PRBO Conservation Science and the California Coastal Conservancy

Scenario planning for climate change adaptation

A guidance for resource managers

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Goal of this guidance:

This document is intended to be a step-by-step guide to using scenarios to plan for climate change adaptation. The intended audience includes natural resource managers, planners, scientists and other stakeholders working at a local or regional scale to develop resource management approaches that take future possible climate change impacts and other important uncertainties into account.

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I. Introduction

I. A. What is scenario planning and when is it useful for climate change adaptation?

> *"Doubt is not pleasant, but certainty is absurd."*
> - Voltaire, Letter to Frederick II of Prussia (1767)

Scenario planning is a tool that embraces uncertainty rather than trying to reduce or eliminate it. It can help resource managers generate creative approaches to climate change adaptation, thinking outside the historical or most obvious trends to incorporate uncertainty as a factor in prioritizing management actions. Scenario planning can help managers identify the most uncertain and most worrisome drivers of change, and enable them to plan around them by putting them into a context of more known (or knowable) drivers.[1]

Natural resource managers often prepare for uncertainty by combining their own field experience with the best available science, or by simply soliciting expert opinion. These approaches may fail to incorporate important drivers which will likely change the manager's decision-making environment radically and unpredictably as a result of climate change. In some cases, the uncertainty associated with climate change may be so great that planning for it—much less taking action to respond to it—seems impossible. Scenario planning can help managers navigate through the potentially paralyzing uncertainties associated with adapting to climate change.

Scenario planning allows managers to envision a range of possible futures. These futures may be near-term and simple (e.g., What will we do if we get the highest projected rainfall in the spring? What if we get the lowest?), or they may be long-term and complex, addressing the interactions of highly uncertain drivers (e.g., What if over the next 50 years we consistently get the highest precipitation and the budget for flood management is cut in half?). All scenarios should take into account relatively well-known trends. There's no point in planning for known improbabilities, such as a volcano erupting and reversing the trend of global warming.

The different futures considered by managers should also ideally be greatly different, and should take into account the drivers that are most critical and most uncertain, such as when the direction of change is unknown. For drivers whose direction of change is known, consider whether their rate and magnitude of change are known. It may be useful to incorporate the driver as defined by its threshold values, such as sea level rising below or above the 3 m height of a levee. It can be helpful to resource managers to weight the drivers of management decisions by degree of importance and

[1] The words "factors," "trends," "forces," "variables," and "drivers of change" are used variously to indicate the same concept in the scenario planning literature. Here we use the term drivers of change, or drivers.

uncertainty and embrace the most critical and most uncertain drivers in planning. Uncertainties ("known unknowns"[2]) in climate change planning may include:

- The direction of change (e.g., Will precipitation increase or decrease?);
- The magnitude (e.g., How much will sea level rise?)
- The rate of change/ timing of impacts (e.g., How soon will we lose most or all our nights with hard freezes? At what time of year will we experience the most rainfall?);
- The interaction of drivers, including climatic and non-climatic environmental drivers, and others, such as socio-economic and technological drivers.

The military and business sectors pioneered scenario planning to prepare for important and plausible– though improbable– events, helping them navigate geopolitical situations such as the 1979 energy crisis and the 1991 collapse of the Soviet Union. Here we provide guidance for using scenario planning for climate change adaptation, to reduce harm from climate change impacts.

> ***Adaptation*** here refers to human efforts intended to reduce the damages or realize gains from opportunities that result from climate change (Agrawala and Fankhauser, 2008, p. 11). It does not refer to the process of evolutionary or biological adaptation in natural systems, or responses to market or welfare signals in human systems, sometimes called **passive** or **autonomous** adaptation (IPCC Fourth Assessment Report 2007).

Adaptation actions can apply to individual, group, or institutional systems, and can apply to both human and natural systems.[3] In the context of conservation, climate change adaptation will likely require natural resource managers to address other known (e.g., pollution) and emerging (e.g., land use change) stressors. It may also require managers to develop strategies that reduce current and future vulnerabilities by minimizing or eliminating greenhouse gas emissions (called *mitigation* in the climate change context).[4] Whatever the given planning goals, this guide is intended to help managers use scenario planning to increase the robustness of long-term management plans by taking into account climate change impacts and other highly uncertain drivers over which managers have no control (see table 1 below on the best context for the employment of scenarios).[5] Scenario planning can be used as a stand-alone brainstorming process, or, ideally, as part of an established planning processes (e.g., strategic plans, General Plans, stakeholder engagement process, or hazard mitigation plans). Ultimately, a successful scenario planning process can help planners work around high, irreducible levels of uncertainty

[2] Rumsfeld, 2002.
[3] Pielke, 1998, p. 159
[4] Many institutions in the U.S. have created plans for climate change *mitigation*–actions to reduce the level of greenhouse gases released into the atmosphere (i.e., reducing your "carbon footprint") to protect future generations. In this guide we are focusing mainly on nearer-term strategies to respond to nearer-term harm, though mitigation actions may be part of an adaptation strategy and vice versa.
[5] Peterson, G. D., G. S. Cumming, and S. R. Carpenter (2003). "Scenario planning: A tool for conservation in an uncertain world." Conservation Biology 17(2) (2003): 358–366.

about critical drivers. It also can benefit goals for gaining broad input on a plan, establishing threshold decision-making points, and producing a prioritized list of robust actions—or at least identifying actions that could increase vulnerability in a worst case scenario.

Another advantage of scenario planning is that supports the interaction of diverse participants (e.g., community stakeholders, political decision makers, resource managers, scientists, etc.) to develop a shared understanding of risks, trade-offs, and possible management actions. In scenario planning to prepare for climate change, the process of developing scenarios gives scientists the opportunity to clearly articulate the potential consequences of uncertain drivers in a manner that empowers decision makers, rather than leaving them paralyzed with no clear path of action.

Table 1. The best context for the use of scenario planning in resource management. (Adapted from Peterson et al., 2003, p. 365.)

	Critical drivers can be controlled	**Critical drivers can't be controlled**
High uncertainty about critical drivers	ADAPTIVE MANAGEMENT: Integrate experience with the best science and use adaptive management, monitoring results and changing plans accordingly as you go	SCENARIO PLANNING: Consider a range of plausible trends/future conditions in planning; question your assumptions to create the most robust plans
Low uncertainty about critical drivers	JUST DO IT: Here, you have optimum control, and your optimal choice for management is obvious, so there is no need to evaluate alternatives (*rare*)	TEST MULTIPLE TOOLS: Plan for the known probable conditions that are out of your control; hedge your bets by implementing a range of approaches

Scenario planning is a highly flexible approach. It can be used in a single-agency or multi-agency context, and can incorporate any level of expert input.[6] The approach can be incorporated at any level of planning with any time horizon. It can also be done at relatively low cost, particularly if an internal facilitator and free meeting space are available.

I.B. What are scenarios?

Scenarios are plausible futures that allow you to envision and evaluate the outcomes of potential decisions in the context of different sets of background conditions.[7] "Plausible" here means

[6] The use of expert input is often a part of scenario planning, but it should be noted that it is not necessarily required. For example, a relatively short-term internal team planning process might be aided by doing a scenario planning exercise to create a work plan around key uncertainties using only the working knowledge of team members (who, in this case, could be considered sufficiently expert). In any case, the use of expert knowledge should be done with consideration of what level of expert is needed and what amount of input would be most useful. The scenarios will sometimes need more heavy integration of specialist knowledge, sometimes less heavy integration, and the knowledge will sometimes need to be more in-depth, sometimes more general.

[7] The Intergovernmental Panel on Climate Change (IPCC) definition of scenario is a "plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Scenarios may be derived from projections, but are often based on

plausible to those engaged in the scenario planning exercise.[8] **Scenario planning is only as useful as the scenarios are plausible to the exercise participants.** Without buy-in to the scenarios, scenario planning becomes a mere exercise in imagination.
Plausibility is key to a meaningful process.

> "The great difference between classical forecasting techniques and the scenario technique becomes clear when so-called 'wild-cards' or 'disruptive events' are included in the scenario." (p. 228, Mietzner & Reger, 2005)

The use of scenarios has strengths and weaknesses. A strength of scenario planning is that it can incorporate multiple types of drivers and information. Using scenarios, managers can project the outcome of a set of relatively certain drivers—like sea level rise and increasing human demand on resources— interacting with relatively uncertain drivers— like rainfall declining or increasing (in addition to how much it will decline or increase), and the changing timing of rainfall or drought. Scenarios can take into account average projections and also extremes or critical improbabilities that would be highly disruptive to the decision-making environment. Both quantitative data, like projected population distribution, and qualitative information, like the projected change in a community's belief in climate change as a political and economic priority, can be incorporated into scenarios. Scenario planning can also be used to consider futures at any planning horizon, both near and long term,[9] and can be used to engage any level of decision maker in a planning process, from a local community member to your top elected official.

Scenarios are not always useful, however. If you are creating a plan that does not involve deep uncertainty about critical drivers, or the uncertain drivers are relatively under control, scenarios are not likely to contribute much to your planning process (see Figure 1 for some alternatives to scenario planning under different levels of uncertainty and control). You will get more out of scenario planning if, for example, you do not know the direction or degree of change of your critical uncertainties and they are completely out of your control. For example, the decision to repair a water main after it bursts does not involve deep uncertainties which are out of control.

Planning with scenarios has weaknesses in other circumstances. Some of the challenges in using scenarios include:

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additional information from other sources, sometimes combined with a narrative storyline" (IPCC 2008). Within the context of IPCC assessment reports, scenarios describe narratives built on scientific assumptions about future greenhouse gas emissions levels given different assumptions about demographics, economics, and technological innovations (NPS 2007).

[8] A note on who should be enlisted in a scenario planning process: the people included in a scenario planning exercise should vary depending on the goal of your exercise. The philosophy behind scenario planning is that a diversity of voices adds to the well-roundedness and therefore usefulness of scenarios, since participants are asked to examine and suspend *a priori* assumptions, and a homogeneous group of people are likely to bring similar assumptions to the table. See section II.a.2. for more details.

[9] A note regarding planning horizons: your planning horizon should be made explicit at the outset of your exercise. Some drivers will be relatively certain in the near term and completely uncertain in the long term. For example, the variation in the date of the last freeze of winter might be relatively certain in a near-term (5-year) plan, but it may become a highly critical uncertainty in a long-term (50-year) plan. See II.c.1 for more on selecting a planning horizon.

- Blind spots: it is hard to identify and address all the presumptions on which projected trends are predicated, so you could easily miss a critical uncertainty
- The complexity of drivers: it is sometimes hard to develop meaningful axes on which to plot your scenarios (e.g., decreasing rain and increasing rain are easy to plot on an axis, but not the shifting trends in types and severity of storms)
- The "rabbit hole" of interactions: trying to project the future by interacting certainties and uncertainties is difficult enough, but once you start multiplying those interactions with other second-order uncertainties, your planning process can drift away from the most relevant uncertain and certain trends. (Good facilitation should help with this issue.)
- Creating sufficiently different scenarios: it can be hard to create scenarios that are structurally different and not just variations on a theme. The scenarios should be mutually exclusive along the critical variables. However, they should be more complex than just two mutually exclusive black and white scenarios (e.g., best case and worst case) to provide a variety of testing grounds for possible management actions.
- Time: the usefulness of scenario planning is partly contingent on sufficient time being spent on the exercise, and, depending on your context, it may be time-consuming. There may be a strong push to condense the scenario-building stage to a half-day or one day activity; this may work for a pilot run, but in a serious engagement of the tool this may not give participants enough time to create scenarios that take into account expert input, incorporate all critical drivers, and are plausible and relevant to all participants. After building the scenarios, sufficient time must then be allowed for discussing the effectiveness of management options within the scenarios. Two or three days may be needed for a sufficiently relevant and useful scenario planning exercise, and key decision makers may not be able to commit to the exercise for that full time. In the end, trade-offs to accommodate people's schedules may be necessary, decreasing the usefulness of the exercise.
- Evaluation: it is hard, or maybe even impossible, to measure the effectiveness of scenario planning.[10]

Before continuing on to the process of scenario planning, it should be clarified that this guide assumes the reader has a basic familiarity with the concepts of climate change adaptation. See Appendix A for a glossary of terms.

I.C. Sources and Acknowledgments

The scenario planning process described below is based on a few national and local efforts to use scenarios for climate change adaptation. The main source for the overall understanding of scenarios and structure of the planning exercise comes from the Global Business Network (GBN/Monitor) consulting firm, as well as a seminal book about using scenarios for planning around high uncertainty written by one of the co-founders of the Global Business Network, *The Art of the Long*

[10] See a suggested list of criteria for effective scenarios in Mietzner and Reger, 2005 (based on Heinecke and Schwager, 1995). Criteria include clarity, plausibility, thoroughness of information, relevance, and dissimilarity.

View (Schwartz, 1991).[11] The main sources used here for the application of the scenario planning tool to natural resource management under climate change are the early scenario planning work of the National Park Service Climate Change Response Program (NPS CCRP) (2007-2010), which adopted the Global Business Network approach from the business context to a park management context, and the experience of organizing the Futures of Wild Marin scenario planning workshop (2011),[12] which adopted the NPS CCRP approach to a multi-agency resource management context. Both employed the help of a senior practitioner from the Global Business Network.[13]

The main innovation of the NPS CCRP was adding the involvement of climate experts to help plan for natural resource management in National Parks. While the scenario planning tool can be used for climate change planning without preliminary climate research, the CCRP strives to assemble the most current projections for climate change for a given National Park unit and incorporate it into that park's scenario planning process.

Inspired by this innovation, the Futures of Wild Marin workshop was developed (led by two California-based scientists[14]) to pilot the CCRP approach to scenario planning in a multi-agency context involving public agencies and private non-profits working in a geographic cluster of local, state, and national protected areas. The results are described in its component white paper in the California Climate Vulnerability Assessment (published 2012).[15,16]

In the following guidance we hope to build on these planning exercises to create a "how to" for managers, making the scenario planning tool accessible for a range of planning contexts.

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[11] Schwartz, Peter (1991). The Art of the Long View: Planning for the Future in an Uncertain World. New York: Doubleday.

[12] The Futures of Wild Marin workshop was a one-day workshop for managers and scientists working in the protected areas of western Marin County (just north of the Golden Gate Bridge in the San Francisco Bay Area), California, held January 28, 2011.

[13] The GBN/Monitor senior practitioner hired as a facilitator by the NPS CCRP and Futures of Wild Marin was Jonathan Star. Read his profile here (accessed December 11, 2012): http://gbn.com/people/peopledetail.php?id=163

[14] The principal investigators of the study were Erika Zavaleta, Associate Professor of Environmental Studies at UC Santa Cruz, and Rebecca Shaw, then Director of Conservation at the Nature Conservancy – California, later Associate Vice President for Land, Water & Wildlife at the Environmental Defense Fund. Sara S. Moore, one of the authors of this guidance, coordinated the project under their supervision.

[15] Read the 2012 California State Vulnerability and Adaptation Study, also called the "Third Assessment," comprising 35 white papers (accessed December 11, 2012): http://www.climatechange.ca.gov/adaptation/third_assessment/

[16] Read the 2012 white paper on which the present guidance was partially based, Decision-Making Under Uncertainty: An Assessment of Adaptation Strategies and Scenario Development for Resource Managers (accessed December 11, 2012): http://www.energy.ca.gov/2012publications/CEC-500-2012-027/CEC-500-2012-027.pdf

II. Step-by-step how to: scenario planning for climate change adaptation in a resource management context

Below are described the suggested steps to developing and implementing a scenario planning process to plan for natural resource management under climate change. While these steps all relate to or build upon the NPS CCRP exercises or the 2011 Futures of Wild Marin exercise, it should be noted that not all steps will apply or be equally valid for every process. A scenario planning process for resource management in a changing climate can be broken down into the following steps:

A. *Set-up and Logistics:*
   1. Define geographic scope, and overarching planning goal/workshop[17] goal
   2. Identify ideal participants and group size
   3. Identify venue and facilitators

B. *Preparing for the workshop:*
   1. Assemble data and develop a brief profile of climate change projections and impacts for the target area, highlighting what projections are most uncertain under what conditions, to provide background and support discussions
   2. Circulate this profile and other important background information in advance to generate a shared understanding of the climatic and other drivers of change

C. *At the workshop:*
   1. Identify shared adaptation goals, relevant planning horizon(s), and definition of adaptation
   2. Brainstorm the most important drivers of change in resource management decisions
   3. Rank drivers by their relative uncertainty and importance to management decisions
   4. Define scenarios based on top two or three most uncertain/important drivers
   5. Describe and name the scenarios
   6. Identify top management actions for the futures of concern (robust to multiple futures/addressing worst impacts)
   7. Identify next steps

D. *After the workshop:*
   1. Identify opportunities to refine the scenarios based on new evidence
   2. Plan to address data gaps

Each of these is explored in greater detail below.

[17] The workshop format is being suggested here, but the scenario planning tool can also be deployed through a series of webinars, meetings, or other formats.

II.A. Set-up and logistics

II.A.1. Define your geographic scope and overarching goals

The geographic area for your scenario planning exercise may be predetermined by the mission of your organization, or you may have the flexibility to think about the optimal size of your area of analysis. Scenario planning for resource management under climate change may be relevant at a wide range of geographical scales. While the Futures of Wild Marin exercise focused on the coastal protected areas of one county, it was suggested by participants that the exercise would likely be useful even at the smallest management scale (e.g., one segment of one creek), while it would be limited on the other end of the scale by the number of management agencies involved (e.g., depending on the goals of the workshop, a county might be the largest scale possible). Workshops with narrower management goals, such as a focus on just one species or taxa, such as salmonids, one resource, such as fire, or one ecosystem service, such as clean water supply, might benefit from a larger, bioregional scale of analysis.

After defining your geographic scale, you should identify your overarching goals for planning and for the workshop. If scenario planning is being used within the framework of a formal planning process, review the goal of that process, then devise the relevant goal of the scenario planning exercise (e.g., how it will inform that formal planning process). Do you need to come up with a concrete set of actions to which funding and deadlines will be attached? Is this just a thought-exercise with no particular product expected? Your prospective participants will want to know.

II.A.2. Identify your ideal participants and group size

When creating your participant list for the scenario planning exercise, start by making your "dream team" list. Think about the overarching goal for your exercise. Think outside your comfort zone.

The people included in a scenario planning exercise should vary depending on the goal of the planning exercise. The philosophy behind scenario planning is that a diversity of voices adds to the well-roundedness and therefore usefulness of scenarios. Utilizing existing teams, tapping existing colleague networks, and reaching out to influential political leaders and groups traditionally underrepresented in natural resource planning processes (including front-line staff, tribal groups, and the tourism sector) are some of the approaches that might be used to assemble scenario planning workshop participants.

In some cases, scenario planning may be implemented by a preexisting team to develop a plan, helping the team examine their presumptions in dealing with familiar problems. Using scenarios in the context of a preexisting team has the benefit of allowing for a streamlined process: participants should be able to identify the most critical uncertainties more quickly, given the probability that participants have shared ideas of the current science, management priorities, and other characteristics that make for easier communication and priority-setting. The trade-off is that a preexisting team with similar ideas about management and prioritization is less likely to develop novel approaches, and is more likely to revert to prioritizing actions within their shared areas of competence. However, scenarios can be a useful tool in any group (however homogeneous) for

overcoming the paralysis caused by the enormity of uncertainty around climate change, building a common understanding about potential climate impacts and prioritizing the response actions that address the most critical uncertainties.

For contexts without a preexisting team, scenario planning may present an opportunity to bring together people with divergent perspectives, such as people representing different disciplines, public and private sectors, levels of authority, and organizations with divergent and even competing missions. If a particular kind of diversity is your goal, establish criteria to help you assemble your ideal set of participants (e.g., minimum 50% women, minimum 1/3 local government representatives, at least one member of a tribal nation, no more than 20% academic institution representatives, etc.). When you are ready to send out your invitations, have an A list and a B list (to invite if the A-list invitee is unavailable) designed around your criteria to help make sure that different categories of participants are adequately represented.

The Futures of Wild Marin showcased the value of scenario planning in addressing an uncertain and climate changed future across a large geographic scale and multiple stakeholders. By tailoring this approach to a one day workshop, a range of interests were able to participate and new alliances were forged across traditional agency boundaries to more effectively address climate change and extreme event impacts on both the natural and built environments. We need more of these types of workshops to break down traditional barriers to communication and action.

- *Futures of Wild Marin workshop participant Ellie Cohen, Executive Director, PRBO Conservation Science, on the value of the multi-agency approach*

The organizers of the five scenario planning workshops across NPS units in Alaska recommend including as diverse a set of perspectives as logistically feasible.[18] They cited the more diverse workshops, with the highest participation of local Native Alaskan tribal representatives and park interpreters, as the most workshops which produced the more engaging scenarios.[19] One of the organizers, Nancy Fresco of the Scenarios Network for Alaska and Arctic Planning (SNAP),[20] emphasized that the ingredients that make for a successful scenario planning process include making it as participatory as possible and having representation from the full diversity of

[18] Based on personal conversations with Robert Winfree, Science Advisor, NPS Alaska Regional Office, Nancy Fresco, Scenarios Network for Alaska and Arctic Planning (SNAP) Coordinator/ Research Faculty at University of Alaska at Fairbanks, and Jeff Mow, Acting Superintendent at Denali National Park and Preserve (December 2012). Read more about the Alaska NPS scenario planning workshops in section III.a.2.

[19] The reason why these workshops were noted as the most engaging is because Native Alaskans and park interpreters bring good storytelling skills to the table, helping make the scenarios compelling and accessible, according to Jeff Mow of Denali National Park and Preserve (personal conversation, December 2012). Native Alaskan tribal representatives were paid honorariums for their participation whenever possible, and often had challenging travel logistics, which the NPS facilitated, so their participation required budgeting and advanced planning more than other participants, but their input was also highly valued.

[20] Learn more about the Scenarios Network for Alaska and Arctic Planning (SNAP) here (accessed February 25, 2013): http://www.snap.uaf.edu/

stakeholders. Their workshop planning process involved careful advance planning of participation, with one organizer, Bob Winfree of the NPS Alaska Regional Office, reporting that he was planning the invitee list two years before the workshops. His goal was having all the major disciplines in the parks (natural, cultural, concessions, etc.) represented, as well as representatives of other governmental and non-governmental sectors including tourism, fishing communities, fire, local residents (represented by borough managers) and trail guides. In the NPS Alaska scenario planning workshops, diversity of participation was emphasized; a less well-funded process might need to be less ambitious, but should still consider the trade-offs of limiting invitees to a preexisting team. As noted above, with a greater diversity of perspectives in the room, there's a greater probability of developing a truly innovative approach.

One way to assemble a diverse team is to use a snowball technique, in which a priority group of prospective participants (the workshop's "dream team") recommends colleagues based on the workshop's diversity goals. In this way, organizers can get an introduction to those with whom they might have few opportunities to work previously. In the case of the Futures of Wild Marin, the snowball technique led to a group of participants who were typically senior scientists or planners interested in interdisciplinary planning, proactively seeking information about climate change, and representing public and private organizations with different management goals.[21] In this example, people recommended colleagues of similar rank, a potential drawback. Futures of Wild Marin participants recommended that future workshops include elected officials and other administrative leaders (i.e., those grappling with the general public, including climate skeptics). Depending on your goals, also consider inviting front-line lower-ranked people, such as seasonal employees and long-time volunteers.

As soon as your participants are lined up, you should send them a description of the goals of your workshop and a synopsis of scenario planning. For an example, see Appendix B, the introduction letter sent to participants attending the Futures of Wild Marin Workshop eight weeks in advance of the workshop.

II.A.2.i. What is the ideal group size?

The Global Business Network approach dictates that scenario planning workshops should ideally be limited to a maximum of 20 individuals.[22] However, if you have diversity goals, a 20-person limit may not allow for sufficient representation across disciplines, stakeholders, agencies, and other constituencies. To meet your goals, a larger group may need to be assembled; with larger numbers of participants, more time should be allowed for small-group discussions. Assembling 40 or more participants should be avoided as it is logistically unwieldy, but if enough resources are provided (sufficient time, facilitation support and break-out opportunities), it could theoretically be managed.

[21] The criteria for Futures of Wild Marin workshop invitees were that they worked presently or previously in the case study site; were involved in long-term planning within their agency or organization; consumed or produced climate change data for decision-making; and were available to participate in the workshop.
[22] This is the recommendation of the Global Business Network facilitators and NPS CCRP organizers.

II.A.3. Identify your venue and facilitator(s)

Your venue should allow participants to take a break from daily pressures. The process of discussing scenarios requires participants to step outside their routine and think very long term, questioning their assumptions about the future. Ideally, scenario development exercises should take place somewhere conducive to the imagination.

Regarding facilitation, ideally, you should hire a facilitator or facilitators (for a larger group) with experience using scenarios to plan. If that is not an option, minimally your facilitator should have experience helping people question their assumptions and create narratives. Your facilitator needs to help your participants imagine and describe plausible futures in tangible, relevant ways.

In the case of the Futures of Wild Marin, the organizers were able to hire the same facilitator used by the NPS CCRP, someone experienced in building scenarios and working with resource managers to talk about climate change. This combination is rare. If a trade-off has to be made, it should be done with a mind to the circumstances of your planning process, which may entail technical resource management conversations (where resource management experience might be more useful), or may be a more general visioning process (where scenario planning experience might be more useful). In any case, if resources allow, it is highly recommended that scenario planning workshop organizers hire a professional facilitator.[23]

Scenario planning workshop organizers should allow at least three months for the venue and facilitation arrangements. This process took approximately eight weeks for the Futures of Wild Marin workshop. Finalizing the contracts for both took an additional four to six weeks.

Figure 1. The main steps and timeline for the development of the Futures of Wild Marin Workshop, August 2010-January 2011.

[23] Jeff Mow, Acting Superintendent at Denali NPP, organizer of approximately 12 scenario planning workshops through the NPS CCRP, recommends that if workshop organizers have to cut back on venue costs, length of workshop, or facilitation, they should cut back on the other items before facilitation (personal conversation, December 2012). In particular, Mow suggests a good facilitator is necessary for helping participants understand the uncertainties at play in the planning process, including defining critical thresholds for different drivers (if necessary). A good facilitator should be able to help participants use uncertainties to develop rich, resonant and strongly divergent futures.

II.B. Preparing for the workshop

II.B.1. Assemble data and develop a brief profile of climate change projections/impacts for the target area to provide background and support discussions

For the next step you will need to identify and collect the best available information about current and projected climate change vulnerabilities and other relevant information about your area of focus. Be as spatially explicit as possible. Indicate where projections are relatively certain or uncertain. For example, your participants will want to know that the projections for precipitation and temperature are relatively certain in *x* inland landscape, but relatively unknown in *y* coastal landscape.

At this stage you need to decide what kind of expert input you need and how in-depth it should be (and what quality of information you want to incorporate, e.g., whether you want to include theoretical science, findings from gray literature, unpublished findings, etc.). The goal of this step is to assemble information to understand where the highest uncertainty lies to help create useful and thought-provoking scenarios.

There are a range of opinions in the scenario planning world about the extent to which you should incorporate scientific information into the development of scenarios. Leigh Welling, the head of the NPS CCRP, who pioneered the use of scenarios for climate change planning in parks, describes scenarios as being, ideally, informed by science but driven by ideas (i.e., not too heavily oriented on scientific projections).[24] On the other hand, one must take into account the participants' appetite for science, which may call for a pre-workshop webinar or other teaching event to give participants a sufficiently thorough and scientific description of projected climate trends and other important drivers which may concern participants.[25] It may fall to workshop organizers to arbitrarily decide what is "good enough" in terms of depth of information, or limitations on this stage may be purely financial or logistical. In any case, organizers should try to set a goal for the minimum amount of information all participants should have in advance of deciding what drivers should define the scenarios.

Those who work in the environmental science fields have alternately recommended the following regarding the use of science in scenario planning:

- **Don't fixate on science:** incorporate scientific input, but do not allow discussions to become stalled because of the nascent state of the science with regard to climate impacts; the science of climate change is far too uncertain to allow it to hold up planning processes pending greater certainty; in some cases, participants' best guesses based on management experience may be as valid or more valid than the divergent, uncertain scientific projections that are available;

[24] Personal conversation with NPS Climate Change Response Program Manager Leigh Welling (October 2010).
[25] Other non-climatic trends can be identified by informal or formal survey methods to identify the top management concerns of workshop participants.

- **Don't ignore science:** if at all feasible, frame your scenarios based on scientific projections (don't ignore existing data related to critical drivers), but be sure participants are on board with the extent to which science is included (not too much, not too little); and,
- **Emphasize science:** science should be important to the planning process; incorporate data and make sure they are as spatially explicit as possible; where lacking, the scenario planning process should be used to build participants' capacity to understand climate science; the management actions coming out of the planning process may not be credible without a scientific underpinning.

These positions are not mutually exclusive, and, depending on the participants' appetite for science and workshop resources, all three recommendations could be addressed.

Given the potential expense and time required for assembling evidence to prepare your workshop participants, at least four months before the workshop organizers should answer these questions:

- How important is this information to our process (how *science-informed* do we want our process to be)?
- How much time and money can we afford to spend on assembling evidence, given its importance?
- What peer-reviewed or otherwise validated information may be readily available?
- How good is *good enough* in terms of depth of information? What will participants need in order to feel sufficiently informed about climatic drivers and other drivers which are critical to building plausible scenarios (and how can we share this information in a way that isn't overwhelming)?
- What is going to be done with the information we gather? Will it need to be interpreted for use by stakeholders? What do we hope they will do with the discussions that the information starts? Will distribution of the information require follow-up (e.g., webinars to help interpret the information)?

Your answers to these questions can guide your process.

Depending on the geographic scope and workshop goals, this stage may or may not be time and resource intensive. In some places there will be more data available to incorporate, so more research may be warranted to identify the relative uncertainties in the data. In other places there may not be any climate projections available at a finer than global scale, and research will be a simple matter. Also, depending on the resource management targets, there may be many uncertain climate drivers which need to be explored, and in others there may be fewer. Additionally, it may help participants to have information on other uncertain trends which would affect management decisions (e.g., trends in building new reservoirs versus removing dams, land use management trends, demographic trends).

This stage may take several months, and may require contracting the services of a climate science lab. Depending on the degree to which you want to incorporate scientific or other expert input, you may want to have information lined up for your participants on:

- Global data: the latest historical evidence and projections for global climate change (e.g., temperature and sea level rise, including past and projected rates of change);
- Local data: available historical evidence and projections (downscaled) for climate impacts in your region of focus;[26]
- Any available vulnerability assessments;
- Important political and socio-economic trends which may be critical to your planning process (e.g., economic growth trends, demographic trends, societal belief in climate change as a problem, social value of natural recreation areas, policy leverage points, etc.);
- Technological and land use trends that might affect resource management decisions.[27]

A note on the importance of vulnerability assessments: climate change projections alone do not reveal the vulnerabilities of a management target (e.g., natural system or human community). Where available, workshop organizers should incorporate the findings of climate change vulnerability assessments. These combine information on the location of impacts (exposure), the expected severity of impacts and how management targets might be differently affected (sensitivity), and capacity to adapt (a management target's ability to take advantage of positive change and avoid or minimize damage). Many helpful resources are available on the subject of climate change vulnerability assessments.[28]

It is foreseeable that you may find yourself working with people skeptical about climate change science. This happened in one adaptation planning process led by the Nooksack Salmon Enhancement Association (N-SEA) in Bellingham, Washington. This organization was working on an adaptation plan for their city (not a scenario planning process) with the support of Climate Solutions University (CSU), a climate adaptation planning organization that supports communities who are dependent on natural resources to create local adaptation plans.[29] CSU's usual practice is to help client communities contract with a local university to develop a local climate report to inform their planning process. N-SEA established a relationship with the Climate Impacts Group at the University

[26] Climate impact projections at a sub-global scale are often done using *downscaling* techniques, where scientists use statistical or dynamic models to bring the results of Global Climate Model projections down to a finer scale in order to get a sense of the future climate for a region. For a brief explanation of downscaling techniques, see the Southwest Climate Change Network website (Lenart 2008; accessed December 12, 2012): http://www.southwestclimatechange.org/climate/modeling/downscaling

[27] Scenario planners in the business world look at five categories of forces and trends: environmental, economic, political, social, and technological (Ogilvy and Schwartz, 1998).

[28] A useful publication on this matter is Glick, Stein & Edelson (2011), Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment, published by the National Wildlife Federation, accessible here (as of May 27, 2013): http://www.habitat.noaa.gov/pdf/scanning_the_conservation_horizon.pdf.

[29] Read more about Climate Solutions University (accessed December 12, 2012): http://www.mfpp.org/csu/

of Washington, which produced projections and maps to help them plan.[30] Presented with the Climate Impacts Group's report, the community members found the level of uncertainty in the projections unacceptable: they were only comfortable planning according to the available historical evidence of climatic trends. Just so, in a scenario planning process, it may be necessary to discard some climate projections in order to create scenarios that are plausible to all participants.

In any case, when incorporating scientific input, participants should be made aware of all qualifications to climate projections and their purpose as background "picture painting"—not weather forecasting. Also, whatever data you incorporate into your exercise, keep in mind that scenarios are not intended to be built and used once, but "reality tested" and refined based on new evidence. If you miss an important climate report or economic trend analysis the first time, you should be able to circle back and incorporate new findings the next time you refine your scenarios.

II.B.2. Circulate the climate profile and background information to generate a shared understanding of drivers of change

It is important to not assume your participants are all on the same page regarding the critical background information for the uncertainties your scenarios will address. After assembling the data that are likely to be relevant to your scenarios, you need to determine:

- How much time can the participants commit to studying this information?
- Given participants' time constraints, what is the best format for sharing this information (e.g., just sharing reports and trusting people to read them, or setting aside time to discuss reports, or setting up an opportunity to converse with the authoring scientists)?
- How can you make the information available in a format that is accessible to the most participants (in terms of technology required, level of jargon, presumed background in the issues, etc.)?
- How far in advance should you make the material available? Will you need to present it in stages?
- What basic things are minimally necessary for participants to know? (How can you deliver enough information without overwhelming people with reading and webinars?)

The time necessary to review and discuss materials will vary depending on your context. Participants will likely require at least a few weeks to read and discuss the information in order to be able to assign relative certainty and relative importance to the drivers described.

Ask for feedback: was any critical information left out of the profile? Were participants' greatest concerns about climate change and other uncertainties in the target area addressed? Refine the profile if necessary.

It may be helpful to hold a webinar, or series of webinars, or use other information-sharing tools to get participants on the same page in advance of the workshop.

[30] Personal conversation with the adaptation project coordinator Lindsey Taylor at the Nooksack Salmon Enhancement Association (April 2011).

In the Futures of Wild Marin workshop, the climate change impact information was circulated ten weeks before the workshop. Information was provided in the form a summary of impacts from six scientific reports on climate change impacts for the geographic area of focus either published within the preceding year or in press at the time of the workshop.[31] No information was provided on non-climatic trends. In the evaluation of the workshop, participants evidenced a wish for a pre-workshop webinar to help orient them on the climate change "certainties" (e.g., temperature and sea level rise), to give them a clearer understanding of the backdrop against which the uncertainties would be playing out. Also, they wished to have an opportunity to ask the authors of the source reports about the qualifications on the climate projections and get more in-depth information on important trends, such as the evidence of change in the upwelling regime off the coast.

The NPS CCRP has taken different approaches to incorporating scientific input. In its early scenario planning exercises it recruited climate scientists to help workshop participants interpret (e.g., via a webinar) downscaled climate model outputs to identify and describe the most important climatic drivers of change in the region of focus. Ten to fifteen variables, including climatic drivers (e.g., temperature, precipitation) and climate-driven environmental drivers (e.g., storm intensity, sea level rise), were usually considered.[32] As noted above, the CCRP manager believes science has an important role, but it is not the single most important thing defining the scenarios. For an idea of the kinds of drivers examined in the CCRP approach, see tables 1a-1c, Drivers of External Change for Joshua Tree National Park, listing drivers related to climate change, budget, and national park value, appended to the 2007 report on their pilot scenario planning exercise (NPS 2007, ps. 13-20).[33] See Appendix C for an excerpt from the Joshua Tree climate change drivers summary alongside an excerpt from the Futures of Wild Marin summary of drivers.

The table lists drivers under these headings:

- Description of driver (Process or event?)
- General direction of change expected
- Specific change expected, reference period
- Size of change expected (compared to recent changes)
- Expected patterns of change (e.g., when is it expected to be greater) – seasonality of change

[31] The reports circulated in advance of the Futures of Wild Marin Workshop consisted of the following: Al and Lorrie Flint (2010). USGS climate projections (PRISM climate layers downscaled to 270 m); Lisa Micheli, the Flints, et al. (in prep. 2011), North Bay Watershed hydrological projections; Will Cornwell, et al. (in prep. 2011). Vegetation projections. UC Berkeley; John Largier, B.S. Cheng, and K.D. Higgason, eds. (2010). Climate Change Impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries. Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils.
James Johnstone and Todd Dawson (2010). Context and ecological implications of summer fog decline in the coast redwood region. PNAS.

[32] Personal conversations with NPS Climate Change Response Program manager Leigh Welling (Climate Change Response Manager) and staff member Matt Rose (Natural Resource Specialist) in October 2010 and August 2011 (Matt Rose).

[33] See the summary report for the Joshua Tree NP scenario planning workshop here (accessed February 25, 2013): http://firecenter.umt.edu/files/documents/JOTR-KAHO%20Climate%20Change%20Scenario%20Planning%20Workshop_Summary.pdf

- Confidence
- Source/ Context

The better participants understand these dimensions of your drivers, the more fluently they will be able to envision their interactions and discuss management responses.

Some part of this educational process may need to be curtailed, or the process may need to be spread out over a long period of time. Particularly if you are working with many different stakeholders, these steps may need to be carried out in small groups over many months before the full group can come together to discuss the final scenarios.

You may want to explicitly lay out your assumptions about participants' basic knowledge about the critical drivers in play and devise a method to test them prior to the scenario planning exercise, such as with an on-line survey. You can then address gaps in people's knowledge in advance of the exercise by means of webinars, question-and-answer sessions with experts, briefings, or other educational tools.

Whether with a pre-workshop webinar, or other information delivery device, the science that informs your climatic scenarios should be seen as valid by participants, even if they do not fully grasp the process by which it is devised. Being given a chance to ask climate scientists questions about their findings directly may help participants understand the level of uncertainty inherent in climate models. It may also help participants understand the upper and lower bounds on key uncertainties, by which one could rank some uncertainties as more uncertain (e.g., projected temperature range may be narrower than precipitation amount range). Also, it may help to know the outside bounds in changes in timing of seasonal events (e.g., thaws, rain, crops ripening). If it is clear that particular climate change impacts are on the minds of workshop participants, workshop organizers can ask for additional input from climate scientists to address those impacts in detail.

One approach is to use a pre-workshop discussion to identify the climate drivers that resource managers are most concerned about, and then identify a climate scientist who can give a presentation at the workshop on the current state of knowledge about those climate drivers.

Keep in mind, you may want to frame climate change projections differently depending on your participants. Nancy Franco of the Scenario Planning Network for Alaska and Arctic Planning notes that the scenario planning participants in the NPS Alaska workshops chiefly wanted to know—bottom line—how will climate change affect their communities: so, to communicate effectively about the science of climate change, data was framed in terms of community impact.

II.C. At the workshop

The steps described below ideally should be done collectively with all participants in the scenario planning exercise. If you are time-constrained, some of the steps below may need to be done in advance. In that case, try to ensure maximum participation in those advance steps, whether they are completed through conference calls, meetings, or collaborative document development (using tools such as Box, DropBox, GoogleDocs, and so forth).

Remember, the usefulness of scenarios is contingent on them being plausible to participants. The scenarios will be more plausible to those who define them. Therefore, try to incorporate as many workshop participants as possible in the selection of scenario-defining drivers. Participants discussing scenarios that are plausible to all will generate more tangible management responses than a room where half the participants are not fully engaged, preoccupied with doubts about the scenarios.

In the Futures of Wild Marin workshop, full buy-in to the scenarios from all participants was hampered by the fact that a subgroup of participants selected the drivers defining the scenarios. In addition to defining the scenarios, this subgroup, called the scenario development team (consisting of ten people who were available to participate in preliminary meetings), defined the goals for the workshop, the goals for adaptation for the purposes of the workshop, and the workshop's planning horizon. These steps were completed via three one-hour conference calls one month apart over the three months before the workshop. If workshop participation had been limited to those who participated in the preliminary conference calls, both the resulting scenarios and management recommendations may have been more refined; however, the exercise would have reached far fewer types of resource managers in fewer organizations. As already noted above, practical considerations when trying to meet diversity goals may lead to making trade-offs such as these.

II.C.1. Identify shared goals, planning horizon(s), and definition of adaptation for the purpose of the workshop

At the beginning of your workshop planning process, you defined an overarching planning goal, a workshop goal, and the geographic scope for your exercise. Now, at the outset of the workshop, participants should affirm the planning goal and workshop goal, and review the geographic scope. Further, the participants should affirm whatever was suggested through preliminary planning meetings regarding:

- A planning horizon or horizons for the workshop; and,
- A definition of adaptation, including a few shared goals for adaptation, if only for the purposes of the workshop.

This may be a very simple discussion. Your overarching planning goal may determine your workshop goal, planning horizon, and adaptation definition, such as if the scenario exercise is being employed within a decision-making process with commitments of funding and deadlines (e.g., the decision of when to upgrade a sea port based on sea level rise projections). The narrower the planning decision at stake, the more these will be predetermined. The broader the decision at stake (e.g., "How can we respond to climate change to facilitate healthy ecosystem transitions?"), the more time you will want to allow to discuss and affirm the goals, planning horizon, and

The Futures of Wild Marin workshop goal:

To use scenarios to determine action steps for multiple, plausible climate futures and for different adaptation goals, and to identify:

A common vision for what good adaptation is; Who is doing what (in terms of adaptation planning); Resources available to support adaptation planning; What's needed for a comprehensive regional adaptation plan; Ways to network as we go forward.

adaptation definition at the start of the workshop.

As stated earlier, scenario planning can be used for a wide range of purposes. The workshop goal could be as simple as a completing thought exercise with a diverse group of participants to improve group understanding about climate impacts, or it could be aimed at determining actual actions to take given a specific circumstance.

The planning horizon should be defined with the workshop goals in mind: if the exercise is informing a particular planning process, such as for a 50-year General Plan, that planning horizon should be addressed. There can also be multiple planning horizons to account for different concerns (e.g., the two-year political cycle, the 50-year General Plan, and 100-year sea level rise projections). Whatever the horizons, they should be salient and useful. The scenario development team defined the planning horizon for the workshop in three time periods, taking into account their organization's planning horizons (official and actual) and the longer-term horizon of projections of temperature and sea level rise, as twenty, fifty and one hundred years. This gave participants a near-term, mid-term, and long-term horizon against which to consider impacts and management responses.

The workshop's definition of adaptation should give participants a working definition of success for adaptation actions. For example, adaptation success might be to provide sufficient drinking water supply for a particular community, or to make the community maximally energy-efficient. For a broader definition, success could be to avoid or reduce damage from climate change impacts on natural and human systems.[34]

The Futures of Wild Marin definition of adaptation:

Climate change adaptation should maintain key ecosystem functions (to provide the benefits of nature to human populations), facilitate a gentler transition under climate change, based on natural systems, and maintain bioregional native biodiversity.

The discussion of a shared adaptation definition will likely require participants to clearly their shared understanding of key concepts. In the Futures of Wild Marin case, there was a question about how to define biodiversity within the definition. One definition offered was evolutionary lineages. The response from one resource manager was that, for the sake of maintaining the function of a landscape, evolutionary lineages may need to be sacrificed. The conflicting beliefs of what constitutes "biodiverse enough" were left aside at this point, but certainly would bear further discussion if the management plan produced by this scenario planning exercise were to be brought into reality. Your participants may choose to articulate their adaptation definition in lesser or greater detail.

[34] This broader definition could be interpreted to include adaptation actions for future generations, a *mitigation* approach: minimizing or eliminating greenhouse gas emissions in the community, and taking action to stop greenhouse gas-generating activities around the world. A "climate smart conservation" approach addresses both near-term climate impacts and greenhouse gas emissions reduction strategies to reduce long-term damage (see Appendix A for a definition of the term "climate smart conservation.")

II.C.2 Brainstorm the most important drivers of change in resource management decisions, both climatic and non-climatic

In the process of planning the Futures of Wild Marin, the Global Business Network (GBN) facilitator asked us, "What would you want to ask the person doing your job in 2050?" And, "What would put you in a totally different decision-making environment?" These are good questions to start a brainstorming process to generate a list of drivers of change that are critical to your participants' resource management decisions.

At this stage a summary of trends and drivers of change based on scientific input and other research should be on hand to prompt participants with information on relevant climatic/environmental, societal, political, technological, and economic drivers. Any driver that constrains or enables action could be a scenario-defining driver, including staffing and funding levels.

In the Futures of Wild Marin workshop, the summary of trends and drivers included information (where available) on the following to help participants think about what would put them in a different decision-making environment.

Table 2. A sample of the drivers of change considered in preliminary research for the Futures of Wild Marin scenario planning exercise.

Driver of Change	**Type**
Sea Level Change	Environmental Process[35]
Air Temperature	Climate process
Sea Surface Temperature	Climate process
Precipitation	Climate process
Runoff	Environmental process
Relative Humidity	Climate process
Wind Speed	Climate process
Sea pH	Environmental process
Sea upwelling / upwelling winds	Environmental process
Fog	Climate process
Waves (driven by wind, distant storms, sea surface temp)	Environmental process
Estuarine circulation	Environmental process
Extreme Temperature	Climate event
Extreme Precipitation	Climate event
Extreme Storms	Climate event
Extreme Wind	Climate event
Land use changes	Other environmental driver
Air pollution	Other environmental driver

[35]Climatic drivers are temperature, humidity, wind, precipitation, and other meteorological elemental measurements such as atmospheric pressure and particle count. Environmental drivers, both climate-driven and non-climate-driven, include sea level, pH, upwelling, and other non-meteorological measurements. A process is something that takes place over a long period of time defined in terms of years, decades, or centuries, and an event is something whose duration is defined in shorter terms, such as hours or days.

Economic drivers that might be worth considering include:

- Rate of economic growth
- Cost of providing energy, water (predicated in part on availability)
- Budget for climate change adaptation projects
- Investment in maintaining/increasing capacity of infrastructure

Political drivers:

- Elections
- Ballot propositions
- Appointed positions in government
- Political will to support climate action

Social drivers:

- Demographic shifts, population growth
- Societal buy-in to the reality of climate change/social value of work on climate change issues
- Visitation of natural areas/social value of access to nature
- Public education
- Press and media coverage

Technological drivers:

- Changing quality and cost of monitoring instruments (e.g., more readily available and/or more accurate monitoring instruments would increase a resource manager's capacity to plan for climate change)
- Changing quality and cost of mapping software/networking

As stated above, ideally all workshop participants would be included in this brainstorming process. However, the Futures of Wild Marin workshop held this brainstorm on a conference call three weeks prior to the workshop. The results of this brainstorm are listed below.

II.C.3. Rank drivers by their relative uncertainty and importance to management decisions, and select the topmost important certainties and uncertainties to define your scenarios

At this stage, participants should assign relative certainty to the drivers brainstormed above. If participants are sufficiently well-briefed about the climate change impacts projected for the target area, this process should not be too time-consuming. If many participants were unable to participate in preliminary outreach and education efforts, this stage may take longer.

Uncertainty/importance rankings should be about the direction of change and/or magnitude of change and relevance to management. For example, "our budgetary future is very uncertain: it may be the same, or more, or our department might be all but closed" may be ranked higher than "pollution from fertilizers in our creeks is likely to get worse, but not catastrophically worse for our management targets."

If any of the top-most uncertain/important drivers has a relatively certain direction of change but highly uncertain magnitude of change, try to define the important threshold values for that driver given the management targets for the exercise. For example, for an exercise concerning shorebirds, the sea level height at which nesting areas will be threatened might be a critical threshold for a driver with a relatively certain direction of change. Another threshold value that might be useful to define is the timing of change (e.g., in the near future or far distant future). In both cases, you should try to devise a threshold value that is meaningful for all participants.

Defining meaningful thresholds can be difficult in an multi-agency context: "severe" sea level rise would be different for someone working on coastal road infrastructure and someone protecting costal native plant species. Because of this difficulty, the GBN facilitator cautioned against defining scenarios using drivers whose uncertainty concerns magnitude rather than direction of change. It is harder to grasp "a little" and "a lot" compared to "more" and "less" change. However, the NPS CCRP scenario planning workshops have in the past used drivers defined by degree of severity (e.g., the 2012 Alaskan scenarios at Kenai Fjords concerning a measurable rate of ocean acidification versus a catastrophically fast and immeasurable ocean acidification rate, and the 2009 Assateague Island scenarios with "low to moderate" and "significant" sea level rise [NPS, 2011]). [36]

Whatever drivers you select to define your scenarios, be sure all participants have sufficient grasp of them to be able to discuss them. If you select drivers that can only be understood with special expertise that not everyone shares, your scenarios will be less vibrant and engaging.

In the Futures of Wild Marin workshop, scenario development team members selected the top-most important drivers of change that they felt were pre-determined (ones that without doubt would move in a predicted and predictable direction over the next few decades), and the top-most important drivers of change that were uncertain (whose direction, magnitude and/or timing of change was unknown).

Table 3. A sample of the drivers of change with certainty and directions of change assigned by the scenario development team for the Futures of Wild Marin scenario planning exercise.

Driver of Change	**Certain/ Uncertain**	**Direction of change**
Temperature	Certain	Will rise
Extreme heat events	Certain	More
Sea temperature	Certain	Will rise
Sea level	Certain	Will rise
Wetlands salinity	Certain	Will rise
Snowpack	Certain	Will decrease
Risk associated with fire intensity	Certain	Will rise
Pressure from biological invasive species	Certain	Will rise

[36] Personal conversation with Leigh Welling, NPS CCRP manager, December 2012. See Figure 8 for the two-by-two matrix showing the scenarios composed with the ocean acidification driver defined by severity.

Soil	Certain	Will be drier
Extreme weather events	Certain	Will be more frequent
Competition for water resources	Certain	Will rise
Tools for habitat restoration	Certain	Will improve
Precipitation	Uncertain	More or less
Length of dry season	Uncertain	Longer or shorter
Frequency of wet springs	Uncertain	More or less
Frequency of high pressure systems, onshore or offshore	Uncertain	More or less
Fog	Uncertain	More or less
Upwelling	Uncertain	More or less
Fire regime	Uncertain	Higher or lower risk
Flood regime	Uncertain	Higher or lower risk
Political willingness to adapt to climate change	Uncertain	Higher or lower/ status quo
Societal commitment to adaptation	Uncertain	Higher or lower/ status quo
Human communities' response to climate change	Uncertain	Sustainable and effective methods or will we just build bigger sea walls?

The top **certainties** were to be the backdrop part of any plausible scenario. The top-most important certainties selected by the Futures of Wild Marin scenario development team were:

- Air temperature: increasing
- Seasonal extremes: increasing
- Sea level: increasing
- Biodiversity: decreasing

The scenario development team reviewed the **uncertainties**, and created this draft list of important uncertainties, with suggested "end-points" for plotting them on a set of axes:

- Precipitation: more or less

- Nearshore ocean dynamics, including fog, offshore winds, and upwelling:[37] how to phrase these in terms of two directions of change? More or less hazardous to life? Conducive to fire or suppressing of fire?

- Management response to biological invaders: more effective or less effective management of all invaders-- aquatic, pathogen, vegetation- and landscape-scale disease

[37] Nearshore ocean dynamics such as fog, offshore winds, and upwelling is an example of a factor that requires special expertise to understand. In this initial draft list the factor was left as a placeholder for some other factor that could serve as a more accessible proxy for these complex processes. The direction of strong wind became this proxy factor, which proved to be more accessible, but still perhaps not accessible enough for all participants.

- Management response to fire/wildfires: more effective or less effective management

- Political willingness to act: increasing or decreasing, underpinning the capacity of organization to act, understand the problem, get funding, fill positions as people retire, collaborate/integrate work instead of build fortresses/silos

A debate about the underlying drivers of these uncertainties (particularly the troublesome question of precipitation, and whether fog or rain was more important) led to this list of three top-most important uncertainties:

- The direction of strong wind: more easterly or more northerly
- Onset of the dry season: earlier or later
- The capacity to act in a resource management context: more or less/status quo

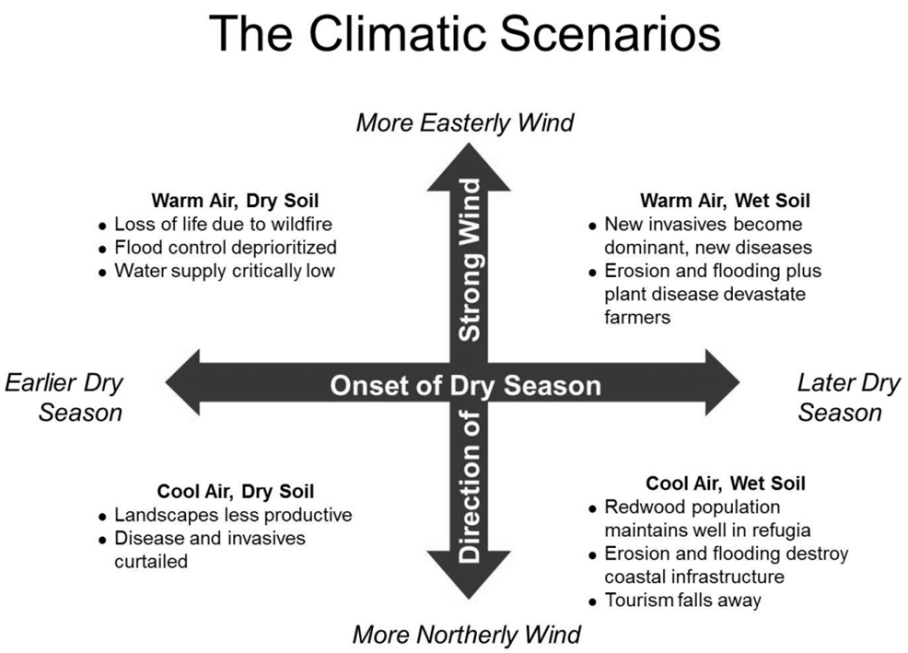
The participants decided that it wasn't the form of precipitation that drove their management decisions, but rather the onset of the dry season combined with the potential fire hazard created by the direction of strong wind. On top of those climatic drivers, they overlaid the driver of "the capacity to act" as a proxy for social and political willingness to act combined with institutional support for action.

II.C.4. Define scenarios based on the top two or three most uncertain/important drivers

Next, take the top-most uncertain/important drivers and define your scenarios.

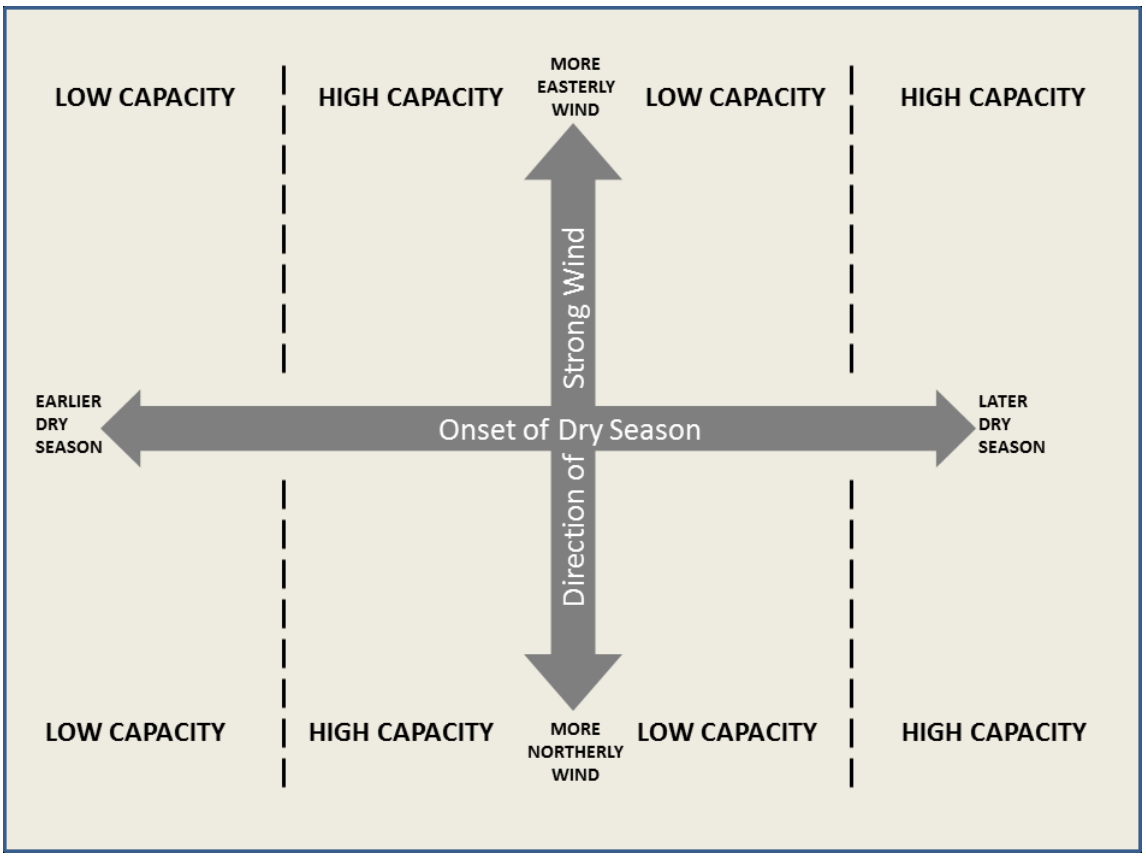
In Figure 2 below, the climate drivers selected by the scenario development team interact to create four climatic scenarios with the possible "end points" plotted on different axes.

Figure 2. The four climatic scenarios from the Futures of Wild Marin scenario planning exercise.



The third critical driver selected by the scenario development team, the capacity to act in a resource management context, adds another dimension, and the four futures become eight. See the eight futures created by this new driver in Figure 3.

Figure 3. The eight scenarios from the Futures of Wild Marin scenario planning exercise, prior to discussion



THE EIGHT SCENARIOS

In our subsequent discussions of the scenarios, “low capacity” translated to “the same capacity as today or less” and “high capacity” translated to “the blank check scenario.” This was helpful, as it gave a high degree of differentiation between the futures.

Before moving on, take the time for discussion to be sure all participants have a firm grasp of the drivers and their main interactions.

Note that not all uncertainties in the Futures of Wild Marin workshop were equally easy to grasp. The capacity to act and the onset of the dry season were easy to grasp. The direction of strong wind—the proxy for nearshore ocean dynamics— was clear enough to the scenario development team, but the larger group of participants found it unwieldy, and tended to substitute “increased El Niño effect” or “increased La Niña effect.” This allowed discussions to continue, but these different

effects are not the same as northerly or easterly strong wind. As noted above, try to ensure that the drivers selected as uncertainties can be understood by all participants.

Be sure to also set aside adequate time to discuss the backdrop of important *certainties* for your scenarios before going on. In the Futures of Wild Marin workshop, there were only a few minutes of discussion addressing certainties, and this was deemed insufficient by some participants.

II.C.5. Describe and name the scenarios

By now, workshop participants have identified the drivers with the highest consequences for the participants' decision-making environment. They have used them to defined four to eight distinct, engaging future scenarios, and created a backdrop of few relative certainties. The next stage, describing and naming the scenarios, relies heavily on good discussion and good facilitation.

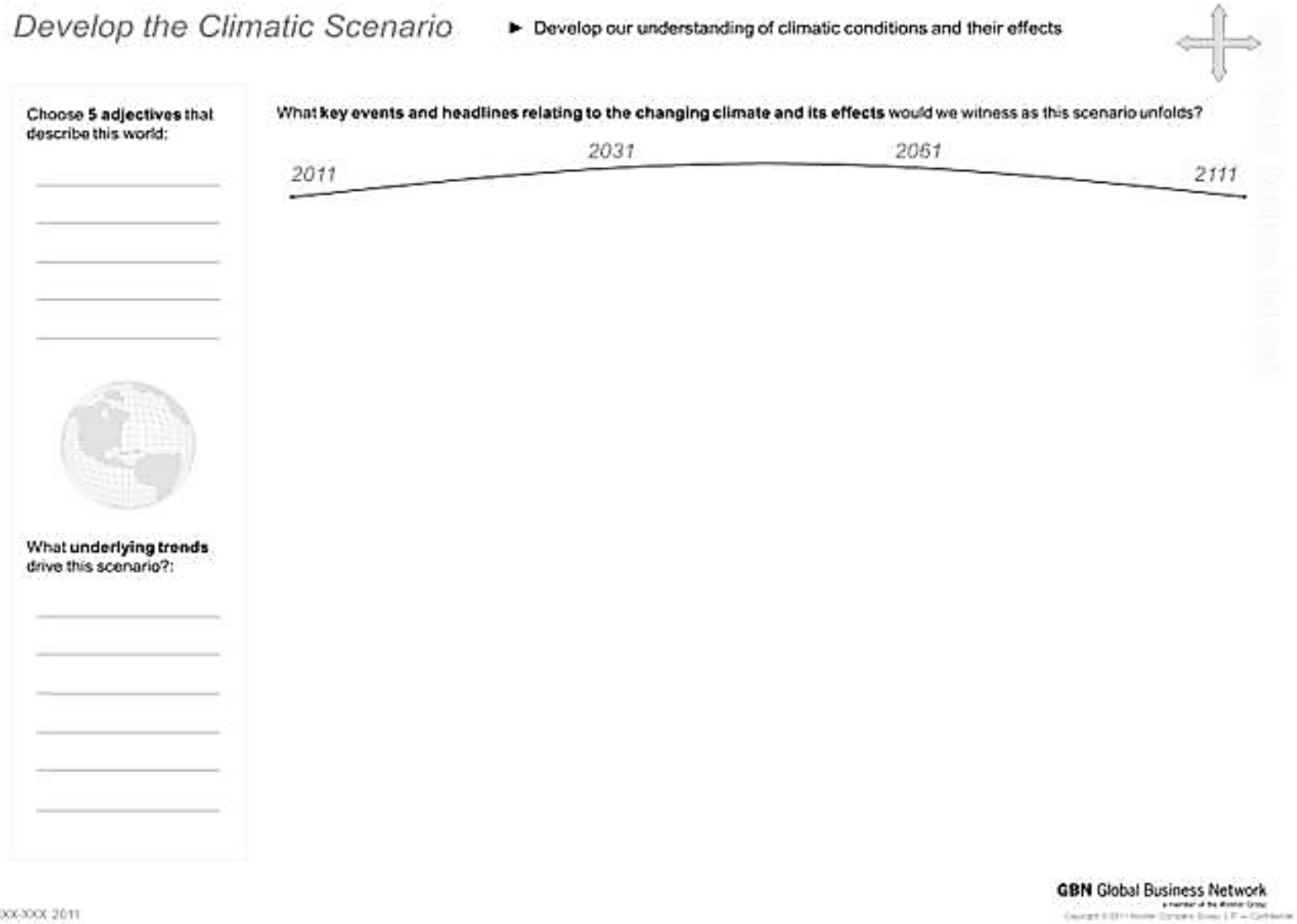
First, participants should look at the climatic futures, brainstorming characteristics for each one. Participants should also brainstorm headlines that might appear in the newspaper—or other events possible—in that climatic future.

In the Futures of Wild Marin workshop, the scenarios were created in advance and presented for discussion at the workshop. Discussion at the workshop essentially began with the brainstorming of descriptors and headlines for the four climatic futures.

Brainstorming headlines is a way to help participants relate to the future scenarios in the context of their own work, and also to help participants learn about each other's concerns and perspectives.

The GBN facilitator used the following template (Figure 3) to walk participants through the discussion of the climatic futures.

Figure 4. Climatic scenario development template (GBN/Monitor, 2011; used with permission).



This template prompts participants to suggest five adjectives to describe this climatic world, suggest a few underlying trends driving this climatic future, and describe the future in terms of headlines. In the Futures of Wild Marin workshop, the headlines were distributed over the near (twenty years out), mid (fifty years out), and long-term (one hundred years out). The facilitator wrote in the headlines and events offered by participants along the timeline from present-day to 2111. The facilitator checked the quadrant being addressed in the upper right schematic of the two-by-two graph.

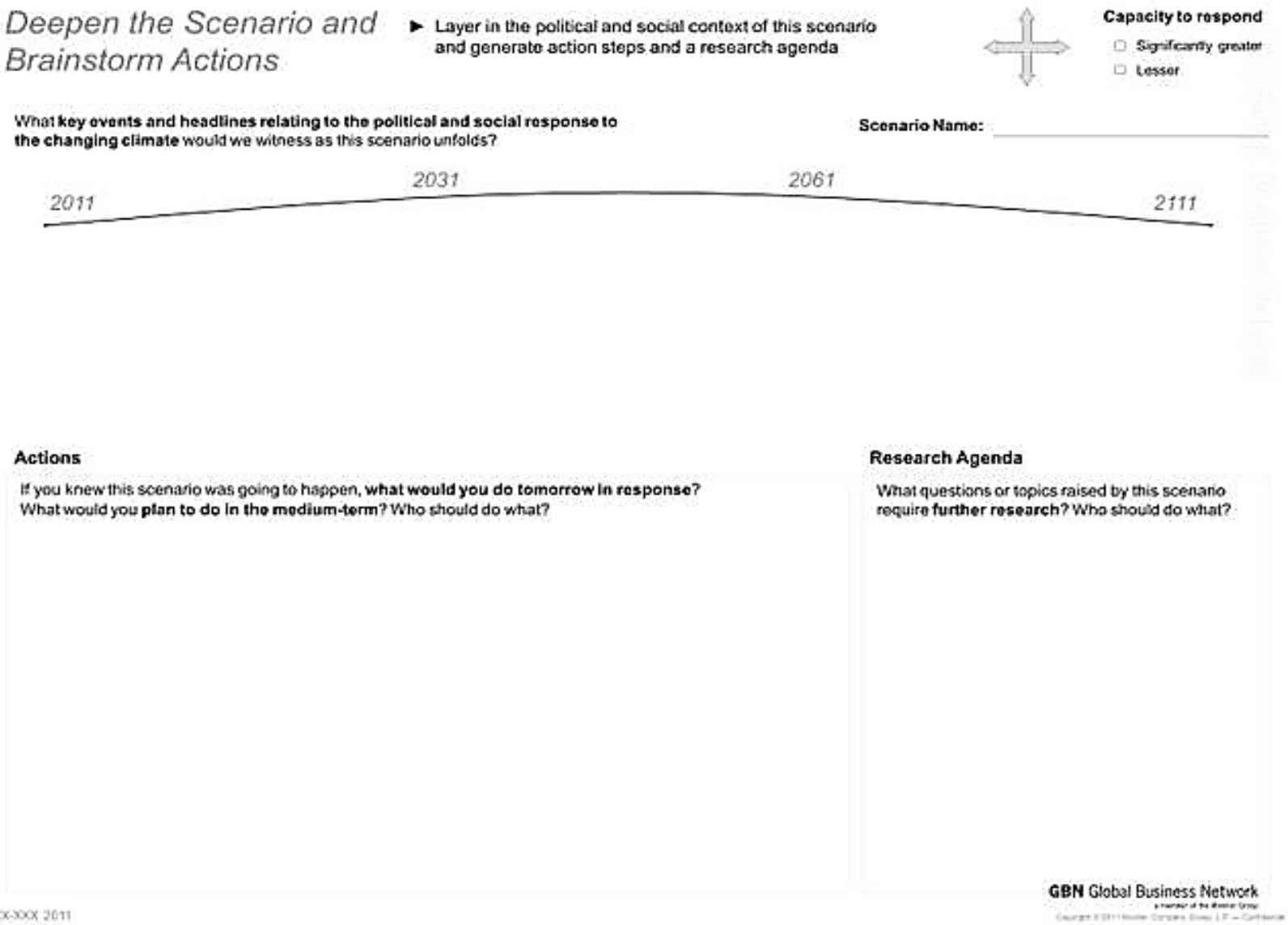
The participants may want to know whether to take into account the impact of adaptation actions: for the sake of discussion, these futures do not benefit from the participants' adaptation actions.

Next, the participants broke into small groups to discuss the capacity to act (more or less/the same) in the four climatic futures. An additional template was used to guide these discussions (Figure 5).

After describing all the scenarios in terms of headlines, participants should next pick memorable title for each scenario. This purpose of the title is to summarize a diverse set of headlines into a vivid, pithy description that effectively communicates the idea of the entire scenario. For example, in one scenario planning exercise participants summarized a scenario of greater rainfall but with little societal investment in adaptation as "The soggy ostrich." While such titles may seem trite, the process by which they are generated, which requires participants to make the complex simple, can be one of the steps that helps people develop a tangible shared understanding.

The eight scenarios created by the Futures of Wild Marin workshop were titled Fryin' and Cryin'/ Phoenix (more easterly wind and earlier dry season); Leaky Boat, No Bucket/Lush Flush (more easterly wind and later dry season); Dry Sweat/Club Marin (more northerly wind and earlier dry season); and Muddy Waters/Playing God (more northerly wind and later dry season).

Figure 5. "Deepen the Scenario," scenario development template for discussion incorporating capacity to respond (GBN/Monitor, 2011; used with permission). The directions read: "Layer in the political and social context of this scenario and generate action steps and a research agenda." In the Futures of Wild Marin workshop the "Research Agenda" was deleted: the aim to devise an action plan, not create a list of new topics to research.



Deepen the Scenario and Brainstorm Actions

► Layer in the political and social context of this scenario and generate action steps and a research agenda

Capacity to respond

☐ Significantly greater

☐ Lesser

What **key events and headlines relating to the political and social response to the changing climate** would we witness as this scenario unfolds?

Scenario Name: _____

2011 2031 2061 2111

Actions

If you knew this scenario was going to happen, **what would you do tomorrow in response?** What would you **plan to do in the medium-term?** Who should do what?

Research Agenda

What questions or topics raised by this scenario require **further research?** Who should do what?

XXX-XXX 2011

GBN Global Business Network

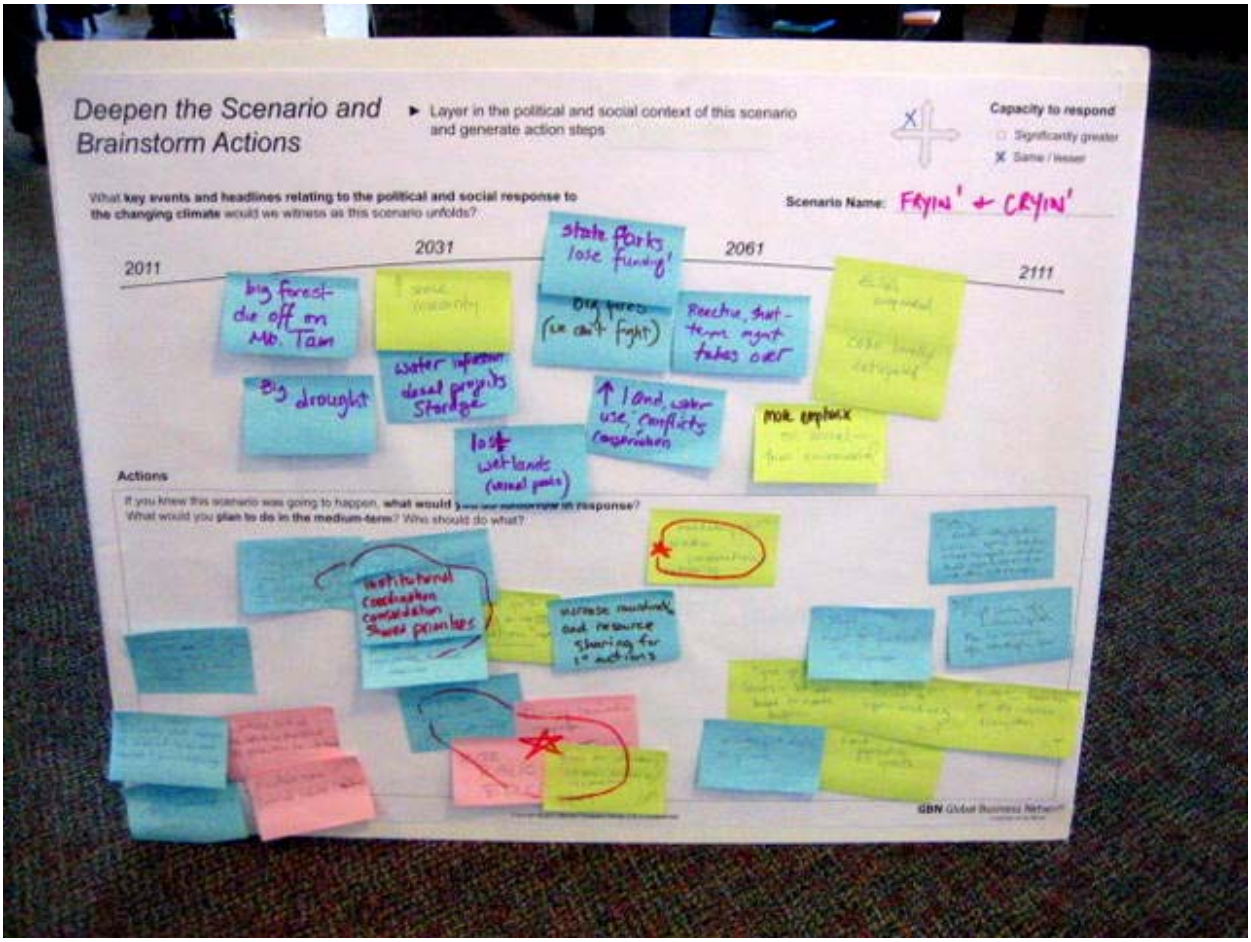
After describing and naming the scenarios, participants can now begin suggesting management actions for each scenario.

In the Futures of Wild Marin workshop, the small discussion groups that named the scenarios then brainstormed management actions to address the near, mid and long-term future. Approximately 30 minutes was allotted for this step: just enough time to create a set of possible actions, but not enough time to flesh them out or adequately discuss the relative benefits of different actions.

With eight scenarios and limited time, it was infeasible to have a full-group discussion of every scenario. In some scenario planning workshops, the full group selects only two or three scenarios to discuss as a group in depth, setting some scenarios aside after naming them.

The small group that discussed "Fryin' and Cryin'" (more easterly winds, an earlier dry season, and the same or less capacity to act), produced the discussion template pictured in Figure 6.

Figure 6. "Deepen the Scenario" discussion template for Fryin' and Cryin.'



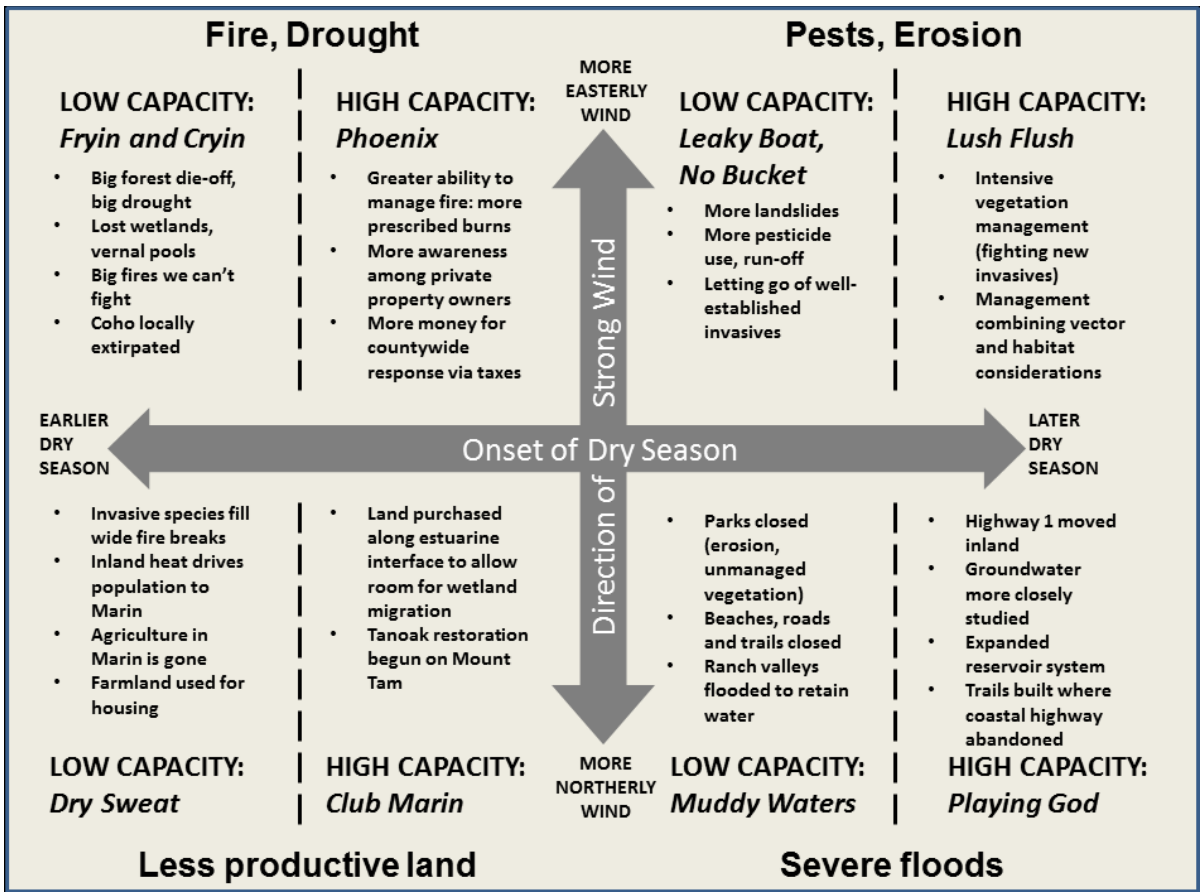
For Fryin' and Cryin,' the participants offered headlines and events like "big drought," "increased land and water use, conflicts," "ESA suspended, Coho locally extirpated," and "big fires we can't fight." Three

top management actions were selected of the many brainstormed to report back to the full group:[38] institutional coordination, mandatory water rationing, and a communication campaign with the inclusion of volunteer science. Each group reported back its top actions for each scenario. Later, when the participants considered all suggested actions together, they noticed overlaps, and the list of suggested actions was condensed accordingly.

This condensed list was recorded in a spreadsheet for use in the following evaluation stage.

The set of eight scenarios from the Futures of Wild Marin, with titles and descriptors, is depicted below in Figure 7.

Figure 7. The Futures of Wild Marin: Eight scenarios with titles and descriptions



II.C.6. Identify top management actions for the futures of concern

The next stage of the scenario planning exercise can be played out in a number of ways.

[38] Note that these large printed templates to guide discussions could easily be replicated by a facilitator using two side-by-side sheets of a flip pad and a marker: there is no need to print special templates. However, it is worthwhile to invest in a supply of good-sized post-it notes: these were very helpful in moving headlines and events along the timeline, and grouping management actions.

Your workshop may end with the top management actions brainstormed for each scenario and condensed into one list. Or, you may try to further refine this list to identify actions that are robust to multiple futures of concern.

Depending on your goals for adaptation, you may want to identify the actions which would be beneficial in any climate future, including a future without climate change (sometimes called "no-regrets" actions), and discuss them further.

You may want to identify the actions which would be beneficial in the worst-case scenarios. These actions may be useful to some degree in most of the scenarios, but could involve costly, novel, or otherwise challenging approaches which would be difficult to implement but potentially highly effective at avoiding or lessening damage from low-probability, high-consequence events.

Good facilitation should help participants explore the most appealing management actions, and, depending on the goals of the workshop, establish the next steps, whether it is merely to document the workshop's findings or use the findings to inform specific management actions. Whatever path you choose, participants should be given the opportunity to do some synthesis of the brainstormed management actions from the individual scenarios.

Some possible ways forward at this stage might be to:

- Post or project a slide with the list of the brainstormed actions for each scenario, and have participants discuss which ones appeal the most and why.
- Group the brainstormed actions into categories and show the participants the types of actions they tended to recommend, and take the discussion from there.
- Discuss and elaborate on the actions which appear on more than one scenario (if any).
- Add another level of analysis to evaluate the brainstormed actions against a few key criteria (either pre-selected to align with a relevant planning process, or selected at the workshop by the participants).

At the Futures of Wild Marin workshop, participants engaged in an additional level of analysis, evaluating the brainstormed actions against criteria they selected at the workshop. This stage is unique to the Futures of Wild Marin exercise, and is not typically done in the GBN or NPS CCRP workshops.

Before brainstorming criteria for evaluation, participants reviewed the workshop goals for adaptation and a set of sample adaptation action criteria from existing government climate change adaptation plans, distributed in the workshop packets. Considering these, participants were asked:

What are the best criteria to use to prioritize actions to manage West Marin's protected areas?

The participants' brainstormed list of criteria was summarized into five criteria:

Adaptation actions can and should be prioritized if they ***are flexible, use adaptive management, are cost-effective, have clarity of design, and are collaborative.***

These prioritization criteria were then applied to the brainstormed management actions.

If an action evaluation stage suits your context, consider providing a blank form with a table to help participants apply the criteria. For example, the following table might have helped guide the participants' discussion

Table 4. A sample table to guide an action evaluation stage. This table uses the top three management actions suggested by the Fryin' and Cryin' scenario discussion group and five prioritization criteria from the Futures of Wild Marin workshop.

Group 1 Actions	***Flexible***	***Uses adaptive management***	***Cost-effective***	***Clear design***	***Collaborative***	**Total** (Yes=1, Maybe=0.5)
Institutional coordination	Yes	No	Yes	No	Yes	3
Mandatory water rationing	No	No	Yes	Yes	No	2
Communication campaign with the inclusion of volunteer science	Yes	Maybe	Yes	Maybe	Yes	4

Note that all of these actions address the workshop's adaptation goal; this step is intended to suss out which actions meet finer-tuned criteria.

The evaluation stage took place in randomly selected groups that reviewed the twenty-five actions suggested by the scenario discussion groups.[39] 10 priority actions were devised, which became 12 actions after participants were given a chance to edit the list after the workshop (see sidebars).

However you get there, at the end of this stage you should have created a list of top actions to address the futures of greatest concern which address your goals (ideally, including actions that apply in multiple scenarios). Where relevant, try to flag spatially explicit

Futures of Wild Marin
Top Management Actions

1. Regional collaborative climate change adaptation planning efforts.

2. Collaborative fire and water management efforts.

3. Early detection and rapid response to biological invaders.

[39] This stage lacked any formal facilitation, and thus the discussion groups took a variety of approaches to applying the criteria. This ranged from one group rigorously grading each action along the criteria, to another group which ignored the criteria completely, choosing instead to flesh out their ideas for the most compelling actions. The evaluation form suggested above might have helped keep the discussions focused on the criteria, but, regardless, all participants had productive discussions with people they may not have had a chance to meet before.

management actions (e.g., actions that are mostly relevant to the coast, or to riparian zones, or to agricultural land, etc.).

II.C.7. Identify next steps

The follow-up steps for a scenario planning exercise are wholly dependent on the capacity of the organization or organizations involved. The Futures of Wild Marin workshop was a one-time exercise with no budget or staff provided for follow-up. The NPS CCRP has not yet run a scenario planning exercise twice in the same National Park unit to refine its initial scenarios (though it acknowledges the need to do so when resources allow). In the military and business sectors, scenarios are regularly reality-tested and refined based on new trends or new evidence. Scenario planning is still a novel tool in the resource management sector, so there are few examples of scenarios being revisited and refined.

At the end of your scenario planning exercise, if there is capacity to do so, try to identify triggering events for re-evaluating your organization's scenarios, such as strategic planning processes or the detection of a threshold value in a key climate change indicator. If you can use this to generate a commitment of resources and buy-in from organizational leadership, you can keep your scenario development process alive.

Also, if there is time, try to create a list of data gaps identified throughout the workshop to inform the participants' research agendas.

II.D. After the workshop

Your participants may want to schedule follow-up events soon after the workshop such as a conference call to share further thoughts on next steps. However, you should be thinking longer term about how to use the output of the workshop.

II.D.1. Identify opportunities to refine the scenarios based on new evidence

Your participants may or may not have had a chance at the end of the workshop to identify decision-making points or threshold events to trigger a

4. Increasing connectivity between protected lands, given projections of species migration under climate change.

5. Riparian restoration (as part of improving water management and connectivity).

6. Coastal wetland restoration (as a buffer for sea level rise and extreme storms, and to provide carbon sequestration).

7. Restoration of connectivity between upland and coastal areas, such as restoring floodplain function.

8. Improvement of regional monitoring and data sharing to track natural resource indicators associated with climate change in a manner that facilitates response through an adaptive management approach.

9. Development of a "Rapid Response Team" to respond to threshold events for a range of ecosystem indicators and work on restoration after extreme weather events such as storms, landslides and wildfires. This team would be prepared to take proactive action to help ecosystems adjust to climate change, e.g., responding to the establishment of invasive species and reductions in native biodiversity, possibly facilitated by a repository of seedlings that would be optimal for restoration after a fire or other disturbance.

reevaluation of the scenarios. In either case, in the aftermath of the workshop, if resources provide for follow-up, try to flesh out a plan to identify these opportunities to refine the scenarios based on new evidence. The triggers may be political cycles, or critical values in key climate indicators.

II.D.2. Plan to address data gaps

In the course of the workshop salient data gaps were undoubtedly identified. Compile a list of these gaps and distribute them to participants to help inform their research agendas. Again, depending on resources for follow-up work, you may want to engage participants in laying out a coordinated plan to address data gaps.

10. Integration of habitat restoration with infrastructure projects, ensuring they work together (e.g., the creation of wetlands to assist with wastewater treatment or the use of riparian and wetland buffers to protect infrastructure from erosion).

11. Development of a triage framework to give guidance on resource allocation within a financially constrained environment.

12. Development of public-private partnerships to support adaptation actions along the National Resources Conservation Service model.

III. Examples of scenario planning in practice

What we have described above is a framework for scenario planning that sets the stage for incorporating uncertainty into a planning process. Depending on the goals of that planning process, scenario planning may be used in many different ways, ranging from quantitative analyses with relatively little stakeholder engagement to address a specific planning goal to broader, more interactive approaches to build shared understanding about critical uncertainties. These different flavors of scenario planning share a focus on looking beyond the historical or most obvious trends to incorporate uncertainty into prioritizing management actions. Here, we provide a series of examples of scenario planning in action to illustrate some of the tool's different applications.

III.A. The National Park Service Climate Change Response Program

The NPS Climate Change Response Program (CCRP) began piloting climate change scenario planning workshops in 2007, in part as a response to a researcher's well-publicized finding that climate change may drive Joshua Trees out of Joshua Tree National Park.[40]

The CCRP's exercises are thus far mainly intended to bring NPS staff and stakeholders together to discuss climate change response actions outside of any formal planning process, which would require compliance with public oversight regulations. As such, they are officially just training exercises, although they may inform management decisions. The CCRP's workshops typically convene a small number of people (15–20) representing two national parks at a time for three days. This gathering is preceded by a set of preparatory conference calls. Alternately, the workshop may be held over two sessions with significant research time between (M. Rose, personal communication, August 2011).

The workshops are conducted with the assistance of a facilitator (either using facilitators from the Global Business Network or internal facilitators) and climate scientists are recruited to help workshop participants (e.g., via a webinar) interpret downscaled climate model outputs to identify and describe the most important climate variables driving change in the region of concern, such as temperature and precipitation.

Participants then select the most critical, most uncertain variables to use as a framework for building the scenarios. Socio-economic and other non-climatic drivers of change are incorporated based on information from vulnerability assessments, peer-reviewed literature, and the experience of park staff. For each scenario participants create a timeline of significant events and headlines, select a title, and brainstorm action steps. The main output of a CCRP workshop is a set of action steps that is appropriate for multiple scenarios. For example, the Assateague Island National Seashore scenario planning exercise (NPS, 2011) devised a set of management actions that would be useful in any climate future ("no-regrets" actions), including actions to increase the seashore's resilience, such as:

[40] Personal communication with Paul DePrey, former Chief of Resources at Joshua Tree NP at the time of the 2007 scenario planning exercise (June 2011).

- Changing to infrastructure to make it more temporary, consolidated, and innovative
- A sand bypassing program
- Easements, land exchanges, migration corridors, changing boundaries
- Reducing existing stressors
- Creating and protecting critical habitats

See the CCRP website for more information:[41] http://www.nature.nps.gov/climatechange/

III.A.1. The Joshua Tree National Park pilot exercise and subsequent exercises

In November 2007, the NPS CCRP held its first scenario planning exercise with NPS staff at the Joshua Tree National Park.[42] This was the pilot exercise to begin refining the scenario planning tool for use with NPS staff. The Futures of Wild Marin workshop was modeled on this training exercise. The workshop was prepared over the course of ten weeks (NPS 2007, p. 4):

Week 1: Engage interdisciplinary scenario planning and stakeholder team (ID teams)
Week 2: Distribute introductory reading; Begin planning workshop
Week 3: Conference call 1: introductions to each other and to concept of scenario planning
Week 4: Conference call 2: discuss readings, brainstorm focal issue; Conference call 3: decide on focal issue
Week 5: Conference call 4: identify uncertainties
Week 6-7: Complete scenario planning tools and tables
Week 8: Conference call 5: review tables, begin to create connections for flow diagram; create flow diagrams
Week 9: Conference call 6: review flow diagrams, discuss
Week 10: 3-day workshop to build and discuss the park-specific scenarios

As noted above, the potential loss of Joshua Trees from the park was one of the motivations for the piloting of scenario planning here. It was conceived as an "in-house brainstorm." The then-Chief of Resources Paul DePrey assembled a climate scientist, a geologist, a wildlife ecologist, a botanist, a vegetation ecologist, an archaeologist, a curator, and an environmental protection specialist to create scenarios to address the issue of climate change in the park. The group developed 12-16 scenarios and then selected four by majority rule to develop in-depth over three days with the help of a pair of outside facilitators from the University of Montana. The scenarios that resulted caused the participants to realize that the park had a boundary that was moving between two ecotones (Sonoran/Mojave desert), upon which the staff began establishing baseline data for that location. When asked if they would have undertaken this management action with or without the scenario planning exercise, DePrey responded, "No, the scenarios sent us down this path to do more research on that one vulnerable site" (personal communication, June 2011). Before the scenario planning exercise, the park's management actions responding to climate change were entirely focused on endangered species. DePrey suggests that it would have been helpful to follow up this

[41] At this writing the NPS CCRP is in the final stages of producing its own step-by-step guide to using scenarios to plan for climate change.

workshop with another that used downscaled climate data and included more people, including more park staff, additional climate experts, and the representatives of local government, the Bureau of Land Management, and the Department of Defense. With its narrow range participants, the workshop was ultimately somewhat "myopic" (Ibid).

III.A.2. NPS Alaska Region

After the Joshua Tree pilot, the NPS CCRP began deploying staff trained in the scenario planning tool to parks across the country that were facing the most immediate threats from climate change, including Assateague Island, the Crown of the Continent, and Alaska. The National Park units in Alaska came together over the period of 2010-2012 to complete five three-day scenario planning workshops around the state.[43] Workshops were constructed around four park networks: Southwest, Coastal, Southeast, Interior, and Central. The first two workshops were completed in 2011, the second three in 2012. Participants included NPS staff from the parks and regional office, climate scientists, local stakeholders, and representatives of nonprofits, educational groups, tourism groups, and Native Alaskans tribal groups. As a result, workshops were on the large side, with 30 to 50 attendees.

The workshops were preceded by webinars designed to (1) introduce the scenarios process, (2) present scientific background and modeling, the "nitty gritty variables" like temperature, precipitation and thawing, and how it translates to the contexts of resource management and economic and social activity, followed by the distribution of brief fact sheets for participants to read and an online survey to generate feedback about which climate change impacts matter the most and (3) discuss the climate change impacts, prioritizing impacts while incorporating participants' experience.[44]

This three-year project is thoroughly documented on the NPS Alaska Regional Office website (accessed February 28, 2013): http://www.nps.gov/akso/nature/climate/scenario.cfm. Available documentation includes photographs of discussion templates (such as the one in Figure 6), maps, pre-workshop webinar recordings, presentation PowerPoints, and scenario narratives.

Generally, the workshops developed two-by-two matrices to produce four climate futures, and then a socio-economic layer (with one or two additional drivers) would be applied, producing up to 16 potential scenarios. The workshop participants would then split into two groups, with one discussing

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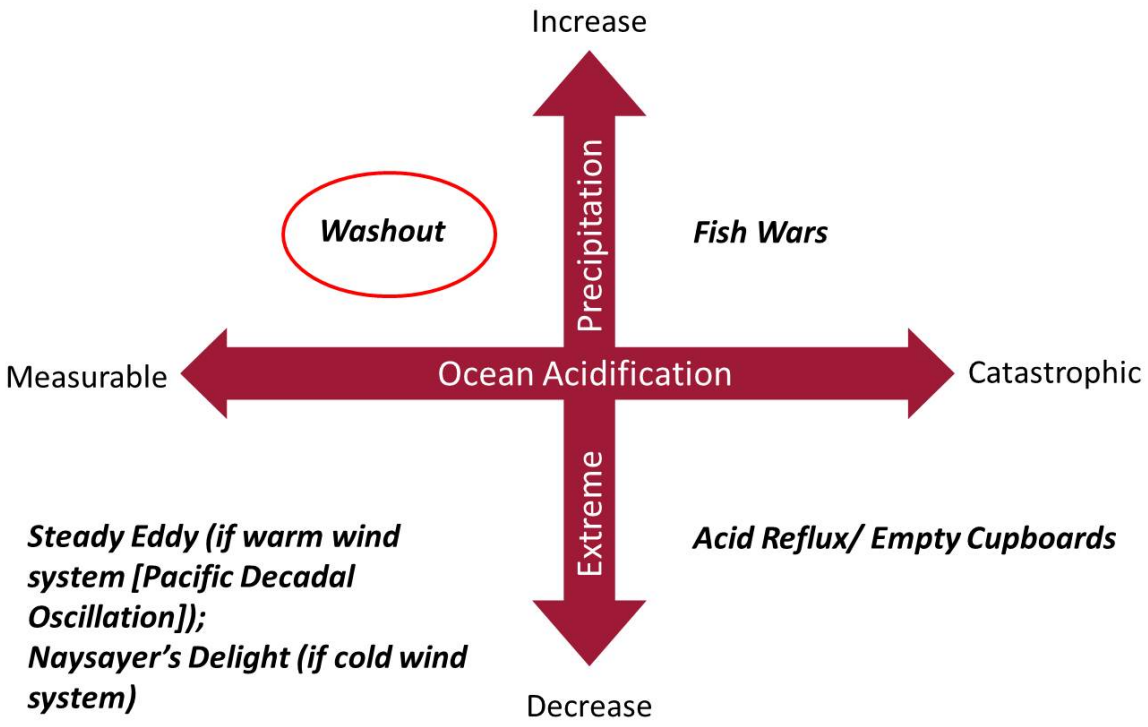
[43] The five workshops were held in Southwest Alaska (Feb. 2011), Northwest Coast (April 2011), Southeast Alaska (Feb. 2012), the Arctic Interior (March 2012), and Central Alaska (April 2012). This and other information in this section are based on personal conversations with Robert Winfree, Science Advisor, NPS Alaska Regional Office, Nancy Fresco, Scenarios Network for Alaska and Arctic Planning (SNAP) Coordinator/ Research Faculty at University of Alaska at Fairbanks, and Jeff Mow, Acting Superintendent at Denali National Park and Preserve (December 2012).

[44] Personal conversation with Nancy Fresco (December 2012). She notes that not all webinars were fully attended, with about 50% attending all three, and 90% attending at least one. Online surveys (using Survey Monkey) had 100% response rates if they were started during the webinar (so all participants started them together). Fresco suggests doing two one-hour webinars (one on scenarios and scientific background and the other highly interactive with additional survey questions) might increase participation.

the most plausible two or three climatic scenarios, and the other discussing the most plausible two or three socio-economic scenarios (often a matrix of drivers such as the extent that the local community cares combined with the extent to which government leadership is engaged). The two groups would come back together and discuss the combined effect of the climate and socio-economic drivers, addressing four to six of the 16 possible scenarios. Facilitators attempted to ensure that all four quadrants of the climate matrix were addressed. The scenarios developed by coastal managers in the Southwest Alaska workshop (referenced above in II.C.3.) are shown in Figure 8, below, combining the uncertainties of storms and precipitation (more severe or status quo) and ocean acidification (slight increase or major increase).

Figure 8. Coastal scenarios developed at the NPS Southwest Alaska scenario planning workshop (NPS CCRP American Geophysical Union poster, December 2012)



"Washout" is circled because subsequent evidence indicates that this is the scenario that seems to be playing out.[45]

Robert Winfree, the Science Advisor for the NPS Alaska Regional Office, points out that the scenario planning process, given that it deals in hypotheticals, allowing people to hold on to their skepticism, was useful in bringing climate change naysayers to the table and helping them engage with the evidence of climate change.

[45] Personal communication with CCRP manager Leigh Welling (December 2012).

The NPS Alaska approach to the scenarios differed somewhat from the standard NPS CCRP approach, according to Winfree. The standard approach focuses on identifying "no-regrets" approaches (things that are good to do in any future) and low-hanging fruit. The NPS Alaska approach focused on unlikely but serious consequences, and ways to monitor whether the worst case scenarios are transpiring over the course of 10-15 years (although, ideally, the scenarios would have been refined by this point, revealing the changes in trends). The Alaska scenarios were geared toward helping "install a way of thinking to help [managers and stakeholders] be observant about what changes are taking place." [46]

Has scenario planning helped the National Park Service prepare for climate change in Alaska? When asked this, Mow gives an anecdotal example of how NPS superintendents, at a meeting in 2009, were reluctant to begin a climate change adaptation discussion because of a lack of formal policy guidance. Then, in 2012, after experiencing scenario planning, a meeting took place in which superintendents engaged actively, getting "to the meat of the matter."[47] The superintendents said that scenario planning helped them to engage, working around the uncertainties.

III.B. The Adaptation for Conservation Targets (ACT) Framework

The Adaptation for Conservation Targets (ACT) Framework was developed by Molly Cross at the Wildlife Conservation Society and a working group of scientists and conservation practitioners in 2008.[48] The ACT Framework includes an abbreviated scenario planning component as one of its steps, and calls for an iterative process, e.g., reevaluating the adaptation goal based on the impact assessment before taking action and monitoring the effectiveness of adaptation actions to inform future actions and planning. The ACT Framework was piloted by the Southwest Climate Change Initiative (SWCCI), representing The Nature Conservancy (TNC), the Wildlife Conservation Society, Climate Assessment for the Southwest (CLIMAS), the Western Water Assessment, the U.S. Forest Service, and the National Center for Atmospheric Research. Patrick McCarthy from TNC states that the ACT Framework workshops have been useful for starting positive conversations: it helps getting people "past despair" to action.[49] The pilot consisted of four workshops[50] held between 2009 and 2010 in the U.S. Southwest (Cross et al. 2013). Each engaged forty-five to sixty people, with break-

[46] Personal conversation with Robert Winfree, Science Advisor, NPS Alaska Regional Office (December 2012).
[47] Personal conversation with Jeff Mow, Acting Superintendent at Denali National Park and Preserve (December 2012).
[48] The group that met in 2008 to develop the ACT Framework consisted of: D. Bachelet, M. L. Brooks, M. S. Cross, C. A. F. Enquist, E. Fleishman, L. Graumlich, C. R. Groves, L. Hannah, L. Hansen, G. Hayward, M. Koopman, J. J. Lawler, J. Malcolm, J. Nordgren, B. Petersen, D. Scott, S. L. Shafer, M. R. Shaw, G. M. Tabor, and E. S. Zavaleta (M. Cross pers. comm. July 2011). The July 2012 *Environmental Management* article describing the ACT Framework (Cross et al. 2012) can be read here (accessed December 12, 2012): http://consbio.org/products/publications/adaptation-conservation-targets-act-framework-tool-incorporating-climate-change-natural-resources-management
[49] Based on a Switzer Foundation webinar by Patrick McCarthy about his work on the Southwest Climate Change Initiative (March 29, 2011), and follow-up correspondence with McCarthy.
[50] The four demonstration landscapes in the SWCCI are Bear River Basin (Utah/ Wyoming), the Four Forests Restoration Initiative (Arizona), the Jemez Mountains (New Mexico), and Gunnison River Basin (Colorado). The ACT Framework pilot collaboration involved a total of 190 people from 43 organizations.

out discussion groups of fifteen to twenty, and consisted of introductory presentations, small group adaptation planning exercises, and full group discussions of challenges, opportunities, and next steps. The small-group exercises consisted of facilitators taking participants through the planning steps of the ACT Framework, wherein the participants:

1. Specified a management goal for a conservation feature (e.g., species, ecosystem, ecological process) that was selected in advance of the workshop;
2. Built a conceptual model to illustrate the climatic, physical, ecological, and socioeconomic drivers that affect that feature;
3. Assessed the effects of two plausible future climate scenarios (developed in collaboration with local climate and hydrology experts in advance of the workshop);
4. Identified potential adaptation actions for each scenario;
5. Selected several high-priority actions on the basis of relative feasibility, effectiveness, cost, and their applicability under both scenarios; and
6. Engaged in a plenary discussion about implementation of high-priority strategies.

A report was generated from each workshop that provides detailed adaptation plans for each conservation feature, including the conceptual models developed at the workshop, expert input on the climate change impacts in each of the two selected climate change scenarios, and proposed strategic actions.

For more information about the implementation of scenario planning in the ACT Framework, contact Molly Cross (mcross@wcs.org) and/or see the following website:[51]

- Wildlife Conservation Society- North America Program: Climate Change Adaptation Planning: http://wcsnorthamerica.org/ConservationChallenges/ClimateChange/ClimateChangeAdaptationPlanning.aspx

III.C. Tucson Water

The City of Tucson is the only utility that has yet published a report about using scenario planning to make management decisions—*Water Plan: 2000-2050* in 2004, part of the city's Long Range Water Plan.[52] In it, the city used scenarios to develop a "highly-flexible, long range water-resources plan," given the dynamic regulatory environment and other drivers which introduce uncertainty (Tucson

[51] The Southwest Climate Change Initiative web page also has a treasure trove of documentation on the use of the ACT Framework, but is scheduled to be shut down on June 30, 2013. Contact the site manager at conserveonline@tnc.org to see if the content is accessible somewhere other than its original location (accessed May 14, 2013): http://conserveonline.org/workspaces/climateadaptation/documents/southwest-climate-change-initiative-0/view.html

[52] Read more about Tucson Water's Long Range Water Plan (accessed February 28, 2013): http://cms3.tucsonaz.gov/water/longrange

Water, 2004). Scenarios were used to identify actions which would be robust to multiple futures, or, in their words, "common elements that lie on […] different pathways" (Ibid). The 2004 and 2008 plans outline the "path of common elements" produced by the scenarios, set against the backdrop of threshold decisions. In the Tucson Water case, stakeholder involvement was not a major component of the scenario planning process: it was driven by a specific set of management decisions.

The 2004 plan identifies two years by when key management decisions must be made.[53] These threshold decisions set the stage for the scenario construction process. The first question was addressed with a two-by-two matrix using the uncertainties of (1) the willingness of public to accept water quality as-is or to pay for enhanced quality and (2) giving no direct treatment of Colorado River Water at a particular plant or giving some direct treatment to the water at that plant. The second question concerned effluent (wastewater), and the public's willingness to tolerate it as a water source. In this case, eight scenarios were created with the three uncertainties (1) the willingness of the public to consider effluent for potable use (more or less), (2) the degree to which the public would require effluent to be processed and treated before using it (more or less), and (3) the purpose for which effluent would be processed and treated (to the highest standards [drinking water] or to specific-use standards). Tucson Water then combined all of these scenarios to create 32 future scenarios (4 from the first x 8 from the second). These were simplified by their characteristics into four "Families of Futures" (Ibid). Ultimately fourteen robust management actions ("possible pathways") were identified.

These management actions were then examined according to a set of nine criteria, developed as performance measures to show the strengths and weaknesses of each action.[54] Ten robust management actions ("common pathways") were then devised, based on this evaluation process.

Apparently pleased with the results of its first bout with scenario planning, Tucson Water returned to the tool a few years later. Tucson Water's 2008 report describes how it applied new evidence about demographic changes to create new scenarios to address new problems, examining different future demand scenarios. In 2007, the city manager moved to restrict the area served by Tucson Water, pending an updated policy on the services provided to the larger area that the utility has traditionally served. So, the first uncertainty was the service area size (larger or smaller). The second uncertainty came from a pending new policy on water conservation. The potential new service area was thus combined with the question of whether the utility would invest or not in implementing more aggressive water demand management measures. This exercise gave the utility a range of potential demand in terms of acre feet of water. Given the results, Tucson Water could see, depending on the decisions of policy makers, that they would need to reevaluate their situation as early as 2014 or as late as 2027.

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[53] The 2004 report cites two years (2006 and 2014) as deadlines for making four water management decisions, and the 2008 report updates these years, resetting the 2006 deadline to 2008, and representing the other as "dependent upon which of the four potential demand scenarios is relevant" (Tucson Water, 2008).

[54] See page 6-15 in Tucson Water's 2004 plan for the table showing the different pathways evaluated along the nine criteria (accessed February 28, 2013): http://cms3.tucsonaz.gov/files/water/docs/waterplan.pdf

The key innovation of the Tucson Water example is the introduction of future decision-making points into the planning process. Looking at the results of the scenarios, the utility could project when they would need to reevaluate their projections, and perhaps refine their scenarios. Tucson Water acknowledges the need for a reassessment of their projections in their 2008 plan's conclusion:

> *This is the first Update to Water Plan: 2000-2050, and there will be others in the years to come. As the present unfolds into the future, the primary necessity is to prepare for change since it is the only certainty.* (Tucson Water, 2008, p. ES-11)

III.D. Prioritizing tidal marsh restoration in the San Francisco Bay Estuary

In the San Francisco Bay Estuary, California, there are several large-scale wetland restoration programs underway. One of the major goals of these programs is providing habitat for tidal marsh birds while also promoting and sustaining other ecosystem services that tidal marshes provide. However, there is concern that planned or in-progress tidal marsh restoration projects will not be sustainable given uncertain projections of increasing rates of sea level rise. A team of scientists at PRBO Conservation Science addressed this uncertainty by using mathematically produced scenarios to prioritize restoration projects which are most likely to be effective at providing high quality tidal marsh bird habitat under different sea level rise rates.

The team created four scenarios of future sea level rise and then evaluated three approaches for using model results to inform the selection of potential restoration projects:

1. Using current conditions alone to prioritize restoration projects.
2. Using a single future scenario (among four) in combination with current conditions to select priority restoration projects.
3. Combining current conditions with four future scenarios, while incorporating uncertainty among future scenarios into the selection of restoration projects.

Unsurprisingly, the team found that using current conditions alone to prioritize projects resulted in the models picking projects that are not robust to future conditions. The third ''combined'' strategy picked the most robust projects. This approach used projections from all four future scenarios, discounting areas with high levels of variability among future scenarios.

This is an example of the deployment of quantitative scenarios to help make a concrete management decision to address a clearly defined problem concerning a single critical uncertainty. It illustrates how scenarios can be used in decision making outside of the more time-consuming scenario planning approach, which is aimed at engaging uncertainty by envisioning the results of proposed management actions in dissimilar plausible futures built on the interaction of multiple critical uncertainties. The use of scenarios as illustrated in this example has the advantage of being faster and producing an obviously superior management action, but it has drawbacks. It does not build a shared understanding of the problem, incorporate diverse views to produce novel approaches, or result in management actions that are robust to more than one uncertainty. However, quantitative scenarios can certainly have a place in helping scenario planning participants

envision the results of specific management actions against the backdrop of one or another uncertainty. Highly elaborate quantitative scenarios can also be used to help create robust plans, such as in the Robust Decision Making (RDM) approach pioneered by the RAND Corporation, although this approach is usually out of the price range of resource management agencies.[55]

III.E. Conservation planning for migratory birds in California's Central Valley

The Migratory Bird Conservation Partnership (hereafter Partnership) is a collaboration of three conservation organizations, Audubon California, the Nature Conservancy, and PRBO Conservation Science aimed at protecting California's wetlands and agricultural lands that support migratory bird populations. In 2013, the Partnership used scenario planning to develop a shared understanding about its goals and strategies related to water, how climate change may impact its work on water issues, and what it can do to prepare.

In advance of a larger workshop a team of 6-10 leadership staff identified how fundamental drivers of water availability may change in the future using published information.[56] The team identified aspects of climate change (e.g., increasing temperatures) and growing human populations as certainties common to all future scenarios. Their axes of uncertainty described total annual precipitation, which climate models suggest could either increase or decrease, and the societal response to climate change: either reactive with existing policies and infrastructure or proactive with aggressive adaptation policies designed to decrease greenhouse gas emissions and reduce climate change vulnerability.

The team then convened a two-day retreat to engage about 40 staff from Partnership member organizations in building and using scenarios to identify opportunities for conservation action. The team employed a professional facilitator.[57] Prior to the retreat, participants were asked to read a paper on scenario planning (Peterson et al., 2002) and a paper on the future of water in California (Hanak and Lund, 2012).

The retreat began with an introduction by the Partnership's water team on its current efforts to secure water and related challenges. This was followed by a presentation on the future of water in California by Ellen Hanak of the Public Policy Institute of California.[58] The participants were then presented with the shared goal, system assessment, and axes of uncertainty that the team had developed in advance.

To develop the scenarios, four breakout groups addressed each of the four alternative futures. Along the lines of the GBN approach used by the NPS CCRP and the Futures of Wild Marin, the small groups generated headlines and a pithy title for each future.

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[55] Learn more about the RAND RDM approach (accessed May 28, 2013): http://www.rand.org/topics/robust-decision-making.html

[56] Primarily Ellen Hanak and Jay Lund (2012). Adapting California's water management to climate change. *Climatic Change* 111(1): 17-44.

[57] The professional facilitator was Will Murray (accessed May 28, 2013): http://www.willmurraycompany.com/.

[58] Learn more about the Public Policy Institute of California (accessed May 28, 2013): http://www.ppic.org.

All of the scenarios described a future in which water would become more limited (even if there is more of it), floods would cause more damage, and public officials would be under pressure to respond. In all futures, balancing supply (full reservoirs for farmers) and storage (empty reservoirs for flood protection) will become more difficult as the snowpack decreases and runoff shifts to the winter.

Under the wetter scenarios, there was consensus that it will be important to identify ways to store and use excess water. Under the drier scenarios, the emphasis shifted away from storage strategies toward fine-scale spatial and temporal modeling of flooding to optimize creation of waterbird habitat.

For the scenarios in which state and federal actors embraced aggressive adaptation there was an opportunity to use new revenue streams that might be generated by adaptation bonds or California's cap and trade program to fund the Partnership's work. In contrast, under scenarios in which society reacts with existing policies and infrastructure, the solutions generally pointed toward trying to attract private funding, whether from major donors or developers, to protect habitat as rapidly as possible.

After developing response strategies to the four scenarios, participants identified early warning indicators that could be used to identify which scenario may be unfolding.

This scenario planning exercise helped the Partnership develop a shared understanding of the challenges that climate change will pose for waterbird conservation. Part of this understanding involved identifying critical information gaps about climate science and water policy that Partnership staff will need to fill. Another outcome was that participants realized that some of their existing projects would be well-suited to addressing conditions in several of the scenarios, suggesting a need to prioritize these actions.

IV. Your mileage may vary: resource constraints

For an ideal scenario planning process, you would have the funding to hire a professional facilitator or facilitators, rent a retreat space for two or three days, and participating agencies could commit staff time to a thorough and thoughtful process. All of these elements may not be available. There are still opportunities to use scenario planning creatively to engage diverse groups of people in preparing for the future.

Ways to shorten the time commitment to the scenario planning exercise include: having the preliminary steps take place over a period of months, or breaking up the workshop itself over a series of one-day meetings (e.g., discussing the factors and assigning certainty and importance on one day, meeting a week later to discuss the most high-consequence factors and how they would interact, and then meeting a week later to collectively describe, name, and assign a few top management actions to each scenario). Another way to reduce the time commitment required is to

break the exercise into discreet, smaller exercises driven by narrowly defined management decisions.

Ways to cut corners on the financial commitment include utilizing free meeting space (e.g, at local funding organizations), and using existing staff for the facilitation.

An alternative to cutting corners is to appeal to a foundation for grant support to finance the exercise. Working collaboratively with other organizations may increase the appeal to a foundation. Alternatively, the scenario planning process could be inserted into an established and funded planning process.

In some cases, scenario planning can be used effectively within an organization (instead of across organizations) at low cost and with a lower time commitment. As noted earlier, this saves time, but has trade-offs. A preexisting team will have similar ideas about management and prioritization, and so is less likely to develop novel approaches to problems presented in the scenarios. To the extent possible the team should be encouraged to consider unexpected future conditions or novel approaches dealing with these conditions.

V. Conclusion

When critical uncertainties cannot be reduced, scenario planning gives resource managers a way to engage with uncertainty to improve the robustness of long-term management plans. Its strengths include its ability to integrate different kinds of information and its flexibility as a tool that can be used within an agency or in a multi-agency, interdisciplinary group, with any level of decision maker. Its weaknesses include its reliance on participants being able to think outside norms and question their own assumptions, and the time required to create plausible and engaging scenarios that are supported by good science (always a moving target in the climate change planning context). Ultimately, the greatest benefit of scenario planning might be its ability to help participants confront the interactions of multiple critical uncertainties. Using only the most important and uncertain drivers, this exercise pulls participants out of a state of paralysis from the overwhelming nature of the uncertainties, and also pulls them away from the search for the one single likeliest future (which tends to be produced by averages, rarely the conditions of highest consequence). With scenario planning in your toolbox, you can flesh out the dimensions of the futures for which you want to be ready—informed by science but driven by imagination—and so hopefully produce better outcomes for your management targets under climate change.

References

Agrawala, S., and S. Fankhauser (Eds.) (2008). Economic Aspects of Adaptation to Climate Change: Costs, Benefits and Policy Instruments. Office of the Secretary-General of the Organisation for Economic Co-operation and Development (OECD).

CBD – Convention on Biological Diversity, Secretariat (2009). CBD Technical Series No. 41: Connecting Biodiversity and Climate Change Mitigation and Adaptation: Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change. Accessed July 31, 2011: http://www.cbd.int/doc/publications/cbd-ts-41-en.pdf.

Chapin, F. S., III, and E. Zavaleta (2010). Planning in the context of uncertainty: Flexibility for adapting to change. In D. N. Cole and L. Yung (Eds.), Beyond Naturalness: Rethinking Park and Wilderness Stewardship in an Era of Rapid Change (216–233). Washington, DC: Island Press.

Cross, M.S., P.D. McCarthy, G. Garfin, D. Gori, C.A.F. Enquist (2013). Accelerating adaptation of natural resource management to address climate change. Conservation Biology online edition: 1–10. Accessed December 12, 2012: http://onlinelibrary.wiley.com/doi/10.1111/j.1523-1739.2012.01954.x/suppinfo.

Cross, M. S., E. S. Zavaleta, D. Bachelet, M. L. Brooks, C. A. F. Enquist, E. Fleishman, L. Graumlich, C. R. Groves, L. Hannah, L. Hansen, G. Hayward, M. Koopman, J. J. Lawler, J. Malcolm, J. Nordgren, B. Petersen, E. L. Rowland , D. Scott, S. L. Shafer, M. R. Shaw, and G. M. Tabor (2012). The Adaptation for Conservation Targets (ACT) Framework: A tool for incorporating climate change into natural resource management. Environmental Management 50: 341–351. Accessed December 12, 2012: http://consbio.org/products/publications/adaptation-conservation-targets-act-framework-tool-incorporating-climate-change-natural-resources-management.

IPCC – Intergovernmental Panel on Climate Change – Fourth Assessment Report (2008). Glossary. Climate Change 2007: Synthesis Report. IPCC Press. Accessed November 19, 2012: http://www.ipcc.ch/publications_and_data/ar4/syr/en/annexes.html.

Leary, N. A. (2006). A Welfare Theoretic Analysis of Climate Change Inequities. In W. N. Adger, J. Paavola, S. Huq, M. J. Mace (Eds.), Fairness in Adaptation to Climate Change (155–178). Cambridge: MIT Press.

Lenart, M. (2008). Climate: Downscaling Techniques. Southwest Climate Change Network website. Accessed December 12, 2012: http://www.southwestclimatechange.org/climate/modeling/downscaling.

Mietzner, D. and G. Reger (2005). Advantages and disadvantages of scenario approaches for strategic foresight. International Journal of Technology Intelligence and Planning, Vol. 1, No. 2: 220 – 239. Accessed May 27, 2013: http://wohlstandfueralle.com/documents/StragegicForesight.pdf

Moore, Sara, Erika Zavaleta, and Rebecca Shaw (University of California, Santa Cruz). 2012. Decision-Making Under Uncertainty: An Assessment of Adaptation Strategies and Scenario Development for Resource Managers. California Energy Commission. Publication number: CEC-500-2012-027.

National Research Council of the National Academy of Science (2004). Adaptive Management for Water Resources Planning. Washington, DC: National Academies Press.

NPS – National Park Service (2007). Summary: Climate change scenario planning workshop: Joshua Tree National Park and Kaloko-Honokohau National Historical Park (Nov. 13–15, 2007, Joshua Tree National Park Headquarters). Accessed February 25, 2013: http://firecenter.umt.edu/files/documents/JOTR-KAHO%20Climate%20Change%20Scenario%20Planning%20Workshop_Summary.pdf.

NPS – National Park Service Climate Change Response Program (2011, March). Scenario Planning: Assateague Island National Seashore (two-page flier).

NPS AK – National Park Service Alaska Regional Office (2011a, Feb.) NPS Climate Change Scenario Planning (CCSP) Workshop, Anchorage, Alaska, 22-25 February 2011. Accessed February 28, 2013: http://www.nps.gov/akso/nature/documents/SWAN_Report-March-28-11.pdf.

Glick, P., B.A. Stein, and N.A. Edelson, eds. (2011). Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment. National Wildlife Federation, Washington, D.C. Accessed May 27, 2013: http://www.habitat.noaa.gov/pdf/scanning_the_conservation_horizon.pdf.

Ogilvy, J. and P. Schwartz (1998, reprinted by GBN 2004). Plotting Your Scenarios. In L. Fahey and R. Randall (Eds.), Learning from the Future. John Wiley & Sons. Accessed February 27, 2013: http://www.gbn.com/articles/pdfs/gbn_Plotting%20Scenarios%20new.pdf.

PRBO Conservation Science (2013, January). Strategy Brief: Climate Smart Conservation. Accessed February 27, 2013: http://www.prbo.org/cms/docs/climatechange/PRBO_StrategyBrief_ClimateSmartConservation_Dec%202012.pdf.

Rumsfeld, D. (2002). U.S. Department of Defense News Briefing. Accessed May 14, 2013: http://www.defense.gov/transcripts/transcript.aspx?transcriptid=2636.

Tucson Water (2004). Water Plan: 2000-2050. Accessed November 19, 2012: http://cms3.tucsonaz.gov/water/waterplan.

Tucson Water (2008). 2008 Update to Water Plan: 2000-2050. Accessed November 19, 2012: http://cms3.tucsonaz.gov/water/waterplan-2008.

Veloz, S. D., Nur, N., Salas, L., Jongsomjit, D., Wood, J. K., Stralberg, D., & Ballard, G. (in press, 2013). Modeling climate change impacts on tidal marsh birds: Restoration and conservation planning in the face of uncertainty. *Ecosphere*.

Welling, L. (2008). Climate Change Scenario Planning: A Tool for Managing Resources in an Era of Uncertainty. National Park Service PowerPoint.

Wilkinson, L. (1995). How to Build Scenarios: Planning for “long fuse, big bang” problems in an era of uncertainty. Global Business Network Briefing.

Appendix A. Glossary of Terms

Adaptation: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploit beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation. (IPCC Fourth Assessment Report 2007)

For the purposes of this paper, adaptation can be understood to mean intentional human action to prepare for climate change, both to realize gains from opportunities and reduce the damages caused by climate change.

Ecosystem-based adaptation: Ecosystem-based adaptation uses biodiversity and ecosystem services in an overall adaptation strategy. It includes the sustainable management, conservation and restoration of ecosystems to provide services that help people adapt to the adverse effects of climate change (CBD, 2009, p. 10).

Adaptive Management: A systematic approach for improving resource management by learning from management outcomes. (National Research Council, 2004)

Climate Smart Conservation: describes actions which address climate change impacts together with other threats and promote nature-based in order to reduce greenhouse gas emissions and enhance carbon sinks, reduce climate change impacts on wildlife and people, enhancing their ability to adapt, and sustain vibrant, diverse ecosystems. (PRBO, 2013)

Mitigation: Actions to slow or constrain climate change. (Leary, 2006, p. 155)

For the purposes of this paper, mitigation can be understood to mean intentional human action to reduce greenhouse gas emissions.

Scenarios: Plausible futures that facilitate one's evaluation of the outcomes of potential decisions in the context of different sets of background conditions.

Scenarios as they are chiefly discussed in this paper are composed of narratives created by considering the interactions of multiple critical uncertain drivers of management decisions. These are different from the scenarios used in the Global Climate Models (GCMs),[59] which are entirely mathematical, representing probable outcomes from the accumulation of greenhouse gases in the atmosphere. The scenarios discussed in this guidance for use in scenario planning can incorporate improbable but plausible drivers of change, extremes, first and second-order interactions, non-climatic drivers, and other elements not explicitly factored into GCMs.

Vulnerability: Vulnerability: The degree to which a system is susceptible to and unable to cope with the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function

[59] The same acronym is used for "general circulation models," which are components of global climate models.

of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. (IPCC Fourth Assessment Report 2007)

For the purposes of this paper, vulnerability can be understood to be a condition produced by exposure (i.e., location of the management target in regard to impact area), sensitivity (i.e., degree to which the impact can damage the management target), and the management target's capacity to adapt to change, taking advantage of positive change and avoiding or minimizing the damage of negative change.
Exposure x Sensitivity x Capacity to adapt = Vulnerability

Vulnerability Assessment: A systematic evaluation of projected or observed exposure to negative impacts from an event or process, analyzing sensitivity and capacity to adapt, and on those bases creating a ranking of impacts to assist in planning.

Appendix B. Letter Introducing Participants to the Futures of Wild Marin Workshop

Dear Friends:

If you are receiving this, then you have either confirmed or are expected to confirm your attendance at the one day workshop on January 28th, 2011, "Futures of Wild Marin." This workshop is part of the California Energy Commission's state climate change vulnerability assessment, one of the tasks laid out in the 2009 California Climate Adaptation Strategy.

The overarching goal of this workshop is to determine, if possible, concrete actions that the resource managers working in the protected areas of West Marin could take to prepare for a set of plausible futures based on climate data and knowledge of other probable future changes which concern resource managers.

These "futures" are being sketched out in advance of the workshop by a subset of attendees. This subset of 11 people was chosen on the basis of being involved in long-term planning for climate change and resource management, being available for one-hour conference calls in Nov/Dec/Jan, being a consumer or generator of climate change data in their agency, and working primarily in our case study target area (Marin Watershed District, Mt. Tam and Samuel P. Taylor State Parks, Point Reyes NS, Muir Woods NM, and the Bolinas Lagoon). This team is setting out a draft set of adaptation goals, selecting a set of highly uncertain and high-consequence factors in local resource management under climate change, and creating rough sketches of a set of plausible futures, defined by those varying factors.

This workshop is being modeled on the work of Leigh Welling in her role as Climate Change Coordinator for the National Parks Service, and we are lucky enough to have at our disposal the facilitator Leigh uses for her climate change scenario planning exercises, Jonathan Star of the Global Business Network. He will be supported by his colleague Mick Costigan.

In the coming weeks I will be sending you a draft agenda for comment, and some preliminary readings on scenario planning. If you would like more information on the scenario development process, please let me know. Attached is the current draft list of attendees, with the scenario development team members' names in bold.

Our workshop is scheduled to begin at 9:00 AM on Friday Jan. 28th, and finish with dinner at 6:00 PM at the Headlands Institute.

Please let me know if you have any questions or comments for me about our workshop preparation process!

Thank you for your interest and enthusiasm,
Sara Moore

Appendix C. Sample Summary Presentation of Variables for Scenario Development

One of three summary charts on drivers of external change for Joshua Tree National Park, starting with climate change, then budgetary, then National Park value (e.g., quality of visitor experience, which is expected to decline over time).

SUMMARY OF PROJECTED CLIMATE CHANGES FOR JOSHUA TREE						
Climate Variable	**General Change Expected**	**Specific Change Expected & Reference Period**	**Size of Expected Change Compared to Recent Changes**	**Seasonal Patterns of Change**	**Confidence**	**Source & Context**
Temperature	Increase	2050: +2±0.6°C 2100: +3.1±1.1°C	Large	More pronounced in summer and early fall	>99.9% *Virtually certain*	Abatzoglou and Brown*

Excerpted from Drivers of External Change for Joshua Tree National Park: Climate Change (NPS, 2007, Table 1a)
* Values extracted from nine climate models used in the IPCC AR4; values based on SRES-A1B.

This summary presentation was adopted for the Futures of Wild Marin, with some columns being harder to complete than others. Climate and environmental (climate-driven or non-climate-driven) variables were separated into processes (such as sea level and temperature rise) and events (such as extreme storms and heat).

Driver (Processes and events)	**General direction of change expected**	**Specific change expected, reference period**	**Size of change expected (compared to recent changes)**	**Expected patterns of change (e.g., when is it expected to be greater) – seasonality of change**	**Confidence**	**Source/ Context**
Environmental Process: Sea Level Change	Increase	**By 2050:** 40 cm (State of CA [Rahmstorf 2007, Cayan 2008]); **75 cm** (Vermeer, Rahmstorf 2009) **By 2100:** 140 cm (State of CA [Rahmstorf 2007, Cayan 2008]); **190 cm** (Vermeer, Rahmstorf 2009)	Over the past 100 years: 15 cm of sea level rise has been observed (CEC 2006)	Temporary cycles like El Niño events can increase sea level; tectonic movements, subsidence/ uplift, wind and wave fields also can affect sea level.		Largier 2010

Appendix D. Recommended Reading and Other Resources for Scenario Planning

Futures of Wild Marin Orientation Documents: the following documents were circulated to the participants of the Futures of Wild Marin scenario planning team after the team was assembled (October 2010) to orient them on the use of scenario planning as a tool to plan for climate change in a resource management context:

- Welling, L. (2008). Climate Change Scenario Planning: A Tool for Managing Resources in an Era of Uncertainty. National Park Service PowerPoint. Accessed May 28, 2013: http://www.fs.fed.us/psw/cirmount/meetings/mtnclim/2008/talks/pdf/Welling_Talk2008.pdf.

- Wilkinson, L. (1995). How to Build Scenarios: Planning for "long fuse, big bang" problems in an era of uncertainty. Global Business Network Briefing. Accessed May 28, 2013: http://www.gbn.com/consulting/article_details.php?id=36.

- National Park Service (2007). Summary: Climate change scenario planning workshop: Joshua Tree National Park and Kaloko-Honokohau National Historical Park (Nov. 13–15, 2007, Joshua Tree National Park Headquarters). Accessed May 28, 2013: http://firecenter.umt.edu/files/documents/JOTR-KAHO%20Climate%20Change%20Scenario%20Planning%20Workshop_Summary.pdf.

• Ogilvy, J. and P. Schwartz (1998, reprinted by GBN 2004). Plotting Your Scenarios. In L. Fahey and R. Randall (Eds.), Learning from the Future. John Wiley & Sons. Accessed May 28, 2013: http://www.gbn.com/consulting/article_details.php?id=24.

• Chapin, F. S., III, and E. Zavaleta (2010). Planning in the context of uncertainty: Flexibility for adapting to change. In D. N. Cole and L. Yung (Eds.), Beyond Naturalness: Rethinking Park and Wilderness Stewardship in an Era of Rapid Change (216–233). Washington, DC: Island Press.

Scenario planning resources for addressing climate change:

• Choy, D.L . et al. (2012). Scenario Planning for Climate Change Adaptation. A report for the South East Queensland Climate Adaptation Research Initiative. A 140-page report created by the initiative's Human Settlements research team, including experts from the Queensland and Australian Governments, the CSIRO Climate Adaptation National Research Flagship, Griffith University, University of the Sunshine Coast and The University of Queensland. It walks you through the development of two scenarios by stakeholder groups. Accessed May 28, 2013: http://www.griffith.edu.au/__data/assets/pdf_file/0004/464251/Griffith-University-SEQCARI-Scenario-Report-Oct-2012.pdf.

• Jones, R. (2010). The use of scenarios in adaptation planning: managing risks in simple to complex settings. A report done for the project "Clarifying and mapping the use of scenarios in climate change adaptation strategies for the state of Victoria" at the Centre for Strategic Economic Studies, Victoria University, Australia. A good, relatively accessible 13-page paper giving a typology of scenarios, and the optimal use of scenarios for climate change adaptation planning. Accessed May 28, 2013: http://piarn.org.au/sites/piarn.boab.info/files/Jones%202010%20-%20The%20use%20of%20scenarios%20in%20adaptation%20planning.pdf.

Two other companion papers on scenario planning created for the same project are available here (accessed May 28, 2013): http://piarn.org.au/resource/249.

• Weeks, D., P. Malone, and L. Welling (2011). Climate Change Scenario Planning, on the Climate Adaptation Knowledge Exchange (CAKE), a database of natural resource management and conservation resources, maintained by EcoAdapt and Island Press. Accessed May 28, 2013: http://www.cakex.org/virtual-library/climate-change-scenario-planning.

Scenario planning at the National Park Service:

• Global Business Network (2009). Using Scenarios to Explore Climate Change: Project Report for the National Park Service. This report summarizes the proceedings of a scenario planning workshop with staff from the Assateague Island National Seashore and Wind Cave National Park. This workshop involved "nested scenarios" (interacting more than two variables) like those used in the Futures of Wild Marin workshop (see Section 4). The report walks the reader through the typical scenario planning process for the NPS. Accessed May 28, 2013: http://nature.nps.gov/geology/nationalfossilday/docs/NPSScenarioProjectSummary.pdf.

A clear, brief PowerPoint (26 slides) that gives a closer look at the Assateague National Seashore scenarios (presented by management assistant C. Zimmerman at the U.S. Fish and Wildlife Service 2010 workshop "Adapting to Climate Change in the Mid-Atlantic"). Accessed May 28, 2013: http://www.fws.gov/northeast/climatechange/conference/pdf/330pm_carl_zimmerman.pdf.

The NPS Alaska Region's three-year series of scenario planning workshops is thoroughly documented on the NPS Alaska Regional Office website. Available documentation includes photographs of discussion templates, maps, pre-workshop webinar recordings, presentation PowerPoints, and scenario narratives. Accessed May 28, 2013: http://www.nps.gov/akso/nature/climate/scenario.cfm.

Scenario planning beyond climate change:

- Holway, J. et al. (2012).Opening Access to Scenario Planning Tools. Lincoln Institute of Land Policy. A slick and readable 60-page resport that addresses the use of scenarios to plan for changes in land use, land markets, and property taxation, and documents the results of a series of community planning workshops and conversations convened by the Lincoln Institute of Land Policy and the Sonoran Institute in 2010 and 2011. Accessed May 28, 2013: https://www.newschallenge.org/open/open-government/inspiration/city-builders-wanted/gallery/2027_1352_opening-access-to-scenario-planning-tools.pdf/.

- Mietzner, D. and G. Reger (2005). Advantages and disadvantages of scenario approaches for strategic foresight. International Journal of Technology Intelligence and Planning, Vol. 1, No. 2: 220 – 239. Accessed May 27, 2013: http://wohlstandfueralle.com/documents/StragegicForesight.pdf