. (Oconnor, 1993)

SECTORS AND POTENTIAL IMPACTS TO CROWN OF THE CONTINENT (CoC) ECOSYSTEM

Sector	Sub-Sector	Impacts (SOURCE: WEBINARS)	Impacts (SOURCE: LITERATURE)
			Two large rock fall avalanches have occurred within the last 100 years in Glacier National Park, Montana, both associated with the eastern edge of the Lewis Overthrust Fault. The 1910 rock fall avalanche occurred after a local cloudburst, but the immediate cause of the 1954 event has not been determined (Butler, 1986)
Natural Resources, con't.	**Disturbance & Hazards con't.**	**AVALANCHE**	
			Large, infrequent avalanches can uproot and snap old trees, leaving openings in mountain forests. Smaller, more frequent slides maintain those openings by destroying slow-growing trees but leaving fast-growing trees and shrubs such as aspen, birch, and alder. The result is greater vegetation diversity and more ecotones—edges between ecological communities. More ecotones means more diverse habitat for wildlife, especially ungulates and birds. We believe the climate patterns that influence the frequency of natural avalanches in the park have broad, long-lasting ecological effects, so any climate changes that alter the frequency or magnitude of natural avalanches will in turn change the forests in the park (NPS)
			The effects of 20th-C climate change are most unequivocally illustrated in the repeat photography pairs illustrating drastic glacial recession. Certainly the case of infilling of snow-avalanche paths is indirectly related to climate change, whether as a result of the milder climate allowing trees to grow in catchment zones and stabilize the snowpack, or as a result of changes in the avalanche climatology of the area. (Butler, 2001)
			Avalanche years were associated with positive Snow Water Equivalent anomalies at a nearby snow course. The findings suggest that changes in Pacific climate patterns that influence snowfall could also alter the frequency of natural snow avalanches and could thus change disturbance patterns in the montane forests of the canyon. (Reardon et al, 2008)
		EARTHQUAKE	
			GNP area is seismically active (Qamar and Stickney, 1983)
		INSECT & PESTS	

SECTORS AND POTENTIAL IMPACTS TO CROWN OF THE CONTINENT (CoC) ECOSYSTEM

Sector	Sub-Sector	Impacts (SOURCE: WEBINARS)	Impacts (SOURCE: LITERATURE)
		Clear evidence of increasing insect infestations in forests throughout west	Insect outbreaks are another component of temperature-driven changes to western forests. Increases in temperature affect bark beetle species in different ways. Warmer temperatures—such as the winter and spring warming and loss of extreme cold days in western Montana—may alter outbreak frequency / duration, reduce winterkills, speed up life cycles, modify herbivory and damage rates, and lead to range expansion or contraction (Carroll et al. 2003; Logan and Powell 2001; Logan et al.); With the Mountain Pine Beetles expansion to higher elevations, novel species/host associations have occurred with the beetle infesting and killing whitebark pine (Pinus albicalus). (in Pederson et al, 2010)
Nat Res, con't.	**Soil**	Soils in driest alpine areas might be wetter or start spring with more moisture in soil (because it won't blow off as snow where nothing holding it down)	This analysis of the geographical and climatic setting of Montana's glaciers suggests that summer temperatures are about three times as important as winter precipitation in controlling modern glacier ELAs in this largely continental environment, and that the ultimate control on the existence of cirque glaciers is a combination of regional windflow (directed by topography), local windflow (similarly directed), and cirque morphology. (Locke, 1989)
		Soils on wetter end of alpine soils, might see more drying relative to present condition. those might be places to be looking for or anticipating change in tree cover (invasion of trees)	
		Major shifts in predominant wind direction [an important local factor] could have major impacts on soil wetness/dryness depending on how snow is blown	
	Glacier Retreat		For the park ecosystem, the disappearance of glaciers is a highly visible reflection of ecosystem-wide change. For instance, the reduced snowpacks that lead to glacier recession also allow high-elevation trees to become established above the current tree line and in subalpine meadows (Peterson 1998). These tree invasions will reduce the diversity of herbaceous plants in open areas. Disappearance of glaciers will change cold air drainages, reduce moisture in glaciated basins during late summer, and increase stream temperatures, thus affecting temperature-sensitive aquatic invertebrates (Fagre et al. 1997). Glacial retreat provides new areas for plant colonization and alters sediment transport in streams. Glacial retreat also reflects other climate-related ecosystem changes, such as changing soil moisture, altered fire frequency, forest growth, and distribution changes in vegetation. (Hall/Fagre, 2003)

Sector	Sub-Sector	Impacts (SOURCE: WEBINARS)	Impacts (SOURCE: LITERATURE)
			Post 1850, glacial retreat coincides with an extended period (>50 yr) of summer drought and low snowpack culminating in the exceptional events of 1917 to 1941 when retreat rates for some glaciers exceeded 100 m/yr. This research highlights potential local and ocean-based drivers of glacial dynamics, and difficulties in separating the effects of global climate change from regional expressions of decadal-scale climate variability. (Pederson, 2004)
Nat Res, con't.	**Glacier Retreat, con't.**		The dramatic recession of glaciers has resulted in part from the accelerated rate of ablation (i.e. melting) that occurs with increasing average temperatures over the critical spring and summer ablation season…. as ice retreats and exposes more of the surrounding bedrock and cirque walls, approximately 50% more long-wave radiation is reemitted due to greatly reduced surface albedo resulting in more sensible heating of the local environment. Thus, the area around the glacier warms non-linearly and increases melt rates along the glacial margins, thereby accelerating the retreat process. (Pederson et al, 2010)
	Air Pollution / Viewshed	Possible air pollution from way outside region, e.g. even mainland Asia	
		Increased pollution due to increase in "dirty" energy coming from coal use	
Cultural Resources	**Historic Structures**	Increasing fuel load due to invasive species/increasing shrubby growth esp. coupled with die-offs caused by insects means more fuel control in proximity to structures, shift away from clearing trees large scale to just concentrating around buildings	
		Also, as result of these changes, higher erosion which will threaten historical park roads, structures, archeological sites.	
		less winter insect kill due to higher temps will mean arrival of insects like termites where they have not been a problem before. Will mean mgmt for preservation of historic structures.	
	Archeological Resources	new exposure of archeological resources previously protected by snow and ice will increase: permanent snowbanks advance and retreat with patterns different from glaciers—don't actually flow—these are really what's critical to melt-outs	

Sector	Sub-Sector	Impacts (SOURCE: WEBINARS)	Impacts (SOURCE: LITERATURE)
		increased fire intensity and perhaps also frequency will increasingly affect archeological sites, including buried artifacts, that weren't affected by lower-intensity fires	
		lowering water tables will cause downcutting rivers in proximity to areas where arch sites tend to occur, thus causing more exposures	
		lowering water tables could also mean disappearance of waterlogged, anaerobic soils that help preserve artifacts	
	Ethnographic	Loss of habitat for traditional plant sources of food, crefting/building materials e.g.. huckleberries—one Kootenai elder in her 70s referred to site where she used to be able to gather 10 gals/day, now gets 1/2gal/day. [Driver: higher temps→water balance changes→changes in vegetation cover, shade or lack of shade→habitat changes that favor or disfavor plant growth]	
		Loss of important plants [e.g. sweetgrass] due to increased competition from invasive species	
	Museum		
Visitor Experience	**Wilderness/ Recreation/ Night Skies/Soundscapes / Security**	Glaciers disappear by 2030	For the park visitor, the disappearance of one of the park's charismatic features presents a great irony and aesthetic loss, because the park was established to protect a landscape that has now changed. Park naturalists report, on the basis of the questions they field, that the general public is very interested in glaciers. Visitors experience a tangible lesson about climate-induced ecosystem change along with the loss of visual beauty. (Hall/Fagre, 2003); From a recreation perspective, the glaciers are, not surprisingly, a strong draw for visitation to the park—the park drew over 2 million visitors in 2007. How that will change as the glaciers disappear is unclear. (Morris and Walls, 2009)
		adverse impacts on protected land from activities in other parts of region	
		land use conversion/increasing development pressure due to immigration in region	

SECTORS AND POTENTIAL IMPACTS TO CROWN OF THE CONTINENT (CoC) ECOSYSTEM

Sector	Sub-Sector	Impacts (SOURCE: WEBINARS)	Impacts (SOURCE: LITERATURE)
		Destabilized slopes [driven by loss of forest cover] lead to more avalanches, landslides, danger to visitors	A statistical model of monthly visitation and climate was developed to examine the direct impact of climate change on visitation. The model projected that annual visitation would increase between 6% and 10% in the 2020s and between 10% and 36% in the 2050s. To explore how climate-induced environmental change could also indirectly affect visitation, a visitor survey was used (N ¼ 425). The environmental change scenarios for the 2020s and 2050s were found to have minimal influence on visitation, however the environmental change scenario for the 2080s (under the warmest climate change conditions) was found to have a negative effect on visitation, as 19% of respondents indicated they would not visit the park and 37% stated they would visit the park less often. The contrasting result of the two analyses for the longer term impact of climate change was a key finding. (Scott et al, 2007)
Facilities	**Circulation**	possible increase in visitors to park in shoulder seasons , and as a refuge from higher temperatures elsewhere	The results of the surveys indicate that climate change could positively affect visitation rates and that temperature is a significant factor in determining visitation behavior, implying that warmer temperatures could encourage more people to visit Rocky Mountain National Park. The authors of the study suggest these findings may be applicable to other high-altitude alpine parks. (Richardson and Loomis, 2004); Assuming recreation will increase with economic growth, simulation models of international tourism demand show that climate change is likely to shift tourism patterns toward higher latitudes and altitudes (Hamilton et al. 2005).; A potential positive impact for ecotourism may arise from weather conditions more amenable to people at the start and end of the traditional summer tourist season—thereby increasing overall tourism numbers and length of visitation season. (Pederson et al, 2010)
	Transportation	Loss of part of Going to the Sun Road due to landslide; potentially irreplaceable if in area where road runs along cliffs →huge drop to visitors in GNP	
	Structures	increasing compliance requirements due to section 106 as more buildings fall under its purview	
		within park there may be conflicts between management priorities e.g.: different regulations e.g. section 106 vs. requirements to make buildings more sustainable regarding energy use	

Sector	Sub-Sector	Impacts (SOURCE: WEBINARS)	Impacts (SOURCE: LITERATURE)
Facilities, con't.	**Structures, con't.**	Increased damage to structures /possible loss of historic facilities caused by avalanches, winter flooding due to rising risk of large rainstorms after lots of snow (e.g. if certain portions of Going to the Sun Road are washed out they could not be rebuilt)	
		Increased termite damage/maintenance needs as rising temps allow them to move into areas where they have not existed before	
	Utilities	high potential for overallocation of water resources that may not be there in the future	
		Anticipated decrease in availability of electricity due to changes in water balance	
		increased power demands for summer cooling as temps rise	
		Possible increase in "dirty" energy as coal use increases	
		rising energy costs: could adversely affect ability to meet visitor expectations for comfort, amenities at park; could also cause drastic drop-off in number of visitors to park [they saw large drop-off when gas prices went over $4], drop-off in regional in-migration [mostly coming from California/Bay Area at present]	
	Fleet Management	Transit systems may go to hybrid vehicles [driver: outside policy]	
	Recreation	Loss of winter snowpack→shorter ski season	Snowmaking requirements to minimize ski season losses in the study area were projected to increase 191% to 380% by the 2080s (Scott et al. 2003). The additional snowmaking requirements and greater energy requirements to make snow in warmer average temperatures would represent an important cost increase that could affect the profitability of some ski areas. (Scott et al, 2003); Conversely, the premiere ski resort industry is likely to see a reduction in profits due to a shortening season over which a high quantity and quality of snowpack is available for skiers (Breiling and Charmanza 1999, in Pederson et al, 2010).

Sector	Sub-Sector	Impacts (SOURCE: WEBINARS)	Impacts (SOURCE: LITERATURE)
Facilities, cont'.	**Recreation, cont'.**	Increasing demand for recreation opportunities driven by regional immigration/population increase	Using statewide aggregate demand models, Mendelsohn and Markowski (1999) extend previous studies (Cline 1992) that focused solely on skiing to predict climate effects on economic benefits from seven recreation activities: boating, camping, fishing, golfing, hunting, skiing, and wildlife viewing. They use cross-sectional data for the lower 48 states (from 1991) and estimate the aggregate number of days spent in these various activities as a function of population, income, prices, and various temperature and precipitation variables. The authors use their results to calculate welfare effects in 2060 from changes in temperature ranging from 1.5°C to 5°C and increases in precipitation of 7 and 15 percent; they also look at welfare effects by using region-specific changes in temperature and precipitation.…The authors find that these climate change scenarios will result in major losses for snow **skiing, camping, and wildlife viewing, but that those losses will be swamped by substantial gains for fishing and boating**. Overall, there are welfare gains in the recreation sector from climate change; for the central case of a 2.5°C temperature rise and 7 percent increase in precipitation, the benefit ranges from $2.8 to $4 billion (in 2060) depending on the model used. (Morrris and Walls, 2009)
		Longer "shoulder" seasons (spring greening, "Indian summer") leading to increased use of park outside traditional season→park no longer able to follow traditional patterns of when facilities are closed/winterized, when seasonal staff are let go. True of Glacier, also natl parks on Canadian side. Where recreation opportunities are more dispersed, the impact is less, but does produce more stress wildlife.	
		Fishing impacted as streams get closed off during periods of water temps rising above some determined trigger e.g. 70 degrees for 3 consecutive days	With a reduction in snowpack, and increased stream temperatures over the spring and summer, fishing guides may expect increasingly more frequent closures of streams and rivers due to reduced flows and increased thermal stress on aquatic species.(Pederson et al, 2010)
		Fishing declines as streams dry up, become ephemeral, esp. during late summer [driver: lower summer flow due to changing snowfall/rainfall regimes, driven by longer summer/shorter winter pattern]	
		Increased visitor targets [driven by changed CA political administration, decreased fed budgets]	
		Potential loss of structures/amenities/trees along route to the sun caused by major fire→adverse impact on number of visitors	

SECTORS AND POTENTIAL IMPACTS TO CROWN OF THE CONTINENT (CoC) ECOSYSTEM

Sector	Sub-Sector	Impacts (SOURCE: WEBINARS)	Impacts (SOURCE: LITERATURE)
Protection & Visitor Services	**Emergency Response**	Possible increasing need due to avalanches driven by destabilized slopes driven by vegetation change/forest loss	
		Possible increasing need driven by flash floods driven by rain-on-snow events	
Interpretation and Education	**Elementary Education**		
	Visitor Programs		
General Management	**Budget**	setting priorities under budget restrictions, e.g., as money for line item construction dries up, less project money available. Question becomes: Is it more important to stabilize what we know we have or to catalog new discoveries?	
		Budget cuts→less ability to provide services within park→park becomes more "primitive"→drop in visitors	
		bigger work loads for park staff—need to do more with less	
		funding difficulties due to economic problems with states, etc	
	Land Use		Although fire suppression and climate change have had the most geographically widespread influences on the changes seen on the GNP landscape, it is increasing human pressure on the periphery of the Park that calls into question its continued viability as an international biosphere preserve.....the very success of nature reserves depends on avoiding the degree of fragmentation and isolation that is currently encircling GNP (Quammen, 1997). Unless substantial changes occur in land-use policies surrounding the Park, GNP will become increasingly ineffective at preserving many of the unique species and features for which it is justly famous. (Butler 2001)
	Agriculture	Increased length of growing season(i.e. frost-free period)—currently on order of 2 weeks longer than 50 years ago; anticipated to be another 2 weeks longer by 2100	

SECTORS AND POTENTIAL IMPACTS TO CROWN OF THE CONTINENT (CoC) ECOSYSTEM

Sector	Sub-Sector	Impacts (SOURCE: WEBINARS)	Impacts (SOURCE: LITERATURE)
General Management	**Agriculture, con't.**	Potential over-allocation of water rights/irrigation rights [NB, this probably pertains to all livelihood strategies, they all need water]	
		Loss of productivity due to invasive species	
Regional Livelihoods	**Forestry, Lumber**	New interest in biofuel, repurposing of lumber mills to go into power generation due to collapse in traditional forest products industry	
		Potential for carbon credits as new way to make living off forests	
	Ranching	Carrying capacity of land for cattle appears to be declining [due to changes in water balance leading to less water, different vegetation]	
	Mining/extractive industries	Currently main econ driver in BC. If econ downturn continues, might mean more coal mining. While some activities are currently banned, future activities have potential adverse impact on water quality downstream, in protected lands	
		While currently banned, any future activity would have potential adverse impacts on water quality in protected due to possible activities elsewhere in the region (e.g., potential mining development in North Fork, possible coalbed methane development in Alberta, BC)	
	Tourism	Currently main econ driver in MT, Alberta	see recreation and ski industry above


Increase in conflict between National Register nominations and need for space in park development + construction
Sect. 106, ARPA, NAGPRA Compliance Load Increases
more visitation
emphasis on curation + archiving; space issues (41 CFR, 36 CFR § 79
Increased visitation
Increased uniqueness + value of park resources (higher stakes)
More "extra-park" non-material heritage features, 'bundling' (e.g., Trail of Tears, Ice Age Floods).
Isolation + Fragmentation of Parks in C of C
Scenario: "MOVING NORTH"
→ Parks surrounded by development, production
Original Research =
Migration up-latitude and to mountain/flatland interfaces in pursuit of "resources" (cooler regimes, nicer views, more dependable H2O)

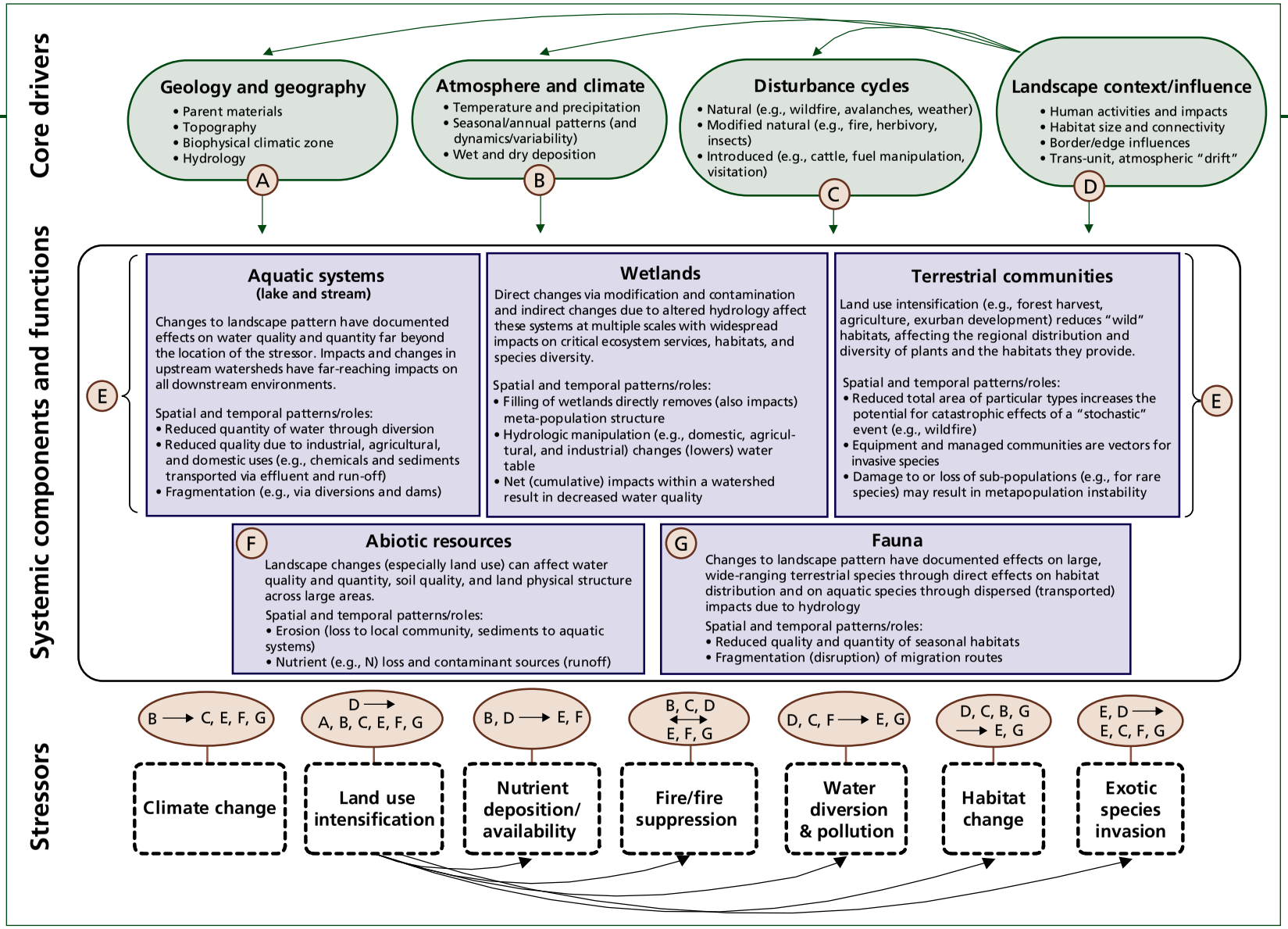


Figure 2.2.1. Landscape characterization model.

Information on how this model functions can be found in Section 2.2. More detailed information on this model can be found in Section 2.2.1 and Appendix A.

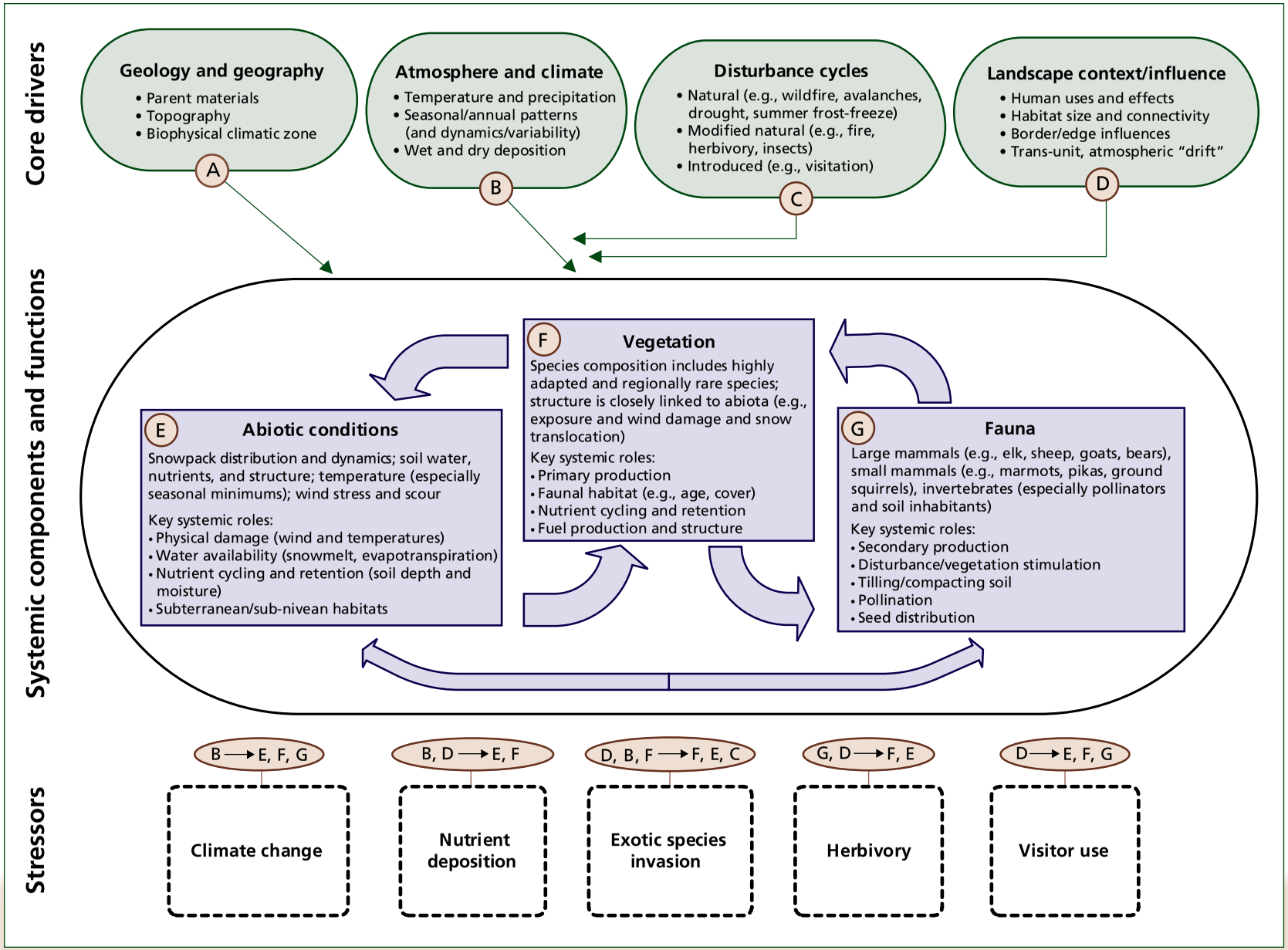


Figure 2.2.3. Alpine characterization model.

Information on how this model functions can be found in Section 2.2. More detailed information on this model can be found in Section 2.2.3 and Appendix A.

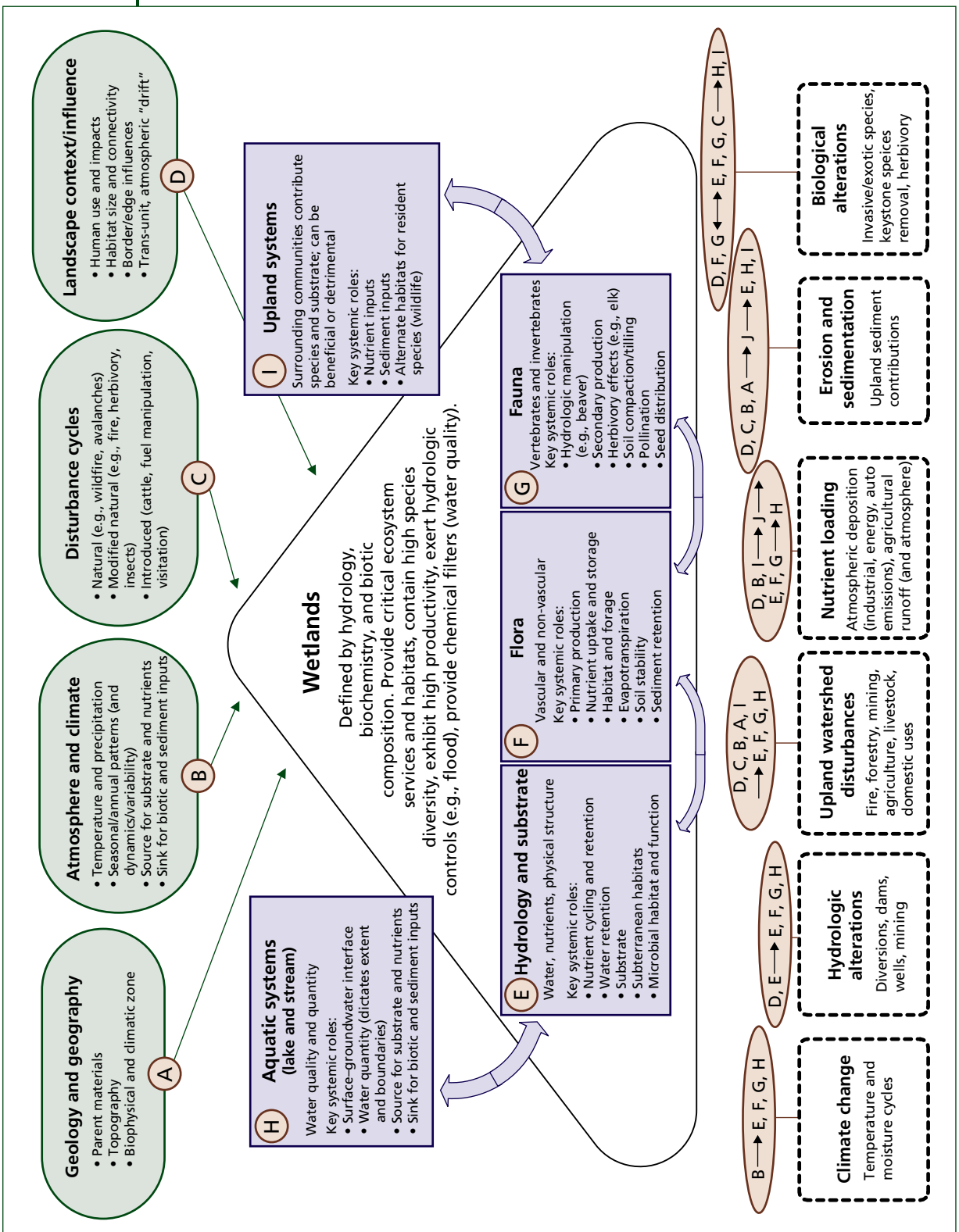


Figure 2.2.5. Wetland characterization model.
Information on how this model functions can be found in Section 2.2. More detailed information on this model can be found in Section 2.2.5 and Appendix A.

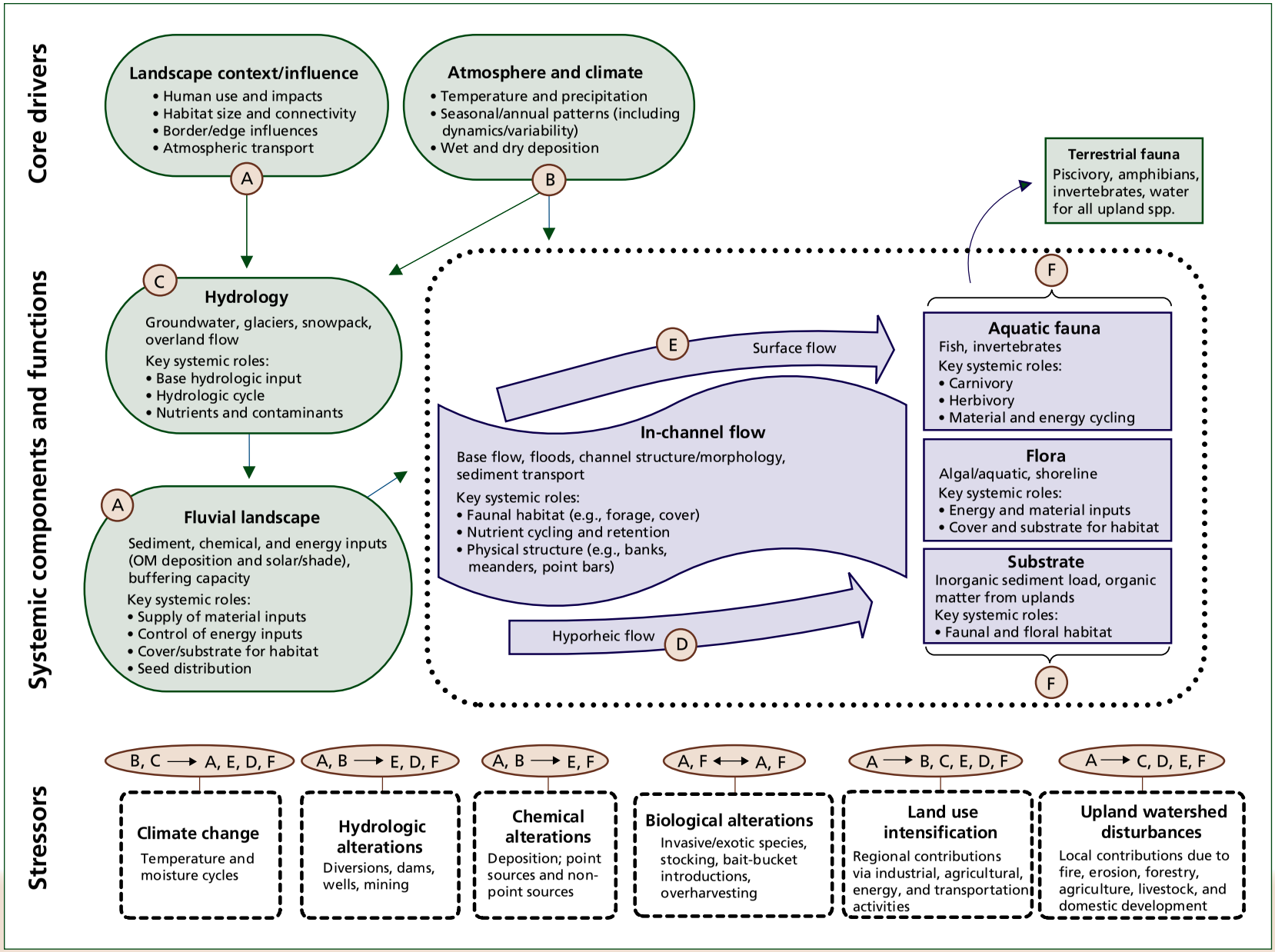
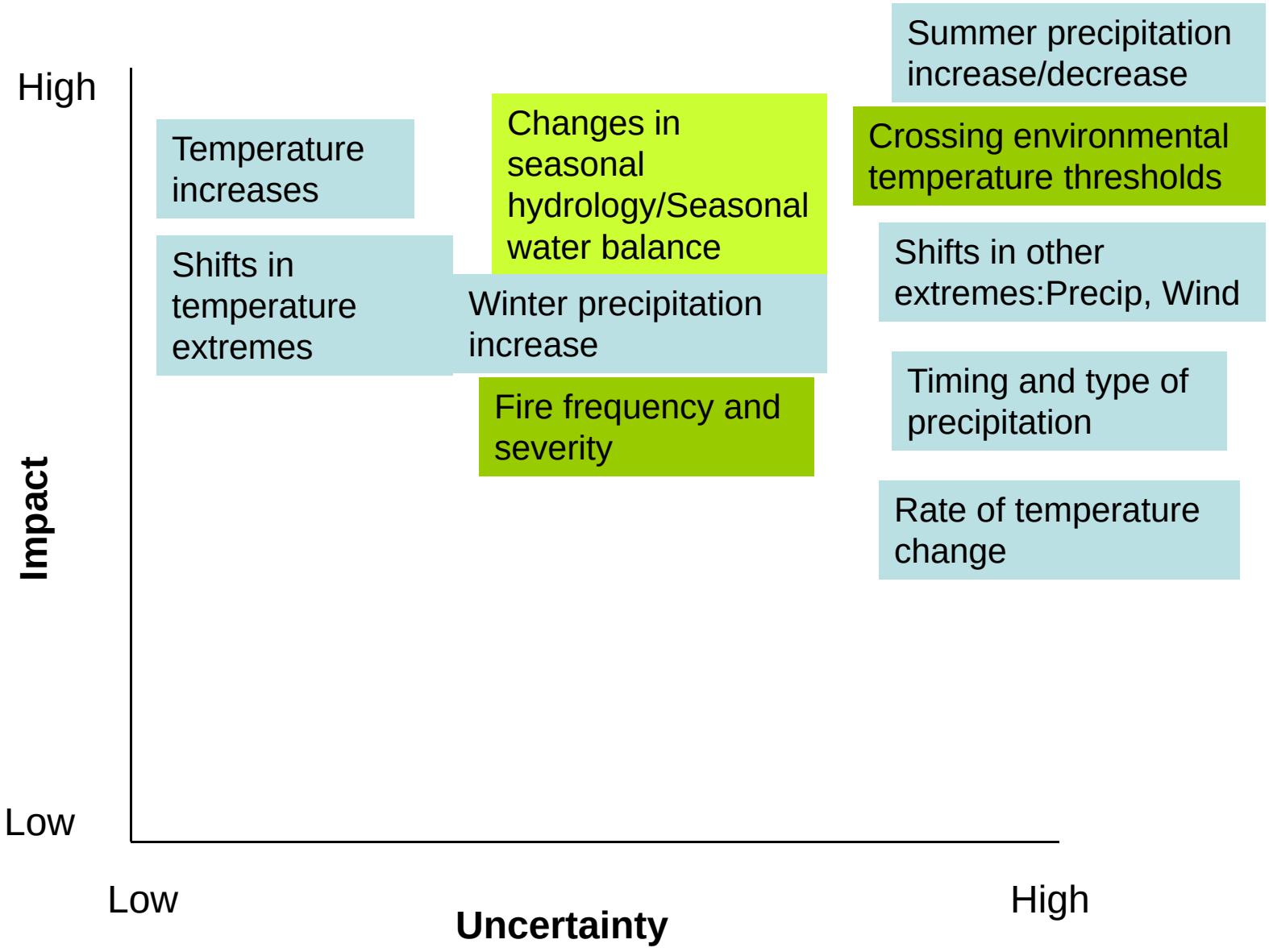
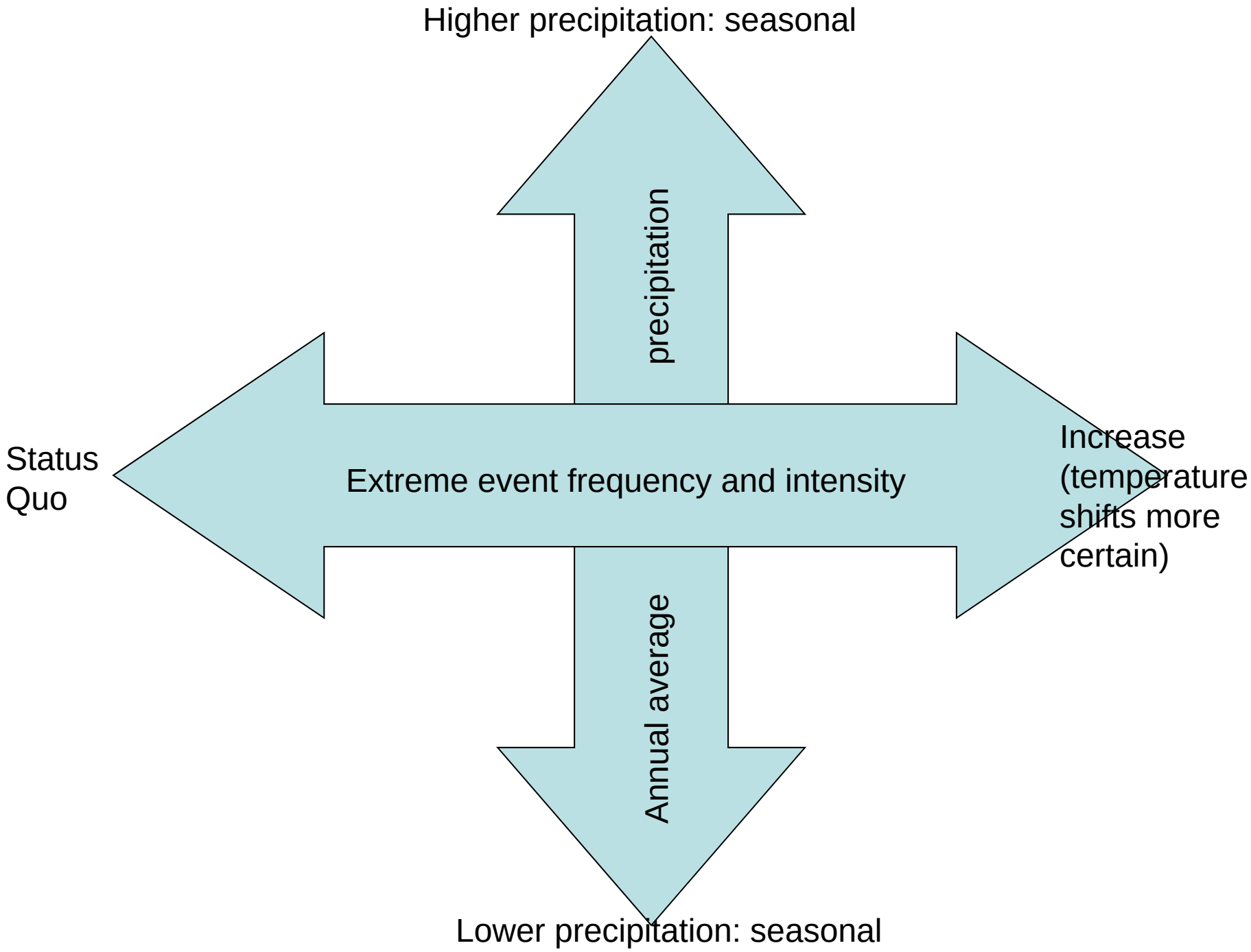


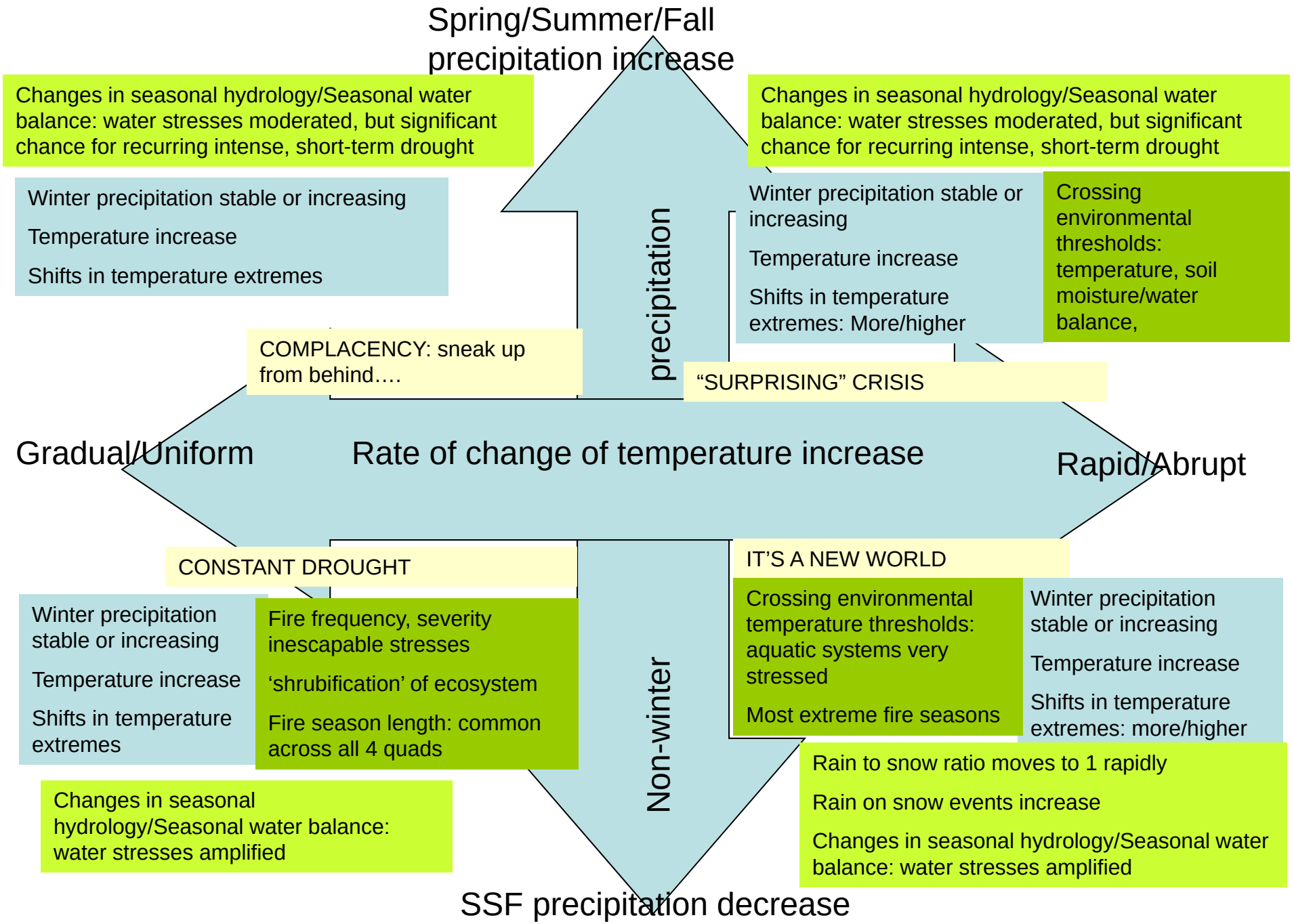
Figure 2.2.4. Stream characterization model.

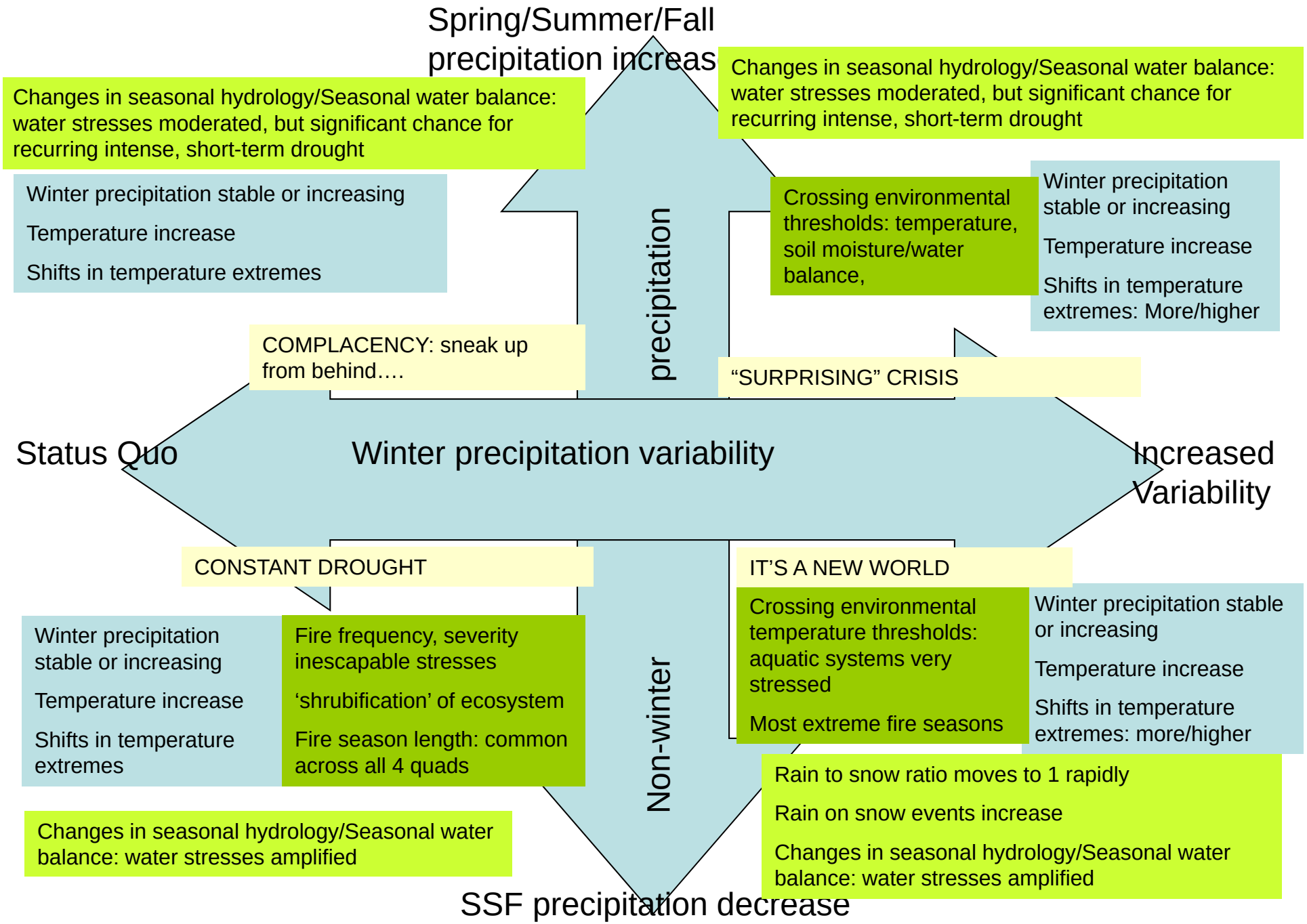
Information on how this model functions can be found in Section 2.2. More detailed information on this model can be found in Section 2.2.4 and Appendix A.

Attachment 5: Scenario Construction Materials
- Rank Ordered Climate Variables
- Draft Climate Axes (3)
- Final Climate Axes
- Figures (2) of Higher-Level Sociopolitical Matrix (from Global Business Networks, 2009)
- Final Nested Scenarios
- Table of Time-Evolving Scenario Outlines


High
Low
Impact
Low
High
Uncertainty
Temperature increases
Shifts in temperature extremes
Changes in seasonal hydrology/Seasonal water balance
Winter precipitation increase
Fire frequency and severity
Summer precipitation increase/decrease
Crossing environmental temperature thresholds
Shifts in other extremes:Precip, Wind
Timing and type of precipitation
Rate of temperature change


Higher precipitation: seasonal
precipitation
Status Quo
Extreme event frequency and intensity
Increase (temperature shifts more certain)
Annual average
Lower precipitation: seasonal


Spring/Summer/Fall precipitation increase
Changes in seasonal hydrology/Seasonal water balance: water stresses moderated, but significant chance for recurring intense, short-term drought
Changes in seasonal hydrology/Seasonal water balance: water stresses moderated, but significant chance for recurring intense, short-term drought
Winter precipitation stable or increasing
Temperature increase
Shifts in temperature extremes
Winter precipitation stable or increasing
Temperature increase
Shifts in temperature extremes: More/higher
Crossing environmental thresholds: temperature, soil moisture/water balance,
precipitation
COMPLACENCY: sneak up from behind….
“SURPRISING” CRISIS
Gradual/Uniform
Rate of change of temperature increase
Rapid/Abrupt
CONSTANT DROUGHT
IT’S A NEW WORLD
Winter precipitation stable or increasing
Temperature increase
Shifts in temperature extremes
Fire frequency, severity inescapable stresses
‘shrubification’ of ecosystem
Fire season length: common across all 4 quads
Crossing environmental temperature thresholds: aquatic systems very stressed
Most extreme fire seasons
Winter precipitation stable or increasing
Temperature increase
Shifts in temperature extremes: more/higher
Non-winter
Changes in seasonal hydrology/Seasonal water balance: water stresses amplified
Rain to snow ratio moves to 1 rapidly
Rain on snow events increase
Changes in seasonal hydrology/Seasonal water balance: water stresses amplified
SSF precipitation decrease


Spring/Summer/Fall precipitation increas
Changes in seasonal hydrology/Seasonal water balance: water stresses moderated, but significant chance for recurring intense, short-term drought
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Winter precipitation stable or increasing
Temperature increase
Shifts in temperature extremes
Crossing environmental thresholds: temperature, soil moisture/water balance,
Winter precipitation stable or increasing
Temperature increase
Shifts in temperature extremes: More/higher
precipitation
COMPLACENCY: sneak up from behind….
“SURPRISING” CRISIS
Status Quo
Winter precipitation variability
Increased Variability
CONSTANT DROUGHT
IT’S A NEW WORLD
Winter precipitation stable or increasing
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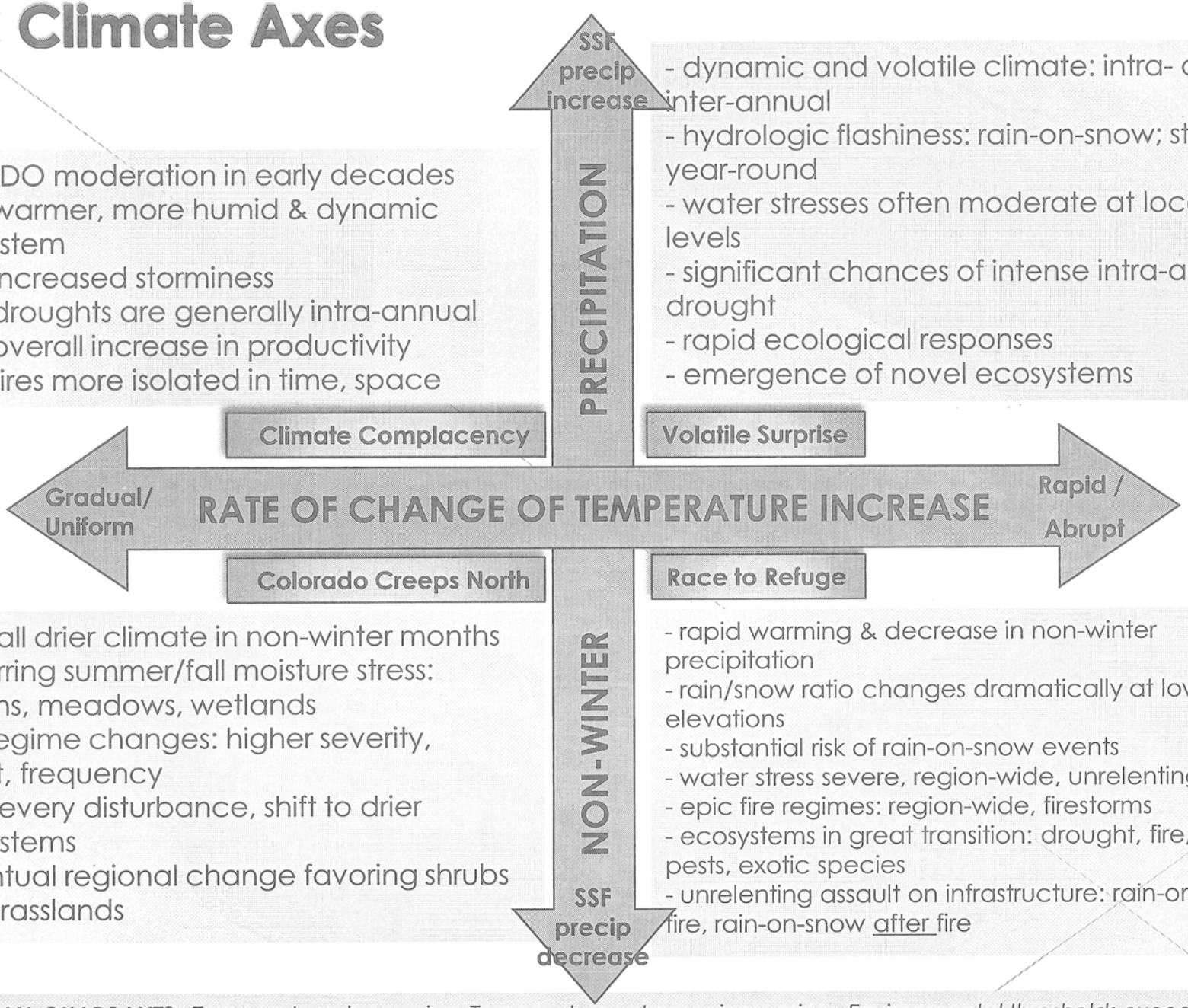
Shifts in temperature extremes: more/higher
Non-winter
Rain to snow ratio moves to 1 rapidly
Rain on snow events increase
Changes in seasonal hydrology/Seasonal water balance: water stresses amplified
Changes in seasonal hydrology/Seasonal water balance: water stresses amplified
SSF precipitation decrease

CoC Climate Axes



-PDO moderation in early decades
- warmer, more humid & dynamic system
- increased storminess
- droughts are generally intra-annual
- overall increase in productivity
- fires more isolated in time, space

- dynamic and volatile climate: intra- and inter-annual
- hydrologic flashiness: rain-on-snow; storms year-round
- water stresses often moderate at local levels
- significant chances of intense intra-annual drought
- rapid ecological responses
- emergence of novel ecosystems

- overall drier climate in non-winter months
- recurring summer/fall moisture stress: streams, meadows, wetlands
- fire regime changes: higher severity, extent, frequency
- with every disturbance, shift to drier ecosystems
- eventual regional change favoring shrubs and grasslands

- rapid warming & decrease in non-winter precipitation
- rain/snow ratio changes dramatically at low- & mid-elevations
- substantial risk of rain-on-snow events
- water stress severe, region-wide, unrelenting
- epic fire regimes: region-wide, firestorms
- ecosystems in great transition: drought, fire, disease, pests, exotic species
- unrelenting assault on infrastructure: rain-on-snow , fire, rain-on-snow after fire

FOR ALL QUADRANTS: *Temperatures increasing; Temperature extremes increasing; Environmental thresholds exceeded; Winter precipitation stable or increasing ; Earlier spring runoff; Growing season & Fire season extended; Phenological mismatches*

Explaining Scenarios: Creating a High-Level Scenario Framework

➢GBN project asked the core team to consider the question:

What will be the social and political landscape around climate change over the next 25 years?

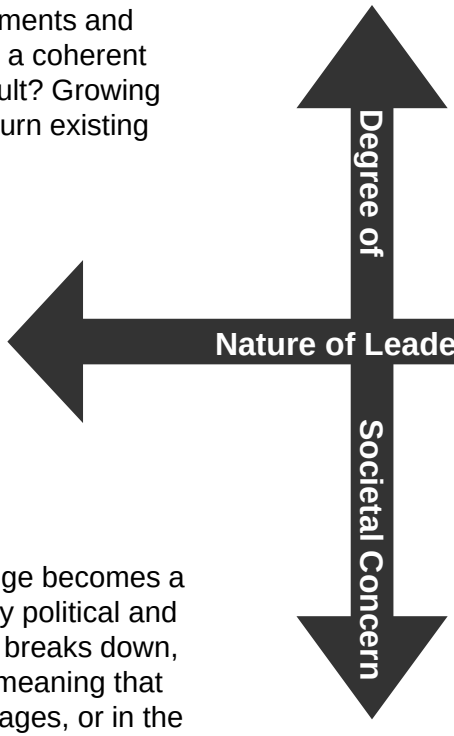
The core team identified the following critical forces that would be likely to affect this issue.

Forces marked in red were deemed to be the most important, and most uncertain, in shaping the future social and political landscape

1.rate and magnitude of GHG emissions
2.mood / position of administration
3.intensity of impacts on average American citizen
4.political stability of oil-producing and quickly-developing nations
5.population growth and development and energy demand
6.regional population shifts and consequent development
7.public perception of federal lands and their purpose
8.leadership
9.budgets (for funding science and management)
10.degrees of cooperation between agencies, sectors, etc.
11.energy availability and cost
12.levels of global conflict
13.public reaction to rate of temperature and sea level change
14.media portrayal
15.sense of public ability to make a difference
16.degree to which CC is a partisan issue
17.economic prosperity
18.knowledge of CC
19.threshold changes and wildcards
20.federal agriculture policies
21.urban planning policies
22.sequestration and technology developments
23.power of carbon tax / cap and trade / Kyoto
24.concern of / in society about natural systems
25.social and environmental movements / renaissance
26.resource availability / scarcity (water, lithium, etc.)
27.global health concerns / epidemics / disease

Explaining Scenarios: High-Level Framework

➢*Cross the critical uncertainties together to form a high-level matrix. This creates 4 different pictures for the future social and political landscape around climate change*



Broad Understanding

Heightened Urgency

Riots and Revolution

At a time of growing social concerns and fear about the impacts of climate change, governments and political leaders are unable to articulate a coherent set of policies and approaches. The result? Growing public unease, and movements to overturn existing systems and structures.

Big Problems, Big Solutions

Coordinated action around the world as climate change (and its effects on weather, resources and people) becomes seen as an increasingly urgent and widespread challenge. Political leaders initiate bold decisions and policies to mitigate the worst, and adapt to the inevitabilities of climate change effects.

Lack of senior commitment

Varied approaches and alignment

Short-term concerns

Nature of Leadership

Senior commitment

International alignment

Long-term perspectives

Is Anyone Out There?

To the frustration of many, climate change becomes a variable concern that is often ignored by political and business leaders. Scientific consensus breaks down, other societal challenges loom large, meaning that climate change is seldom on the front pages, or in the forefront of political and business leaders' minds.

Wheel-Spinning

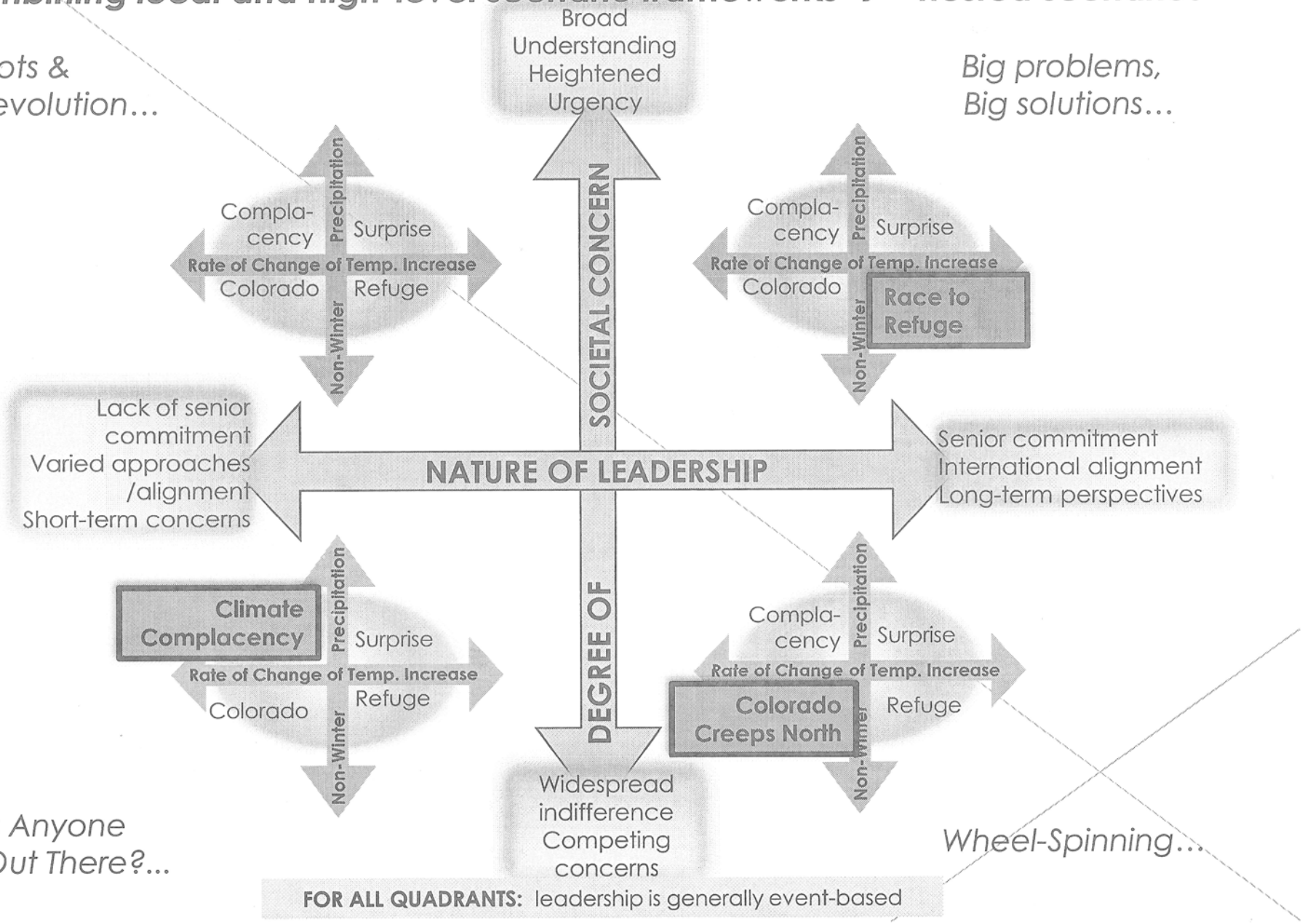
Despite growing scientific evidence that has convinced leaders across the world, climate change remains a remote concern for the majority of everyday people. Consumers and businesses rail against carbon caps and prices, claiming them to be "just another tax" imposed by the elite.

Widespread indifference

Competing concerns

Case Study : **Crown of the Continent (CoC)**

Combining local and high-level scenario frameworks → "nested scenarios"



CCE Drivers and Impacts: *distributed temporally and spatially*

Legend: Association with Climate Scenarios:
white background = A+B+C (i.e., things common to all scenarios because they are virtually certain or highly likely), brown = A, B = blue, C = yellow, B+C = green
A = Race to Refuge, B = Climate Complacency, C = Colorado Creeps North
Note: Current conditions (2010-2011) are common to all scenarios, because it is a common starting point….
Using this table: For a single scenario, look at the unique items, then the common items. I don't have everything laid out in a neat order…

	Global	Regional (CCE)	Local (E/W, etc.)
2010 - 2011	**Temperature** **Precipitation** ENSO and Pacific Decadal Oscillation largest influence in PNW/IMR interannual and decadal-scale climate variability **Air pollution**: from Asia, Sahara and coal use/mining **Fire** - Western US fire season: 78 days longer, - 4x increase in fires >1000 acres, - 6x increase in acres burned **Population Migration** - tourism primary industry in MT, AB **Economy** - interest in biofuels - interest in mineral extraction projects	**Temperature** - 16.6-17[C1] (compared to 16.56 in 1990) - extremely cold days (<17.8C) terminate 20 days earlier; - extremely hot days (>32C) 3 times more common and >3-week larger window of occurrence **Precipitation** - annual precipitation at ~103% the 1931-80 mean mean July-Aug **Snow** - decline in peak SWE results in ~14 more snow free days **Drought** - worst historical drought: 1917-1941 **Streamflow** - increasing temperatures in winter months over last 30 years has produced more rain vs snow events, rain-on-snow, and early runoff in the winters - earlier runoff with declining summer flows **Glaciers** - remaining glacier areas 2.44 – 5.69[2]km[2] - reduced ice cover decreases surface albedo and further increases local heating **Growing Season**	**Temperature** - changes most rapid >2000m elevation **Streamflow** - flooding response differs - west-side, east-side, high- and low-elevation basins, and "transient" basins each respond differently - flooding more common on west-side - decline in late summer flows in some areas, due to increased temperatures and agricultural water withdrawals to meet crop demands **Drought** - local soils can foster more common and severe drought at local level **Fire** - frequency up, especially over 6500 ft elevation - 65% of the Flathead Basin has burned since 1984; invasive species moving in after disturbance **Terrestrial Systems** - forest mortality i.e. sudden aspen decline, beetle kill - decline in tundra plants; 30-65% decline in abundance of 7 species 1989-2002 - fragmentation of krummholz from human activity in treeline ecotone - tundra to forest transition - increase in tree cover at treeline ecotone (transition zone)

[1] Most drastic change based on co2 doubling scenarios, lowest change based on linear temperature extrapolations

		- 2 weeks longer than last half of 20th century **Terrestrial Systems** - new species assemblages being noticed **Fire** - frequency and intensity of fires increasing - disturbance provides opportunity for exotic specices - June-September now have temperatures over 90F and more hot days, amplifying the fire regime - fire regime in western Montana strongly controlled by temperature and precipitation (i.e., water balance) **Population Migration** - to CoC region: increases among highest in Intermountain Rockies (IMR) **Resource Extraction** - minerals, gravel - fuels potential - biofuels potential, interest	- tundra plant communities growing more upright, filling in gaps - more frequent insect infestations **Aquatic Systems** - glaciers provide base flows during hot, dry summers to moderate stream temperatures; controls distribution & abundance of invertebrates - slope instability after loss of glaciers produces sediment in streams **Glaciers** - as glaciers retreat, remaining landscape is highly unstable, producing avalanches and landslides - with melt, glacier dam lakes grow - ice dam lakes shrink and have increased risk of dam failure and outburst floods - rock/debris avalanche (eastern edge of Lewis Overthrust fault) : 2 large rockfalls in 20th century: 1910 after storm, 1954 cause unknown **Cultural Resources** - local sites traditionally used for plant gathering are less productive **General:** - increased erosion, - increase in water withdrawals for local agriculture - traditional plant sources diminished (i.e., huckleberry)
2020	**Drivers (A1B):** External pressure for resource extraction: fuels, minerals Population migration: continued movement to mountain areas by retirees and distance workers. B: Pacific Decadal Oscillation is in decadal-scale regime inherent in natural patterns of climate variability. PDO regime favors cooler and wetter conditions, masking regional impacts of continued global	**Temperature** - mean July-Aug. temperature: 16.66-17.3C (compared to 16.56 in 1990) **Precipitation** - annual precipitation at 103.7% the 1931-80 mean. **Glaciers** - remaining areas ~5km2; - remaining areas <1km2 **Growing Season** **Fire** - frequency and intensity of fires increasing - length of fire season increases	**EvapoTranspiration** -increased water demands of crops - ET demands moderated by SSF precipitation **Drought** - shifts in wind direction can have fine-scale impact on soil moisture, via snowpack deposition and melt patterns and drying after melt. - these droughts can happen, but they are infrequent and short-term - **Water Demand** - increase to meet ET needs for crops - calls for increased water withdrawals for agriculture? - not a problem, because growing

	warming. All climate drivers at regional and local levels continue to look indistinguishable from 20th century variability. So, all the impacts look the same as for 2010-2011, too. There is still warming, but the SSF precipitation is higher and mediates the effects of temperature increases, keeps ET lower, and moderates water stresses in the summer and fall. C: Follows A1B more 'typically', but with the specification that SSF precipitation is reduced. This amplifies the temperature increase impacts on stresses related to internal water balance dynamics. A: This pushes everything forward, i.e., use 2050 entries for 2020, and use 2100 entries for 2050. The new 2100 entries are listed there… A: Emissions continue to increase. Global amplifying feedbacks are started (e.g., emissions from melting permafrost regions). While a aggressive emissions reductions may be developed between 2050 and 2100, the amplifying feedbacks mean that we are considering CO2 levels ~800-1000ppm.	- disturbance provides opportunity for exotic species to move in - fire season is more variable: SSF precipitation increases fine fuels and short-term drought may have higher risks. Fire season is still longer, due to higher temps, though. **Terrestrial Systems** - loss of habitat and species in most vulnerable regions - diseases, pathogens appearing - plant distributions changing in sensitive areas - new species assemblages being seen more - the mix is different between B and C, but in ways that are not completely predictable **Aquatic Systems** - loss of habitat and species in most vulnerable regions - diseases, pathogens appearing - B: stresses on aquatic systems moderated by summer flows not being as low, but there are still higher water temperatures **Cultural Resources** - loss of plant harvest locations becoming more common - loss of glaciers impact perceptions of the region **Facilities** - aging of buildings means more fall under section 106 compliance requirements - risk of damage increases region-wide, although site risks are mediated or exacerbated by location **Visitor Services/Recreation** - Increase in park visitors - Shorter ski season - visitation increase 6-10% in 2020s (relative to 2000???) - visitation increases during the shoulder seasons - visitation higher under C than B, because the 'weather' is more recreation-friendly in the 2020s	season precipitation is available **Streamflow** - greater summer flows: produce local increase in stream sediment - summer flow problems are magnified, because there's increased temperatures and increased SSF storm flows - potential for reservoirs and streams to cry up with "perfect storm" of extremely hot summer, reduced flows, increased calls on over-allocated water **Terrestrial Systems** - local increases in area/density of trees, which then affect snowpack and fire fuels - local decreases in forest cover - plant distribution changing in sensitive areas - bears out later in season, so more vulnerable/exposed to hunting, less available foods (huckleberry, moths, whitebark pine) - phenology disruptions being noticed at the local scale in specific habitats **Aquatic Systems** - as glaciers melt, streams have greater summer flows, but more sediment, affecting aquatic life - summer flow problems are magnified, because there's increased temperatures and increased SSF storm flows - change in surface-groundwater interactions, which foster biodiverstity, means concentration of fish to location where the interactions still occur: B has this occur over less area than C - fish species shift northwards; - increased fish mortality i.e. bulltrout; - invasion of specific bulltrout areas by nonnative Lake Trout **Cultural Resources** - locations used for plant harvest being lost **Facilities and Services** - destabilized slopes increase risk of avalanches, landslides, damage to structures, risk to visitors

			- higher risk of facility damage under B than C because of SSF storm increases - snowmaking to serve ski industry drives increased water demand at local scale **Cultural Resources** - Less snow pack and greater fire intensity and lowering water tables expose more archeological resources
2050	**Temperatures** **IPCC A1B** **Precipitation** - intensified dynamics due to increase temperatures **Population Migration** - tourism shifts to higher latitudes and higher elevations as temperatures and water stresses increase in many region - continued movement to mountain areas by retirees and distance workers. **Energy Security and Costs** External pressure for resource extraction: fuels, minerals B: the transition is quick, because the warming impacts were delayed by the PDO regime in the 2020s, but now can be fully expressed by 2050 (i.e., back on the A1B track). A: permanent drought by 2050 in SW US, with levels of aridity comparable to 1930s Dust Bowl stretching from Kansas to California, with sustained decrease in soil moisture of about 15%. These are also "very hot weather droughts", not cool droughts.	**Temperature** - 1.5 to 2.1^{C} higher (=1.7-3.7 F higher). This is a moderate to large increase compared to 1990-2010 observations. (IPCC A1B) - Temp increases slightly greater in summer. - Increase in extreme high temperatures - increase in minimum temperatures **Precipitation** - 2-5% increase in winter precipitation - No change in summer totals; slight increase in SSF precipitation (10%, i.e., enough to moderate the increase in ET demand) - 4% decrease in summer totals - changes within bounds of observed record - increase in intensity of storms but decrease in their frequency, with bigger increase for B than C due to SSF storms **EvapoTranspiration** - Increases are moderate to large compared to 1990-2010. - Primary impacts: SSF. - cancelled by SSF Precip increases - tied to increased temps **Snow** - ~50% reduction in average late-spring snow depths - Decreased snow accumulations - Greatest impact in fall, late-winter, early-spring. - Increased in snow-free days - projections that April 1 snowpack in northern Rockies will be completely gone by 2070 **Drought (soil moisture)**	**Temperature** - Temp increases greater at higher elevations. **Snow** - Windward/western slopes **:** heavier snow storms - Low- to mid-elevations (compared to 1990-2010 snowlines) most susceptible **Drought** - local impacts influenced by slope, soils, orientation to wind-deposited or -removed snow cover - drought risk greater on east-side of divide and amplified by C **Glaciers** - gone, except for tiny remnants **Streamflow** - increased flooding from rain-on-snow events in (now) mid-elevations - west-side, east-side, high- and low-elevation basins, and "transient" basins each respond differently to combined temperature and precipitation changes - flood risk greater on west-side: enhanced under B - loss of glaciers means summer flows in headwaters is dependent on summer precipitation. That summer precipitation is not there as reliably under C **Aquatic Systems** - loss of glacier melt-based streamflows means loss of stable aquatic systems in headwaters - problem magnified under C - loss of crucial localized habitat for native fish - loss of herpetological habitat as ponds and wetland dry up in late summer, fall - magnified under C

		- Moderate to large compared to 1990-2010 - Increased frequency and severity of region-wide droughts, i.e., recurring intense, short-term droughts - possible increase in duration of region-wide droughts - greatest impacts in summer due to ET demands **Glaciers** - remaining glacier area: ~4km2 - remaining glacier area: gone **Streamflow** - winter flows increase - spring peak flows arrive earlier - summer and fall flows diminished - amplified under C - change in annual flows uncertain - more intense spring floods - amplified under B - more intense flash floods during summer - amplified under B **Length of growing season** - increase large relative to 1990-2010 variability - 4 weeks longer than last half of 20th century (from Steve Gray; note equivalent value for 2100 from webinar discussions) - days above critical high temperature thresholds increase - days above critical low temperature thresholds increase **Fire** - frequency and intensity of fires increasing - length of fire season increases - disturbance provides opportunity for exotic species - fire season is more variable: SSF precipitation increases fine fuels and short-term drought may have higher risks. Fire season is still longer, due to higher temps, though. **Terrestrial Systems** - loss of habitat and species throughout the region, in all ecosystems - diseases, pathogens becoming more frequent throughout - plant distributions changing throughout region; new species	**Terrestrial Systems** - plant species moving into formerly ice-covered areas - tree-line moving upward in elevation at fine-scales - at local scales, terrestrial systems affected most strongly at earliest stages of stand development (e.g., after disturbance) - local loss of butterfly habitats as soil moisture stress becomes untenable - amplified under C **Facilities** - Transportation: Risk of landslide on Going to the Sun Road increases (especially with SSF precipitation increases as well as winter issues). - - Wildcard: GTSR washes out where road runs along cliffs -

		assemblages occurring throughout region (at local scales) - species shifting northward in general - exotic species occurring more frequently throughout - conditions favor species that can handle frequent disturbance, e.g., Grasses, Shrubs, - with each disturbance, ecosystem trends toward drier, shrubbier, grassier systems - nature of ecosystem change is different species mix between B and C - overall treeline response is highly variable, affected by local conditions and disturbance - combination of multiple stresses at different scales, underlain by temperature-driven stress produces fragmentation into more localized habitats - phenology disruptions being noticed throughout region **Aquatic Systems** - loss of habitat and species throughout the region, in all ecosystems - increased cold-water fish mortality as water temperatures periodically exceed 70F for >3 consecutive days - diseases, pathogens becoming more frequent throughout - loss of population recruitment in native fish species (trout) with higher water temperatures and low flows in the fall, and increased winter flooding that destroys spawning beds - increased hybridization of cutthroat trout as streams are degraded by warm temperatures, reduces fish fitness and survivability - species shifting northward in general - exotic species occurring more frequently throughout - conditions favor species that can handle frequent disturbance of hydrologic regime, e.g., Lake Spawners **Cultural Resources** - widespread loss of traditional plant gathering sites, i.e., plants	

		not available in their traditional location in harvestable quantities - loss of glaciers impact perceptions of the region **Facilities** - aging of buildings means more fall under section 106 compliance requirements - risk of damage increases region-wide, although site risks are mediated or exacerbated by location - risks have been rising for some time, and over that time, some risks will have been realized. The incidences may be small or huge (e.g., the GTSR). - risk of termites moving into region, increasing damage and maintenance needs at large scale - amplified under B - increase in conditions that prompt summer cooling, increasing power demand **Visitor Services/Tourism** - visitation increase 10-36% (relative to 2000s?? - cold-water fishing opportunities limited - visitation season increases during shoulder seasons and as a refuge from high temperatures elsewhere - loss of skiing, wildlife viewing, cold-water fishing, and other traditional activities outpaced by increases in gains in warm-water fishing and boating	
2100	**Drivers: A1B** **"Hell and High Water" global scenario** - even a very strong mitigation effort that kept carbon emissions this century to 11 GtC a year on average would still probably take us to 1000 ppm - Sea level rise of 5 feet, rising some 6 to 12 inches (or more) each decade thereafter - Dust Bowls over the U.S.	*Same as above, but more extreme* **Temperature** - mean July-Aug temperature: 17.04C (compared to 16.56 in 1990) Staggeringly high temperature rise, especially over land — some 10°F over much of the United States, maybe 15-18F increases **Precipitation** **Snow**	*Same as above, but more extreme* **Terrestrial Systems** - up to 50% loss of lynx habitat with 7F degree rise in winter temperatures in snow-covered regions - snowshoe hare population loss from predation at their color is linked to daylength not snow, but snow season is much shorter Facilities - snowmaking requirements increase by ~200-400% relative to (what period??), increasing local water

	SW and many other heavily populated regions around the globe. Most of SW and South sees loss of soil moisture ~50%. - large parts of US have temperature rises of 15-18F. - Massive species loss on land and sea — 50% or more of all life A: poses incredible pressures on the healthiest places re: food production and population migration	- winter (snow) season 1 month shorter than late 20th century **Glaciers** - remaining glacier area: ~3km2 - remaining glacier area: 0 (gone) **Growing Season** - summer season 1 month longer than late 20th century - water balance stresses counterbalance actual growing capacity, however **Fire** - frequency and intensity of fires increasing - length of fire season increases - disturbance provides opportunity for exotic species - think of Australia's firestorms **Terrestrial Systems** - where stresses have recurred and overlap spatially, spatial patterns are growing in scale to biomes (e.g., grassland patches merging into a grassland biome) - think of northern NM! **Facilities** - aging of buildings: now building are nearly 2 centuries old! - risk of damage increases region-wide, although site risks are mediated or exacerbated by location - risks have been rising for some time, and over that time, some risks will have been realized, and a few incidences are nearly inevitable. The incidences may be small or huge (e.g., the GTSR), temporary (e.g., grassfire) or effectively permanent (e.g., loss of GTSR). - termites have moved into region, increasing damage and maintenance needs at large scale	demand

Attachment 6: Workshop Invitation and Questionnaire

Crown Managers Partnership

December 18, 2009

Dear members of the CMP:

The *Crown Managers Partnership* Steering Committee (CMP) is pleased to offer this opportunity to invite you to the Crown of the Continent Climate Change Scenario Planning (C4-SP) Workshop in Whitefish, Montana, March 9 and 10, 2010, sponsored by the U.S. National Park Service and the Glacier National Park Fund. The purpose of this workshop is to create and assess alternative futures for the *Crown of the Continent ecosystem*, *cultural resources, facilities, and services*. Managers will find this information critical to informing their decisions about managing agency resources in light of potential changes due to climate change. There is **no registration or tuition** and the Grouse Mountain Lodge has reserved a block of rooms at the government per diem rate of $91.00 per night.

Why should you attend? Climate change poses dilemmas for the Crown of the Continent that must be managed with foresight and insight. In situations, such as climate change, where there is high uncertainty about the future and little ability to control its direction; scenario planning provides information to support management within a science-based decision-making framework. Through this workshop and pre-workshop activities, you and others will develop the skills to support on-going scenario planning efforts and link it with other decision support processes, such as vulnerability assessments, decision analysis, and management plans. Prior to the workshop, an assessment of climate change projections and potential impacts will be completed with input from your agencies. After the workshop, you will have access to an *adaptation planning toolkit*, and a database of adaptation options.

Who should participate? Based on past scenario planning workshops, participation will be most meaningful for individuals that are comfortable with uncertainty, complexity, and ambiguity. The participant should be interested in exploring issues across several disciplines, considering both policy and management challenges, and connecting science and management, all through constructive dialog with others of diverse backgrounds and responsibilities. Attendees will be from members of the Crown Manager's Partnership, selected scientists, and the U.S. National Park Service national staff.

We have high expectations for the interactive and insightful exchanges required within this Scenario Planning process. All participants will be asked to prepare for the workshop. This preparation is critical for constructive participation over the 2 days. You should plan on completing roughly 5 hours of reading and listening to information from the workshop website prior to the event. We need participants who can commit to active participation from 9am to 4:30pm on both days of the workshop. All selected participants are also encouraged to participate in a kick-off pre-workshop Webinar on January 11th, 2010 at 9am MST. It will focus on the process

Crown Managers Partnership

of scenario planning compared to other decision support tools. Please mark this date and instructions will follow on how to connect to the Webinar.

Due to space limitations (50 slots), we encourage each agency to nominate one participant to attend but we will accept more than one applicant per agency on a provisional list. Please let us know information about each of your candidates no later than January 8th, 2010 by return email.

You can either forward the form below by email to the address provided or complete the form on-line, (URL found below). Since space is limited, your agency's spot will be forfeited after January 8th.

We look forward to your participation.

Sincerely,

Bill Dolan
Alberta Tourism Parks & Recreation
Chair, CMP Steering Committee

Enclosure (1)

Crown Managers Partnership

CANDIDATE FOR PARTICIPATION
In the CROWN of the CONTINENT CLIMATE CHANGE SCENARIO PLANNING
(C4-SP) WORKSHOP, 9-10 March 2010, Crown of the Continent

Instructions: *To be completed by those nominated from your agency/unit (1 form per candidate, please).Please send by email to lezlie@email.arizona.edu or complete on-line (URL below) no later than January 8th, 2010. (Click or paste into your browser:* http://www.surveygizmo.com/s/219876/c4-sp-crown-of-the-continent-climate-change-scenario-planning-workshop-nomination*)*

Agency/Entity:_____ Unit/Dept:_____
□ No one in this entity is available
*Recommend someone else? (provide agency/candidate contact)*_____

Candidate Name:_____ Title:_____
Number of years working in Crown:___

1. Please indicate your area(s) of expertise (*if more than one: indicate 1-2-3 for highest…*):

□ Planning
□ Policy
□ Communication /interp. & education
□ Compliance
□ Land Management
□ Facilities / transportation
□ Cultural resources
□ Science / monitoring
□ Climate Change

□ Natural resources

□ Aquatic (*Circle*: biology, streamflow, fisheries, meltwater, amphibian, _____)
□ Terrestrial (*Circle:* alpine, wildlife, amphibian, other:_____)
□ Other:_____
□ Fire or other disturbance:_____
□ Adaptation
□ Mitigation
□ Other: _____

2. Please describe contemporary climate concerns or consequences in the Crown that you have noticed during your daily work:

3. What do you hope to get out of the Crown Climate Scenario Planning workshop?

4. What can you bring to the workshop that is unique?

Your sending (or uploading) of these answers indicates both your interest and availability for the March 9-10, 2010 CCSP workshop in Whitefish, Montana.

Attachment 7: Workshop Agendas
- Short Agenda for Participants
- Annotated Agenda for Facilitators

Crown of the Continent Ecosystem – Climate Change Scenario Planning Workshop
Draft: 1 March 2010

Draft Agenda
==========

Monday, March 8

Reception 6-8pm – Grouse Mountain Lodge

Tuesday, March 9

Goals for Day 1:

- Introduce scenario planning within the context of climate change adaptation
- Understand what scenarios are and methods for constructing them
- Explore 2 to 3 scenarios for CCE to work with for Day 2

9:00-9:20 am	**Introductions and Welcome**
9:20-9:50 am	**Workshop Overview**
9:50-10:20 am	**Planning for Climate Change**
10:20-11:00 am	**Drivers of Change in the Crown of the Continent / Northern Rockies**
11:00-11:15 am	**BREAK**
11:15 am -12:15 pm	**Impacts of Change to CCE Resources**
12:15-1:30 pm	**LUNCH – in house**
1:30-3:00 pm	**Scenario Building 101**
3:00-3:15 pm	**BREAK**
3:15-4:30 pm	**Example Scenarios for the Crown of the Continent: putting flesh on the bones**
4:30-5:00 pm	**Recap Day 1**
7:00-9:00 pm	**Deep History of the Crown of the Continent Ecosystem: Perspectives from Tribal Nations**

Wednesday, March 10

Goals for Day 2:

- Evaluate how climate change affects or alters management objectives
- Explore how climate change scenarios can be used in the planning process

8:00-8:15 am	**Welcome Back and Introduction to Day 2**
8:15-9:15 am	**Management Objectives and Adaptation Options**
9:15-9:45 am	**Linking Scenario Assessment and Planning - Preparation for Breakout Groups**
9:45-10:45 am	**Scenario Assessment and Planning – Breakout Groups I**
10:45-11:00 am	**BREAK**
11:00am -12:00 pm	**Scenario Assessment and Planning - Breakout Groups II**
12:00-1:15 pm	**LUNCH**
1:15-2:00 pm	**Scenario Assessment and Planning - Plenary Report Out and Discussion**
2:00-2:15 pm	**Policy Screening - Preparation for Breakout Groups**
2:15-3:15 pm	**Policy Screening - Breakout Groups**
3:15-3:30 pm	**BREAK**
3:30-4:15 pm	**Screening Report Out - Plenary**
4:15-4:45 pm	**Workshop Synopsis and Discussion**
4:45-5:00 pm	**Closing Remarks**
5:00 pm	**Adjourn**

Crown of the Continent Climate Change Scenario Planning Workshop
Final: 1 March 2010

Background Considerations

- Primary Workshop Goals:
    - Participation: fun, engaging, leading to new perspectives useful for further climate change-related planning/adaptation processes
    - Strategic Planning: to help CMPs 'think big' about climate change over large time, space, and organizational scales, and the interconnectedness of climate change with other forces of change, and to use scenarios as a device to explore the role of policies and management objectives in preparing for climate change challenges
    - Decision Support: to identify and evaluate options for adaptation that can accommodate diverse futures, with a focus on the roles of scale and management objectives
- Secondary Workshop Goals:
    - Exploration: To bring together information from different disciplines and sectors to highlight the complexity and interconnectedness of climate change with other problems
    - Scientific Assessment: To combine qualitative and quantitative information about the future evolution of management challenges in the CoC region, and help bridge scientific and political aspects of management challenges
- Tertiary Workshop Goal:
    - Information: To inform and consult with CMPs about climate change and its challenges
- Process Goal: If you can't fully engage stakeholders in scenario development, you at least should be transparent in how you came to those particular scenarios. In the sessions prior to working with specific scenarios, we are at minimum aiming for transparency in our process. We are also testing some ways to engage people with scenarios and the scenario development process, even though they weren't involved in the initial development activities.
- Assumption: participants have a basic understanding of climate change as an issue. If people are here to debate whether climate change is happening, what might be causing it, or the appropriateness of any mitigation policies, this is the wrong workshop.
- Assumption: This scenario planning workshop is only one early piece within a longer and multi-pathway process with a lot of organizations and people not present at this workshop. We will ask for input in different ways throughout the workshop. Some input will influence the activities and outcomes of this workshop, while other input will be made available to inform activities in other processes.

Draft Agenda
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Draft Agenda -- Annotated

Monday, March 8
Reception 6-8pm
Focused meeting of Steering Committee and webinar participants. Meet & Greet, so people can see who they have been talking to over the webinars and phone calls.

Tuesday, March 9
Introductions and Welcome – Jack Potter
9:00-9:20am Introductions and Welcome
The group is too big to have everyone go around the room and say who they are. The goal here is to have people connect without one-by-one introductions.

(1) Have a list in the workshop packet showing who and what organizations are at the workshop.
(2) We need to have an opportunity for people to list their organization management objectives if they do not send them prior to the workshop. Have a sheet of paper for people to fill out and return; Lezlie/Katherine will combine any additional submissions with the returned information, to use on Day 2. i

Workshop Overview – Holly Hartmann
9:20-9:50am Workshop Overview
- goals/focal question (2-3 min)
- challenges (2-3 min)
- the scenario planning process – generalized (10 min)
- our work up to this point: the process leading to this workshop (webinars, small group, pre-workshop materials etc) (10 min)
- how we will conduct this workshop - breakout groups and process (5 min)

Planning for Climate Change – Leigh Welling
9:50-10:20am Planning for Climate Change
- prior work in CoC (10 min) (strategic plan, annual forum)
- other climate change planning/adaptation processes – and how scenario planning fits in
    - USGS, USFWS, NPS (10 min)
    - prior scenario planning work (10 min)

Drivers of Change -- Steve Gray
10:20-11:00am Drivers of Change
- focus: external forces outside CoC control
- distinction of high/mid/low uncertainty, scale of drivers (global, national, regional, local/organization--all large scale drivers – discussion of social and economic drivers as well as exotic species, etc.

- climate drivers →, presentation of table—this is where we present key drivers (based on expert input, webinars, literature, etc.) to consider for scenarios.
- Brief overview of how climate is tied to other drivers of change (e.g. fire)—use this to set up Dan Fagre and impacts discussion, not as a stand-alone piece. Other area to emphasize: Distinction of external drivers from the regional response (i.e., internal system dynamics) that is driven by the external forces.

BREAK 11:00-11:15am

Impacts of Change - Introduction by **Holly** (5 min)
11:15-12:15
– presentation of key impacts and impact table - **Dan Fagre** (40 min)
    - focus: key impacts that are pervasive and link issues across all sectors/jurisdictions, emphasis on key impacts that are ultimately considered in the scenarios
    - discuss uncertainty, scale of impacts
    - include: terrestrial, aquatic, cultural, facilities, services
- what's missing: **Holly** (15 min)
    - short input exercise (sticky notecards prepared by tiny groups, ~3-5 people, 15 minutes). Will post note cards and use these for consideration in storylines/management objectives → day 2

12:15-1:30pm LUNCH

Building Scenarios - Holly introduce
1:30-3:00pm Building Scenarios – **Leigh Welling/Steve Gray**
- here is where we walk people through the exercise of scenario
- key point: why it's important to simplify (its not about prediction) and how the four quad approach helps us wrap our minds around complex problems and uncertainty
- start with overview and explanation of the higher-level quad (socio-political and institutional landscape)
- continue with exercise whereby participants choose climate variables from the list of key drivers presented in the morning session, and then build out a small group (2-3) climate-based scenarios in small groups. Logistically speaking, this might be accomplished by 1) breaking the large group into four smaller sub-groups and then 2) assigning each quadrant or storyline to one of these sub-groups. SG

3:00-3:15pm BREAK

3:15-4:00 pm Example Scenario matrices using the drivers and impacts information presented – **Jeff Mow**
-
    - Using 3 key drivers, introduce how they were crossed and explore the resulting scenarios and their implications.

- This is where we can begin to add detail and flesh out full scenarios that will be used in Day 2.

4:00-4:30 pm Presentation of 2 to3 Scenarios that were identified as having highest "value" for scenario planning – – **Jack Potter**

- These scenarios will be generated by the planning group over the next two weeks. Presentation should emphasize the commonalities between these pre-selected scenarios and the scenarios developed in the "build out" exercise above. Should also emphasize that these scenarios were built using information from the webinars
- Identify some critical areas of uncertainty and consequence that are plausible for the CCE and may prompt new management objectives to be set
- This is where we more or less finalize scenarios that will be used in Day 2

Day 1 Wrap-up -- Holly
4:30-5:00pm

- discuss where we are for day 1 – are we good to go with 2-3 scenarios?
- logistics for day 2
- think about scenarios in context of the evening presentation/discussion

Evening
7-9pm Deep History of the Crown of the Continent Region -- Sally Thompson and workshop participants from tribal Crown Management partners.
Roundtable discussion of the deep history of the Crown of the Continent region by CMP tribal representatives. Current formats being considered:
- a panel with Elliott Fox talking about watersheds and then Sally facilitating discussion among the workshop's already-registered tribal participants,
- adding Germaine White to the panel to talk about forests
- adding Vernon Finley to the panel to talk about the coyote stories related to climate and changes

Wednesday, March 10
8:00-8:15am Welcome Back and Introduction to Day 2

- simple reintroduction of pre-developed scenarios
- logistics for Day 2

Management Objectives and Adaptation Options -- Bill Dolan,
Then review workshop participant input. Then go through the rest (thinking whether mgmt objectives will 'hold up', adaptation option categories and database)
8:15-9:15am Management Objectives and Adaptation Options
The emphasis here will be confronting that some present-day management objectives may not be attainable, and considering that mandates and policies may be needed to give managers the flexibility, direction, or authorization they need. The consideration of

adaptation options will then occur within the context of relating to specific management objectives. The purpose of the "adaptation option" portion of this session is to (1) quickly move beyond the initial-level thinking about adaptation, (2) productively build on the extensive work already done by others, and (3) be able to consider a wide variety of adaptation options in the screening phase of the scenario planning.

- revisit the focus question of the scenario building effort: "How do CoC management objectives need to adapt in response to climate change?"
- review of CMP management objectives, now and in the past. This is based on participant input from Introduction session. This highlights that management objectives are not static, even if legal mandates are static. This could be a panel discussion within this session.
- Review of adaptation options: lots of options available as 'tools' for considering in our scenario planning exercises
- categories of options
    - reduce occurrence, increase robustness, increase resiliency, etc.
    - policies, management, I&M, research,

Linking Scenario Assessment and Planning - Preparation for Breakout Groups -- Holly

9:15-9:45am Linking Scenario Assessment & Planning

- objectives of scenario assessment and planning: looking for pattern, not specific values; looking for occurrence of thresholds and cascading events, not their specific details; don't "anchor" to a specific scenario or its details; not just an intensification of the present; distinguishing low/high uncertainty within different part of the scenario; does scenario incorporate multiple scales or integrate natural and human systems
- Scenario evaluation: relevance, creativity, legitimacy, credibility
- process: review, vet, management objectives, adaptation options to achieve new management objectives
- round robin breakout process

Scenario Assessment and Planning Round Robin Breakout Groups -- TBD

9:45-10:45am Scenario Assessment and Planning - Breakout Group Round Robin I
10:45-11:00 BREAK
11:00-12:00 Scenario Assessment and Planning - Breakout Group Round Robin II

Setup: With 3 scenarios developed beforehand, each of 4 groups will rotate through each scenario. With additional scenarios developed beforehand, we will organize the rotation so each group deals with 2 different scenarios. The number and size of the breakout groups is flexible and dependent in part on the facilities available, and who we have to help in the facilitation. Certain availability: H. Hartmann, L. Moriniere, K. Waser, Melanie G; Mary Riddle/Kathy Tonnesson; Cat H.; others (Leigh; Steve; Jeff Mow).
To be decided: whether the facilitators go with a specific group, or are they attached to a specific scenario(s)?

For each scenario:

- brief review of the scenario (10 min)
    - basic narrative elements
    - supplementary materials: maps, pictures, 'story'
- engage with the scenario at the management objective level
    - 'write' yourself (your organization) into the scenario. (10 minutes)
        - I'm still reviewing some options for different ways of doing this. Working backwards in time, for specific years in the future, in alignment with the scenario presentation (option: 2020, 2050, 2100), as congressional hearings (or equivalents), local newspaper headlines, at CMP meetings, organization annual reports, telling your replacement why you did what you did and what your organizations priorities are, what a visitor or new resident of the CoC region might experience)
    - what management objectives will your organization have at that time? (15 minutes). Post organizational management objectives under each time slice on cards on foam core board.
- work with the scenario at the adaptation options level
    - working backwards in time, what adaptation options need to have been done to achieve the future management objectives?
    - Process: work with prepared notecards that are pre-developed and contributed from the prior session. Place notecards under management objective headlines. Allow people to develop new options, if the existing pool of options is insufficient.

12:00-1:15pm LUNCH

Scenario Assessment and Planning Round Robin - Plenary Report Out and Discussion

1:15-2:00pm Scenario Assessment and Planning Round Robin - Plenary Report Out
The goal is not to have each group report out, one by one. The goal is to compare management objectives, and adaptation options over time for each scenario. For this to be efficient, we need 'rapporteurs' to be working with the outcomes of each round robin group to prepare this presentation. Option: if Leigh and Steve are facilitators for the round robin groups, then Lezlie and Katherine can prepare the results, or vice-versa….

- Results of Round Robin
- Presentation ('mapping') of scenarios, management objectives, and adaptation options over time
- Things to look for:
    - Clarification from participants about messages/outputs from the round robin groups
    - Do results from different groups look really different, for the same scenario?
    - Do some objectives and/or adaptation options show up throughout?

Policy Screening
2:00-2:15pm Policy Screening
- objectives of policy screening
- description of the process
- breakout group process

Policy Screening - Breakout Groups
2:15-3:00pm Policy Screening - Breakout Groups
Have each group look, beyond the cursory look for obvious patterns in the plenary session, for
- commonalities across all scenarios and assessments
- differences that cannot be accommodated across scenarios
- can an ordering of adaptation options increase the ability to accommodate the difference scenarios
- what indicators might be important for determining when you have to make choices about which options to use
- do any policies need changing to accommodate any of the adaptation options, their ordering, or choosing a pathway in the future?
- how can the results of the screening connect with other planning processes?

3:00-3:15pm BREAK

Screening Report Out - Plenary
3:15-4:00pm Screening Report Out - Plenary
The goal is not to have each group report out, one by one. The goal is to compare management objectives, and adaptation options over time for each scenario. For this to be efficient, we need 'rapporteurs' to be working with the outcomes of each round robin group to prepare this presentation. Option: if Leigh and Steve are facilitators for the round robin groups, then Lezlie and Katherine can prepare the results, or vice-versa….

Workshop WrapUp
4:00-4:30 pm Workshop Synopsis and Discussion
4:30-4:45pm Workshop Evaluation
4:45-5:00pm Closing Remarks

Attachment 8: Breakout Session Exercises
- Sea Lion Scenario Exercise
- Scenario Assessment and Adaptation Breakout Group Exercise Instructions
- Policy Screening Exercise Instructions

Sea Lion Cave National Seashore – planning thought exercise

Natural Resources: coastal sanctuary and marine protected area – most notably a large pod of stellar sea lions that utilize the low-lying offshore volcanic islands and a coastal cave that is not accessible during high tide – the sea lions come into and out of it during high tide; also many marine birds such as puffins, murre, and shore birds

Cultural Resources: historic landscape – was settled in early 1900s; contains the original mansion of Mr. Cochino and a botanical garden that he had created for his wife contain a wide range of native and some introduced ornamental species. Also a lighthouse

Visitor Experience: beaches, coves, abundant wildlife viewing opportunities; trails through conifer forests. Concessions include a lodge and some small cabins. Visitors can hike trails and the beach and go horse-back riding on some limited trails.

Climatic Setting: is a cape along the west coast of N America. Located in the transition zone between the subtropical and subarctic climatic zones. Is a temperate climate with significant interannual and interdecadal variability. In summer the park lies within the subtropical high pressure system and coastal upwelling provides nutrients to maintain the marine food web and also brings fog that is important to the maintenance of forest health. Keeps fire danger relatively low. During the winter the dominant weather patterns come from the subartic system, bringing frequent winter storms. Spring is variable and fall can have very extended mild and sunny days – in many ways this is best season for outdoor activities in the park.

Coastal upwelling is an essential process for the marine system and for the wildlife along the coast. Winds coming out of the north-northwest drive the current from north to south and bring cold, nutrient rich waters up to the surface.

Management issues to resolve through the planning process

- Primary historic structure – Pendleton's home – is need of major renovation if it is to remain in tact. Home site is at the edge of forest.
- Increased visitation is causing traffic jams; need to pave the southern access, which is a gravel road that washes out with major flash flood events in winter.
- Some marine species appear to be in decline – notably, the Steller Sea Lion. Park does not have good baseline data.
- Whale-watching tours from neighboring areas harass wildlife.

Issues to consider in building your scenarios

- Assume air temperature is going up significantly
- Assume some level of sea level rise impact
- uncertainty related to precipitation – affects facilities and ecosystems
- El Nino may present an analog for the region - decreased upwelling, warmer winters, and warmer summers.
- Consider the influence of the following (but keep in mind this is not an exhaustive list)
    - Drought
    - Winds -> currents
    - Ocean temperature
    - Cold vs warm water species (fisheries, predators, etc)
    - Flash flooding impacts to facilities and infrastructure

DAY 2 GROUP WORK

INSTRUCTIONS for FACILITATORS AND RAPPORTEURS
SCENARIO ASSESSMENT AND ADAPTATION BREAKOUTS I AND II

There will be two sessions, I and II. Each session will work through 3 identical activities, but using a different scenario: Activity 1: PERSONALIZE THE SCENARIO, Activity 2: MANAGEMENT OBJECTIVES and Activity 3: ADAPTATION OPTIONS. Each group should have no more than 15 participants, one facilitator and one rapporteur. ***The group session should start with the facilitator presenting the details of the session scenario, using the powerpoint prepared by UA (10 minutes).*** *All participants should have a copy of the set of scenario descriptions. The Race to Refuge scenario will be completed by all 4 groups during Breakout II; each group will also* ***complete one other scenario during BREAKOUT I. Facilitators: L. Welling, S. Gray, J. Mow, H. Hartmann***

Activity 1: PERSONALIZE THE SCENARIOS (15min)

Participants must "write themselves into" the given scenario. Encourage them to take 5 minutes to quietly jot down what that scenario would mean for their organization's management in 2100 and in 2050. The last 10 minutes are to go around and let participants highlight a few of the key challenges and opportunities they thought about.

Activity 2: MANAGEMENT OBJECTIVES (15min)

Remember the focus question: *How do CoC management objectives need to change*? First, brainstorm and discuss: What new and/or common management objectives will need to be in place to manage CoC effectively under the given scenario in 2050? Then, do the same for 2020. Think beyond what your objectives are today. Tease out the highlights or trends. Each new management objective will be written on separate sticky note cards (these will be used for the next activity).

Activity 3: ADAPTATION OPTIONS (30min)

Each group will have 3 tack boards. The first, titled "Set A", will have cards on them that represent options that **build adaptive capacity (BAC)**. These options are in CAPS and typically leave space for added personalization (i.e., a specific description of how participants' agencies would conduct a given BAC). The second board, "Set B", shows cards that are examples of **delivering adaptation actions (DAA).** These options are in grey type. The third board, entitled "New Set", is empty at the start of the exercise: it will get filled up as you carry out Activity 3.

At the top of this "New Set" board, you should first post the new management objectives listed on sticky cards (from Activity 2). **Put the 2020 management objectives on the FAR LEFT and the 2050 management objectives on the FAR RIGHT, at the TOP of the board.** Next, ask participants to remove cards from Sets A and B, fill them in with specific details when appropriate, and post them on the "New Set" board, organized by management objectives, based on importance to them and their agencies. The goal is not to use all the cards, but initiate thinking. Remind them that both types of activities are important: you may need to build adaptive capacity before undertaking adaptation actions, but building adaptive capacity alone does not mean that you've adapted. Also, tell them to bear in mind the following two questions as they do this: *"Which objectives have long-term consequences?"* and *"Which objectives need to be in place in 2050 but require long prep times?* Finally, we recognize that neither of these lists of actions are exhaustive. All groups will have an ample supply of sticky notes for participants to list new BACs or DAAs that they feel should be added to the "New Set" board.

Rapporteur Form

Activity 1, nothing to record

Activity 2: **Management Objectives**

Record MAIN NEW mgmt objectives resulting from the discussion

	Session I: Race to Refuge	**Session II: Scenario _____**
2050	• • •	• • •
2020	• • • •	• • • •

Activity 3: **Adaptation Options:**

What options, **BAC or DAA,** are given most importance, and when?

What options are common across **BOTH** scenarios studied?

How do the options change across time?

Policy Screening—Breakout Groups

The morning's four working groups will be combined into two working groups for this exercise. Each group will have the following "New Sets" of adaptation options to work with: one set for "Colorado Creeping North", one set for "Climate Complacency", and 2 sets for "Race to Refuge."

The first purpose of the exercise is to practice sorting adaptation activities into those that work for all three scenarios , those that work for only two out of three scenarios, and that work for only one scenario of the three. Once this is done, a "decision tree" can be constructed that will help managers choose appropriate adaptation activities over time, as it becomes more evident which scenario is in fact becoming more likely. Once the decision tree is constructed, managers can begin to determine how they will decide that it's time to implement new adaptation strategies.

Part 1
Given the time constraints for this exercise, each group will be asked to identify:

- at least one adaptation activity works for all three scenarios;
- at least one that works for any two out of the three scenarios;
- at least one adaptation strategy that is suitable for only one scenario.

Part 2
Next, they will arrange these activities into the form of a decision tree. This will allow them to identify at least two "decision nodes"—that is, points at which they would have to make a decision to switch to a more narrowly applicable adaptation option. This will allow a discussion about:

- Can the order of adaptation options increase the ability to accommodate the different scenarios?
- How will a manager know they are at the decision node? What indicators are required? Would the indicators be different for an option requiring a long lead-time to implement vs. one with a short time to implementation? What information would be required to make the choice between one option or the other, when you are at the point of making the choice about which path to satisfy?
- Do any any policies need to change to accommodate any of the adaptation options, their ordering, or choosing a pathway in the future?
- How can the results of this screening connect with other planning processes?

Attachment 9: Workshop Participants

Crown of the Continent Climate Change Scenario Planning (C4-SP) Workshop

9-10 March 2010, Whitefish, Montana

62 people

C4-SP Workshop Participant List

In alphabetical order, by name of agency

FIRST &	LAST NAME	AGENCY	TITLE
Bob	Manteaw	Alberta Environment	
Bill	Dolan	Alberta Tourism Parks and Recreation	Land & Resource Management Coordinator
Rob	Hugill	Alberta Tourism Parks and Recreation	Area Manager
Thedis	Crowe	BIA Blackfeet Agency	Acting Deputy Superintendent
Gayle	Skunkcap	Blackfeet Tribe	
Elliott	Fox	Blood Tribe	Director, Lands Program
Clint	Folden	Confederated Salish, Pend d'Oreille and Kootenai Tribes of the Flathead Nation	Wetlands Conservation Coordinator/Fisheries Biologist
Mike	Durglo	Confederated Salish-Kootenai Tribe	
Caryn	Miske	Flathead Basin Commission	Executive Director
Jeff	Harris	Flathead County Commissioner	
Cathy	Barbouletos	Flathead National Forest	
Jimmy	DeHerrera	Flathead National Forest	District Ranger
Virginia	Kelly	Greater Yellowstone Coordinating Committee	
Peter	Holmes	Ministry of Environment	Ecosystem Biologist
Steve	Frye	Montana Department of Natural Resources and Conservation	
Chris	Hammond	Montana Fish, Wildlife and Parks	Wildlife Biologist
Jim	Williams	Montana Fish, Wildlife and Parks	
Shawn	Carter	National Park Service	Climate Change Liaison and Monitoring Coordinator
Dennis	Divoky	National Park Service	Fire Ecologist
Matt	Rose	National Park Service	Environmental Specialist
Don	Weeks	National Park Service	Hydrologist
Melanie	Graham	NPS Climate Change Response Program	Assistant
Leigh	Welling	NPS Climate Change Response Program	Climate Change Coordinator
Tara	Carolin	NPS Crown of the Continent Research Learning Center	Director
Chas	Cartwright	NPS Glacier National Park	Superintendent
Chris	Downs	NPS Glacier National Park	Fisheries Biologist
Stephanie	Dubois	NPS Glacier National Park	Deputy Superintendent
Jim	Foster	NPS Glacier National Park	Chief of Facilities Management
Bill	Hayden	NPS Glacier National Park	Interpretive Specialist
Lon	Johnson	NPS Glacier National Park	Cultural Resource Specialist
Dawn	LaFleur	NPS Glacier National Park	Supervisory Biologist
Joyce	Lapp	NPS Glacier National Park	Restoration Ecologist
Jack	Potter	NPS Glacier National Park	Chief, Division of Science and Resources
Mary	Riddle	NPS Glacier National Park	Planning, Environmental Protection and Compliance Specialist
John	Waller	NPS Glacier National Park	Wildlife Biologist
Tom	Olliff	NPS Greater Yellowstone Area	I&M Coordinator

Con't.

FIRST &	LAST NAME	AGENCY	TITLE
Jeff	Mow	NPS Kenai Fjords National Park	Superintendent
Cat	Hawkins Hoffman	NPS Olympic National Park	Chief, Natural Resources
Kathy	Tonnessen	NPS Rocky Mountain CESU	Research Coordinator
Pei-Lin	Yu	NPS Rocky Mountain CESU	Cultural Resource Specialist
Michael	Britten	NPS Rocky Mountain I&M Network	Program Manager
John	Kimball	UMT Flathead Lake Biological Station	Research Associate Professor
Holly	Hartmann	University of Arizona	Director, Arid Lands Information Center
Katherine	Waser	University of Arizona	Editor
Lezlie	Morinière	University of Arizona	Research Assistant, PhD Candidate
Steve	Running	University of Montana	Professor of Forestry
Erin	Sexton	University of Montana	Research Scientist
Sally	Thompson	University of Montana	Director, Regional Learning Project
Stephen T.	Gray	University of Wyoming	Wyoming State Climatologist
Yvette	Converse	US Fish and Wildlife Service	Interim Coordinator Great Northern LCC
Jim	Morrison	US Forest Service	Air Safety Investigator
Daniel	Fagre	US Geological Society	Ecologist
Roy	Doore	USDA Blackfeet Conservation District	
Kim	Keating	USGS Northern Rocky Mountain Science Center	Research Wildlife Biologist
Kate	Kendall	USGS Northern Rocky Mountain Science Center	Research Biologist
Clint	Muhlfeld	USGS Northern Rocky Mountain Science Center	Fisheries Biologist
Barb	Johnston	Waterton Lakes National Park	
Dennis	Madsen	Waterton Lakes National Park	Resource Conservation Manager
Dave	McDonough	Waterton Lakes National Park	
Randall	Schwanke	Waterton Lakes National Park	Resource Conservation Specialist

Workshop 10: Workshop Notebook Selected Materials

- Workshop Notebook Table of Contents
- Project Website Welcome Page
- Definitions and Acronyms
- Webinars and Resources
- Key Figures
    - VUCA and Peterson (2003)
    - Scenario Planning and Comparison with 1-Dimensional Planning
    - IPCC Scenario Descriptions and Emissions Status
- Adaptation Options Sheet

Crown of the Continent Climate Change Scenario Planning (C4-SP) Workshop

9-10 March 2010, Whitefish, Montana

Workshop Objectives

- To explore, assess and respond to alternative futures for the Crown of the Continent ecosystem, cultural resources and facilities, which managers can use to help inform decisions in light of potential climate change and impacts
- To apply scenario planning in the Crown of the Continent ecosystem as a tool to facilitate partners' management of the region
- To assess how the scenario planning process might best be packaged and replicated for the NPS and others

*Packet Contents

This packet contains the following elements: (= items contained in this Attachment for the Project Final Report, Other material available in other Attachments.)*

Part A: Workshop

- C4-SP Workshop Agenda
- C4-SP Workshop Participant List

Part B: Regional Maps (4):

1. Map 1: CoC Ecosystem
2. Map 2: CoC Jurisdiction
3. Map 3: CoC Partners & CMP
4. Map 4: Waterton/Glacier Peace Park

Part C: Scenario Planning Process:

- *Basecamp website, welcome page
- *Definitions & Acronyms
- *Description of webinars series with objectives and supporting materials
- Figure Series :
    a. *VUCA and Peterson et al. 03
    b. *Scenario Planning and Comparison with 1-Dimensional Planning
    c. High Level Framework and Climate Drivers
    d. Climate Axes (full page)
    e. Nested Hierarchies (full page)
    f. Connections (NPS): Landscape (full page)
    g. Connections (NPS): Alpine, Streams
    h. Connections (NPS): Wetland and Pei-Lin Yu Cartoon
- Table Series : (*description of tables)
    a. Distributed Drivers Table
    b. Impacts Table: From Webinar and Literature
    c. Adaptation Database
- CoC Scenarios
- Peterson et al 2003 Article on Scenario Planning

Part D : Misc.

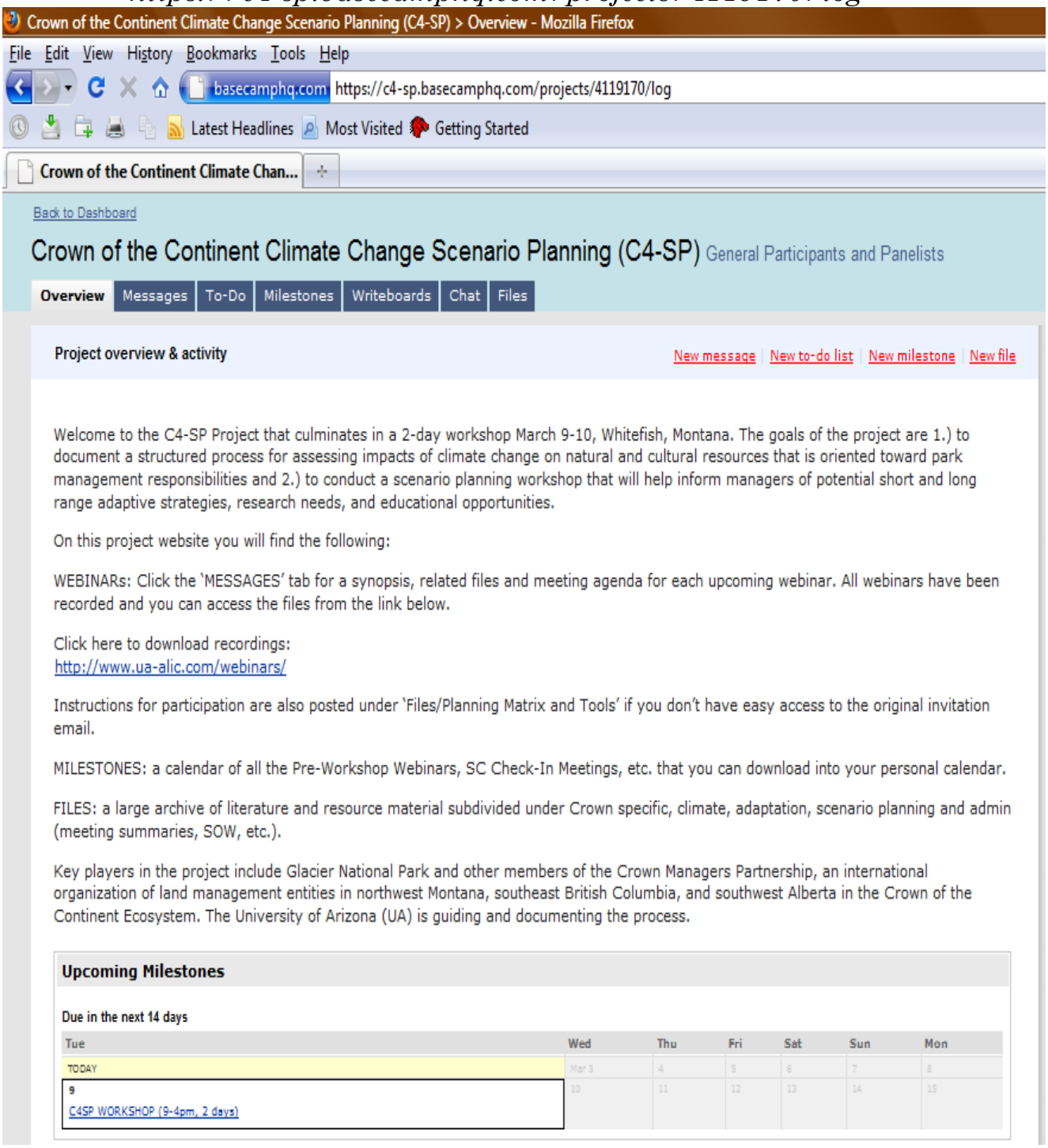
- Climate inspiration, Excerpts from CC Guidebook (Snover et al., 2007), Chapter 3
- Blank pages for note-taking

Crown of the Continent Climate Change Scenario Planning (C4-SP) Workshop

9-10 March 2010, Whitefish, Montana

Scenario Planning Process Materials: **Base-Camp Web Site, Welcome Page**

https://c4-sp.basecamphq.com/projects/4119170/log



Crown of the Continent Climate Change Scenario Planning (C4-SP) Workshop

9-10 March 2010, Whitefish, Montana

Scenario Planning: **Key Definitions & Acronyms**

In alphabetical order

- **Adaptation and Mitigation: Adaptation** involves initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects. Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, *moderates harm or exploits beneficial opportunities*.
  - **Anticipatory** (or proactive) adaptation –takes place before impacts of climate change are observed.
  - **Autonomou**s (or spontaneous) adaptation – does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems.
  - **Planned** adaptation – the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

  Mitigation describes all human interventions that *reduce the sources or enhance the sinks* of greenhouse gases. (IPCC, AR4)

- **Adaptive Management:** a systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices (Millennium Ecosystem Assessment). Adaptive management is encouraged to deal with the complex and dynamic nature of ecosystems and the absence of complete knowledge or understanding of their functioning. (IPCC, AR4)

- **Decision Analysis:** Decision Analysis (DA) is a way to structure and analyze decision problems under uncertainty in a systematic and rational manner. Using probabilities (either objective or subjective) and utility functions, DA is a process that enables the decision-maker to select a single option from a set of alternatives. In this sense, DA is a form of optimization. Because DA is a probability-based approach, it can be severely limited under conditions of high uncertainty. Common tools deployed in DA include decision trees, influence diagrams and utility functions. In Structured Decision Analysis, multiple management objectives are considered simultaneously. (Morino, 2010)

- **Forcing and feedback:** A(n external) forcing refers to a forcing agent *outside* the climate system causing a change *in* the climate system. Volcanic eruptions, solar variations, and anthropogenic changes in the composition of the atmosphere and land use change are external forcings. An interaction mechanism between processes is called a **feedback**. When the result of an initial process triggers changes in a second process and that in turn influences the initial one. A *positive* feedback intensifies the original process, and a *negative* feedback reduces it. (IPCC, AR4 – WGI)

- **Global Climate Models and Downscaling:** A numerical representation of the climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes, and accounting for all or some of its known properties. Coupled Atmosphere-Ocean General Circulation Models (AOGCMs) provide a representation of the climate system that is near the most comprehensive end of the spectrum currently available (IPCC, AR4). **Downscaling** is a method that derives local- to- regional-scale (10 to 100 km) information from larger-scale models or data analyses. **Dynamical** downscaling uses the output of regional climate models, global models with variable spatial resolution or high-resolution global models) and **empirical/statistical** downscaling develops statistical relationships that link the large-scale atmospheric variables with local/regional climate variables). (IPCC, AR4)

- **Impact assessment:** The practice of identifying and evaluating, in monetary and/or non-monetary terms, the effects of climate change on natural and human systems. (IPCC, AR4)

- **Integrated Assessment:** An interdisciplinary process of combining, interpreting and communicating knowledge from diverse scientific disciplines so that all relevant aspects of a complex societal issue can be evaluated and considered for the benefit of decision-making. (IPCC, AR4)

- **Resilience:** The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change. (IPCC, AR4)

- **Robust Decision Making:** an approach to decision making under highly uncertain circumstances ('deep uncertainty') when there is a rich and complex set of decision options. It utilizes existing models to generate a large and systematically varied range of plausible futures. It then utilizes various tools to identify robust management strategies, characterize the vulnerabilities of such strategies, and evaluate their trade-offs. RDM is similar to scenario planning in that it explores multiple plausible futures but is different in that many more futures are considered and there is a higher degree of quantitative analysis. However, RDM is limited by the scope of the models used. Management options are evaluated according to their robustness and vulnerabilities across the range of plausible futures (Morino, 2010).

- **Scenario Planning:** development of plausible futures using creative thinking. Plausible futures can be generated based on extrapolation (exploratory scenarios); envisioning conditions to be achieved or avoided (anticipatory scenarios); or attempting to integrate different models used to describe complex systems (strategic scenarios). In some approaches, a small number of scenarios are developed and organized to qualitatively illustrate extremes along axes identified as important by the scenario planners, eg.,having high impact and low predictability. Scenarios are often represented as narratives (Morino, 2010).

- **Sensitivity Analysis:** examines of how specific outputs of a mathematical model vary when target input quantities are systematically varied (Morino, 2010).

- **Vulnerability Assessment:** Vulnerability assessment is an evaluation of system resources that focuses on relative impacts. For the same forcing, resources that are more negatively impacted are thought to be more vulnerable (Morino, 2010). In disaster risk science, vulnerability refers to the fragility of an element that, when combined with a hazard (i.e., extreme event or disturbance) heightens risk; vulnerability assessment is the study of the fragility / resilience of human or ecological systems that are exposed to external drivers of change (Morinière, 2009).

Acronyms

C4-SP Crown of the Continent Climate Change Scenario Planning

BC	British Columbia	GNP(F)	Glacier National Park (Fund)
CCE	Crown of the Continent Ecosystem	GSR	Going to the Sun Route
CMP	Crown Managers Partnership	IPCC	Intergov. Panel for Climate Change
CoC	Crown of the Continent	NF	National Forest
DNR	Dept Natural Resources	NPS	National Park Service
ELA	Equilibrium Line Altitudes	PDO	Pacific Decadal Oscillation
ENSO	El Niño-Southern Oscillation	SWE	Snow Water Equivalent
GCM	Global Climate Models	USDA	US Department of Agriculture
GMP	General Management Plan	VUCA	Volatility, Uncertainty, Complexity, Ambiguity

Crown of the Continent Climate Change Scenario Planning (C4-SP) Workshop

9-10 March 2010, Whitefish, Montana

Scenario Planning Process: **List of Webinars and Supporting Materials**

Note: all of the "review" and "supplementary materials" listed below are available at https://c4-sp.basecamphq.com/projects/4119170/log, unless otherwise specified

#	Name	Objective	Preparation
1	**Scenario Planning Process and Focus / Main Drivers**	*a.) To set the stage for "Scenario Planning" as a decision making tool, b.) to confirm focal question and c.) to explore exogenous drivers of change*	***Review*** *A.Peterson et al., 2003: "Scenario Planning: A Tool for Conservation in an Uncertain World".* ***Think about the following questions:*** *• What are your concerns about the future of the Crown of the Continent region?* *• What external factors (climatic and non-climatic) affect management within the Crown of the Continent region* *• Which of these external factors have both high impact and high uncertainty?* ***Prepare a list*** *(short or long):* *• Please list the management, policy, or decision approaches you use within your organization. These may be reports, processes, tools, or methods, e.g., general management plans, 10-year plans, vulnerability analysis, sensitivity studies, etc.*
2	**State of the Art: Future Change in the Crown of the Continent**	*To explore future changes outside the predictability and control of the CoC and Crown Management Partners (CMPs)*	***Review two documents:*** *• 2 slides from the scenario planning presentation of Webinar1* *• Schiermeier, 2010. The real holes in climate science. Nature 423: 284-287* ***Think about the following questions:*** *• What surprises have there been in the Crown of the Continent region over the past 100-200 years? For the Crown Management Partner organizations (50-100 years)? For you in your career (5-25 years)?* *• What are your concerns about the future of the Crown of the Continent region? It might help to think about your concerns over the next 1-2 years, 10 years, 25 years, 50 years, 100 years.* *• What external factors (climatic and non-climatic) affect the Crown of the Continent region? Which external factors affect the Crown Management Partner organizations? Which of these external factors have both high impact and high uncertainty?*
3	**Natural resources: Terrestrial Impacts**	*To explore sensitivities, vulnerabilities, and resiliency of terrestrial systems within CoC and their relationships to climatic and non-climate stressors.*	***Review 3 key documents*** *:* *1. Chapter 4 from "Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments" by the Climate Impacts Group (CIG) at the University of Washington. See especially the 12 pages in Ch. 4. Download it directly from CIG at: http://cses.washington.edu/cig/fpt/planning/guidebook/gateway.php* *2. The recent report "Impacts of Climate Change on Forests of the Northern Rocky Mountains" by Dr. Steve Running, University of Montana. Download it from URL: http://www.bipartisanpolicy.org/library/research/impacts-climate-change-forests-northern-rocky-mountains* *3. Sections 1 and 4 of Pederson et al. (2010) "A century of climate and ecosystem change in western Montana: what do temperature trends portend?"* ***Think about the following questions:*** *• What is different about climate change stresses compared to other stresses that CoC has faced in the past, now, and in the future?* *• Are there gaps in understanding that preclude any discussion about potential impacts? Or that could make any discussion today seem pointless over the next few months or years?* *• What changes to the drivers and impacts tables make sense for the CoC?*
4	**Natural resources: Aquatic Impacts**	*To explore sensitivities, vulnerabilities, and resiliency of aquatic systems within CoC and their relationships to climatic and non-climate stressors.*	***Review 3 key documents:*** *1. Chapter 4 from "Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments" by the Climate Impacts Group (CIG) at the University of Washington. See especially the 12 pages in Ch. 4; download from: http://cses.washington.edu/cig/fpt/planning/guidebook/gateway.php* *2. Milly et al (2008) "Stationarity is dead: whither water management?"* *3. "Aquatic ecosystems and global climate change" from the Pew Foundation. The relevant sections for this webinar: Section IIIA-C (pp. 7-23) and Section V (pp. 34-35). This is an older report that will lead us to questions about what level of information is "actionable".* *4. Panelist Clint Muhlfeld: Hamlet2001, Muhlfeld 'Fine Scale' and Williams et al 2009.* ***Think about the following questions:*** *• For aquatic systems, what is different about climate change stresses compared to other stresses that CoC has faced in the past, now, and in the future?* *• For aquatic systems, are there gaps in understanding that preclude any discussion about potential impacts? Or that could make any discussion today seem pointless over the next few months or years?* *• For aquatic systems, what changes to the drivers and impacts tables make sense for the CoC?*
5	**Impacts on Cultural resources**	*To explore sensitivities, vulnerabilities, and resiliency of cultural resources and systems within CoC and their relationships to climatic and non-climate stressors.*	***Think about the following questions:*** *• For cultural systems and resources, what is different about climate change stresses compared to other stresses that CoC has faced in the past, now, and in the future?* *• For cultural systems and resources, are there gaps in understanding that preclude any discussion about potential impacts? Or that could make any discussion today seem pointless over the next few months or years?* *• For cultural systems and resources, what changes to the drivers and impacts tables make sense for the CoC?* *• Identify topics in cultural resources that you would find most immediately useful in the context of scenario planning (with regard to both research and stewardship).* ***Supplementary material:*** *1. The Mystic Lake Declaration, a declaration of an international consortium of indigenous peoples on the issue of climate change (attached and posted at the C4-SP website).* *2. A National Geographic Television video that touches on the issues of melting ice patches as a cultural impact of climate change. URL: http://channel.nationalgeographic.com/series/naked-science/4233/Overview#tab-Overview.*

#	Name	Objective	Preparation
6 (7=small group)	**Impacts on Facilities and Services**	*To explore sensitivities, vulnerabilities, and resiliency of facilities and services within CoC and their relationships to climatic and non-climate stressors.*	***Review two key documents:*** *1. Milly et al (2008) "Stationarity is dead: whither water management?"* *2. Hamlet and Lettenmaier (2007) "Effects of 20th century warming and climate variability on flood risk in the western US." If you don't want to read the entire article, please focus on the Introduction and Conclusions.* ***Think about the following questions:*** *• For facilities and services of the Crown Management Partners (CMPs), what is different about climate change stresses compared to other stresses that CoC has faced in the past, now, and in the future?* *• For facilities and services of CMPs and the CoC, are there gaps in understanding that preclude any discussion about potential impacts? Or that could make any discussion today seem pointless over the next few months or years?* *• For facilities and services of CMPs, what changes to the drivers and impacts tables make sense for the CoC?* ***Supplementary material*** *Detailed reports on the impacts of climate change in parts of the Pacific Northwest, produced by the University of Washington. The reports deal with water, stormwater, and energy supply and demand. http://cses.washington.edu/cig/res/ia/waccia.shtml.*
8	**Feedbacks, tipping points and cascades**	*To explore and identify key feedbacks, thresholds, and cascading effects important for the Crown of the Continent region over this century, related to climate and non-climate forces.*	***Review two sections of CCSP SAP 4.2: Thresholds of Climate Change in Ecosystems:*** *1. Section 2.4: Ecological Thresholds Defined (pp.24-25)* *2. Section 4.3: Temperature Increases Are Pushing Ecosystems Towards Thresholds (pp.76-86)* ***Think about the following questions:*** *• What are the key feedbacks within the CoC region that may amplify impacts of external change from climate or non-climate forces?* *• What are thresholds or tipping points that may irrevocably change the character of conditions within the CoC region if they are crossed? If a threshold is crossed, would the effects cascade across the region and sectors (e.g., terrestrial systems, aquatic systems, cultural resources, facilities, services)? How?*
9	**Building Scenarios**	*Based on discussions in prior webinars, choose basic elements of the scenarios to be developed for the workshop.*	***Review two key documents:*** *Ogilvy, J. and P. Schwartz, 1998. Plotting your scenarios. Global Business Network.* *Slides 13-16 from Hartmann's presentation in Webinar #1* ***Consider the following possibilities:*** *• Focal question : o How do our management objectives need to change over the next 50 years? o How will our organization need to manage?* *• What are the TWO most important and most uncertain climate forces for the CoC region ? Possibilities:* *o water balance; o shifted seasonality; o rate of change; o changes in extreme events; o drought; o others?* *• What are the major elements of the theme "Nature of Leadership" (please refer to slides 13-16 of Hartmann's presentations in webinar 1 for a description of this theme): o budget levels; o flexible vs. entrenched policies; o degree of accountability; o level of coordination among agencies; o political-level support; o long-term vs. short-term outlook; o others?* *• Major elements of the theme "Level of Societal Concern" (please refer to slides 13-16 of Hartmann's presentations in webinar 1 for a description of this theme)o regional population shifts; o demands posed by other issues (economics, energy, crisis elsewhere, health); o degree that people are affected by or concerned about CoC region and conditions; o perception of role of federal/public lands; o sense of ability to make a difference; o social and environmental movements; o others?* *• In getting from 2010 to 2100, what are the implications of emerging trends that are likely to have large impacts over the next decade? o Emerging trends: diasporas and emerging economies, commons and collaboration, food and water disruptions, integration of technology with human and environmental systems, intensifying rich/poor divide (from Johansen, 2009. Leaders Make the Future and the Institute for the Future)* *• How might the following "Plot Lines" work for the CoC region?* *o Winners and losers, Crisis/response, Good news/Bad news, Evolutionary change vs. Revolution/Tectonic change vs. Perpetual chance, Wild cards, others?*
10	**Adaptation Options**	*To explore options for climate change adaptation within the CoC region. The session agenda for Webinar #10 can be found at the end of this message.*	***Review 2 key documents*** *1. Baron et al., 2009. Options for National Parks and Reserves for adapting to climate change. Environmental Management 44:1033-1042.* *2. Joyce et al., 2009. Managing for multiple resources under climate change: National Forests. Environmental Management 44: 1022-1032.* ***Think about the following questions:*** *• What resources describing adaptation options have you found particularly useful?* *• In the last several years, the number of adaptation options mentioned in the literature, workshops, and meetings has expanded tremendously, posing challenges for managers in simply organizing adaptation option information. One product of this C4-SP project is a database of adaptation options, as part of a broader scenario planning toolkit. Do you have any suggestions for what would make an adaptation options database most useful for managers?* *• From a manager's perspective, how much certainty is required to move from 'considering' an option to actually implementing it?* *• How might adaptation options differ under different management objectives?* ***Supplementary material:*** *1. Craig, R., 2009. "Stationarity is dead" – long live transformation: five principles for climate change adaptation law. Harvard Environmental Law Review 34:1, 2010. This is a long article (57 pages), but it contains a good organization of legal principles to support climate change adaptation by resource managers.* *2. Brekke et al., 2009. Climate Change and Water Resources Management: A Federal Perspective. USGS Circular 1331. This is fairly long, too, but it captures adaptation principles and options related to water resources and facilities.*
11	**Policy screening**	*To explore how to consider adaptation options within a scenario planning framework, and their relevance to CoC managers.*	***Review 2 key documents*** *1. Chapter 6 of Tucson, Arizona's "Water Plan: 2000-2050": The Planning Process.* *2. Section 6 of the 2008 Update to Water Plan: 2000-2050. In particular, look at Figure 6.4 (Demand-Resource Scenario Summary).* ***Think about the following questions:*** *• How can you apply the results of a scenario assessment and development of adaptation options?* *• What 'end product' of scenario planning is most useful for different CoC planning processes?* *• From a manager's perspective, how much certainty is required to move from 'considering' a set of options to actually implementing it?*

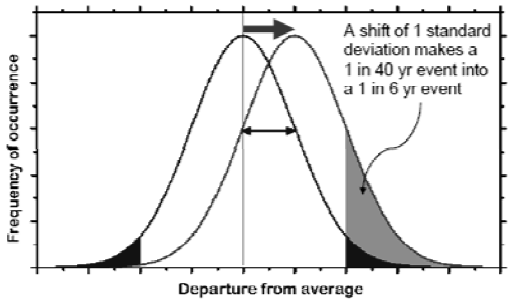
VUCA is the "New Normal"

Volatility

Uncertainty

Complexity

Ambiguity



IPCC WG1

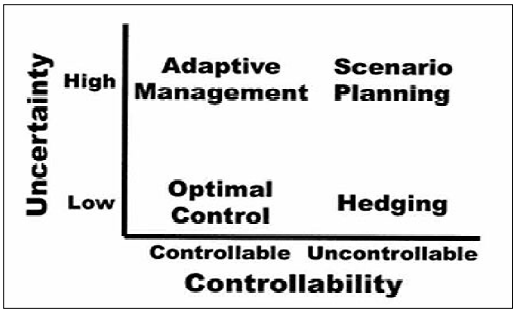
- **VUCA is not 'new'**
  - but scale and intensity are increasing
- **Dilemmas:**
  - problems that cannot be solved & will not go away
- **Policy/management dilemma:**
  - committing too soon vs. deciding too late

Institute for the Future: multiple publications over 40+ years

SCENARIO PLANNING

Scenarios Are:
A tool for long-term strategic planning
Compelling narratives of alternative environments in which decisions may be played out
Coherent, internally consistent, and plausible

Scenarios Are Not:
Predictions or Forecasts
A method for arriving at the "most likely" future

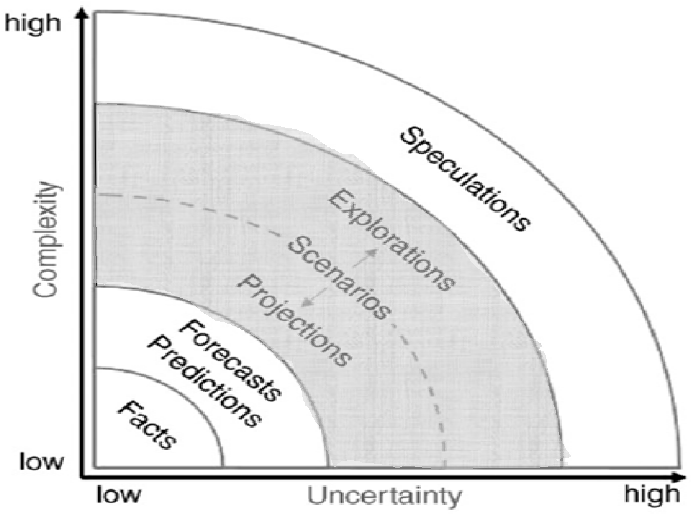


Peterson et al., 2003

Goal:

- **Challenge thinking about the future;**
- **Foster strategic thinking about responses to different possibilities;**
- **Catalyze system-wide thinking about interconnectedness**

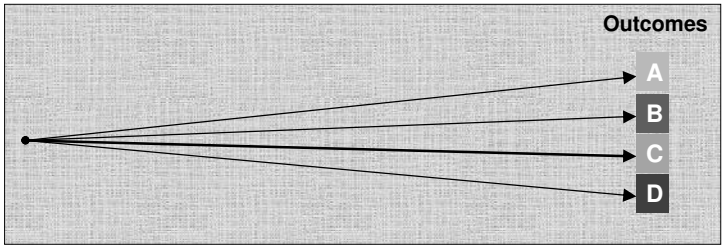
Scenarios: More than Projections



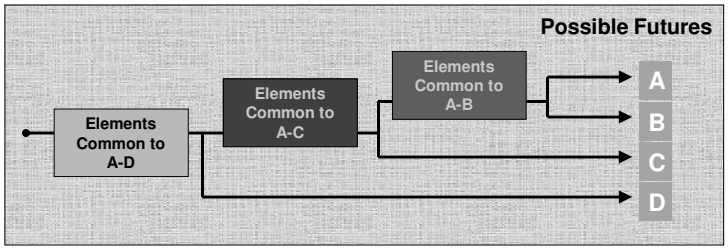
Zurek and Henrichs, 2007

One-Dimensional Planning vs. Robust Planning

1-Dimensional Planning



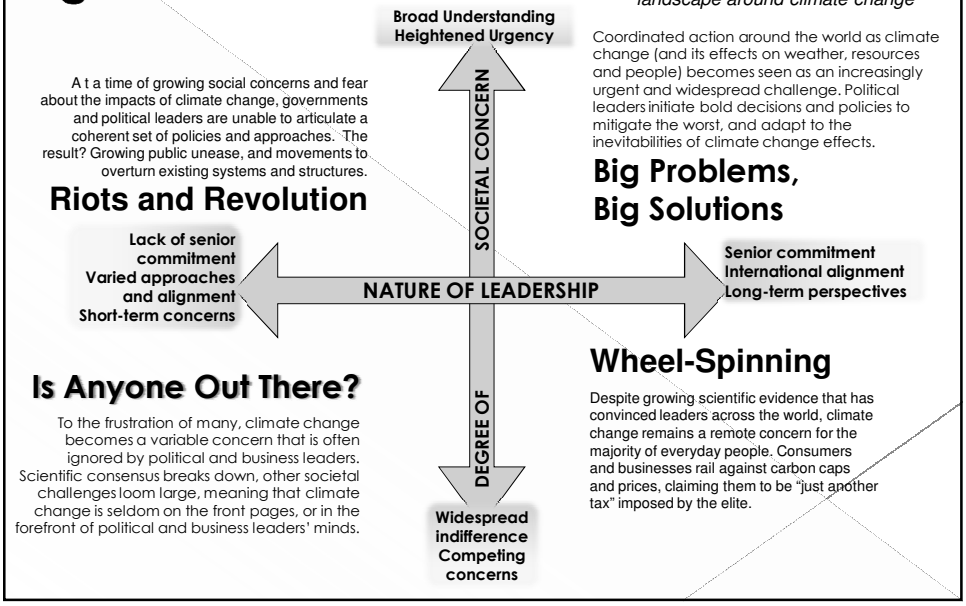
Scenario Planning



Good example: City of Tucson Water Plan: 2000-2050 Updated Version

Explaining Scenarios: High-Level Framework

*Cross the critical uncertainties together to form a high-level matrix. This creates 4 different pictures for the future **social and political** landscape around climate change*



A t a time of growing social concerns and fear about the impacts of climate change, governments and political leaders are unable to articulate a coherent set of policies and approaches. The result? Growing public unease, and movements to overturn existing systems and structures.

Riots and Revolution

Coordinated action around the world as climate change (and its effects on weather, resources and people) becomes seen as an increasingly urgent and widespread challenge. Political leaders initiate bold decisions and policies to mitigate the worst, and adapt to the inevitabilities of climate change effects.

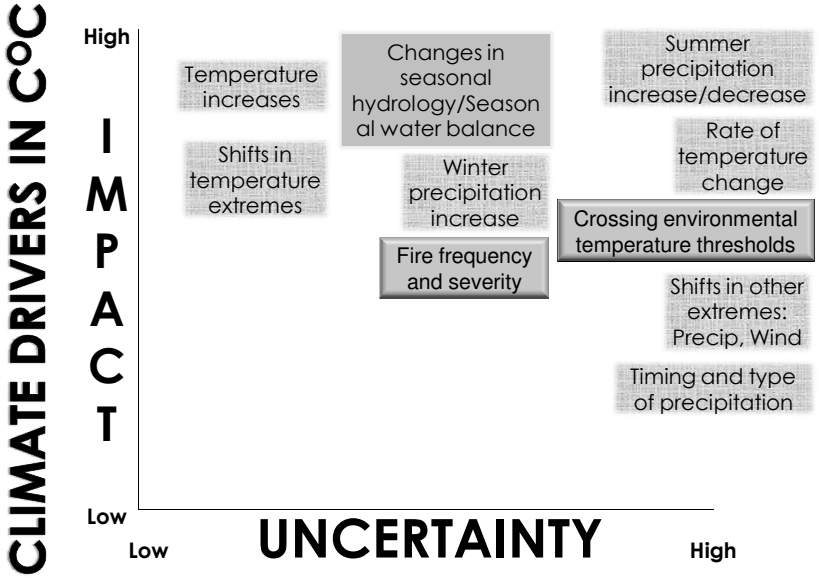
Big Problems, Big Solutions

Is Anyone Out There?

To the frustration of many, climate change becomes a variable concern that is often ignored by political and business leaders. Scientific consensus breaks down, other societal challenges loom large, meaning that climate change is seldom on the front pages, or in the forefront of political and business leaders' minds.

Wheel-Spinning

Despite growing scientific evidence that has convinced leaders across the world, climate change remains a remote concern for the majority of everyday people. Consumers and businesses rail against carbon caps and prices, claiming them to be "just another tax" imposed by the elite.



IPCC Emissions Scenarios

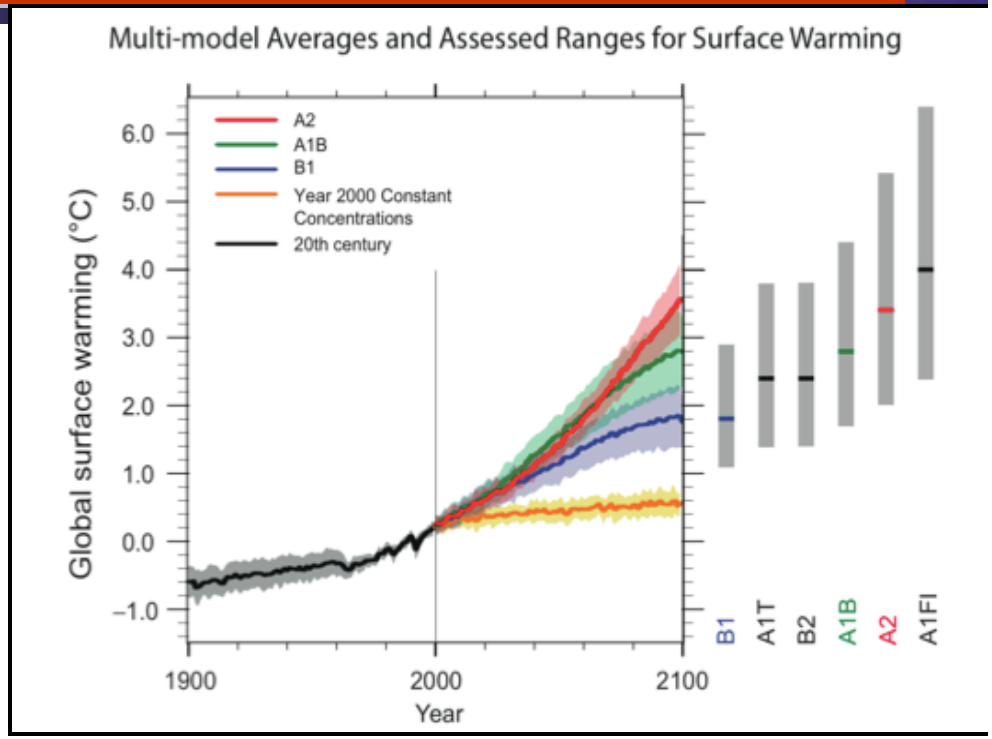
A1: Rapid economic growth, population 9B in 2050 then decline, quick spread of efficient technologies, convergent world

A1F: fossil fuels
A1B: mix of fuels
A1T: non-fossil fuels

A2: more divided/diverse world, continual population increases, regional economic development, slower and fragmented technological and economic gains

B1: Same as A1, but change toward service and information economies, reductions in material intensity

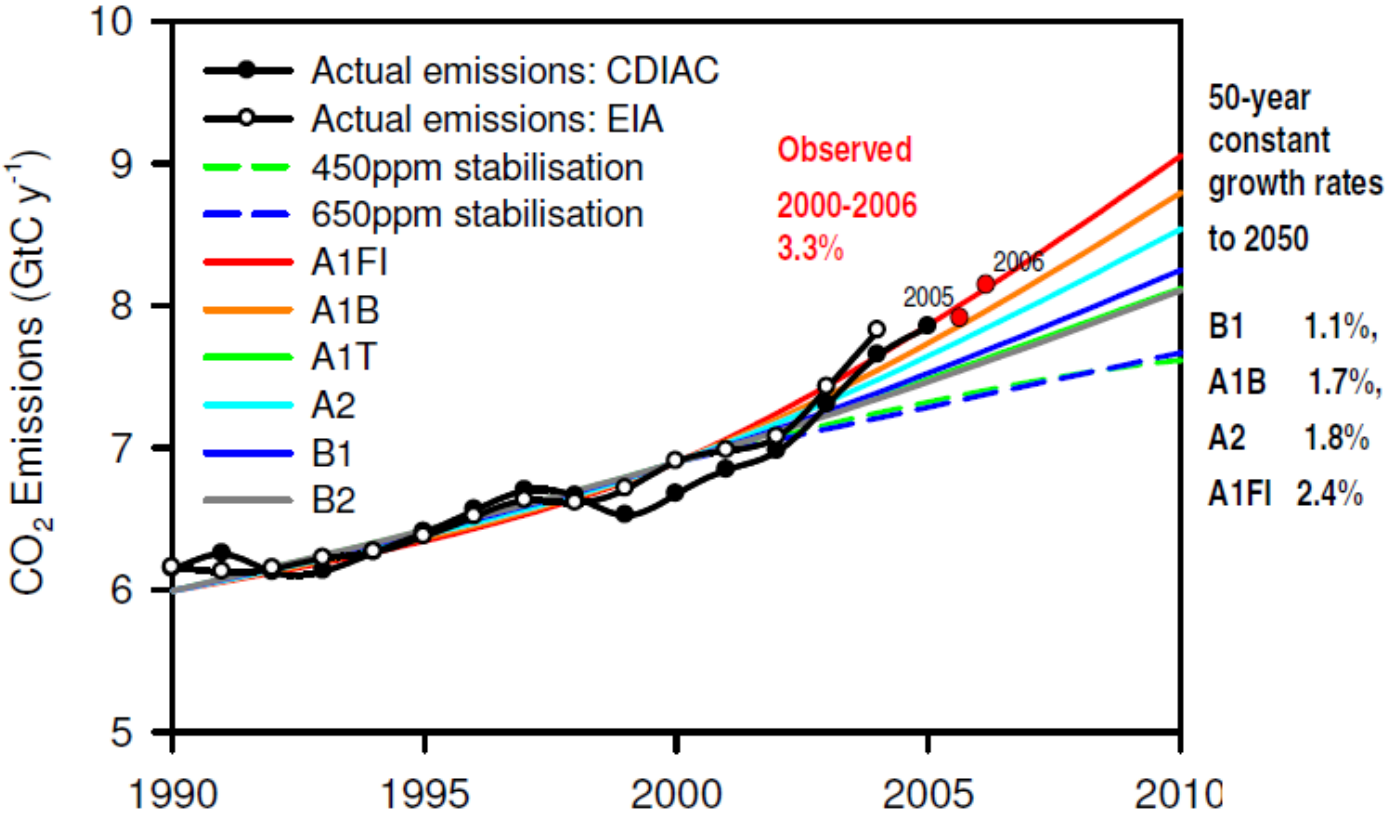
B2: More divided world but ecologically friendly, slower population growth than A2, intermediate economic development, less rapid technological change, more fragmented change at more local level



IPCC Fourth Assessment Report May 2007

Moving Beyond IPCC 4 Scenarios

Trajectory of Global Fossil Fuel Emissions



Raupach et al. 2007, PNAS

Liverman et al., 2009: planning should consider 4 deg C rise by 2060

Crown of the Continent Climate Change Scenario Planning (C4-SP) Workshop

9-10 March 2010, Whitefish, Montana

Scenario Planning Process Materials: **Table Series**

The following tables are works in progress, to be improved during the workshop

- **Distributed Driver Table**
  This table, compiled by the University of Arizona team, combines Steve Gray's climate drivers table with ecosystem impacts discussed during C4SP Webinars or defended within academic literature. It suggests how driving forces external to the Crown of the Continent Ecosystem may manifest themselves at global, regional and local scales and through time: present, 2020, 2050 and 2100.

- **Impacts Table**
  This table was compiled by the University of Arizona team by studying the webinar series and available scholarly literature. Columns showing impacts inside the Crown of the Continent Ecosystem are organized by Sector and Subsector and by source (webinar or literature).

- **Adaptation Database**
  The Adaptation Database is meant to be a starting point for the discussions on *what to do* with scenario planning results. The list of adaptation options include those that have already been implemented by other agencies, categorized by general theme of option. They do not typically include *mitigation* options, although the two are easily confused. This list will be used during the group work on the morning of Day 2.

Table 3: C4-SP ADAPTATION OPTIONS

Natural: AQUATIC Ecosystems (Hydrology & Fish)	Natural: TERRESTRIAL (Soils, Vegetation, Wildlife, Glacier)	HAZARDS (Hazards, Emergency Response and Security)	CULTURAL (Historic, Archeological, Ethnographic, Museum)	FACILITIES (Infrastructure, Circulation, Structures, fleet, recreation services)	INTERPRETATION & EDUCATION (Visitor programs, elementary)
CROSS SECTORAL (*Italics* : actions to build adaptive capacity; **Bold:** adaptation options)					
(BASELINE) INVENTORY					
MAP, MODEL or DOCUMENT					
ASSESS or ANALYSE					
INCREASE / MAINTAIN MONITOR or EARLY DETECTION / WARNING PROGRAMS					
PRIORITIZE NEEDS					
INTEGRATE CLIMATE CHANGE INTO ALL PLANNING EFFORTS					
IMPROVE COORDINATION (GOV, TRANSDISCIPLINARY, PRIVATE SECTOR)					
DEVELOP PROTOCOLS					
ENHANCE RAPID RESPONSE EFFORTS					
CREATE SUPPORTIVE SOCIAL STRUCTURES (SENIOR MGMT BUY-IN, IDENTIFY CLIMATE CHANGE CHAMPIONS, TRANS-DISCIPLINARY PARTNERSHIPS)					
ENFORCEMENT OF STANDARDS					
IDENTIFY & LOBBY FOR BUDGET RESOURCES / FUNDS					
ACCEPT THE IMPACTS AND BARE THE LOSSES (SOME HABITATS/SPECIES WILL DISAPPEAR, CONSCIOUS DECISION TO DO NOTHING)					
OFFSET LOSSES BY SPREADING OR SHARING RISKS, I.E., INSURANCE					
PROMOTE POLICY OR PROCEDURAL CHANGES					
SECTORAL SPECIFIC (Representative examples)					
Form science advisory group	Form science advisory group	Form science advisory group	Identify trigger point for protection or moving of resources	Scale down: consolidate structures	Raise awareness of climate sensitivities
Choose between potential management strategies (ex: as predator control, habitat manipulation, and species reintroduction)	Choose between potential management strategies (ex: as predator control, habitat manipulation, and species reintroduction)	Update or prepare emergency action plans	Relocate collections	Modify: rennovation, removal or relocation	Scale down: reduce services
Reintroduction, removal or relocation of species	Reintroduction, removal or relocation of species	Establish non-burn days, alternative fuel fires, or spatial / temporal fire restrictions	Increase social acceptance of shared resilience goals	Promote revegetation where infrastructure has been removed	Communication strategy extended to community
Water conservation efforts	Realign ecosystem processes of the disturbed landscape into the range of current or anticipated future environments, rather than historical pre-disturbance conditions	Manage the natural regeneration process to enhance disturbances that initiate increased seedling development and genetic mixing	Assist communities in making their livelihoods resilient	Water conservation efforts	Water conservation efforts: public and employee education
Improve techniques for and do more restoration wetlands, rivers	Establish "neo-native" plantations and restoration sites	Plan for higher elevation insect outbreaks	Use social networks for education about climate change	Treat buildings to prevent termite incursion	Create education programs for public about landuse practices and effects on and with climate
Protect refugia (current and predicted)	Increase connectivity (design corridors, remove barriers for dispersal, locate reserves close to each other, reforestation)	Mitigate threats, i.e. invasive species, fragmentation, pollution	Establish flexible boundaries for materials collection (i.e. huckleberry)	Organize / enhance services for boating and fishing (as recreation)	Increase communication of knowledge about climate change impacts to policymakers and stakeholders
Stop implementation of CO2 emission mitigation projects that negatively impact biodiversity	Create and manage buffer zones around reserves	Create culturally appropriate adaptation/management options	Establish new cultural traditions		
Schedule dam releases to protect stream temperatures	Anticipate surprises and threshold effects i.e. major extinctions or invasions	Maintain natural disturbance dynamics of ecosystems	Triage (protect what you can)		
	Locate reserves at northern boundary of species' ranges	Drought interventions in glacier-fed regions			
	Manage human-wildlife conflict as change occurs				

Attachment 11: Workshop Results
- Agency Purpose and Mission
- Management Concerns
- Contributed Climate Change Impacts
- Breakout Session Results

Table A11-1. Fundamental purpose and mission of the agencies represented at the Crown of the Continent Climate Change Scenario Planning Workshop, contributed by workshop participants.

Organization	Purpose and Mission Contributed by Participants at Workshop
Alberta Tourism, Parks and Recreation	• Conservation of natural and cultural resources • Conservation of significant landscapes and resources • Recreation • Provide opportunities for visitors to interact, learn, recreate on and in those sites • Education • Provide value and enhance Alberta's economy
British Columbia Ministry of Environment	• To maintain and restore the natural diversity of provincial ecosystems, fish and wildlife species, and their habitat
Bureau of Indian Affaire – Blackfeet Agency	• Learn about climate change • Discuss and exchange information on land management issues • Network
Confederated Salish and Kootnai Tribe	• Preserve and protect the natural and human resources of the Tribes • Preserve and protect the culture, languages, and resources of the Tribes • Conservation and preservation of ecosystems with cultural and historical importance • Fish and wildlife conservation and preservation • Wetland conservation and preservation
Flathead Basin Commission	• Protect water quality • Protect other natural resources • Sustainable economic development
Flathead Lake Biological Station – University of Montana	• Research • Education • Outreach and supply information to managers, communities, and politicians
Glacier National Park	• Preserve and protect natural and cultural resources unimpaired for future generations (5 responses) • Provide for the benefit and engagement of the public • To celebrate the ongoing peace, friendship and goodwill among nations, recognizing the need for cooperation in a world of shared resources (2 responses) • Celebrate the longstanding peace and friendship between the US and Canada • Celebrate the Peace Park and deep cultural connections with First Nations • To provide opportunities to experience, understand and enjoy the park, consistent with the preservation of resources in a "state of nature" (3 responses)
Greater Yellowstone Coordinating Committee	• Coordinate management of federal lands in the greater Yellowstone area • Manage the greater Yellowstone area as an ecosystem, including the 2 National Parks, 2 National Wildlife Refuges, and 6 National Forests
Indian Nations Conservation Alliance	• Conservation of the natural resources • Awareness of global warming • Protection of the cultural values of Native Americans
National Park Service	• Protect and preserve resources • Conserve re natural and cultural resources (including traditional uses and lifeways) in an unimpaired condition • Preservation of cultural resources • Preserve and protect resources, the land base, and ecosystems

	• Preserve ecosystem goods and services • Preservation of ecological processes • Preservation of biodiversity • Allow disturbance to continue to affect the landscape and change the flora and fauna • Protect and preserve historical landmarks for future generations • Maintain and operate Park infrastructure to prevent any natural resource degradation • Enhance visitor experience • Provide for public enjoyment, recreation, etc. Provide education • Allow for appropriate use of the landscape by the public so as to not degrade the resources • Recreative use of resources while preserving and protecting those same resources • Long-term ecosystem monitoring for Rocky Mountain National Parks • Ecological data management and reporting • Ecological inventories for Rocky Mountain National Parks • Research and education to support the above • Learn how to do all the above better using the parks as a classroom for research into perpetuity Be proactive to address changing conditions to preserve and protect
Parks Canada	• Preserve and protect: to protect and manage the natural and cultural resources for future generations • Maintain and restore the ecological integrity (biodiversity and natural processes) • To provide opportunities for visitor experiences so that visitors can enjoy the natural and cultural resources today • Present parks to visitors and provide visitor experiences • Education and outreach • Education and outreach to provide opportunities for folks who don't have an opportunity to visit, to learn and develop an understanding and appreciation of protected places
Regional Learning Project – University of Montana	• Collaboration with Tribes to created educational resources about regional cultures, history and knowledge • Hunter-gatherer adaptations to climate change • Cultural resources and impacts of climate change
US Forest Service	• Conservation of all natural and cultural resources on national forest land • Provide goods and services for American people • Manage these resources to produce desirable future conditions
US Geological Survey	• Research in support of Department of Interior agency information needs • Providing credible and objective scientific information that the nation needs to make decisions • Provide scientific tools to Department of Interior managers • Basic and applied research on biological resources, particularly those of interest to Department of Interior agencies and the US National Forest Service

Table A11-2. Concerns about the future of the Crown of the Continent region and management of its resources, contributed by workshop participants.

Concerns for the Future
• Cultural links to the landscape are climate dependent • Local land use decisions are being disconnected from climate information • Federal personnel are separated from States and Counties • Fire • Invasives • Drought • Water demand • New dams • Raising heights of reservoirs in the Park • Needs for land use change • Range carrying capacity • Perspectives about impacts on broader animal species • Future of bog lemmings as pocket gophers invade formerly wet meadows • Redirection of resources from protected areas to protection of towns and inholdings for fire, flood risks • Thinking about alternatives previously dismissed • British Columbia micro-hydroelectric power • New demands for crop changes faster than infrastructure can change • Infrastructure shifts are costly • Introduction of species from further south • How to define biodiversity goals • The Park as a place where ecological processes are allowed to proceed vs. preserving existing vignettes • Current model of park management is based on a relatively short historic window of heavy visitation • Changes in logging practices • Changes in harvesting strategies

Table A11-3. Anticipated impacts of change on the Crown of the Continent region, contributed by workshop participants.

Impacts of Changes Affecting the Region
• Increased population • Rapid increases in population as other areas suffer from greater impacts from climate change • Changes in the coincidence between maximum temperatures and maximum rainfall (moving from Mediterranean climate to a monsoon climate) • Changes in fog and visibility

- Air pollutants change in rain vs. snow due to scavenging
- Flushing of nutrients early in the season before they are biologically available
- Change in water regime
- Loss of snow
- Increased demand for water
- Increased competition for remaining water
- Water rights conflicts
- Conflicts relating to human water use
- Impact on groundwater levels
- Demands on aquifers in mountains and National Forests
- Changes in water quality because of increased fire regime
- Creative plumbing opportunities
- Increased consideration of cost/benefit
- Increased economic benefits from conservation
- Migration/increase in invasive plants and diseases
- Increase in exotic species
- Longer growing season
- Impact on plant communities and wildlife
- Conflict in urban/forest interface
- Fire impacts on structural threats, personnel to protect facilities, stress on response resources and funding, visitor safety, and visitation
- Cascading effects of interactions of multiple stressors including changes in disturbance regimes
- Loss of pothole water resources and impacts to migratory species
- Vegetation cannot migrate elevationally to overcome high temperatures or drought at lower levels because there is little to no soil at high elevations and soils develop over centuries and millenia
- Loss of heritage value to descendant communities from changing landscape characteristics
- Loss of ethnically significant and treaty right resources
- Increase in Section 106 load from climate change-related undertakings
- Increase in unfunded impacts to cultural resources
- Higher losses of “relic” plant and animal communities
- Higher losses of narrow-niche species rather than generalist species
- Higher trophic level species in peril
- Phenology bloom times are no longer synchronized with feeding or pollination
- Loss of traditional use species of plants and game animals
- No budgets due to catastrophic events elsewhere
- Potential for no plowing or road opening due to lack of snow
- Increased demand on facilities due to longer seasons
- Seasonal employee issues due to longer seasons
- Potential impacts on natural resources from longer back-country season
- More back-country day use
- Trails open earlier
- Increased demand on trail maintenance

Table A11-4. Breakout group ideas for new management objectives for year 2020 suggested in response to scenario narratives.

Colorado Creeps North/Wheel Spinning	Climate Complacency/Is Anyone Out There?	Race to Refuge/Big Problems, Big Solutions
Restructure staffing	Provisions of water	Restructure staffing
Rethink preservation	Energy development pressures	Novel approaches for conserving cultural and historical resources
Private land management	Hold, preserve, protect	Proactive management for refugia
Water allocations	Adaptation not yet an objective	Redefined purpose for public lands
Public lands services	Emphasis on non-climate issues	Management of conflict among services
Shifted expectations for multiple-use areas	Seeking understanding and traction for change	Major water infrastructure
Shifted expectations for protected areas		Manage higher risks of damaging events
Biosphere reserve		Pre-emptive transformation of systems
Accommodate societal pressures		Protect and maintain ecosystem services
Recreation access without roads or trails		Struggle to change objectives
		Rethink roles for public lands services
		Cooperation
		Local flexibility

Table A11-5. Breakout group ideas for new management objectives for year 2050 suggested in response to scenario narratives.

Colorado Creeps North/Wheel Spinning	Climate Complacency/Is Anyone Out There?	Race to Refuge/Big Problems, Big Solutions
Restructure staffing	Entrain adaptation	Triage
Rethink preservation	Changed fire objectives	Water management
Private land management	Save the pieces	Save the pieces
Water allocations	Energy concerns	Disaster management
Public lands services	Food production	
Shifted expectations for multiple-use areas	Focus on major system components, not details	
Shifted expectations for protected areas		

Biosphere reserve		
Accommodate societal pressures		
Recreation access without roads or trails		

Table A11-6. Breakout group ideas for building capacity for adaptation by year 2020 in response to scenario narratives. Numbering of the type of idea is simply for convenience in comparing tables and does not imply any priority ordering.

Type of Building Capacity to Adapt	Colorado Creeps North/Wheel Spinning	Climate Complacency/Is Anyone Out There?	Race to Refuge/Big Problems, Big Solutions
1. Conduct baseline inventory	High-risk areas for rock or debris slides	General	Species
		Better quantify aquatic resources	Habitat
		Better quantify use and consumption of aquatic resources	Genetic and phenotypic response
		Identify water resources that can be developed to support existing enclaves	Adaptive potential
			Cultural Resources
2. Increase/maintain monitoring	General	General	General
	Ecosystem health	Forest health	Water discharge
	Cultural resources	Native plants	Cultural resources
	Critical populations	Invasive plants	Water quality
	Effect of climate changes	Wetland habitats	
	Surprise and threshold effects	Wildlife corridors	To detect tipping points
3. Map, model or document	Vegetation changes	Invasive species	Cultural resources
	Historical ranges	Rare plants	Groundwater resources that support major enclave water systems
	Population numbers	Diseases	Data management
	Species diversity		
4. Assess or analyze	How to distinguish natural ecosystem changes from climate change impacts	Vulnerability and risk assessments for species	General
	How to manage natural ecosystem changes	Vulnerability and risk assessments for	Ongoing vulnerability

	compared to climate change impacts	ecosystems	
	Establish carrying capacities by location, recreation type, and visitor experience	Vulnerability and risk assessments for processes	Dry slope stabilization
	Identify appropriate species to bolster forest longevity	Vulnerability and risk assessments for facilities	How to make forecasts and tools more relevant and tuned to needs
	Threshold effects	Threshold effects of major extinctions	New management tools
		Threshold effects of invasions	Methods for capturing, storing, and distributing winter precipitation
	Anticipate surprise	Anticipate surprise	Minimal flows to sustain demands for water supplies
	Improved techniques for restoration of rivers		Improved techniques for restoration of rivers
	Improved techniques for restoration of wetlands		Improved techniques for restoration of wetlands
			Assess current water use for ecosystems
			Assess current water use for human demands
5. Develop protocols	For facility and infrastructure retention or decommissioning	For documenting how terrestrial systems are changing	General
	For responding to extreme weather events	For documenting how aquatic systems are changing	For creating plant collection areas for 1855 treaty tribes (because ongoing relationships are essential for the plants to be productive)
	Update or prepare emergency action plans	For documenting how disturbances are changing	Update or prepare emergency action plans
			For capturing, storing, and distributing winter precipitation
			Monitoring methods for adaptive management
6. Develop early detection and warning systems	Rock and debris slides	Invasive plants	General

		Forest insects	Threats detection for archeological sites
		Diseases	Threats detection for traditional plants for foods and medicines
		Flood warning devices in more places for facilities (e.g., Divide Creek)	Water resources
			For watershed protection
			Species habitat
7. Enforcement of standards		Cultural resource management not up to capacity.	Need new rules and enforcement as park purposes change
8. Improve communication and education	Create communication and interpretation program that educates the public about climate change		Establish local, regional, and broader education programs to help public understand how their choices and actions (e.g., carbon footprint, water use) affect the Crown and its resources (water, wildlife, fish, cultural)
	Great climate change communication for staff	Education and awareness focused on vulnerabilities	Education campaign about the importanceof protected areas for ecosystem services
	Raise awareness of climate sensitivities	Raise awareness of climate sensitivities	New training for staff
	Increase communication to policy makers of climate impacts knowledge	Increase communication to policy makers of climate impacts knowledge	
	Increase communication to stakeholders of climate impacts knowledge	Increase communication to stakeholders of climate impacts knowledge	
	Great climate change communication for media		
	Great climate change communication for school kids		Promote water conservation for ecosystems in conjunction with human use

	Water conservation education for staff		Water conservation education for staff
	Water conservation education for public	Education and awareness focused on drought planning	Significant education effort to change society's perspective on water conservation
	Use social networks for education about climate change		Initiate education to instill attitudes that cherish free-flowing streams and natural water flows
9. Improve coordination	More coordinated tourism communications with different options clearly offered	Establish coordination and cooperation in solid waste recycling between commercial, state, and federal groups	General
	Land management agencies are actively engaged in K-12 climate change education	Extend climate change communication strategy to community partners	Extend climate change communication strategy to community partners
		Better address multi-jurisdictional complications associated with water and aquatic organisms	Leverage existing procedures (e.g., PAs, MOUs, MOAs) and existing partnerships (e.g., LCCs, CESUs) to reduce redundancies
		Between land management agencies and owners	Use multi-jurisdictional planning in advance of crises
			Integrate government and NGO community response, at all levels, that translates into management and sustainability for water and energy
			Cross-boundary collaboration
			Multi-agency cooperation for disaster planning
			Between agencies for quick response to resource emergencies
			Pooled fire units that include states and Parks

10. Create supportive social structures	Volunteer groups are organized to monitor and protect cultural and historically important sites	Rebuild cultural resources program	Begin an endowment so that necessary actions can be funded after the "boom" in support has ended
		Encourage linkages between cultural resources personnel	New collaboration with citizens as park purposes change
		Increase connectivity with community organizations, states, tribes and other agencies in collaborative projects	Work with tribal communities to learn from their traditional "low-carbon footprint" lifeways (e.g., tipis, earth lodges, adobe apartments)
		Offset losses by sharing risks	
		Increase heritage tourism	
		Increase education partnerships	
		Increase capacity building	
11. Integrate climate change into planning efforts	Planning for siting new construction away from hazards	Plan now for the future for all resources	General
	Plan for limited take from fishing, e.g., season restrictions, species allowed	Plan now for the future for aquatic resources	Re-evaluate the role of stakeholder enagement in planning
	Plans for increased efforts at controlling exotic species	For planning, develop new programs to address changing audiences	Use seamless engagement in planning with communities and the public
	Plan to limit disturbances that promote exotic species	For planning, develop comprehensive interpretation language that addresses climate	Prepare designs and plans to convert all facilities to dual plumbing to reduce water consumption
	Plan to use appropriate species that promote forest longevity (e.g., larch vs. lodgepole)	Fire management plans	
	Plan for park transportation system options (hike, bike, tram, gondola,	Forest insect and disease management plans	

	alternative roads)		
	Plan for new places where visitors will be going, not just doing what has always been done	Flood mitigation	
	Identify trigger point for protection or moving of resources (e.g., like current cultural regulations)	Identify trigger point for protection or moving of resources (e.g., like current cultural regulations)	Identify trigger point for protection or moving of resources (e.g., like current cultural regulations)
	Choose between potential management strategies		Choose between potential management strategies
12. Prioritize needs	Emphasize maintenance	Adjust priorities in programming efforts to reach broader audiences outside Park	General
	Stop funding new construction		Align with survival themes
			Ensure existing needs and capacity shortfalls are adequately supported before adding new programs
			Emphasize buy-in from stakeholders and policy makers
			Recruit staff for new functions
13. Promote policy change	General	Instream flow and water allocations	General
	Require water conservation by all, e.g., agricultural producers, golf courses, citizens		Water and energy development
	For water use practices that are less polluting		State water laws and policies
	Recognition of ecological function and wildlife use at as legitimate beneficial water use		
	Legislative authority to manage food and attractant storage on private lands		

	Enable outside partners to participate in preservation of historic infrastructure		
	Incentives and restrictions on private land use related to fire hazards		
	Incentives and restrictions on private land use related to water use and conservation		
	Incentives and restrictions on private land use related to development and travel corridors		
	To not have traditional Going to the Sun Road access to park interior		
14. Identify and lobby for budget resources and funds	General	For everything	General
	Funding for enforcement		
	To protect historical sites		
15. Enhanced rapid response efforts			Integrated across agency mission
			To intervene when desired plant and animal species are endangered
			Build SWAT teams of expertise that cross jurisdictions and bring in expertise to deal with time-critical needed actions
			Prepare and train for rapid response to crisis and need to make quick, less informed decisions
			Pool fire response
			Pool disaster response

Table A11-7. Breakout group ideas for building capacity for adaptation by year 2050 in response to scenario narratives. Numbering of the type of idea is simply for convenience in comparing tables and does not imply any priority ordering.

Type of Building Capacity to Adapt	Colorado Creeps North/Wheel Spinning	Climate Complacency/Is Anyone Out There?	Race to Refuge/Big Problems, Big Solutions
1. Conduct baseline inventory	Do a more complete inventory of cultural resources	Education	
	Conduct cultural resources interviews in surrounding areas		
	Inventory cultural resources at risk		
	Inventory facilities at risk		
	Inventory facilities that are soon to be "historic"		
2. Increase/maintain monitoring	Cultural resources	General	General
3. Map, model or document	Model expected cultural resources exposures from erosion		
	Vulnerability and value of facilities (dollar value and operational value)		
	Vulnerability and value of services (dollar value and operational value)		
4. Assess or analyze	New ecosystem dynamics	Scenarios developed in planning exercises	Scenarios developed in planning exercises
	Vulnerability	New and creative technologies for managing water	Research on ecosystem services valuation
	Analyze archeological data from surrounding area to model shifts in cultural and settlement patterns	New and creative technologies for managing facilities	Research on siting of dams
	Assess facilities energy consumption, carbon footprint with high frequency		Research on predicting water distribution
	Assess facilities water		Colonizing the moon! :)

	use with high frequency		
	Analyze effects of new technologies for public access to park, to support management decisions		
7. Enforcement of standards			No plant consumption for cultural uses
8. Improve communication and education	Produce K-12 resources about fire on the land to educate children who will be the leaders	Create education programs for public about land use practices	
	Produce K-12 resources about bull trout to educate children who will be the leaders	Social marketing	
		Raise awareness of climate sensitivities	
		Increase communication to policy makers of climate impacts knowledge	
		Increase communication to stakeholders of climate impacts knowledge	
9. Improve coordination	Collaborate with zoos to conserve genetic diversity	Develop partnerships with local communities	Bring in agencies with core mission and expertise in water rights issues (e.g., Bureau of Reclamation, Army Corps of Engineers)
		Use brokering and leveraging entities to scope, fund, and implement climate change research, actions, and education	For “hot button” issues, bring in agencies having related core mission and expertise
10. Create supportive social structures	Train and use citizen scientists to monitor alpine plants and animals	Reinforce flexible, responsive, coordinative capacity (e.g., via CESUS, brokering and leveraging entities)	Restructure public lands agencies to create supportive social structures that ensure production for food, water and shelter
	Provide interpretive services in multiple languages as different		Ensure inter-agency linkages are long-term

	people relocate to the region		
	Use advanced interactive IT and web strategies for services		
11. Integrate climate change into planning efforts	General	Develop separate line-item or tactic (e.g., FMSS for maintained sites) to address 'orphaned' resources	Plan to fight dam and irrigation plans for Park water
	Increase efforts at all levels of planning	Plan for high elevation insect outbreaks	
	Revisit scenario planning on a scheduled frequency using new information from monitoring		
	Set threshold triggers for directing management responses		
	Set threshold triggers for rapid response		
	Create plans for cultural resources exposed from erosion		
12. Prioritize needs	New ecosystem dynamics		Protection of social resources for future generations
	Deprioritize endangered species which will not survive and adjust management		Protection of water resources for future generations
			Protection of land resources for future generations
13. Promote policy change	From natural processes to adaptive management	General	Transition to carbon based economy that rewards mitigation
	Require highway construction to incorporate wildlife crossing structures to facilitate population linkage and migration	Mobilize multiple stakeholders to influence policy	More clarity on what purpose parks will serve for society
	Require highway construction to include conservation easements		Restructure federal government so that management

	or purchase to facilitate population linkage and migration		boundaries disintegrate
	Policy on how we define exotic species in a new climate or habitat scenario		
	Policy for deciding at what point we let a species or population disappear from the Crown ecosystem		
	Visitor use policies rethought in the face of drastic increases in visitation, e.g., consider limitations on numbers of visitors		
	For alternative staffing strategies		
14. Identify and lobby for budget resources and funds	Alternative transportation		
15. Enhanced rapid response efforts			Fire suppression rapid response crews with training and volunteers
			Reseeding and replanting immediately after fires to prevent sediment and slides
			Extreme heat events

Table A11-8. Breakout group ideas for adaptation actions for year 2020 suggested in response to scenario narratives.

Colorado Creeps North/Wheel Spinning	Climate Complacency/Is Anyone Out There?	Race to Refuge/Big Problems, Big Solutions
Reintroduction of species	Reintroduction of species	Increase law enforcement to protect resources
Removal of species	Removal of species	Stop CO_2 emission mitigation projects that negatively impact biodiversity
Relocation of species	Relocation of species	Drought intervention in glacier-fed regions

Manage human/wildlife conflicts as change occurs	Manage human/wildlife conflicts as change occurs	Increase water reservoir capacity
Water conservation	Water conservation	Water conservation
Protect current refugia	Protect current refugia	Establish “neo-native” plantations and restoration sites
Protect predicted refugia	Protect predicted refugia	Increase fire suppression to reduce carbon release
Increase connectivity	Increase connectivity	Aggressive logging and thinning on larger scales than previously done, primarily for human safety
Triage	Acceptance of impacts and losses	Aggressive prescribed fires on larger scales than previously done, primarily for human safety
Mitigate threats	Mitigate threats	Treat buildings to prevent termite incursion
Renovate facilities	Relocate collections	Relocate collections
Remove facilities		Establish new cultural traditions
Relocate facilities		Close or remove infrastructure (roads, trails, buildings) from areas in high risk of mass wasting
Scale down: consolidate structures		Close or remove infrastructure (roads, trails, buildings) from areas in high risk of flooding
Promote revegetation when infrastructure has been removed		Assist communities in making their livelihoods resilient
Create and manage buffer zones		Shift management strategies
Establish flexible boundaries for materials collection		
Locate reserves at northern boundaries		
Realign ecosystem		

processes		

Table A11-9. Breakout group ideas for adaptation actions for year 2050 suggested in response to scenario narratives.

Colorado Creeps North/Wheel Spinning	Climate Complacency/Is Anyone Out There?	Race to Refuge/Big Problems, Big Solutions
Water conservation		
Protect "neo-native" plantations and restoration sites		
	Protect current refugia	
	Protect predicted refugia	Prohibit plant consumption for cultural uses
Increase fire control on timber harvest and silviculture areas		Vegetation management
Increase connectivity	Large-scale connectivity	
		Treat buildings to prevent termite incursion
Acceptance of impacts and losses	Acceptance of impacts and losses	Acceptance of impacts and losses
Triage		Triage the Going to the Sun Road and don't repair or rebuild
	Scale down: consolidate structures	Scale down: reduce services
Locate reserves at northern boundaries	Locate reserves at northern boundaries	
Realign ecosystem processes	Manipulation and intervention	Active intervention
Manage the natural vegetation regeneration process	Change in ESA and SARA application	
Schedule dam releases	Schedule dam releases	Active management of dams
Increase water reservoir capacity	Develop water resources infrastructure identified in 2020 assessment and planning (e.g., surface water treatment plants, groundwater wells)	Convert facilities to dual plumbing for 50% of supplies and use that water to stay in habitat
Increase hydropower	Flood mitigation in	Install micro-

production	place in highest risk areas	hydroelectric systems at major enclaves to disconnect from the grid and provide regeneration
Lower evaporation in irrigation canals and delivery systems		
Use gene banks to preserve genetic diversity of threatened and endangered plants and animals		
Convert dryland crops to rangeland		
Increase grazing pressure on all public lands		
Greatly increase use of public and private lands for wind energy production		

Attachment 12: Workshop Evaluation
- Workshop Evaluation Questionnaire
- Workshop Questionnaire Results
- Open-ended Comments

E V A L U A T I O N

Crown of the Continent Climate Change Scenario Planning (C4-SP) Workshop

9-10 March 2010, Whitefish, Montana

1.Did we meet our objectives?	Please answer YES or NO and state briefly why you feel this way.
a. To explore, assess and respond to alternative futures for the Crown of the Continent ecosystem, cultural resources and facilities, which managers can use to help inform decisions in light of potential climate change and impacts	
b.To apply scenario planning in the Crown of the Continent ecosystem as a tool to facilitate partners' management of the region	
c.To assess how the scenario planning process might best be packaged and replicated for the NPS and others	

2. What three things did you find most useful in this workshop?

a.

b.

c.

3. What do you think could be improved for the next Scenario Planning workshop?

a.

b.

4. On a scale of 1 to 4, how well do you think the three C4SP Workshop scenarios fulfilled the following criteria?

1=not at all; 2=somewhat; 3=mostly; 4=very well	Race to Refuge	Colorado Creeping North	Climate Complacency
Creative			
Legitimate			
Credible			
Relevant			

5. What concrete tools (that could be prepared by a university) do you need to manage more efficiently in 2050?

C4-SP Workshop Evaluation Results

WORKSHOP OBJECTIVES (1:yes; 0: No)		SUM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	#
To explore, assess and respond to alternative futures for the Crown of the Continent ecosystem, cultural resources and facilities, which managers can use to help inform		**17**	1	1		0	1	1		1	0		1	1	1	1	1	1	1	0	1	1	1	0	1	0	1
To apply scenario planning in the Crown of the Continent ecosystem as a tool to facilitate partners' management of the region		**15**	1	1			1	1		1	1	0		1	1	0		1	1	0	1	1	1	1	0	1	
To assess how the scenario planning process might best be packaged and replicated for the NPS and others		**8**				1		0		1	0	1	1					0	0	1	1		1		0	1	0
WHAT PARTICIPANTS FOUND MOST USEFUL		**SUM**																									
SP process: exploring, learning, walking through, understanding		**12**				1		1					1				1	1	1	1			1	1	1	1	1
Climate change presentations/scientists		**12**		1	1		1			1	1		1	1			1	1	1				1			1	
Dialogue: networking, sharing with other agencies; thinking outside your own agency/tribe		**11**		1				1	1			1	1	1				1		1		1	1				1
Scenarios: actually working with the descriptions		**5**	1	1				1							1										1		
Diversity of expertise, intersectoral/disciplinary		**5**		1	1						1					1						1					
Webinar process		**3**								1								1					1				
VUCA		**1**	1																								
Freedom to contribute, openness of the workshop		**1**											1														
IMPROVEMENTS PROPOSED		**SUM**																									
FOCUS	Gain focus in content, or define focus areas (i.e., the crown)	4				1		1								1					1						
	Clarify objectives: learning/training in SP or participants developing scenarios? ToT?	2			1													1									
TONE	Make less pedantic, academic	1																							1		
	Simplify and/or generalize	2														1										1	
	Enable more discussion	1										1															
CONTENT	Strengthen link between scenarios and mgmt actions / planning	8						1				1		1			1	1					1		1	1	
	Reduce explanation / rehashing of the process	4		1					1														1				1
	Improve actual scenarios / descriptions, try different axes	3		1				1								1											
	Allow participants to develop the scenarios during the workshop	2																							1		1
	Make results more tangible, add closure	2															1	1									
	Give more exposure to other agency mandates	1																			1						
	Find a way to stress where we are today "so we can move more effectively to the SP futures"	1									1																
STRUCTURE	Improve break out sessions, esp. repackage Day 2	5								1		1		1					1								1
	Strengthen organization: general, shorter breaks, start on time, projector, split apart those from different levels of decision making for certain sessions	4				1	1					1	1														
	Allow for more time: workshop, webinars, to process	4													1					1			1	1			
PARTICIPANT PROFILES	Improve expertise around the table (communicators, cultural, facililties, tribal)	**2**	1																								1
	Add more sectoral expertise: energy, water, technology	2									1											1					
	Improve presence of leadership	1																				1					

C4-SP Workshop Evaluation Results

WEBINARS	Have fewer webinars or more drawn out over 6m. pre workshop	1	1
	Replace sectoral impact sessions in webinars with on-site face-to-face dialogue during conference	1	1

SCENARIOS	(1: not at all, 4: very well)	AVG																										
Colorado Creeping North	Creative	**3.3**	4	4	3	3	3	4		3	3		3	4	4	3	4	3	3	4	2	3	4	2	4	3	3	
	Legitimate	**3.1**	3	4	3	2	3	4		4			4	2	3	3	4	3	3	3	2	3	3	4	4	2	3	
	Credible	**3.3**	4	3	3	3	3	4		3	2		4	3	4	3	4	3	3	3	3	3	4	3	4	4	3	
	Relevant	**3.5**	4	4	3	2	3	4		4			4	3	4	3	4	2		4	3	4	3	4	4	4	4	
Climate Complacency	Creative	**3.3**	3	4		3	3	4		3	1		3	4	3	4	2		3	4	3	3	4	4	4	3	3	4
	Legitimate	**3.1**	3	4		2	3	4		3			4	2	3	4	3		3	3	2	3	3	4	4	2	3	3
	Credible	**3.2**	4	4		3	3	4		3	2		4	3	1	4	4	3	3	3	3	3	4	3	4	4	3	3
	Relevant	**3.6**	4	4		2	3	4		4			4	3	4	3	4	3		4	3	4	3	4	4	4	4	4
Race to Refuge	**Creative**	**3.2**	4	4	1	3	2	4		4	3		4	4	4	3	2	2	3	4	3	3	4	2	4	3	3	4
	Legitimate	**2.6**	3	4	1	2	2	4		2			4	2	3	1	3		3	3	2	3	3	4	1	2	3	3
	Credible	**2.3**	2	2	1	3	1	4		2	2		1	1	4	1	1		3	2	3	3	4	3	1	4	2	2
	Relevant	**3.1**	2	3	1	2	2	4		4			3	3	4	3	2	2		4	3	4	3	4	4	4	3	4

	TOOL KIT	SUM																										
	Link from SP to planning and mgmt, database, etc.	**3**					1														1							1
	better scenarios	**2**				1		1																				
	evaluation of cultural resources	**1**			1																							
	fund rasising	**1**		1																								
	staffing	**1**			1																							
	distribute presentations from workshop (Basecamp or CD)	**1**																		1								
	ecosystem vulnerability assessments	**1**																					1					
	trigger points, studies	**1**																						1				

	THE FOLLOWING ARE DIRECT QUOTES
MAGNITUDE	*way too big a process, too complex, too diffuse, interconnectedness was daunting, interesting but frightening,*
TIME	*not enough time, too much in little time, rushed, complexity required more time, frustration due to too much info in too little time*
FRUSTRATION	*too NPS centric, overall too academic* *not OK for cultural, limited on cultural considerations* *not enough baseline; frustration that process does not draw more knowledge from the disciplines*
the PROCESS	*we only responded to existing pre-packaged products, not enough application of scenarios* *we don't need to know HOW to do it, just be guided to do it (SP); "train the trainer" attempt was NOT successful*
NEED CLOSURE	*no closure on what to do with this in short-term, not much mgrs can USE NOW, final products not useful* *how does this relate to our planning?*
VALUE	*valuable and applicable to many disciplines, opened my eyes, very provocative, thought provoking and excellent first step* *very worthwhile and pushing us to face the challenges ahead, challenged us to think broadly*
YES WE CAN	***NPS CAN improve the process*** ***I can apply this tool***

Post-Workshop Feedback

Comments are collated from diverse sources other than the workshop evaluation form, including email, comments consolidated and forwarded by NPS staff, discussion among Steering Committee, and post-workshop debriefing.

Public acceptance and managerial support was great.

The Tucson Water approach for dealing with multiple futures rather than a single future was good. It would be good to pursue this.

There's a lot of "hand holding" that's required in working with the Crown Management Partners, just to get and sustain participation in anything. There were 15 no-shows for the workshop!

"I hear rave reviews about the workshop from all sides!! It went very well!"

Posting the presentations after the workshop was really helpful.

Too much explanation of scenario planning, almost like a training workshop although no one expected to walk away a trained scenario planner.

The day 2 recap of scenario planning basics was unnecessary considering how well the group at large seemed to grasp the concept. The Tuscon water example was also much too long.

Expected something more concrete in terms of management actions

Needed much more time to explore the scenarios on day two and go through the exercises. Any time the group began to explore some new ideas, they had to move on, or redirect efforts to save time.

It was good to re-hash results of the breakouts with the larger group.

The dam building as a common action between all groups was out of context for many managers, especially because it hadn't been discussed up to that point. More time would have allowed the groups to flesh out their ideas, which would have in turn made it easier for the facilitators to identify a common thread that everyone could remember from the breakouts and related to.

Cultural resource incorporation was weak into actual scenarios and breakout activities, although it was appreciated that there was a concerted effort, such as the evening program.

Comments
"We have to make daily decisions on so many things. We don't ever have a chance to breathe and do strategic planning."
"But all the handbooks in the world don't make for action on the ground."

Need to strengthen the link with Adaptation Planning, Vulnerability Assessment, GMP, Resource Stewardship Strategies. Do we really need a new planning process, i.e., Adaptation Planning? A separate Adaptation Plan won't work unless it's required from the National Level, and the GMP and RSS processes are not realistic because they are onerous (GMP) or deactivated (RSS) processes.
- how should we unify at the right layers, given that there are so many agency purposes?
- how do you navigate from one scenario to another?

Not a lot of interest in a large regional plan among the Crown Management Partners
USFWS managers and others are requesting or exploring interagency scenario planning
The adaptation template would be duplicative and is now not needed from this project.

Overall, I though the workshop went very well and I heard good comments, particularly by the Alberta contingent and my staff. I thought the chosen scenarios certainly stimulated thought. We have documented the issues some had in Race to Refuge with having those climatic extremes, with resulting societal upheaval, and still having resources available.

When we were planning for the Workshop, we were worried about participants being pulled into one or more of the following "traps". I don't feel like this happened at all, so I thought this was an indication of various parts of the workshop that went very well.

- Overemphasis on "right answers" for the scenarios.
- Disagreement with choice of scenarios.
- Fundamental disagreement with climate change background.
- Too much concentration on scenario narratives and the details.
- Difficulty understanding the scenario concept.

What I felt is that if anything, we put too much emphasis on developing the scenarios and scenario planning instructions, and it took up some of the time that participants wanted/needed for critical thinking for management.

There was confusion in our group about the purpose of the whiteboards and the ready made "answers" that needed to be stuck somewhere. I felt that the participants could come up with those concerns, in their own words, without that part of the exercise which took up significant time.

I felt one of the most illuminating and helpful exercises was the stepped, multiple management response exercise, that built out futures for different scenarios. This was done at the end of the second day, and I and others would have liked more time for this. The stock answers provided as a start were somewhat confusing. This was a modification of the Tucson water scenario exercise that had the non-linear planning diagram.

The PowerPoint and presentations were great and the continued availability of those, the readings, and to some extent the webinars has been very beneficial. Having Leigh, Steve, and Dan there was invaluable.

I heard several comments about the need for a third day, especially given the value of the summaries and explanatory presentations. Part of this was due to some not participating in the webinars.