

# **DECISION-MAKING UNDER UNCERTAINTY: AN ASSESSMENT OF ADAPTATION STRATEGIES AND SCENARIO DEVELOPMENT FOR RESOURCE MANAGERS**

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## ABSTRACT

This paper contributes an analysis of natural resource management tools for planning for climate change, including a case study on scenario planning, to the Climate Vulnerability and Adaptation Study for California. It presents the findings of a literature review on decision-making tools for climate change planning and consultations with adaptation planners, resource managers, and scientists. In addition, it discusses lessons learned from a one-day climate change scenario planning workshop with resource managers and scientists working in Marin County that focused on analyzing the scenario approach in the context of other approaches. It also describes cases of public agency and private conservation non-profit organizations working on resource management problems under climate change.

The conclusions include the following:

Planning for climate change requires tools for making decisions under conditions of uncertainty. The decision-making tool of scenario planning, which incorporates the best available information on climatic and socio-economic trends to create multiple, plausible future scenarios built on the variables of highest concern to resource managers, can help resource managers interpret data to create concrete action steps to prepare for climate change.

The planning approach most helpful to resource managers may be a combination of different approaches, including scenario planning within the context of the experimental, iterative adaptive management approach and inter-agency collaboration.

Once planning for climate change impacts has begun, organizational commitment and follow-through are essential for long-term success. Constrained public budgets and flagging political interest in climate change pose barriers to planning for the impact of climate change on the state's natural resources. Nevertheless, resource managers can use the ongoing climate change impact planning process to promote the understanding of the imperative to protect natural systems as an integral part of society's defenses against climate change impacts.

**Keywords:** Adaptation, climate change, ecosystem, resource managers, management, scenario planning, scenario development, decision-making, uncertainty

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# EXECUTIVE SUMMARY

## Natural Resource Management under Climate Change Presents Special Challenges

Given the current level of greenhouse gas emissions in the atmosphere, a certain amount of climate change is inevitable. Natural resource managers are now engaging in *adaptation planning* for the present and future impacts of climate change. Adaptation planning involves preparing to minimize the negative impacts of climate change and, where possible, take advantage of its opportunities. By necessity, all decision-making about the future is done with some uncertainty; climate change is one of the many uncertainties which resource managers must face in planning.

Resource managers are turning to scientists for better climate projections, impact and vulnerability assessments, and other products to help define the climate threat. Scientists can create knowledge products, but there are limitations on what scientists can project, and their projections do not necessarily map a path to action. This paper seeks to address the gap between scientific outputs and resource management action. What tools exist to help resource managers bridge that gap? Here we present findings on available tools for decision-making for climate change adaptation based on a literature review and a case study involving a climate change scenario planning exercise, one of the tools resource managers might use for incorporating climate change into planning for an uncertain future.

Scenario planning is recommended as a tool when decision makers have little control over major influencing factors and uncertainty is high (see Section 3.3.1.1 for more on its optimal use). In our case study exercise, we sought to create a set of resource management action steps that are robust to multiple climate futures by discussing responses to a set of critical factors for resource management decision-making. In this exercise the critical factors for decision-making define the future scenarios around relative probabilities and uncertainties, and those alternative futures guide the design and evaluation of management actions to address areas of concern to resource managers.

## Adaptation Actions Should Follow Best Practices, Be Robust to Multiple Futures, and Use Adaptive Management

The following are the main recommendations of this paper regarding the design of climate change adaptation actions:

- Adaptation actions should be designed within a framework of accepted best practices for resource conservation and management to avoid decisions that are maladaptive or otherwise harmful. Traditional conservation practices in many cases may be sufficient to prepare appropriately for climate change. However, traditional tools should be reevaluated and in some cases used differently under climate change. In addition, available climate science projections should be incorporated when possible, keeping in mind their limitations.

- Adaptation actions should be robust to a range of alternative futures, given the uncertainty about the complex systems involved in climate science, climate change impacts (both primary and secondary), and threshold effects, as well as interaction effects with demographics, economic conditions, land use practices, political and cultural attitudes toward climate change, and other critical non-climate factors.
- Adaptation actions should follow the practices of adaptive management, including setting of criteria for good adaptation and monitoring of decision-critical indicators that inform the ongoing evaluation and improvement of actions. Where possible, pilot projects should precede large-scale deployment of adaptation actions. Actions should be designed to do no harm, be flexible (maintaining the ability to reverse mistakes), and address the areas of greatest need, effectively minimizing negative climate impacts on biodiversity and natural resources.

## **Climate Models and Scenario Planning Together Can Improve Decision-Making**

When responding to climate change in the natural resources realm, one of the first steps is an assessment of climate impacts and the vulnerability of conservation targets based on scientific climate model outputs. But are these model outputs sufficient for planning? Climate models are not well-suited for demonstrating some aspects of climate such as extremes, interactions, and feedback effects, and do not take into account decision-critical factors that fall outside the climate system, such as political will or budgetary constraints.

Scenario planning can be used in tandem with climate model-based assessments to explore the stories not told by climate models. *Scenario* in this paper refers to a description of a future built on the variables critical to decision-making, considering different projections of highly uncertain trends on a backdrop of highly certain trends.<sup>1</sup> In scenario planning, managers create a variety of scenarios, and then consider in depth a small number of varied but equally plausible futures (Schwartz 1991). This approach can help overcome decision-making paralysis caused by the lack of scientific certainty inherent in climate models.

However, scenarios alone are also insufficient for climate change planning. Scenarios are plausible futures, but are no more *likely* than the average conditions or coarse trends described by a climate model. Ideally, resource managers planning for climate change can bridge the gap between science and action by combining climate model outputs—and climate-driven biophysical model outputs—with scenarios of different uncertain trend projections to address emerging management concerns and ensure actions are robust to a range of plausible futures.

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<sup>1</sup> Note that the word “scenario” is also used by the Intergovernmental Panel on Climate Change to describe the different futures produced from interacting climate model outputs (from Global Climate Models or GCMs) with different technological development paths, producing more or less greenhouse gases to drive climate change.

## The Futures of Wild Marin

This paper uses a case study to illustrate how a scenario-based decision-support process can help decision makers use information about climate change to shape specific resource management policies and actions. Specifically, this paper presents the results of a one-day scenario planning workshop, *The Futures of Wild Marin*, held in January 2011 for resource managers and scientists working in the protected areas of West Marin County, California. Participants, who represented fourteen public agencies and private non-profit agencies, developed and discussed eight scenarios defined by factors they ranked as the most critical for decision-making (both factors with relatively high certainty, such as sea level and air temperature rise, and factors with relatively high uncertainty, such as the timing of the onset of the dry season). Participants evaluated the exercise at the end of the day.

Recommendations for future scenario planning exercises include the following:

- Employ more scientific input on the critical variables defining the scenarios.
- Give participants an initial, basic presentation on local climate change impacts and existing resource management responses to climate change (“Adaptation 101”).
- Allow at least two days for the workshop to provide sufficient time for discussion of the scenario-defining critical variables, their interactions, and each resulting scenario.

After the workshop, participants affirmed the usefulness of this exercise for beginning an important collaborative discussion about climate change planning—a daunting and pressing problem.

## Paper Structure

This paper begins with a background on the problem of climate change adaptation, with a description of types of goals and interventions (Section 1: About this Paper). The paper goes on to describe a typology of goals and strategies for climate change adaptation (Section 2: Strategies for Ecosystem Adaptation), and then present a way to begin to take action on climate change adaptation: defining the problem, assembling evidence, constructing alternatives, and selecting criteria for evaluation (Section 3: How to Begin Planning for Climate Change). The paper then presents the context and findings of the case study *Futures of Wild Marin* which illustrates the use of the scenario planning tool for decision-making under uncertainty (Section 4: Case Study: The Futures of Wild Marin). The paper concludes with recommendations (Section 5: Recommendations).

## Conclusion

Where and however possible, uncertainty should be reduced for resource management decision makers facing climate change, and where it cannot be reduced, it should be incorporated as a factor in planning. To these ends, the climate models and other scientific tools for projecting climate impacts must be improved, and the tools for interpreting climate projections into action in an uncertain future must also be improved. Adaptation actions must be designed carefully to promote best practices (including relying on natural systems to reduce impacts where possible,

employing an ecosystem-based adaptation approach), be robust to multiple futures, and incorporate adaptive management principles. Effective responses to climate change threats will incorporate both climate model outputs and the results of broader discussions that address the uncertain but decision-critical trends that are not described by climate models. The impacts of climate change are already requiring resource managers to change their practices. California's state agencies may pay high costs if they delay climate change preparation while waiting for greater scientific certainty about impacts. The present paper will hopefully provide guidance on bridging the gap between science and concrete planning processes, facilitating near-term and effective action to protect California's natural resources under climate change.

# SECTION 1: About This Paper

## 1.1 The California Climate Vulnerability Assessment

State agencies have begun a state-level plan to prepare for climate change in California, responding to an executive order by Governor Arnold Schwarzenegger (Executive Order S-13-08, signed November 14, 2008). This state plan builds on past and ongoing research financed by the California Energy Commission's Public Interest Energy Research (PIER) climate change program. In December 2009, the state released a Climate Adaptation Strategy for California, directing the preparation of a state climate vulnerability study led by the PIER program. The assessment was recommended to be completed as follows:

Develop a California Climate Vulnerability Assessment (CCVA) to ensure the best available science informs climate adaptation decision-making. State agencies will work through the CNRA [California Natural Resources Agency] to develop the state's first CCVA focused on sharing information, providing opportunities for public discussion on climate risk research and policies, and developing cross-sector strategies.

- Climate Adaptation Strategy 4: Expand California's Climate Change Research and Science Programs and Expand Public Outreach of Research to Policy-Makers and General Public (p. 28)

The overarching goal of this assessment is to **develop appropriate, feasible, and robust options for climate change preparation (adaptation) in California.**

### 1.1.1 The Ecosystem Focus of the State Vulnerability Assessment

The state vulnerability assessment considers two aspects of vulnerability: physical vulnerability (the natural dimension) and socio-economic vulnerability (the human dimension). The research is divided into the following categories: (1) cross-cutting studies that generate data to support all studies, such as climate modeling), (2) statewide studies and regional or local studies that combine research into physical and socio-economic vulnerability, and (3) ecosystem adaptation studies. The present study falls under the category of ecosystem adaptation studies.

The ecosystem adaptation studies are led by Drs. David Ackerly (University of California [UC] Berkeley), Jim Thorne (UC Davis), Erika Zavaleta (UC Santa Cruz), Craig Moritz (UC Berkeley), Max Moritz (UC Berkeley), Lee Hannah (UC Santa Barbara), Rebecca Shaw (Environmental Defense Fund, formerly of the Nature Conservancy), and Peter Moyle (UC Davis). Their studies evaluate ecosystem vulnerabilities to climate change in the context of the distribution of California's protected areas.

The present study was led by Drs. Erika Zavaleta and Rebecca Shaw. This paper addresses the question of how to use impact and vulnerability data to develop robust adaptation plans and explores the strengths of different decision-making tools and adaptation strategies under multiple scenarios of climate change. It addresses this research question by presenting findings from a literature review of adaptation strategies and decision-making tools for resource managers and a case study concerning a scenario planning exercise for resource managers in Marin County, California.

### 1.1.2 What is Adaptation and Why Are We Studying It?

The term *adaptation* in the context of biological science is understood as a natural process that is reactive rather than proactive; this paper uses the term to refer to intentional human action to prepare for climate change, both to realize gains from opportunities and reduce the damages caused by climate change (Agrawala and Fankhauser 2008).<sup>2</sup> Examples of adaptation actions in the context of resource management include:

- Creating wildlife corridors to account for future habitat migration, such as the Redwood Heartland initiative in the Santa Cruz Mountains<sup>3</sup> or the Yellowstone to Yukon conservation corridor;<sup>4</sup>
- Moving a vulnerable species to a place where the future habitat is expected to be more hospitable than its present habitat after climate change, such as the Assisted Migration Adaptation Trial (AMAT) of British Columbia, which experiments with planting vegetation in novel locations on a massive scale;<sup>5</sup>
- Taking measures to reduce the vulnerability of critical habitat, such as Dr. Carlos Drews' work to artificially cool beaches where sea turtles nest by restoring vegetation<sup>6</sup> or the protection of economically important parts of the Great Barrier Reef from bleaching with floating cloths and sprinklers.<sup>7</sup>

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<sup>2</sup> Another way to define *adaptation* includes both actions intended to prepare for climate change (regardless of how much they in fact increase climate change preparedness) and actions that, regardless of intention, effectively respond to climate change and increase climate change preparedness. Ekstrom, Moser, and Torn (2011) use this inclusive definition: "Adaptation involves *changes in social-ecological systems* ... in response to actual and expected impacts of climate change in the context of interacting non-climatic changes." (p.1, italics added). For the purposes of this study, adaptation means proactive steps to address climate change impacts, regardless of the result of action, and does not include reactive changes in systems responding to climate change.

<sup>3</sup> Read more on the Redwood Heartland initiative (accessed August 29, 2011):  
[http://www.savetheredwoods.org/newsroom/news\\_detail.php?id=249](http://www.savetheredwoods.org/newsroom/news_detail.php?id=249).

<sup>4</sup> Read more on the Yellowstone to Yukon Conservation Initiative website (accessed April 2, 2011):  
<http://www.y2y.net/>.

<sup>5</sup> Read more on the AMAT (accessed June 28, 2011):  
<http://www.for.gov.bc.ca/hre/forgen/interior/AMAT.htm>.

<sup>6</sup> Read more on Dr. Carlos Drews' work: Turtles are Casualty of Warming in Costa Rica (NYT 2009, reposted by Restoring Our Watershed, accessed April 2, 2011):  
<http://www.ourwatershed.org/turtles-are-casualties-of-warming-in-costa-rica>.  
Also read: Adaptation to Climate Change: Options for Marine Turtles (Fish & Drews 2009, accessed April 2, 2011):  
[http://assets.panda.org/downloads/adaptation\\_to\\_climate\\_change\\_options\\_for\\_marine\\_turtles.pdf](http://assets.panda.org/downloads/adaptation_to_climate_change_options_for_marine_turtles.pdf).

<sup>7</sup> Read more about these reef-protection measures here: Shadecloth Might Protect Great Barrier Reef from Global Warming (Field 2006, accessed April 2, 2011):  
<http://www.abc.net.au/am/content/2006/s1780258.htm>.

Other actions that help a species or ecosystem adapt to a changing climate may not explicitly address specific climate change impacts, but rather reduce threats that generally exacerbate vulnerability to climate change, such as detrimental land use practices, habitat fragmentation, or pollution (Lawler et al. 2009). Adaptation actions are often undertaken as measures embedded within broader sectoral initiatives such as coastal defense, water resource management, and disaster management (Adger et al. 2007).

While other papers in the state vulnerability assessment analyze different aspects of vulnerability (e.g., exposure [physical and social], sensitivity, and capacity to adapt to climate change<sup>8</sup>), this paper focuses on the utilization of information about vulnerability in the decision-making process involved in preparing for natural resource management under climate change. This paper is not intended as a guidebook to preparing an impact assessment, a vulnerability assessment, or other necessary parts of an adaptation plan.

Another paper within the state vulnerability assessment, led by Dr. Susanne Moser and Dr. Julia Ekstrom, addresses barriers in the context of the adaptation decision-making process (Moser and Ekstrom 2010). This paper does not duplicate the efforts of Moser and Ekstrom, who have analyzed selected challenges in the institutional response to climate change. Rather, this paper aims to provide planning process guidance to help translate vulnerability information and other pertinent knowledge into actionable plans which might arise in the planning process, without examining planning process challenges. For more on how to overcome those challenges, the authors recommend readers review the findings and recommendations of the PIER-funded paper, *Identifying and Overcoming Barriers to Climate Change Adaptation in San Francisco Bay: Results from Case Studies* (Moser and Ekstrom 2012).

## 1.2 Problem and Background

California's natural resource managers may have access to climate change data and yet not be able to interpret the data to arrive at planning decisions. This gap between data and planning leaves government agencies unprepared to protect biodiversity and support healthy ecosystems that are critical to life. Even if all gaps between scientists, managers, and policy decision makers were to be closed, natural resource managers would still face the challenge of incorporating the unexpected into planning processes.

Natural resource agency leaders and politicians responsible for funding those agencies should be highly concerned about the lack of support for a process to translate climate change data into decisions and incorporate uncertainty into decision-making processes. Californians look to the

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<sup>8</sup> The concept of vulnerability has many dimensions additional to these three elements, including the difference between starting point vulnerability (pre-exposure, a measure helpful for identifying ways to reduce vulnerability) and end-point vulnerability (post-exposure, an evaluation of impact) (O'Brien et al. 2004). Also, vulnerability is a dynamic quality, so that a target deemed non-vulnerable could suddenly become vulnerable after reaching some threshold value (such as heat), an increase in rate or scope of climate change, or the addition of an unforeseen stressor. Because of this, vulnerability must be assessed iteratively. See Appendix A for more on the definition of vulnerability.

government to protect the clean air and water on which life depends, and insofar as climate change impacts are already taking a toll on public health and safety (e.g., through exacerbated drought, a prolonged and more intense wildfire season, severe storms, and coastal erosion), the government should take action to ensure that climate change impacts are being incorporated into planning decisions at all levels and that *climate headroom* is being built into plans to allow for unexpected interaction and threshold effects.<sup>9</sup> It costs little to avert a planning decision that will increase vulnerability to climate impacts, such as averting a plan to allow housing and other infrastructure to be sited in a future seawater inundation zone, compared to the cost of recovery from a decision that puts people and ecosystems in harm's way.

The state also has an interest in protecting a healthy California landscape, maintaining its essential functions in terms of natural processes beneficial to humans (ecosystem services<sup>10</sup>), and the preservation of biodiversity.<sup>11</sup> Climate change will exacerbate existing challenges and introduce some never seen before, making it increasingly difficult to protect these state interests. California Senate Bill (SB) 375, California's Sustainable Communities and Climate Protection Act, which went into force in 2009, encourages the consideration of climate change in regional planning, but stops short of mandating statewide preparedness for climate change impacts.<sup>12</sup> Top-down support for planners to consider the robustness of their plans in the face of climate change is needed. The present vulnerability assessment is a step in that direction.

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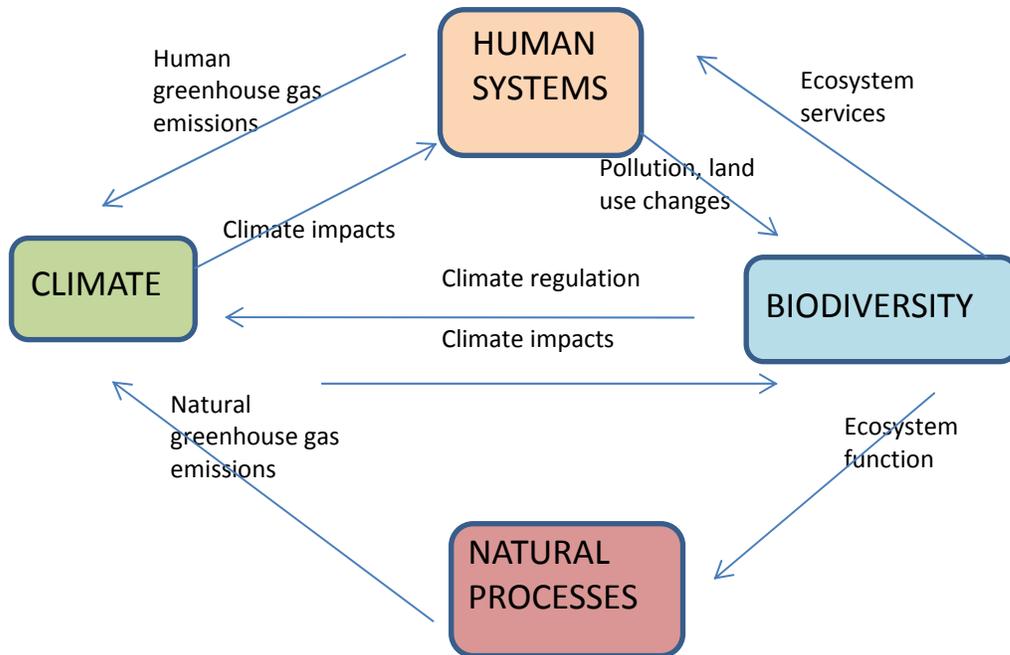
<sup>9</sup> See Section 2.2.2 on strategies that incorporate *climate headroom*.

<sup>10</sup> *Ecosystem services* describes "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life" (U.S. Climate Change Program 2008). In other words, it is the concept of evaluating natural processes in terms of how they support human life. The provision of clean water by a watershed is an example of an ecosystem service.

<sup>11</sup> Native biological diversity or *biodiversity* refers to ecosystem/biological community diversity, species diversity, and genetic diversity (Jenson, Torn, and Harte 1990). The Global Invasive Species Programme uses the definition of *invasive alien species* as set out in the Convention on Biodiversity: "species whose introduction and/or spread outside their natural past or present distribution threatens biological diversity." (For more on the Global Invasive Species Programme [accessed August 31, 2011]: <http://go.worldbank.org/TAG88LH6L0>; for more on the Convention on Biodiversity definition [accessed August 31, 2011]: <http://www.cbd.int/invasive/WhatareIAS.shtml>) (On the question of the relationship between biodiversity and a landscape's capacity to adapt to climate change, the Secretariat of the Convention on Biological Diversity asserts that plantations and modified natural forests "will face greater disturbances and risks for large-scale losses due to climate change than primary forests, because of their generally reduced biodiversity" (in Forest Resilience, Biodiversity, and Climate Change, SCBD, 2009, p. 7). Hooper et al. (2005) asserts that "[h]aving a range of species that respond differently to different environmental perturbations can stabilize ecosystem process rates in response to disturbances and variation in abiotic conditions," and "[u]sing practices that maintain a diversity of organisms of different functional effect and functional response types will help preserve a range of management options" (p. 4).

<sup>12</sup> Read the final text of SB 375 as of September 30, 2008 (accessed April 3, 2011): [http://www.leginfo.ca.gov/pub/07-08/bill/sen/sb\\_0351-0400/sb\\_375\\_bill\\_20080930\\_chaptered.pdf](http://www.leginfo.ca.gov/pub/07-08/bill/sen/sb_0351-0400/sb_375_bill_20080930_chaptered.pdf).

Figure 1 illustrates the role of biodiversity in supporting human life, and how climate change impacts human life both directly and indirectly by threatening biodiversity (after the Royal Society 2008).



**Figure 1: Human Well-being, Biodiversity, and Climate Change<sup>13</sup>**

Although the benefits of planning for climate change might be clear, often political will around taking action to prevent harm from climate change is lacking because of the assertion of the uncertainties of climate science. Even given the limitations on climate science (see Section 3.2.1.1), it has been shown to be a relatively reliable source of general guidance on the low-end values of long-term climate trends, such as increasing temperature. It would be irresponsible for a government agency to ignore climate projections due to the presence of uncertainty in the models, delaying action until there is greater certainty. By the time certainty in the climate models is deemed sufficient, action might be prohibitively expensive or infeasible.

In addition, many public agency workers may lack the capacity. The case study described in Section 4 resulted in the construction of a set of plausible futures under climate change that differed along two climatic variables (the timing of precipitation and the direction of strong wind) and a third non-climatic variable: capacity to act in a resource management context. The

<sup>13</sup> Adapted from figure from Biodiversity–climate interactions: adaptation, mitigation and human livelihoods, The Royal Society, February 2008, p. 3, Figure 1. (Accessed July 21, 2011): [http://royalsociety.org/uploadedFiles/Royal\\_Society\\_Content/policy/publications/2007/7991.pdf](http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/2007/7991.pdf).

participants in the case study selected this variable because in any climate future the capacity to act could dictate the resource management future. Then, among the criteria selected by participants for evaluating possible climate change preparation actions (considerations of flexibility, use of adaptive management, cost-effectiveness, clarity of design, and whether it is collaborative in approach), the criterion of *feasibility* was missing. When asked why that criterion was not included, a participant responded that if they were restricted to actions that were feasible right now, then nothing would meet the criteria. Whether this response is informed by a real or perceived absence of all capacity to act, it speaks to the paralyzing effect of the fear of a lack of capacity to act.

For more on uncertainty, lack of capacity to act, and other institutional barriers to acting to prepare for climate change, see the earlier-referenced work of Moser and Ekstrom (2010 and 2012). Four top barriers on which they focus are leadership, resources, values/ beliefs, and communication/ information (Moser and Ekstrom 2010). However, the point is made in their work that overcoming all barriers does not ensure successful preparation for climate change (Ibid).

### 1.2.1 Gaps in the Process

Researchers have observed a lack of feedback loops between basic science and practice. An opinion piece in *Trends in Ecology and Evolution* in 2004 by Sutherland, Pullin, Dolman, and Knight asserted the following regarding gaps between science and management practice:

Current conservation practice faces the same problems as did old-fashioned medical practice. For example, most decisions are not based upon evidence, but upon anecdotal sources. Furthermore, very little evidence is collected on the consequences of current practice so that future decisions cannot be based upon the experience of what does or does not work. Much accumulated experience is solely in the memory of individual practitioners, and the collection of information in a form that could be used by others is very limited. (p. 305)

This lack of a system for incorporating evidence into decision-making sounds like a lack of *adaptive management*, a systematic approach for improving management practices that emphasizes learning from experience, including engaging in deliberate experimentation and monitoring (National Research Council 2004; BCMFR 2011). The lack of a process whereby scientific findings inform management and, reciprocally, management experience informs future decisions, including the bases for scientific inquiry, is a fundamental concern motivating this paper. Based on the present literature review, it seems that, while these gaps are observed by researchers, the gaps and ways to bridge them are not widely studied through empirical research. This paper focuses on the first gap, the lack of a process whereby science informs management. The second gap, the lack of a process whereby management informs science, is critically important, but falls beyond the scope of this paper.

Ongoing science-management partnerships are a key way to bridge both gaps. For further discussion of this, see Littell et al. (2011), which presents and discusses two science-management partnerships created to assist with climate change planning in the Olympic National Forest (Washington) and Tahoe National Forest (California). This report characterizes the science-management gap in climate change planning in one case study thus:

Critical gaps in scientific information hinder adaptation by limiting assessment of risks, efficacy, and sustainability of actions. Managers would also like assistance and consultation on interpreting climate and ecosystem model output, so that the context and relevance of model predictions can be reconciled with managers' priorities for adaptation.

Before proceeding to a discussion of ways to incorporate climate science into management decisions, first we will examine some key terms and concepts for discussing climate change planning.

### 1.2.2 Kinds of Uncertainty

When discussing the subject of planning under conditions of uncertainty, it is important to remember that not all uncertainties are equally uncertain. This famous quote is helpful to illustrate the range of uncertainties at play in climate change planning:

[T]here are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns – there are things we do not know we don't know. (Rumsfeld 2002)

This creates a matrix with two variables: whether we know something, and whether we know we know it.

We know x, and we know we know it	We know x, but we don't know we know it
We don't know x, and we know we don't know it	We don't know x, and we don't know we don't know it

When the term *relative uncertainties* is used in the present paper, it refers to the type of uncertainty described in the bottom left cell. The bottom right cell represents the element of surprise – all that cannot be included among the uncertain factors but that might nonetheless determine the future.

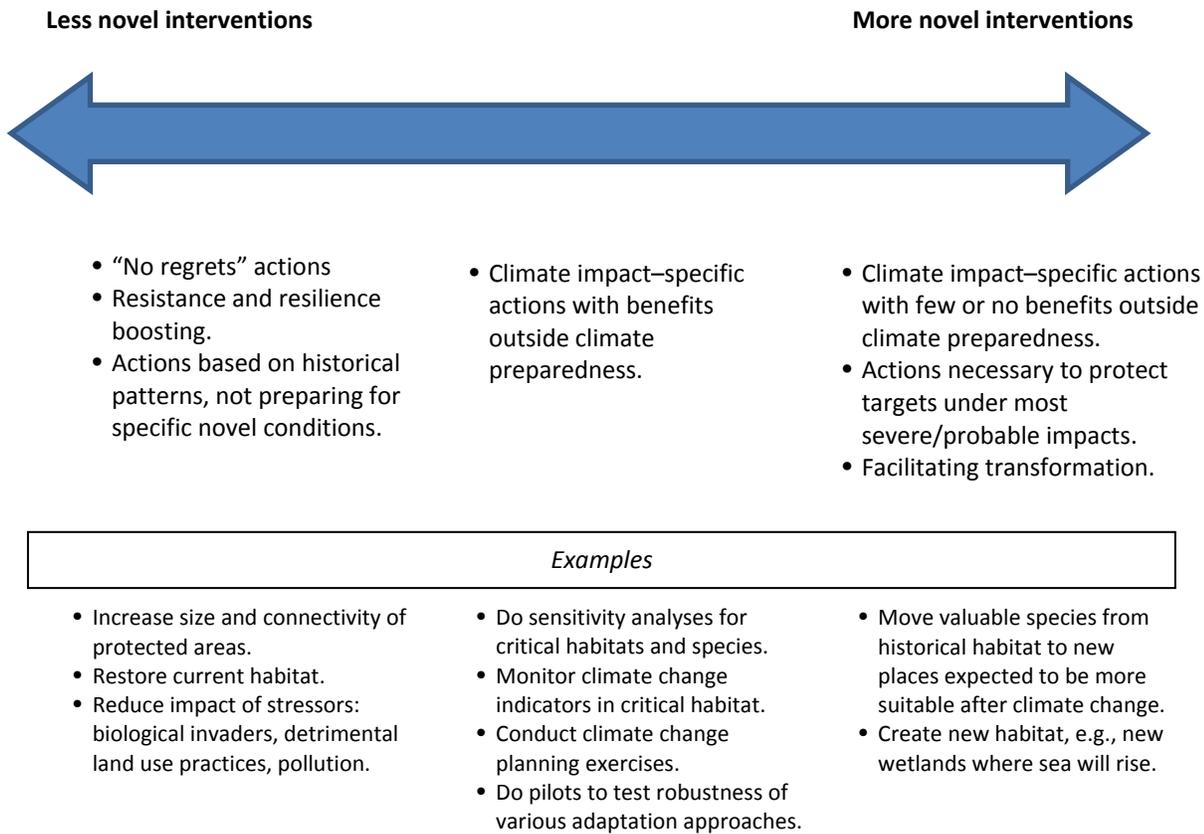
### 1.2.3 Managing Natural Resources under Climate Change

When managing natural resources under climate change, managers must plan for climate impacts insofar as they are known. This is called *adaptation* to climate change. Adaptation, according to one definition, consists of actions to realize gains from opportunities or to reduce the damages that result from climate change (Agrawala and Fankhauser 2008; see Appendix A for more). Resource managers can choose to help a landscape resist change, be more resilient to change, or transform in a healthy manner as inevitable change takes place, and ideally should employ a suite of different kinds of ecological interventions, addressing both short- and long-term climate threats (discussed in greater detail in Section 2) (Chapin and Zavaleta 2010; Hansen and Hoffman 2011; Heller and Zavaleta 2009; Lawler et al. 2010; Millar, Stephenson, and Stephens 2007).

There are numerous ways to classify adaptation actions (see Section 2.2. for more on typologies of adaptation strategies). One way is to consider the novelty of the intervention in a conservation context. More novel approaches will rely heavily on climate projections and may

involve more conservation trade-offs, particularly if climate does not change as projected. Less novel, business-as-usual approaches will often have benefits regardless of how climate changes. A novel action, for example, might be responding to climate change by constructing a sea wall that otherwise would not be built and building it to a height determined by sea level rise projections. Less novel conservation actions, such as those reducing pollution, invasive species, and other stressors (and many other traditional conservation practices), would help prepare a landscape for a range of plausible climate futures, promoting its resistance or resilience to oncoming change without relying heavily (or at all) on climate impact projections. The more novel approaches may be less feasible within an agency constrained by limited funds or political willingness to take action to prepare for climate change. However, novel measures may be important to consider, especially in the case of the most severe, probable climate impacts.

Figure 2 illustrates one possible classification of resource management actions under climate change, according to novelty of intervention (after Heller and Zavaleta 2009 and Hansen and Hoffman 2011).



**Figure 2: Continuum of Interventions by Novelty in a Conservation Context**

Adaptation actions can be classified in other ways, such as by the degree to which they accommodate climate change: the *resistance*, *resilience*, *response* typology (Millar, Stephenson, and Stephens 2007). This and other typologies are described in Section 2.2.

#### 1.2.4 Adaptation Goals versus Mitigation Goals

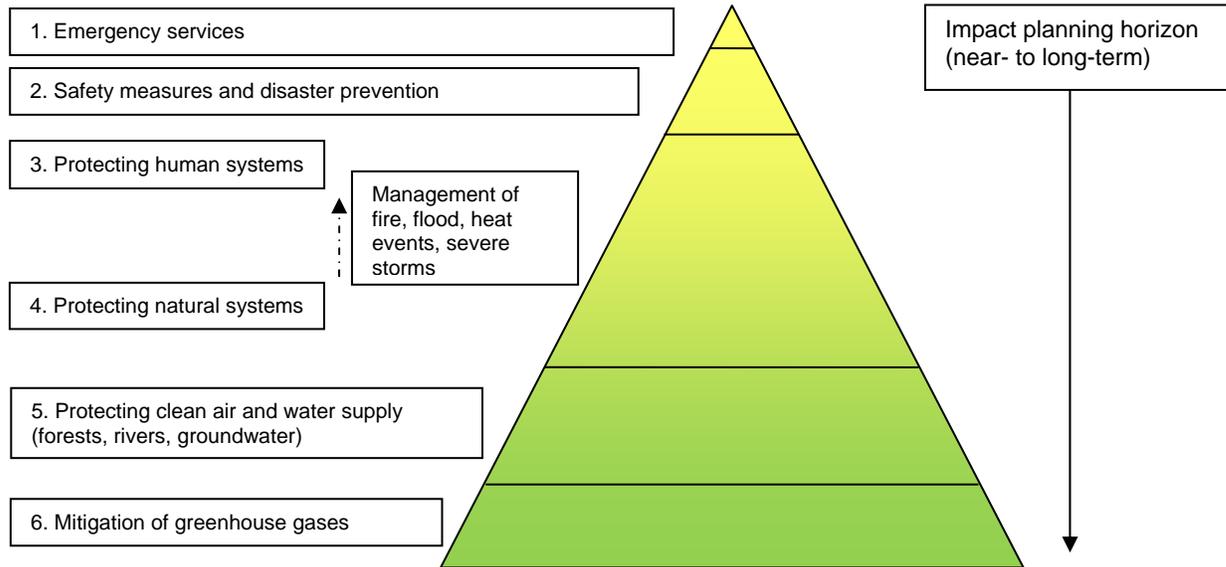
Adaptation measures, such as those described above, may or may not also reduce the amount of greenhouse gases emitted into the atmosphere. In fact, some measures may require a certain amount of new emissions (such as those involving vehicular travel, new infrastructure, or even new sources of methane from restored or newly created wetlands). Greenhouse gas reduction efforts, or *mitigation* efforts,<sup>14</sup> are more prominent in U.S. public discourse than those promoting climate change adaptation. Mitigation and adaptation are sometimes discussed as alternate—even competing—approaches to climate change. Insofar as adaptation seeks to reduce the negative impacts of climate change, mitigation should be considered critical to any adaptation strategy. However, there are trade-offs in any strategy choice. In the case of planning for climate change, adaptation planners should consider how adaptation strategies might conflict with greenhouse gas emission reduction targets, and mitigation planners should consider their projects' potential impact on a system's or species' resilience to climate change, such as a solar energy farm degrading the habitat of the threatened desert tortoise.<sup>15</sup>

Figure 3 shows how mitigation ultimately is a part of long-term climate change adaptation, illustrating a continuum of goals with near-, mid-, and long-term planning horizons and associated strategies for reducing negative climate impacts. Here, improvement of emergency services is shown addressing the nearest-term impacts, while mitigation of greenhouse gases is shown as addressing the longest-term impacts.

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<sup>14</sup> In the field of hazards management, mitigation is also used to mean, generally, “reduction of harm;” here the term refers to the reduction of the harm specifically from greenhouse gas emissions.

<sup>15</sup> Read a Woods Institute for the Environment “Uncommon Dialogue” brief about one desert tortoise/solar energy project conflict here (accessed August 31, 2011): <http://woods.stanford.edu/docs/solar-forum/stanford-solar-forum-siting-background-info.pdf>.



**Figure 3: Continuum of Adaptation Planning Horizons and Associated Strategies**

The following briefly explains how a given adaptation strategy should directly support the nearer-term strategy above it in Figure 3.

- The improvement of emergency services addresses the nearest-term climate change impacts.
- Safety measures (e.g., air conditioners, cooling centers, barriers to flood waters, evacuation planning for wildfires) and disaster prevention (e.g., discouraging maladaptation with permitting and insurance regulations) should support the improvement of emergency services.
- Measures to protect transportation systems, food delivery systems, residential properties, and other human systems from impacts should support safety measures and disaster prevention.
- Measures to protect natural systems (in particular, to manage the impacts of fire, flood, heat events, severe storms, and other climate events) should support the protection of human systems such as transportation and housing.
- Measures to safeguard the supply of the resources most essential to life—clean air and water—should support measures to broadly protect natural systems.
- Mitigation measures should reduce the necessity of all of the above climate adaptation strategies.

### 1.2.5 Traditional Conservation versus Adaptation

In traditional conservation, natural resources are typically managed with a baseline for restoration set at an historical reference point in a landscape’s state, such as pre-

industrialization or pre-European-settlement. This approach may need to be amended under a changing climate (Hobbs et al. 2010; Polyakov et al. 2011). As the climate changes, conservation goals, especially restoration goals, become moving targets.

The philosophy driving restoration ecology has begun to evolve: resource managers recognize the need to change their practices, including replacing historical reference sites with contemporary, undisturbed reference sites (van Andel and Aronson 2006). Climate change may bring novel climate conditions to bear on landscapes, making past conditions less and less relevant for future planning and requiring novel approaches. The pace of climate change in some cases might make it unrealistic to use contemporary reference sites and may instead call for resource managers to “restore” (or perhaps *prestore*) the landscape to anticipate *future* climate conditions.<sup>16</sup> Hobbs et al. (2011) calls for—in place of traditional restoration—intervention “with an eye to the future and toward managing for future change” (p. 444).

Resource managers adjusting their conservation goals must not only decide whether to facilitate a landscape’s transition, but to what extent and when to depart from in kind, in place—the restoration principle of repopulating a landscape with species of the same kind that previously grew there, planted in the same place. Opportunities to facilitate a more positive transition may come unexpectedly. For example, a wildfire may offer the opportunity to replant with a bioregionally native plant that is more robust to possible future conditions instead of with a local native that is climate change-sensitive. Planning ahead with climate change impacts in mind is essential to taking advantage of such opportunities. In line with this type of planning, Millar, Stephenson, and Stephens (2007) suggest that forest plantations might be assisted in their healthy transitions using modified harvest schedules and thinning prescriptions, replanting with different species, and shifting a desired species to new locations.

One of the first steps in adapting to climate change is evaluating conservation goals in the context of available climate change data. This will be discussed further in Section 2.

#### *1.2.5.1 Some Traditional Conservation Tools May Need to Be Used Differently Under Climate Change*

The present usage of some common conservation tools may not be sufficient for protecting ecosystems under climate change. Protected areas and the Endangered Species Act (ESA)<sup>17</sup> are two tools which may need to be used differently. For example, work to maintain a species in a particular protected area may become an inefficient use of resources after the species migrates

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<sup>16</sup> For example, the City of Chicago is changing its tree-planting regime to prepare for future conditions. NYT (2011, May 22), “A City Prepares for a Warm Long-Term Forecast” (accessed June 28, 2011): <http://www.nytimes.com/2011/05/23/science/earth/23adaptation.html?pagewanted=1& r=2&ref=general& src=me>.

<sup>17</sup> The Endangered Species Act (ESA) is a uniquely powerful U.S. law as a tool for conservation in that it stipulates that economic factors cannot be considered in the designation of a species as endangered and also that the ecosystem on which the species depends becomes protected as a result of the species being listed as endangered (Sullins 2001).

out of its designated protected home. Also, the ESA may cease to function as a tool to protect habitat on the basis of the presence of an endangered species if climate change causes that species' extinction. Property law professor J. B. Ruhl of Florida State University asserts that, should climate change cause a mass extinction of endangered species, the U.S. Fish and Wildlife Service (FWS) "might as well pack up its bags and close shop," as the ESA will become irrelevant (Ruhl 2008). On the topic of the optimal present usage of the ESA under climate change, Ruhl (2008) states:

[While] [t]he ESA has not solved urban sprawl or invasive species—it has helped species deal with them. Likewise, we must find a way for the ESA to help species deal with the effects of climate change, not its causes. The statute provides this flexibility—the means to proactively identify the threat of climate change and focus on helping those species that can be helped. (p. 62)

Ruhl (2008) notes that the ESA can be used to identify species with the potential to survive climate change impacts and to design management plans that will help build a bridge to the future for those species. Section 10(j)<sup>18</sup> of the ESA allows FWS to transport and release a population of endangered or threatened species outside its current range as an "experimental population," if the transporting agency "determines that such release will further the conservation of such species" (Ibid).

California resource managers also rely on the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA). These conservation tools allow for environmental factors to be weighed alongside others when carrying out government policy and planning. As with NEPA, CEQA provides for the public disclosure of estimated environmental impacts of proposed projects, but it goes beyond the requirements of NEPA to demand that project planners adopt all feasible measures to reduce project impacts. While both acts are defensive tools, protecting ecosystems and species from economic development projects rather than advancing conservation goals, CEQA offers leverage for preparing for climate change impacts through its requirement of not only disclosing environmental impacts but avoiding them (O'Brien 2009). California resource managers and those working on the policy level might consider ways to leverage this provision of CEQA in protecting species and habitats not just in their historical state and distribution, but in their future states and distributions.

### 1.2.6 Planning for Climate Change under Resource-Scarcity

Under the currently widespread conditions of resource-scarcity in agencies, it is important to not reinvent the wheel, and to identify low-cost opportunities to plan for climate change.

Traditional tools for resource management may need to be used differently to prepare for climate change, but they are still valuable and in many cases may be fully adequate as-is in order to prepare appropriately for climate change. The key is to determine whether the

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<sup>18</sup> Authorization for relocation of a population is obtained under Section 10(a)(1)(A) of the ESA, which provides for the FWS to grant permits "to enhance the propagation or survival of the affected species, including, but not limited to, acts necessary for the establishment and maintenance of experimental populations." (Ruhl 2008)

traditional tools are adequate as-is, or if they need to be used differently, and if so, how differently. In the case of prescribed burns in forest lands, for example, climate change considerations might call for a shift in the priorities, locations, or goals of treatment, but the tool itself does not need to change (C. Millar, personal communication, January 2012). As new tools such as scenario planning are introduced in this paper, let it be understood that they are intended to complement, not supplant, existing tools.

Also, low-cost opportunities to further climate change planning goals can and must be identified. These opportunities may come in the form of volunteer citizen science projects<sup>19</sup> or free online information-sharing networks.<sup>20</sup> In California, opportunities might arise in new multi-sector planning efforts, such as the Health in All Policies initiative,<sup>21</sup> or activities pursuant to the goals of SB 375, California's Sustainable Communities and Climate Protection Act.<sup>22</sup> In any case, resource managers will occasionally be drawn into planning processes with managers from other sectors, and they should see these occasions as opportunities to further climate change planning goals (for an example of this, see Section 3.6 on ecosystem-based adaptation).

### 1.3 Summary

The California Climate Vulnerability Assessment consists of a set of 33 papers analyzing the state's exposure, sensitivity, and capacity to adapt to climate change. The present study offers an analysis of tools available to help resource managers apply vulnerability information to planning for climate change. Climate impact and vulnerability assessments do not easily translate into resource management decisions. The state government has a clear interest in assisting resource managers to create and carry out adaptation plans. The well-being of the state's population depends on proactive adaptation to climate change to protect the natural systems that support life. Uncertainty, lack of capacity, and other barriers need to be identified and addressed so that planning is not delayed until the point at which action is infeasible. A range of approaches are available to resource managers; they can and should address both short- and long term impacts, employing a range of interventions to effectively achieve their goals. Traditional conservation goals may need to be reevaluated, and tools such as protected areas, the Endangered Species Act, and the California Environmental Quality Act may need to

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<sup>19</sup> A relevant citizen science project is the Oak Mapper Project by the Kelly Lab at UC Berkeley, monitoring sudden oak death by means of a smart phone application. More information (accessed February 14, 2012): <http://kellylab.berkeley.edu/oakmapper/>.

<sup>20</sup> A relevant information-sharing network is the Adaptability Climate Adaptation Network on LinkedIn (accessed February 14, 2012): [http://www.linkedin.com/groups?home=&gid=934207&trk=anet\\_ug\\_hm](http://www.linkedin.com/groups?home=&gid=934207&trk=anet_ug_hm).

<sup>21</sup> California's Health in All Policies Task Force provides a venue for state agencies and departments to advance goals supporting a healthier and more sustainable California. More information (accessed February 14, 2012): <http://sgc.ca.gov/hiap/>.

<sup>22</sup> A relevant SB 375-driven project is One Bay Area, coordinating efforts among the region's nine counties and 101 towns and cities for a more sustainable future. More information (accessed February 14, 2012): <http://www.onebayarea.org/about.htm>.

be used differently under climate change. Resource managers can and must find opportunities to prepare for climate change even in a time of budgetary shortfalls, capitalizing on the strengths of existing tools and the shared resources available within multi-sector planning efforts. The next section presents in more detail some strategies resource managers might use to prepare for climate change.

## SECTION 2: Strategies for Ecosystem Adaptation

This section describes in more detail strategies available to resource managers for adapting to climate change. For the purposes of this paper, a *goal* (or *objective*) is the desired end result; an *action* (or measure or tactic) is an act that supports the desired end result; and a *strategy* is the method for achieving the desired end result—a bridge between actions and goals (Nickols 2011; Joy Compass 2011). A *tool* is the means whereby some act is accomplished (Princeton University Wordnet 2011).

As stated earlier, adaptation strategies can be categorized in different ways. One way is by the degree of novelty in the approach. Another way is the degree to which it accommodates climate change. For example, *resistance* strategies are designed to prevent change (as in the example of floating cloths over a reef to prevent bleaching); *resilience* strategies aim to improve a conservation target's ability to recover from disturbance (as in the example of reducing the impact of stressors such as pollution and detrimental land use practices); and strategies to facilitate *transformation* are designed to help conditions change in a healthier way (e.g., after a wildfire, replanting with bioregionally native plants that are more robust than local native plants to the impacts of climate change) (Millar, Stephenson, Stephens 2007; Chapin and Zavaleta 2010).

Before discussing examples of strategies, first we consider different adaptation goals in light of projected climate impacts. Agencies and organizations working in the same bioregion should consider how, under climate change, their conservation goals might need reinterpretation, how their various goals might cause planning efforts to be duplicative or at cross-purposes, and whether there might be a need for greater alignment of efforts across agencies in some cases and more specialization by agency in other cases. New collaborations might be necessary to achieve climate change adaptation goals, in particular new partnerships across silos, such as between scientific institutions and resource management agencies, or emergency responders and resource managers.

Examples of resource management goals, strategies, actions, and tools included here are selected on the basis of being current (in the planning stages or recently implemented), and documented in print or online resources.

### 2.1 A Brief Typology of Adaptation Goals

Different conservation entities have different management goals, and therefore different climate change adaptation goals. In one bioregion, a public water management agency might be working to protect fresh water resources under climate change, focusing on water production under a shifting hydrological regime, while state park staff, prioritizing the maintenance of recreation resources, might focus on reducing the loss of beaches due to coastal erosion. Diverse agencies will need to work collaboratively in some instances and will be more successful operating autonomously in others.

Adaptation goals may converge and diverge from one another at different points under climate change. When extreme climate events occur, differences may be exacerbated. For example, under severe and prolonged drought, a water district may demand increased water storage, a salmon advocacy group may demand that stream flow be maintained for spawning fish, and a state park may demand increased emergency water supplies for public safety uses (e.g., to combat wildfire). Inevitably, there will be competition for scarce resources between groups.

It is worthwhile to examine an agency's conservation and adaptation goals in light of expected climate change impacts, and consider ways in which goals might need to be revised, or might come into conflict with others.

## 2.1.1 Defining Goals by Species or Biodiversity

### 2.1.1.1 *Maintaining a Species in a Place*

One adaptation goal may be to maintain a native species or community of species in its historical habitat. For example, the Salmon Protection and Watershed Network (SPAWN),<sup>23</sup> a community-based private non-profit organization located in West Marin County, works to protect endangered salmon in the Lagunitas Watershed. A 2008 SPAWN press release regarding a steep decline in local Coho salmon<sup>24</sup> states their concerns regarding climate change, and their adaptation vision:

“This severe decline demonstrates how fragile this population is and how important it is to re-double our efforts to protect and restore this population. Global climate change is likely to cause larger storm events and more severe droughts in the future, making it even more important to safeguard remaining habitat, to increase ecological resiliency, and to also restore the habitat that has already been degraded,” said [SPAWN Executive Director] Todd Steiner.

The group's goal of maintaining a fragile native population of one species in a single place is an example of a goal that may be viable to pursue in the short term, but not over the long term, given projected climate change impacts on this species' habitat. Over time the adaptation goal may need to shift from specifically reducing impacts on Coho salmon to generally reducing climate impacts on the local riparian system, whether the population remains or not. SPAWN may be prepared to shift its goal: the adaptation vision presented here indicates a broad focus on the environmental system of concern (safeguarding and restoring habitat). Increasing ecological resilience, as stated in the group's goals, also implies a broader systemic focus beyond a single species. Efforts to specifically conserve a particular taxon, like salmonids, might need to shift from watershed to regional scales to help a particular species to shift its range in response to climate change.

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<sup>23</sup> SPAWN's mission: SPAWN works to protect and restore the population of Coho salmon and steelhead trout in the Lagunitas Watershed through habitat restoration, research and monitoring, public education, and science-based advocacy and grassroots action. More information: <http://www.spawnusa.org>.

<sup>24</sup> SPAWN (2008), “Marin Salmon Populations Plummet” (accessed April 4, 2011): <http://www.spawnusa.org/pressreleases/number-19>.

An example of a place-based species-specific adaptation goal to maintain a population within its historical habitat using a larger-scale definition of that habitat (larger than a watershed) is the blue oaks conservation component of the Nature Conservancy of California's Mount Hamilton Project. The Nature Conservancy is an international private non-profit organization concerned with preserving biodiversity through land conservation.<sup>25</sup> In 1997 the Nature Conservancy of California began its Mount Hamilton Project, which aims to abate the threat of habitat conversion and fragmentation, increase connectivity between public lands, and build partnerships for protecting the area (Nature Conservancy California 2007).<sup>26</sup> In this project, scientists are refining a species distribution model, looking closely at patterns of blue oak recruitment, regeneration, and mortality in the Mount Hamilton range. The Nature Conservancy will use this observational evidence together with climate model projections to evaluate conservation opportunities for the blue oak population under climate change. This larger-scale approach to species conservation in a specific place is more robust to long-term climate change than one with a smaller-scale definition of habitat.

#### 2.1.1.2 *Maintaining a Species Migrating with Climate Change*

Another adaptation goal may be to maintain a native species or community of species outside its historical habitat, preparing for the shift of habitat ranges with climate change. Some of the strategies available for pursuing this goal are to redefine a species' native/invasive status within the context of its historic range, strategically constructing wildlife corridors and increasing habitat connectivity, and experimenting with translocation.<sup>27</sup>

One example of a species that is discussed as possibly be maintained both within and beyond its recent historical range in California is *Pinus radiata*, the Monterey Pine, which is classified both as an invasive and as a rare species targeted for conservation in different locations. With climate change, some are questioning its "invasive" status where it is found outside its historic range, but *within* its *prehistoric* range (Millar 1998). It is proposed that the conservation scope for this species should extend beyond the current small, scattered populations that "represent only a snapshot in time of Monterey pine's dynamic biogeography" (Ibid). Currently, all conservation efforts are focusing on the remaining five native Monterey pine populations, three in California

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<sup>25</sup> The Nature Conservancy's mission is to preserve the plants, animals, and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive. More information (accessed February 15, 2012): <http://www.nature.org/aboutus/visionmission/index.htm>.

<sup>26</sup> For more information on the current parameters and goals of the Mount Hamilton Project (accessed February 15, 2012): <http://conpro.tnc.org/346/> (and) <http://conserveonline.org/workspaces/CA.climate.change/documents/mount-hamilton-climate-adaptive-strategies/view.html>.

<sup>27</sup> For an example of a translocation experiment, see British Columbia's Assisted Migration Adaptation Trial (accessed February 14, 2012): <http://www.for.gov.bc.ca/hre/forgen/interior/AMAT.htm>.

and two off the coast of Baja California; although it is acknowledged that historically the populations have expanded and contracted in response to changing climate (Perry 2004).<sup>28</sup>

Another example of maintaining a species with climate change migration in mind is the Redwood Heartland initiative in the Santa Cruz Mountains of California, launched in 2011 to preserve the Central Coast's coastal redwood trees and their dependent species through landscape connectivity. The initiative's goal is to link 30,000 acres of redwood forests to provide wildlife corridors, protect clean water, contain urban sprawl, and "make our landscapes more adaptable to the effects of climate change and other future threats" (Save the Redwoods 2011). The Redwood Heartland project is part of the Living Landscape Initiative, a collaborative effort by five conservation organizations operating in the Central Coast region (the Land Trust of Santa Cruz County, the Nature Conservancy, Peninsula Open Space Trust, Save the Redwoods League, and Sempervirens Fund).

A continental-scale effort that should help species as their migration patterns shift is the Yosemite to Yukon (Y2Y) conservation corridor. The corridor is being constructed with consideration of specific species' habitat migration in response to climate change. In 2010 the Y2Y Conservation Initiative launched Phase I of a "Climate Change Readiness Program" (Y2Y 2011).<sup>29</sup> Some species whose habitat changes are being considered in construction of the corridor include the grizzly bear, caribou, Canada lynx, red fox, and snowshoe hare (Ibid).

The adaptation goal of preserving habitat as it shifts with climate change should be robust to climate change, but actions to support this goal depend heavily on climate change model outputs, which vary in certainty and which might require protecting land that may not yet be critical habitat. This is an adaptation approach that might involve relatively more risks and costs than protecting a species or community of species within its historical habitat, but might in the long run be more important to the survival of the target species.

## 2.1.2 Defining Goals by Ecosystem Service

### 2.1.2.1 *Maintaining a Service in a Place*

As stated earlier, the term *ecosystem services* describes "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life" (U.S. Climate Change Program 2008). Examples of ecosystem services include a forest providing clean air, a watershed providing clean water, or wetlands and seasonal stream systems providing flood control.<sup>30</sup> An adaptation goal that is defined by an ecosystem service is typically

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<sup>28</sup> At present, the authors are not aware of examples of otherwise invasive species which have been identified by ecologists as candidates for being re-classified as native (or neo-native) in parts of their prehistoric range beyond *Pinus radiata*.

<sup>29</sup> For more information see the Y2Y 2010 climate change adaptation report (accessed February 15, 2012): [http://www.y2y.net/data/1/rec\\_docs/898\\_Y2Y\\_Climate\\_Adaptation\\_Report\\_FINAL\\_Web.pdf](http://www.y2y.net/data/1/rec_docs/898_Y2Y_Climate_Adaptation_Report_FINAL_Web.pdf).

<sup>30</sup> Along with the U.S. Climate Change Program's definition of ecosystem services, there are other, more precise definitions in use, including that of the Organisation for Economic Co-operation and Development, which describes environmental services as covering the "provision of ecosystem inputs,

also defined in terms of geographical location, given the place-based nature of ecosystems, and so the ability to meet an adaptation goal focused on an ecosystem service will depend on the expected impacts in that ecosystem's location.

An example of an ecosystem service-related agency goal is the provision of clean water to rate-payers in a water district, such as the Marin Municipal Water District (MMWD). The MMWD has a mission defined by its watershed and service area. It protects the water quality of its reservoirs and provides clean and safe drinking water to its customers in Marin. The MMWD also aims to reduce the threat of wildfire, biological invaders, and protect and restore fragile ecosystems (e.g., meadow and oak woodlands) as part of its work to protect soil water storage capacity and runoff quality.<sup>31</sup> As MMWD defines its goals for climate change adaptation, it will need to consult projections on climate change impacts, monitor impacts, and adjust its goals accordingly. The MMWD has not yet established adaptation goals, but has created a Board of Directors committee on climate change "to investigate the effects of climate change on District operations and water supply and evaluate potential adaptation responses that could be implemented by MMWD" as well as "assess District efforts to achieve goals for reducing greenhouse gas emissions" (MMWD 2011).

Another example of an adaptation goal for a geographically bounded ecosystem service is the U.S. Army Corps of Engineers' (USACE's) goal to project how Northern California's flood control projects respond to "climate changed" inflows (Fissekis et al. 2008). The mission of the USACE Responses to Climate Change Program is to develop, implement, and assess adjustments or changes in operations and decision environments to enhance resilience or reduce vulnerability of USACE projects, systems, and programs to observed or expected changes in climate.<sup>32</sup> The Responses to Climate Change Program website specifies its concerns further:

The entire portfolio of USACE Civil Works water resources infrastructure and programs, existing and proposed, could be affected by climate change and adaptation to climate change. This affects design and operational assumptions about resource supplies, system demands or performance requirements,

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the assimilative capacity of the environment and the provision of biodiversity," presumably within economic models (OECD 2005, Glossary of Statistical Terms). Another definition comes from the Millennium Ecosystem Assessment, a set of reports describing the global change (enhancement or degradation) in ecosystem services. The report defines ecosystem services as "the benefits provided by ecosystems," including "provisioning services such as food, water, timber, fiber, and genetic resources; regulating services such as the regulation of climate, floods, disease, and water quality as well as waste treatment; cultural services such as recreation, aesthetic enjoyment, and spiritual fulfillment; and supporting services such as soil formation, pollination, and nutrient cycling" (MA 2005, p. 39).

<sup>31</sup> For more information on its landscape management plan, see the MMWD vegetation management webpage (accessed April 4, 2011):

<http://www.marinwater.org/controller?action=menuclick&id=415>.

<sup>32</sup> Read more about the USACE Responses to Climate Change Program (accessed February 15, 2012):

<http://corpsclimate.us/about.cfm>.

and operational constraints. Both droughts and floods can affect the operations of these projects. Numerous regulatory decisions made by USACE will need to be informed by climate change impacts and adaptation considerations throughout the U.S., especially in western states. (USACE Responses to Climate Change Program 2010)

In Northern California, the USACE is testing the behavior of flood waters under climate projections for 2030, working collaboratively with the Institute for Water Resources, the Bureau of Reclamation, the California-Nevada River Forecast Center, and the Hydrologic Engineering Center. Preliminary findings indicate that adapting to changes in peak flow timing and snowmelt runoff is crucial to ensure an adequate summer and fall water supply, but also to ensure adequate flood storage (Fissekis et al. 2008). The western states are a special focus of the USACE Response to Climate Change Program, which began its impact assessments by looking at the seventeen western states before proceeding to assess impacts in Alaska, Pacific Islands, the Caribbean, and eastern regions (USACE Responses to Climate Change Program 2010).

#### *2.1.2.2 Cross-Jurisdictional Collaboration to Maintain Ecosystem Services on a Large Scale*

Ultimately, all natural resource protection efforts are defined by geography. However, with climate change, groups are coming together in new ways to work collectively on a large scale across jurisdictional boundaries. These collaborations are in a position to monitor and respond to the shifting functioning of natural systems on a large scale. Some examples include groups working on global monitoring of, and response to, coastal and ocean climate change impacts.

One such international governmental coalition is the Pacific Coast Collaborative, spanning the international region of five member governments (Alaska, British Columbia, California, Oregon, and Washington). These governments created a memorandum of understanding regarding ocean health and climate change adaptation in February 2010 (PCC 2010). This agreement promotes coordination of efforts to reduce ocean debris, spread of invasive species, toxins, and non-point source pollution; promote sustainable fisheries; and collaborate on climate change research. The overarching goal of this adaptation effort is coordination for maximum effectiveness and efficiency, minimizing duplication of effort (Ibid).

Another ocean adaptation effort was initiated in October 2010 by the Partnership for Observation of the Global Oceans (consisting of 36 oceanographic institutions from 21 countries), which coordinates global monitoring of ocean acidification, a poorly understood impact of climate change that threatens to degrade the ocean, and the ecosystem services it provides, at a global scale (POGO 2010).

These coalitions are preparing for climate change at a large geographic scale, focusing on the health of the natural resource across major jurisdictional boundaries, including national boundaries. This kind of high level collaboration will be useful regardless of the speed and scope of climate change. However, the scale of work and number of collaborators, with the primary goal being coordination, may constrain its application to relatively low-risk, low-cost actions, such as monitoring.

The scale of the threat presented by climate change to ecosystem services makes collaborative resource management across jurisdictions more important than ever. California stands to

benefit from collaborative action with neighboring states and countries to address threats to ecosystem services, such as coastal erosion, invasive species, wildfire, and flood. The state can foster these collaborations through top-down initiatives, as well as through support for bottom-up efforts within regions.

## 2.2 A Brief Typology of Climate Change Adaptation Strategies

Before presenting different ways to organize strategies, it should be reemphasized that no one approach to adaptation will fit all institutional or environmental situations, so multiple strategies should be considered. Also, the best way to organize possible strategies depends on the context of implementation, so categories of strategies as they are described here should be considered generalized and flexible.

In adapting to impacts, resource managers can choose to sort their options according to different systems, such as by the degree of accommodation of climate change, the feasibility of the action, or the novelty of the action. They can work to help a landscape resist change, be more resilient to change, or transform in a healthy manner, but in any case should consider different kinds of ecological intervention, addressing both short- and long-term climate threats (Chapin and Zavaleta 2010; Hansen and Hoffman 2011; Heller and Zavaleta 2009; Lawler et al. 2010; Millar, Stephenson, and Stephens 2007). This section describes in more detail one possible typology of strategic approaches to adaptation planning (novelty of intervention, below).

The typology of adaptation strategy organized by the degree of accommodation of climate change was introduced by Millar, Stephenson, and Stephens (2007):

Adaptive strategies include *resistance* options (forestall impacts and protect highly valued resources), *resilience* options (improve the capacity of ecosystems to return to desired conditions after disturbance), and *response* options (facilitate transition of ecosystems from current to new conditions).

An example of a *resistance* action given is the intensive removal of invasive species. An example of a *resilience* action given is surplus seed banking. A *response* action is assisting species to migrate along expected climatic gradients or introducing species over a range of environments to provide redundancy (instead of only using historical habitat or “preferred” habitat guidelines). Each of these is described as being appropriate under different conditions, with *resistance* and *resilience* being advised in short-term action plans for high-value conservation targets; *resilience* being also advised in environmental conditions that are relatively insensitive to climate change; and *response* being advised in circumstances where there is a risk of rapid threshold effects (a wide variety of circumstances). The present paper would typify *resistance* and *resilience* as less novel approaches within a conservation context and *response* as more novel, assisting in the transformation of landscapes under climate change.

Swanston and Janowiak (in press 2012) cite these three “Rs” in their typology of adaptation strategies, and then plug them into a continuum of scale, going from broad concepts to location- and situation-specific approaches (tactics). The authors recommend selecting the relevant adaptation concept, such as *resistance*, and then using it as a foundation for developing a

specific tactic, such as using prescriptive burns in forest lands. The point of this continuum is to emphasize the importance of considering the scale of action and the broader strategy before devising specific tactics.

Joyce et al. (2008), Stephens et al. (2010) and Peterson et al. (2011) introduce a fourth “R” to this typology: *realignment*. A realignment strategy is a relatively moderate approach that “uses restoration techniques to enable ecosystem processes and functions (including conditions that may or may not have existed in the past) to persist through a changing climate.” An example of a *realignment* action given is establishing new refugia. *Realignment* should be considered under conditions where historical (pre-disturbance) baselines are likely to be inappropriate restoration targets in the face of a changing climate.

Another typology to consider is introduced by Snover et al. (2007) in *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*. This guidebook suggests planners sort actions into three tiers based on current feasibility (p. 105):

Tier 1 actions are those that can and will be implemented in this planning process;

Tier 2 actions are those that could be implemented now or in the future but require additional information, resources, or authorities before implementing. Note that you may want to begin exploring these additional information, resource, and authority needs as part of your current planning effort;

Tier 3 actions are those that are not suitable candidates at this time.

The typology discussed more in detail here is a hybrid of the “Rs” typology and the feasibility-based typology. Actions are organized by novelty within a conservation context; novelty here is considered a critical variable based on the assumption that a novel action is usually less feasible. However, what is novel will vary by institutional context: one agency’s risky proposal is another agency’s business as usual.

As noted above, in this paper tactics that fall under the *resistance*, *resilience*, or *realignment* categories are considered more moderate—less novel—while *response* actions are considered more novel. For example, a less novel adaptation action might be reducing pollution, which will help prepare a landscape for a range of climate threats, promoting its general health and therefore resistance or resilience to oncoming change. On the other end of the continuum, moving a species into new areas where conditions are expected to be better than historical habitat under climate change is a more novel approach. This kind of intervention would be designed to respond to climate change, i.e., to facilitate the transformation of a landscape to address a specific climate threat.

Less novel, more traditional conservation measures will have benefits regardless of how climate changes, while more novel approaches will rely heavily on climate projections and may involve more conservation trade-offs, particularly if climate does not change as projected. The less novel approaches include *no regrets* interventions, “investments and policies with high payoff under

the current climate risks as well as in a future with riskier climate” (Heltberg et al. 2008, p.11)—in other words, actions that would be a good idea for conservation even if they do not turn out to be useful for addressing climate change, but would also be helpful if climate changes as expected (Hallegatte 2009; Smith and Lenhart 1996; Pielke 1998).

A word on the term *regrets*: this term is subjective, and, depending on the framing of the problem, could refer to monetary costs, poor conservation outcomes, and other trade-offs. In a resource-constrained world, any choice that commits resources will necessarily have trade-offs, and, in this sense, there is no such thing as a true “no-regrets” adaptation action. But, to the extent that benefits for climate change adaptation can be found within traditional management practices, less novel actions have fewer regrets and prepare a landscape for more future climates than measures that are outside traditional practices and can only be justified by climate change projections. *However*, there will also be regrets if the climate change planner does not prepare adequately for impacts, e.g., if the *only* step taken to prepare for nine feet of sea level rise in a coastal town is a “no regrets” approach, such as a flood preparedness public education campaign. The fewest regrets may come from a hybrid approach of different kinds of intervention, such as combining a public education campaign with the creation of a new wetland to reduce the impact of sea level rise. In this paper we are presuming that resource managers will gauge their kind of intervention to the severity of impact, using a range of approaches.

Table 1 expands on the information presented in Figure 2, “Continuum of Interventions by Novelty in a Conservation Context,” adapting schematics from Heller and Zavaleta (2009) and Hansen and Hoffman (2011).

**Table 1: A Brief Typology of Adaptation Strategies by Novelty in a Conservation Context**

	<b>No Regrets (Less Novel)</b>	<b>Bet-Hedging</b>	<b>Focus on the Future (More Novel)</b>
<i>Description</i>	Actions with significant benefits in today's climate, possibly also in tomorrow's climate; not reliant on climate models.	Actions with benefits for today's and tomorrow's climate; uses climate models to build "climate headroom" into plans.	Fully outside business as usual, actions with benefits for tomorrow's climate; addresses specific impacts projected by climate models. <sup>33</sup>
<i>Why this strategy may be chosen</i>	Feasible where there is little or no support for climate change planning (politically, or financially); may be the best strategy where there is high climate uncertainty.	May be the best strategy where climate impacts are still uncertain, but not expected to be the most acute.	May be the best way to address the most acute, highly likely impacts (where the benefit of unprecedented action is clearly evident).
<i>Why this strategy might be problematic</i>	May be insufficient to prepare for unprecedented—mild or acute—impacts.	May be insufficient to prepare for the most acute impacts.	May have unintended consequences that exacerbate climate-driven problems; these actions are typically hard to undo.
<i>Example</i>	Reducing impact of present stressors (invasive species, habitat loss, pollution, etc.), e.g., the Bay Area Early Detection Network's work curtailing invasive species on their way into a system. <sup>34</sup>	A pilot project to test the robustness of different adaptation approaches, e.g., British Columbia's Assisted Migration Adaptation Trial, planting a variety of tree species in sites extending from Yukon to Oregon. <sup>35</sup>	These types of actions are largely theoretical at present, but could include the creation of a new wetland to address future sea level, such as in the San Francisco Redevelopment Agency's plan for the Hunters Point Shipyard/Candlestick Point. <sup>36</sup>

<sup>33</sup> "Focus on the Future:" These interventions are more reliant on climate model projections. See Section 3.2.1.1 for more on the strengths and weaknesses of climate models as planning tools.

<sup>34</sup> For more information on BAEDN (accessed February 15, 2012): <http://www.baedn.org/>.

<sup>35</sup> For more information on the AMAT, see Footnote 5.

<sup>36</sup> The San Francisco Redevelopment Agency is incorporating adaptation to sea level rise within its coastal development plans, including measures to anticipate wetlands migration and the creation of new wetlands. Building company Lennar Urban's draft plan for the Hunters Point Shipyard/Candlestick Point redevelopment project in southeast San Francisco has a sea level rise strategy that includes a new wetland (Navy-proposed) (Lennar Urban 2010, p. 169).

### 2.2.1 The Benefits of a Less Novel Approach (Restoring Habitat, Reducing Stress)

A less novel management approach has many potential benefits for preparing for climate change. Resource managers are already experienced taming complex management problems under vast uncertainty: the approaches in place for handling the problems of the past in many cases will be appropriate for managing under climate change. These approaches, which include “no regrets” measures, as described above have significant benefits in the present climate and additional benefits if climate change occurs as expected (Heltberg et al. 2008; Hallegatte 2009; Smith and Lenhart 1996; Pielke 1998). Moser (2009) asserts that “no regrets” adaptation strategies account for the majority of planned and implemented climate adaptation in the United States. These adaptation options are particularly appealing for near-term implementation, being justifiable on the basis of their high payoff regardless of future climate risk (BECCA 2009). “No regrets” actions include those that avert *maladaptation*, or actions that increase the future climate risk (e.g., investing in short-term, unsustainable coping mechanisms like digging deeper wells as the water table drops or allowing people and resources to be placed in harm’s way, such as by issuing permits for infrastructure projects in future inundation zones) (Ibid, UNDP 2010). Given their benefits under a range of climate futures, it follows that measures in the “no regrets” category are relatively feasible under budget constraint and climate skepticism.

An example of an organization using a “no regrets” strategy is the Bay Area Early Detection Network (BAEDN). BAEDN is a collaborative partnership of regional land managers, invasive species experts, and concerned community members engaging in Early Detection and Rapid Response to control infestations of invasive plants.<sup>37</sup> This strategy eliminates invasive plants before they spread. This is a relatively low-cost and cost-effective strategy, considering the exponential rise in removal costs as invasive plants are allowed to become established.

Invasive species control is considered part of a climate change adaptation strategy insofar as invasive species increase stress on a landscape, the reduction of their impact is likely to contribute significantly to a landscape’s resilience to climate change impacts (Steffen et al. 2009). The BAEDN Climate Change Adaptation Strategy (2010) describes the organization’s approach as “a ‘no-regrets’ strategy” that applies well-developed and understood tools to achieve significant benefits for a range of conservation targets, and provide ecosystems with increased resilience, “both now and in the future, under a range of potential future climate scenarios.”

Less novel adaptation approaches may support increased landscape resilience in a wide range of future climates, but resource managers may need to go beyond this kind of approach to prepare for climate change, using “bet-hedging” strategies that account for uncertain impacts, or, in some cases, more novel, deterministic strategies that prepare for highly certain, acute future impacts (Millar, Stephenson, and Stephens 2007).

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<sup>37</sup> See Footnote 10 for definitions of *biodiversity* and *invasive species*.

## 2.2.2 Hedging Bets (Pilot Projects, Targeted Protection)

“Bet-hedging” adaptation actions have benefits regardless of future climate, but also have benefits in the case of unprecedented climate impacts. These approaches include “low regrets” measures, potentially lacking benefits in the present climate, but being low-cost enough and having enough significant benefit if projected climate impacts come to pass to make them worthwhile (BECCA 2009). Examples of this kind of approach include building *climate headroom* into present plans (accounting for possible future conditions), increasing protections of habitats with importance to biodiversity targets that are expected to be especially threatened under climate change, and monitoring key indicators relevant to future climate preparedness, such as the impact of extreme events and the effectiveness of existing adaptation measures (Ibid, UKCIP 2008). Integrating climate vulnerability information into planning processes has both significant present benefits for planning (given existing climate variability) and significant benefits if climate projections come to pass (UKCIP 2008).

An example of a bet-hedging measure is a large-scale pilot project experimenting with the impact of climate change on vegetation ranges in Northwest North America. In 2008, the Ministry of Forest and Range of the Canadian province of British Columbia (BC) launched its Assisted Migration Adaptation Trial.<sup>38</sup> It is the first climate change adaptation experiment of its kind, moving trees threatened by climate change into places where they might thrive in future conditions (AP 2009). For example, scientists are planting the Western larch, found in southern BC, just below the Arctic Circle, and coastal rainforest species are being planted in Idaho (Ibid). Seeds from 15 species from BC will be planted at 48 sites, with about 3,000 seedlings planted at each site, from the Yukon to southern Oregon (Ibid). The AMAT webpage describes the project:

[The seedlings’] growth and health will be monitored, and related to the climate of the plantations, enabling researchers to identify the seed sources most likely to be best adapted to current and future climates. The information will be used to revise BC’s species and seed source selection guidelines, helping to ensure maximum health and productivity of BC’s planted forests well into the future.

The results of the AMAT pilot project will guide BC’s Ministry of Forest and Range plan in the face of uncertain climate impacts.

Other government agencies are hedging their bets by managing for shifting habitat by developing strategic plans for critical landscapes. One example of an agency preparing in this way for habitat shift is the U.S. Fish and Wildlife Service (2009), where, within the draft strategic objectives for climate change response, the agency lists the need for strategic landscape conservation of jaguar habitat along the U.S.-Mexican border (Objective 2.10).<sup>39</sup> Addressing impediments to the potential northward shift of the jaguar, such as the U.S.-Mexican security

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<sup>38</sup> For more on AMAT, see Footnote 5.

<sup>39</sup> Efforts by the Center for Biological Diversity and the American Society of Mammalogists have contributed to the Fish and Wildlife Service’s commitment to creating a recovery plan and designating critical habitat for the jaguar, citing climate change as one of the drivers for the need of a border conservation plan (CBD[2] 2009; ASM 2007).

fence, is a way to assist a species' adaptation to climate change while stopping short of moving species into historically unprecedented habitat.

These and other bet-hedging measures might have only limited benefits in the present climate, but significant benefits in multiple future climates. However, no regrets and low regrets measures may be insufficient for acute and highly certain climate impacts. In those cases, resource managers might consider more novel, deterministic strategies, for preparing for specific challenges.

### 2.2.3 Focus on the Future: Novel Actions for Adaptation (Protecting Future Habitat, Translocation)

Acute projected climate impacts with high probability attached might call for completely novel interventions. According to the current literature, these kinds of climate change adaptation measures appear to be in the early planning stages or entirely theoretical. These measures are more deterministic, preparing for specific projecting impacts: they imply an acceptance of the reliability of information about the future (Millar, Stephenson, and Stephens 2007).<sup>40</sup> These novel measures include protecting land that is currently not important but is expected to become important for biodiversity conservation or helping species move (or translocate) out of increasingly degraded habitat into novel places where conditions are expected to become more favorable under climate change (also called *managed relocation*, or *assisted migration*). This latter action might involve assisting species to migrate along expected climatic gradients, or accommodating the loss of species' populations on warm range margins (Millar, Stephenson, and Stephens 2007).

While species translocation as a climate adaptation strategy is still primarily theoretical, researchers are developing decision-making tools for determining when (or if) to move species to ensure their persistence under climate change. McDonald-Madden et al. (2011) propose a quantitative decision framework for evaluating the timing of species relocation in the face of climate change. The authors frame their approach to managed relocation thus:

There are two key components of climate change that are particularly challenging: management in the face of system changes; and management in the face of uncertainty surrounding these changes. Regarding the first challenge, we have shown that by using time-dependent dynamic optimization methods we can make informed decisions in the face of system change. The second challenge has paralyzed the ability of agencies to make decisions in a changing world, and caused some to advocate broad-based monitoring to reduce uncertainty without any link to what should actually be done if the systems are found to be in decline. Instead, we have shown here that by explicitly articulating uncertainty in the form of alternative models of system change, and evaluating the evidence for these different models with information gained about the system, we can make informed decisions regarding adaptation in the face of uncertain climate change. (p. 264)

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<sup>40</sup> As noted above, see Section 3.2.1.1 for more on the strengths and weaknesses of climate models as planning tools.

The McDonald-Madden et al. decision-making tool provides guidance for tackling the risky proposition of moving species out of their historic habitat; other such tools are sure to follow, making these theoretical approaches more realistic. However, in these measures, success is highly contingent on the accuracy of climate model outputs; these measures are the least robust to multiple climate futures. They have the potential to cause long-term unforeseen problems, and are difficult to undo. However, novel actions may be required to meet conservation targets under relatively probable, acute climate change impacts.

## SECTION 3: How to Begin Planning for Climate Change?

In this section we take a step back from discussing specific interventions and focus on the first steps in devising a climate change adaptation plan. As stated earlier, this paper is not intended as a guidebook for creating an adaptation plan, but we will briefly describe the general steps involved, including defining the problem and related goal, assessing impacts and vulnerability, selecting a strategy, defining criteria, taking action, and evaluating results.

When solving any policy problem, the most important initial step is defining the problem.

The stages of policy development referenced here are taken from Bardach's *A Practical Guide for Policy Analysis: The Eightfold Path to More Effective Problem Solving* (2nd ed., 2005), which articulates the stages as follows:

1. Define the Problem
2. Assemble Some Evidence
3. Construct the Alternatives
4. Select the Criteria
5. Project the Outcomes
6. Confront the Trade-offs
7. Decide
8. Tell Your Story

In this section we will discuss the first four stages. The stages are not intended to be completed necessarily in a linear fashion: policy development is typically iterative. Decision makers should redefine the problem as new evidence is uncovered.

### 3.1 Defining a Wicked Problem

Climate change is a problem so hard to define that it has been called a *wicked problem*—not in the sense of evil, but rather as an issue highly resistant to resolution (Australian Public Service Commission 2007). As stated earlier, resource managers are experienced working on complex management problems under vast uncertainty. The purpose of this section is not to emphasize the particular wickedness of climate change as a problem, but to include in this paper some guidance from those studying climate change as a wicked problem.

The Australian Government summarizes the qualities that make climate change wicked thus:

Climate change is a pressing and highly complex policy issue involving multiple causal factors and high levels of disagreement about the nature of the problem and the best way to tackle it. The motivation and behavior of individuals is a key part of the solution as is the involvement of all levels of government and a wide range of non-government organizations (NGOs). (Ibid, p. 1)

In dealing with wicked problems such as climate change, the Australian Public Service Commission (2007) recommends the problem definition not be made so narrow that it avoids underlying causes altogether (Ibid). While it may be necessary to break the problem down into

components and find practical solutions to sub-problems, this fragmentation should follow an initial problem definition which takes into account the complexities inherent within the problem. A warning about defining a wicked problem too narrowly:

Unintended consequences tend to occur even more frequently if the problem has been artificially tamed, that is, it has been too narrowly addressed and the multiple causes and interconnections not fully explored prior to measures being introduced. (Ibid, p. 12)

In addition to considering the special challenge of developing a problem definition for climate change, given its wickedness, one should also consider recommendations regarding defining more straightforward problems. Bardach (2005) recommends the following be kept in mind when defining a policy problem:

- When facing a complex problem, determine a primary (or initial) problem focus to keep the analysis manageable.
  - For a water management agency, instead of “climate change threatens our environment” use “climate change threatens our clean water resources.”
- Try to frame the problem in terms of deficit and excess.
  - Instead of “climate change threatens our clean water resources” use “there are insufficient water resources to meet demand in a future under climate change.”
- Make the definition evaluative in terms of systemic failures (such as market failures).
  - Instead of “there are insufficient water resources to meet demand in a future under climate change” use “there are insufficient government leverage points to manage scarce water resources to enable them to meet demand in a future under climate change.”
- Quantify the problem if possible.
  - In the water management agency example, the problem definition could potentially cite the estimated amount of acre feet of water needed to meet future demand and the amount projected to be available under climate change.
- Try to diagnose underlying causes of the problem.
  - In the water management example, the “government leverage points” element would be diagnostic of an underlying cause.

Bardach cautions against writing the solution into the problem. For example, “there are insufficient government leverage points to manage scarce water resources to enable them to meet demand in a future under climate change” may be presumptive of a lack of power in government: there should be supporting evidence for that diagnostic element in the problem definition. The irresponsible behavior of private water consumers may be the larger problem. Deciding on a diagnostic element for the problem definition can be “treacherous” (Bardach 2005, p. 133). Most good problem definitions are limited to a description of the problem (Ibid).

An organizational mission statement or adaptation goal may define the problem sufficiently. However, a mission can be too broad to help define the problem. For example, the Nature Conservancy’s mission, “to protect ecologically important lands and waters for nature and people,” provides little guidance on where to begin working on climate change adaptation. An

organizational long-term planning process may be necessary to identify the organization's greatest area of concern before the problem can be defined at an actionable scale.

After defining the climate change problem provisionally, then, in the context of that problem definition one should assemble evidence on climate change vulnerability (and revise the problem statement accordingly). After the vulnerability is projected, suitable alternative responses should be developed. From there, one should determine the criteria for alternatives in order to compare them and select the best path.

Before discussing ways to assemble evidence, first, it may be helpful to reframe the climate change problem temporally and spatially.

It is important for planners to select the most useful temporal and spatial frames, given the scale of impacts on a given territory. Temporally, rather than just using customary institutional planning cycles (e.g., two to five years), it might be useful to think far into the past and future, using frames of centuries or longer. Starting with the longer timeline perspective, planners can determine the most useful spans to assign realistic short-term, mid-term, and long-term goals. Spatially, it might be useful to go beyond traditional boundaries to think on a much larger scale, even continentally.

### 3.1.1 By Time Scale: How Did Flora and Fauna Adapt in the Distant Past?

Looking into the distant past may be helpful in defining the present climate change problem, and perhaps develop novel approaches. Millar and Woolfenden (1999) discuss the importance of taking climate change into account when applying historical analysis of ecosystems to current management practices, suggesting that managers look further back in time beyond the typical focus on *presettlement* periods. These periods often fall within the Little Ice Age (1400–1900), so ecosystems at that time would have been responding to different climate conditions than the present. The warmer centuries before the Little Ice Age may show conditions more analogous to those of the present day or the future under climate change. Looking at historical reconstructions of past, warmer climates, such as the Medieval Warm Period (900–1350), which could show how ecosystems behaved in a warming climate without human intervention, could help scientists model and prepare for ecosystem changes as they unfold under current climate change. Taking into account ecosystem conditions under past warming trends, managers could focus on bringing their management targets into alignment with where they would naturally be without human intervention rather than focusing on restoring the targets to presettlement conditions (Millar and Woolfenden 1999). Millar (1998) also makes specific recommendations for management under climate change based on prehistoric ecosystem analysis. According to Millar, the endangered Monterey pine (*Pinus radiata*) is currently considered an invasive species in some places<sup>41</sup> where it was found during prehistoric warming periods.<sup>42</sup> Millar notes the

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<sup>41</sup> “Where it has escaped cultivation and become naturalized, or where old plantations occur within the bounds of current wildlands or parks, (the Monterey pine) is viewed as an invasive exotic weed. In these situations, Monterey pine has been aggressively removed through ecological restoration projects, such as at Jughandle State Reserve in Mendocino County.” (Millar 1998, p. 13)

prehistoric fluctuations of the tree's distribution, and how current coastal land use practices would likely prevent the tree from repeating its historical expansion of habitat during warming trends. So, areas not currently within the tree's native range could be evaluated for suitability as new habitat for conservation. Millar introduces the term *neo-native* in that context:

Many of the areas where Monterey pine has naturalized along the coast coincide with fossil sites for the species. Several of these also currently contain associates that were to be found aligned with Monterey pine fossils (as well as with extant populations)... In many of these coastal sites Monterey pine thrives. The naturalized sites that coincide with Monterey pine's historic range and include many of its historic associates could be considered candidate "neo-native" populations, that is, human-assisted sites for Monterey pine expansion and restoration. High priority areas would include the Point Reyes coast and vicinity, the San Francisco peninsula, Big Sur coast, many locations along the San Luis Obispo/Santa Barbara coast, and coastal areas near San Diego. Such populations could be managed as new native populations, providing opportunity for genetic recombination, divergence, and adaptation. (Millar 1998, p. 15)

Following Millar's example of analysis of the historic habitat of this one highly valued and endangered species, expanding the definition of native habitat to include prehistoric native habitats under warming trends analogous to current climate conditions might be helpful in considering novel management alternatives.

### 3.1.2 By Spatial Scale: What is Happening Beyond the Traditional Area of Focus?

Along with a deeper historical analysis, climate change problems should be considered within a larger-than-normal spatial scale. Broadening the scale of analysis might reveal opportunities for management alternatives, such as revising guidelines for selecting new protected areas, developing connective corridor systems between protected areas, creating buffer zones, and assisting species to migrate to more hospitable habitats (Halpin 1997).

One climate change-driven threat that can benefit from a broad spatial analysis is the mountain pine beetle outbreak in western North America. Between 1998 and 2008, partly as a result of favorable climatic conditions and poor forest health, more than 47 million hectares (about 116.1 million acres) of forest lands in the western United States and British Columbia were damaged by bark beetle outbreaks (Raffa et al. 2008; Petersen 2010). The mountain pine beetle has expanded its range well beyond historic limits, calling for enhanced coordination of efforts across affected sectors and jurisdictions (Petersen 2010). In 2002, in order to coordinate response to an unprecedented bark beetle outbreak and the associated catastrophic fire risk in the mountains outside of Los Angeles, California, the Mountain Areas Safety Taskforce (MAST) was formed, consisting of federal, state, county, and local fire departments (currently 27 agencies and organizations) working in two California counties (San Bernardino and

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<sup>42</sup> Monterey pine conservation plans are still typically placing their reference point for restoration at 1850, pre-industrialization or pre-European settlement (Perry 2004).

Riverside) (Petersen 2010; MAST 2011).<sup>43</sup> Public agencies and private organizations stepping outside of their ordinary scale of operations to collaborate on meeting regional management goals are more likely to reduce spatially widespread climate threats than those working in isolation (Petersen 2010). Resource managers from other parts of western North America are conducting visits to learn about MAST, hoping to form similar coalitions elsewhere (Ibid). A broad spatial analysis of a climate change threat detected at a local level could raise collective awareness that leads to broad, effective action.

## **3.2 Assembling Evidence: Vulnerability Assessments**

In the iterative process of climate change planning, problem definition should be informed by evidence over time as climate models become more sophisticated and impacts more measurable. New evidence should help reframe and refocus a climate change problem definition to make it more useful for directing action. As stated earlier, this is not a step-by-step guide to preparing an impact or vulnerability assessment. The following sections are only intended as brief description of the component parts of an adaptation plan.

### **3.2.1 Vulnerability: What Do We Expect to Be Hurt Most and First?**

A climate change vulnerability assessment,<sup>44</sup> together with an initial impacts assessment, can provide the starting-point evidence informing the climate change problem definition. Based on available information on the size and scope of climate impacts, a vulnerability assessment should reveal what species and ecosystems are likely to be exposed to physical impacts (exposure), how sensitive they are likely to be to impacts (sensitivity), and to what degree the targets of concern can accommodate change, taking into account non-climatic factors (capacity to adapt) (Abraham 2009).

While an impact assessment synthesizes research on future impacts of climate change, a vulnerability assessment goes further, identifying, quantifying, and prioritizing (or ranking) the vulnerabilities in a system (Abraham 2009; UKCIP 2011). For example, the Intergovernmental Panel on Climate Change (IPCC) issues periodic impact assessments, with the fifth assessment report due out in 2014.<sup>45</sup> The IPCC impact assessments are often the starting point for a vulnerability assessment, but consist chiefly of synthesis of scientific research on impacts: they do not evaluate the exposure, sensitivity, or adaptive capacity of any specific system. Building on the findings of the IPCC, the present California Climate Vulnerability Assessment represents an important benchmark in the work of the California Energy Commission's California Climate Change Center, founded in 2003 as the first state-funded climate change research center in the United States, and since then producing over 150 studies on climate change impacts on the state

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<sup>43</sup> For more information on the Mountain Areas Safety Taskforce (MAST) (accessed February 15, 2012): <http://www.sbcounty.gov/calmast/>.

<sup>44</sup> See Footnote 8 for more on the concept of vulnerability.

<sup>45</sup> For more information, see the schedule of IPCC Fifth Assessment Report (AR5) document outputs (accessed February 15, 2012): <http://www.ipcc.ch/activities/activities.shtml>.

(CEC 2009). With this vulnerability assessment, the impacts information in those and other reports and papers can be used to paint a picture of the state's exposure, sensitivity, and capacity to adapt to climate change.

Ideally, vulnerability assessments should provide planners with a ranked set of priorities for intervention. In addition to the vulnerability assessment, other tools can be employed to help set priorities. The triage tool and the climate project screening tool are two which are described in this paper (respectively, Sections 3.3.2 and 3.3.5).

### *3.2.1.1 Interpreting Climate Models to Assess Climate Impacts and Vulnerability: Climate Model Strengths and Shortcomings*

The IPCC and other scientific organizations assess climate impacts with the use of climate models (Randall et al. 2007). A climate model is a numerical representation of the component parts of the climate system (IPCC 2008b). These models are used because they are based on well-established principles of physical science and have been shown to reproduce observed features of recent climate, as well as changes in climate that occurred in the past (Randall et al. 2007). Models are steadily improving. Models in use include atmosphere-ocean global climate models (GCMs), with scientists sometimes averaging multiple models to find the *ensemble mean*, which consistently shows more accuracy than any one model alone (called the *ensemble approach*). Also in use are other models which have coarser resolution, are less dynamic, and are less well-tested than GCMs, such as the Earth System Models of Intermediate Complexity (Lenart 2008). The IPCC Fourth Assessment Report relies on the ensemble approach for its projections of average annual global temperature with doubled carbon dioxide concentrations compared to pre-industrial times (Ibid).

Scientists are seeking ways to focus in on climate projects at a sub-global scale. GCMs are considered the most reliable when considered at a global level. However, improvements in their resolution and other enhancements are making GCMs more reliable at the regional scale, e.g., the Pacific Northwest region (Lenart 2008). With the increased resolution of GCMs, scientists are experimenting with statistical downscaling, focusing in on local impacts by using equations to convert projections at the global scale to projections at the regional scale (Ibid). Another kind of downscaling is dynamical, using numerical meteorological modeling to project how global climate patterns might affect local weather conditions (Ibid).

Climate models have strengths and weaknesses. The current state of the science is such that scientists cannot model future climate with complete certainty; in particular, reliance on climate models should be tempered with the knowledge that they are better at showing the lower bound than the higher bound on risk, they are better at predicting temperature patterns than precipitation patterns, and the global projections they produce are considerably more certain than localized ones (Farber 2008).

Other GCM weakness should be kept in mind. For example, GCMs tend to underestimate the magnitude of precipitation events and are therefore better at modeling average conditions than extremes, such as droughts and floods (Lenart 2008). Factors that reduce the accuracy of GCMs include their relatively coarse resolution (e.g., when testing fourteen climate factors, only one of the three best-performing GCMs had a resolution greater than one degree latitude by one

degree longitude), and also the uncertainty generated in GCMs by clouds (particle size and timing/behavior), pollution particles, and natural variability in climate (Ibid). Climate remains a highly complex system which is challenging to model accurately, even with advanced GCMs.

For California's coasts, the problem of cloud condition uncertainty should be kept in mind when building climate vulnerability assessments on the basis of GCMs, given the dominance of the cooling effect of fog on coastal ecosystems, e.g., as a factor in the persistence of the iconic coastal redwood tree (Johnstone and Dawson 2010). One study suggests that coastal fog has decreased in frequency over the past century (1901–2008), which is likely to increase the drought sensitivity of coastal plants (Ibid). However, there is some debate over whether this will be the predominant trend. Another recent study's finding simply California will have a stronger sea breeze and more extensive coastal cloudiness (Lebassi et al. 2009, as noted in Largier, Cheng and Higgason 2010). This study even showed a cooling trend in low-elevation coastal air basins (Ibid).

The science of climate modeling is ever-evolving, and should be kept in the sights of every natural resource manager. Meanwhile, GCMs can be relied upon to show at least the lower bounds of global temperature trends and perhaps other long-term, large-scale trends. As stated earlier, the limitations of the climate models should not be used as an excuse to delay all action until full certainty is achieved; by then action could be cost-prohibitive or completely infeasible.

### **3.3 Constructing Alternatives: Scenario Planning and Other Tools**

After formulating a provisional climate change problem definition, gathering evidence on impacts and vulnerability (using climate models and other tools), and thereupon revising the problem definition, resource managers can begin identifying alternative courses of action to reduce the climate change threat. Keep in mind that alternative actions may not be in competition, and a combination of alternatives may be the best course of action (Bardach 2005).

Also, at the outset of constructing alternatives, analysis of the successes and failures of analogous institutions coping with similar problems could improve the efficiency of an adaptation planning process (Ibid; also see Section 3.4, Examples of Current Planning Processes). Climate change in particular demands a holistic approach to policy formulation: the problem's complexity, with many interacting causal factors and uncertainty, requires a broad, multi-pronged approach, explicitly taking uncertainties into account rather than narrowing alternative responses to the areas of certainty (Australian Public Service Commission 2007).

Presently, climate can only be modeled with limitations (see Section 3.2.1.1), and so climate change impacts and the prospects for successfully reducing their threat are relatively unknown (Waser 2009a). Any given institution's capacity to respond to climate change is also relatively unknown (Ibid). As discussed earlier in this paper, one tool that has become regularly employed for decision-making under uncertainty, including for long-term strategic planning for climate change in National Parks, is *scenario planning* (Ibid). This and a selection of other tools that can be used to strategically plan management alternatives for climate change under conditions of uncertainty are described below.

### 3.3.1 Scenario Planning

As employed by the National Park Service, scenario planning brings together scientists, resource managers, and other stakeholders to develop a small number of internally consistent, plausible narratives (*scenarios*)<sup>46</sup> based on the best available science regarding future climate conditions for a given system of interest (Waser 2009a; NPS 2007; Schwartz 1991). These narratives are used to discuss and decide on management alternatives that are robust to the range of plausible future conditions, given the high uncertainty and low controllability of climate change (Ibid). Each scenario is developed to capture critical elements of a system's uncertainty, and to reveal underlying drivers of change and potential trends within a system (Waser 2009a). Scenario planning helps decision makers challenge their own assumptions and think holistically and flexibly about multiple plausible futures, rather than fix on the single most likely future (Waser 2009a; NPS 2007; Schwartz 1991).

To create management plans robust to multiple plausible futures, for example, scenarios can give managers the opportunity to discuss uncertain climate conditions that are hard to model numerically (e.g., clouds and fog, and precipitation [see Section 3.2.1.1]) in the context of relatively predictable conditions (e.g., rising temperatures). Scenarios can also facilitate discussions of these varying climate futures in the context of different non-climatic factors, such as continuing budget constraint or increasing human community demand for resources (both relatively certain), and the political will to act or shifting demographics (relatively uncertain).

Scenario planning has its origins outside of the realm of resource management. It grew out of World War II military planning and was adopted by the business sector, notably by Shell Oil in the 1970s in the context of the depletion of U.S. oil reserves and the emerging strength of the Organization of Petroleum Exporting Countries (OPEC) (Schwartz 1991). Shell used scenarios to plan for both oil prices remaining stable and a sharp rise in oil prices caused by OPEC, putting the company at a crucial competitive advantage at the onset of the 1973 oil price shock: Shell was the only oil company with a contingency plan for sharp price increases (Ibid, p. 7–8). After many years of routine use within the commercial context, natural resource managers are now using scenario planning to assist with decision-making under conditions of uncertainty (Bennett et al. 2003; Peterson et al. 2003).

A key strength of scenarios is that it relies on—but goes beyond—numerical models and expert opinions (what is “known”) to explicitly take into account important unknowns by way of

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<sup>46</sup> The 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 additional information from other sources, sometimes combined with a narrative storyline” (IPCC 2008b). 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).

imaginative speculation, preparing decision makers for surprises that models and experts may not be able to predict (NPS 2007; Waser 2009a). Ideally, the process of creating scenarios and planning responses to them should be iterative, not a one-time exercise, in order to develop an organization or coalition's skills around speculating about plausible futures (Schwartz 1991). With an iterative process, the scenarios can guide monitoring of key indicators, which can then be used to assess the validity of the scenarios and to both improve the scenarios and adjust management plans accordingly (NPS 2007). Over time, incorporation of scenario planning into decision-making practices should increase understanding of critical uncertainties, incorporate alternative points of view into management plans, and make management plans more flexible in case of surprises (Peterson et al. 2003).

So how does an organization begin engaging in scenario planning for natural resource management under climate change? A description of the National Park Service (NPS) model can be found in Section 3.4.1, and a description of the process used in this paper's case study, based on the NPS model, can be found in Section 4. Essentially, the NPS model is based on one proposed by Peterson et al. (2003) in the essay "Scenario planning: a tool for conservation in an uncertain world" (Waser 2009a). In this essay, the authors present a six-step process for scenario planning (from Peterson et al. 2003, p. 360–362):

1. Identify a focal issue.
2. Use the focal issue to assess the people, institutions, and ecosystems (and the linkages among these) that comprise the target system and assess external influences to the system; identify the most important uncertainties that impact the focal issue and separate them from the factors of concern that are under the influence of the scenario makers.
3. Identify alternative ways the system could evolve. Alternative paths can be defined by two or three uncertain or uncontrollable driving forces with differences that are directly related to the focal issue. This gives the framework for the construction of scenarios.
4. Build the scenarios by fleshing out three or four alternative paths defined by key uncertainties. The assumptions on which the scenarios are built should be clear, and the differences between alternative paths should also be clear. Each scenario should be given an evocative name and a plausible, vivid narrative that links historical, present and hypothetical future events.
5. Test the scenarios for plausibility and consistency. This may involve gathering expert opinions, discussing the scenarios with stakeholders, or measuring quantifiable indicators. Scenarios must be refined iteratively and retested before they can be used to evaluate policy decisions.
6. Use the scenarios to test, analyze, and formulate policy, i.e., discuss how a policy might fare under the different scenarios. Identify characteristics of policies that would work in all scenarios. This process might result in the discovery of new research questions, new issues to monitor, and policy innovations.

Should the outputs of climate models be a central consideration of scenarios for resource management under climate change? The degree to which scenarios should be informed by climate models depends on the scenario planning goal. If the goal is a discussion of the relative strengths of broad policy options, climate science may be less important, but if the goal is to make a specific resource management decision, climate models should be considered more carefully (Dessai 2005).

### 3.3.1.1 Some Pros and Cons of Scenario Planning

Scenario planning, as described above, is a tool that should contribute to strengthening the robustness of any planning process. However, scenario planning may be more useful in some instances and less useful in others. When decision makers have little control over major influencing factors and uncertainty is high, scenario planning is an effective planning tool; in other situations, other tools may be more appropriate (Peterson et al. 2003). For example, when uncertainty is high but decision makers have control over influencing factors, managers might better emphasize increasing the adaptive management aspects of planning (e.g., monitoring results and letting them inform management decisions) (Ibid). When decision makers have little control over major influencing factors but there are few unknowns in the planning process (uncertainty is low), managers might better emphasize *hedging* practices (e.g., creating reversible plans) (Ibid).

In the case when there are few unknowns and decision makers have control over influencing factors, the planning process would be optimal, and scenarios would provide little advantage over a more linear approach (Peterson et al. 2003). With more certainty and more control, managers could create highly probable predictions; scenarios can only produce stories of plausible futures, not the most likely future (Global Business Network 2011). For more on the theoretical framework of ecological management under different conditions of uncertainty and “controllability” see Peterson (2005) “Ecological Management: Control, Uncertainty, and Understanding.”

In summary, scenario planning is a tool that provides a structure for decision-making under conditions of uncertainty. Scenarios should be based on known facts and projected trends, but driven by ideas of how these facts and trends will interact. Scenario planning is most effective when it is carried out as an iterative process, rather than a one-time exercise, to allow scenario-based thinking to be internalized by decision makers. It will be most useful in situations where resource managers are facing high uncertainty and little control over the factors influencing the problem.

### 3.3.2 Triage

Triage is a tool for decision-making under uncertainty that comes from the military battlefield, providing a system for prioritizing treatment based on the severity of injury when there is more urgency than capacity to respond (Millar, Stephenson, and Stephens 2007; Millar 2009). The basic triage categories are (Chipman, Hackley, and Spencer 1980):

- Those likely to live, regardless of treatment

- Those likely to die, regardless of treatment
- Those for whom immediate treatment might improve the outcome

Triage in a resource management context offers a system to sort situations into categories according to urgency, sensitivity, and the resource capacity to respond in order to achieve goals (Millar, Stephenson, Stephens 2007). Situations would be sorted into “treat immediately,” “treat later,” or “no action” (highly urgent but untreatable given current capacity to act) (Ibid). In a triage approach, it is necessary to reassess and re-prioritize in response to changing (especially rapidly changing) conditions (Ibid).

A possible example of a triage approach for management under climate change might be when managers choose to deprioritize eradication of an invasive species that is expected to suffer under climate change, regardless of treatment. Managers might also choose to stop treating an area that has been overrun by invasive species that is expected to thrive under climate change such that intervention is prohibitively expensive. Instead, managers might focus treatment on eradicating invasive species which might thrive under climate change with new footholds in otherwise relatively intact areas—low hanging fruit—through early detection and rapid response. The triage approach is discussed in multiple publications by the research paleoecologist Connie Millar of the U.S. Forest Service.<sup>47</sup> She notes that a triage framework for resource management choices would require an evaluation of species and ecosystems based on their ability to be resilient or to transform under climate change rather than their vulnerability and rarity.

Triage as an approach has clear drawbacks. Millar, Stephenson, and Stephens (2007) assert its usefulness where resources are scarce or choices are overwhelming, but do not recommend it as a long-term approach for prioritization. Scientists have an imperfect understanding of climate, and are basing projections on climate models which have limitations (see Section 3.2.1.1); it is also uncertain what the loss of a species or population might mean for a given ecosystem’s function (Lawler 2009). Triage is a bitter pill for conservationists to swallow (Ibid, Kareiva, and Levin 2003). Louda and Rand (2003) ask:

The critical issue seems to be this: how can we use and manage natural systems in a way that will minimize the probability that component, potentially important species will be lost? (p. 15)

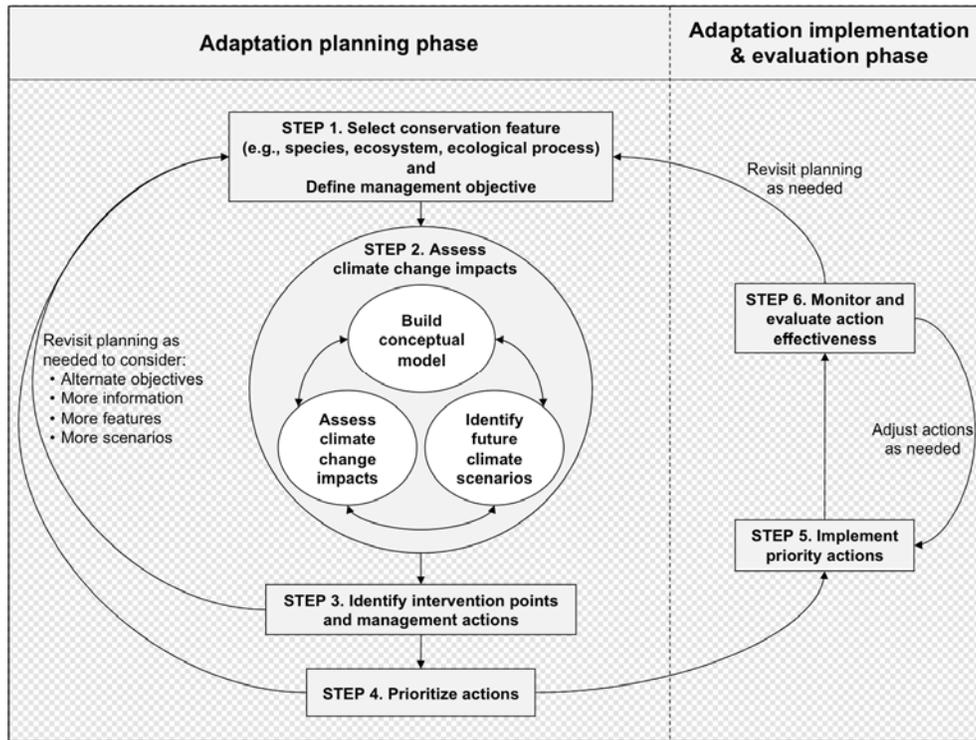
As far as available research shows, triage remains a theoretical approach to climate change adaptation. However, given limited funds for resource management and the potential for rapid climate change, a practical approach to planning under uncertainty would include advance consideration of a framework for making triage decisions.

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<sup>47</sup> A good explanation of how triage might work in climate change decision-making can be found on p. 2150 of Millar, Stephenson, and Stephens (2007). Accessed August 11, 2012: <http://naldc.nal.usda.gov/download/9757/PDF>.

### 3.3.3 Adaptation for Conservation Targets (ACT) Framework

In 2008, Molly Cross of the Wildlife Conservation Society with the Center for Large Landscape Conservation and the National Center for Ecological Analysis and Synthesis convened a working group of scientists and managers to develop the Adaptation for Conservation Targets (ACT) Framework.<sup>48</sup> The framework is described in Figure 4 below (from Cross et al. 2012).



**Figure 4: Adaptation for Conservation Targets (ACT) Framework**

The ACT Framework has been used at workshops for resource managers to develop climate change adaptation plans for species, ecological process, and ecosystem targets, including in the Jemez Mountains in New Mexico, the Gunnison River Basin in Colorado, the Four Forest Restoration Initiative area in Arizona, the Bear River watershed in Utah, the Adirondack State Park in New York, the Great Plains Landscape Conservation Cooperative region, and for the

<sup>48</sup> 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 (Cross et al. 2012). The date of the working group gathering was confirmed in personal communication with M. Cross (July 2011). A description of the ACT Framework is available on the Climate Adaptation Knowledge Exchange (CAKE) website here (maintained by EcoAdapt and Island Press, accessed September 1, 2011): <http://www.cakex.org/virtual-library/2285>.

management of grizzly bears and wolverines in the northern U.S. Rocky Mountains (SCCI 2010; personal communication with M. Cross, July 2011).<sup>49</sup>

The ACT Framework was designed specifically to overcome *uncertainty paralysis* or *analysis paralysis* by collaboratively combining practical experience with scientific information about climate change. The framework can be used in the context of information from climate model outputs, though the framework does not require their use (Schrag 2010; WCS 2010). The Wildlife Conservation Society describes the framework thus (2010):

The ACT Framework for climate change adaptation planning begins by selecting a concrete conservation target (e.g., species, ecological process or ecosystem), and articulating the conservation goal that we are striving [for] given our understanding of projected climate change. Graphic conceptual models are then used to illustrate and understand the key climatic, ecological, social, and economic drivers, and how these may change under different climate scenarios. Stakeholders then identify what conservation actions are necessary to achieve identified goals in light of different scenarios, with the goal of identifying those actions that are recommended across multiple scenarios, and therefore are relatively more robust to uncertainty in projecting future conditions.

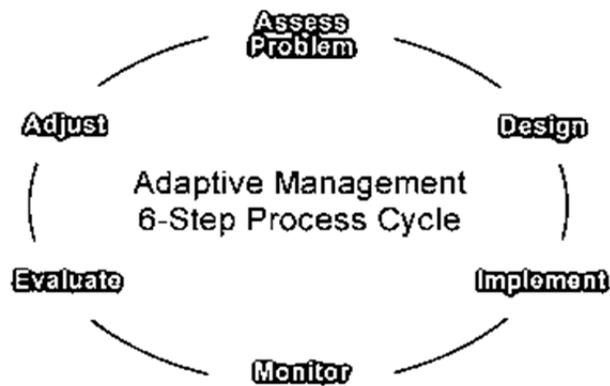
One of the key principles of the framework (see the lower right oval in the center of the graphic) is an abbreviated element of the scenario planning approach in order to identify actions that will be robust to multiple plausible futures. Another key principle of the framework is the re-evaluation of the management goal at different points in the planning process (after identifying actions, after evaluating actions pre-implementation, and again after evaluating actions post-implementation).

An advantage of the ACT Framework is that it gives a complete structure for planning that is specifically designed for addressing conservation targets. A drawback of this tool is the general nature of the framework, resembling a modified adaptive management system, providing no specific action steps for accomplishing some of the more confounding steps in the process, such as the evaluation of actions. For more information on the application of the ACT Framework for planning, the reader can obtain workshop reports describing how different groups approached each step (see Footnote 50).

For the purposes of comparison with the ACT Framework, Figure 5 depicts the six-step adaptive management cycle, which emphasizes learning from experience, including engaging in deliberate experimentation and monitoring (BCMFR 2011).

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<sup>49</sup> Reports on the ACT Framework workshops in New York, the Great Plains Landscape Conservation Cooperative, and for the management of grizzly bears and wolverines in the north Rocky Mountains can be obtained from M. Cross ([mcross@wcs.org](mailto:mcross@wcs.org)). Reports on the ACT Framework workshops in Arizona, Colorado, New Mexico, and Utah can be found on the Southwest Climate Change Initiative website (accessed February 15, 2012): <http://conserveonline.org/workspaces/climateadaptation/documents/southwest-climate-change-initiative-0/view.html>.



**Figure 5: Adaptive Management Cycle**

The ACT Framework adds complexity to the Adaptive Management Cycle with the intent of flagging special considerations for climate change planning (such as identifying future climate scenarios), but the basic steps of adaptive management are clearly foundational to the ACT Framework. All climate change planning tools reviewed in this study emphasize the importance of an iterative process, but the schematic depicting the ACT Framework adds a visualization of the centrality of that principle.

### 3.3.4 “Prepare for Surprises”: Rapid Response to Ecological Disaster

The National Research Council Panel on Strategies and Methods for Climate-Related Decision Support states in its 2009 book *Informing Decisions in a Changing Climate*:

Decision makers must expect and prepare for surprises—the likelihood that the results of climate change will include events not now predicted by scientific models and even events not yet imagined by scientists. The surprises could include more (or less) rapid changes in environmental processes already linked to climate change or even the appearance of totally unexpected environmental or human-environmental phenomena that emerge from poorly understand relationships in complex physical or ecological systems. (NRC 2009, p. 18)

Given that surprises are by definition unexpected events, it seems illogical to expect resource managers to prepare for them. However, managers can look at historical sources of surprises and likely thresholds to monitor (such as summer water deficits), and anticipate where opportunities for action may arise (Schwartz 1991; Millar, Stephenson, and Stephens 2007). Just as resource managers are taking tools from the military, business, and medical communities to improve their decision-making processes, they could also borrow preparedness practices from disaster response agencies.

Maladaptive practices, those which increase vulnerability to climate change, include actions which the disaster response community has long cited as a threat to public safety, including removing protective sand dunes to make room for houses along hurricane-prone seashores

(UNDP 2010; Auf der Heide 1989). It stands to reason that disaster planning offices might welcome collaboration with natural resource managers to reduce long-term vulnerability to climate change. Also, coordination by resource management agencies and disaster response agencies is not without precedent, such as after natural disasters in wilderness areas, as in the case of the eruption of Mount St. Helens in 1980, when three county sheriff departments and the U.S. Forest Service created a joint decision-making team (Auf der Heide 1989).

The response at Mount St. Helens was likely coordinated under the incident command system (ICS). The ICS was developed in the early 1970s to coordinate massive wildfire suppression efforts in California (NWCG 1994).<sup>50</sup> ICS is now widely used throughout the U.S. by fire agencies and is increasingly used for law enforcement and other public safety organizations (Ibid). The institutional framework for ICS might be used to respond to a climate change–related resource management disaster. From the U.S. Federal Emergency Management Agency ICS website:

Designers of the system recognized early that ICS must be interdisciplinary and organizationally flexible to meet the following management challenges:

- Meet the needs of incidents of any kind or size.
- Allow personnel from a variety of agencies to meld rapidly into a common management structure.
- Provide logistical and administrative support to operational staff.
- Be cost effective by avoiding duplication of efforts. (FEMA 2012)

These design criteria resemble criteria for climate change adaptation actions (see Section 3.5.2).

A coordinated approach to disaster response was suggested by participants at this study’s case study workshop (Futures of Wild Marin, January 2011): a *rapid response team* that would bring together members of the resource management community and the disaster response community to coordinate action after natural disasters to benefit both public safety and climate change adaptation for ecosystems. The disaster response/resource management joint decision-making team envisioned by the participants of the case study workshop included specific ideas for preparing Marin County for appropriate post-disaster responses to enhance public safety and ecosystem adaptation. The vision for this team included having an inter-agency agreement on priorities for response to certain critical situations (e.g., the detection of a new biological invader or catastrophic wildfire) and having contingency plans and resources set aside for responding. For example, the team could set aside resources in advance of disaster by keeping a strategically chosen set of seedlings ready to plant in the aftermath of climate-driven events that destroy native plants: the seedlings would be selected for their qualities contributing to the healthy transformation of the ecosystem under climate change (e.g., being bioregionally native or locally native, and having other qualities beneficial under climate change, such as being

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<sup>50</sup> For more information on the ICS and available courses in ICS core competencies, see the Federal Emergency Management Agency (FEMA) ICS webpage (accessed February 13, 2012): <http://www.fema.gov/emergency/nims/IncidentCommandSystem.shtm>.

better for water retention, better for preventing erosion, contributing less to wildfire danger). With plans in place and resources set aside for response to disaster, resource managers would have more latitude to act in what might otherwise be a paralyzing situation, and over the medium- and long-term be better able to stabilize or reduce the threat to public safety from climate change-driven disasters.

The main advantage of this approach is that it could enhance both human community and ecosystem preparedness for extreme climate events. The main drawback to this approach is that, unlike triage, it does not provide formal guidance on prioritization after a disaster: a joint decision-making team for disaster responders and resource managers is only a forum within which preparations could be made.

For a recent literature review on resource management for disaster risk reduction, see the Partnership for Environment and Disaster Risk Reduction's 2010 report *Demonstrating the Role of Ecosystems-based Management for Disaster Risk Reduction*, which is directed at disaster risk reduction policy makers, but also issues "a challenge to the environmental community to fine-tune existing tools and instruments so they can add value by reducing vulnerability to hazard impacts" (PEDRR 2010, p. 9).

### 3.3.5 The Climate Project Screening Tool

In 2007, the Westwide Climate Initiative (WWCI) was funded by the U.S. Forest Service (USFS) to develop tools and guidelines for adaptation to climate change on national forests (Furniss, draft 2010). In 2008, it began developing a Climate Toolkit as a joint project of three western U.S. Forest Service research stations: the Pacific Southwest Research Station, the Pacific Northwest Research Station, and the Rocky Mountain Research Station.<sup>51</sup> In 2009, this collaboration began developing the Climate Project Screening Tool.<sup>52</sup> The tool is intended to help land managers incorporate climate science information into planning, set priorities, and reduce uncertainty. It does this by asking land managers to answer a list of key management questions about potential climate change responses, organized by climate trend (Morelli in press 2012). The screening tool sorts information into these columns:

- Project Activity
- Climate Change Trends and Local Impacts
- Key Questions for Managers
- Response Narrative (to be completed by land managers)
- Continue with the Project? (Yes without modification; No; Yes with modification)

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<sup>51</sup> See a description of the WWCI Toolkit Project (accessed February 14, 2012): [http://www.fs.fed.us/psw/topics/climate\\_change/wwci\\_toolkit/](http://www.fs.fed.us/psw/topics/climate_change/wwci_toolkit/).

<sup>52</sup> See a brief description and sample screening analysis using the Climate Project Screening Tool (USFS 2011, accessed February 14, 2012): [http://www.fs.fed.us/rm/pubs\\_other/rmrs\\_2011\\_short\\_subject04.pdf](http://www.fs.fed.us/rm/pubs_other/rmrs_2011_short_subject04.pdf).

The screening tool was piloted with two USFS units: the Tahoe National Forest (California) and the Inyo National Forest (California and Nevada). One example from the Inyo National Forest pilot screening analysis:

- Activity: Grazing
- Trends and Impacts: Suitable range for livestock grazing may be altered
- A Key Question: Are recommended utilization levels still appropriate?

Recommendations for the screening tool's improvement and possible alternative uses are forthcoming, based on the pilot projects (Ibid). At this stage, it is too soon to evaluate its effectiveness in assisting with adaptation planning.

### **3.4 Examples of Current Planning Processes for Adaptation to Climate Change**

Below are descriptions of a sampling of climate change adaptation planning processes. These examples provide concrete illustration of the range of approaches already being taken both in and beyond the natural resource conservation context and also serve as a guide for managers seeking information on existing planning processes. This is not an exhaustive list of current adaptation planning processes; these examples are selected for their relevance to the West Coast and California context, the natural resource management context, or both. For more reference materials, see Appendix J for a list of resources to help natural resource managers plan for climate change.

#### **3.4.1 The NPS Climate Change Response Program**

Since 2006, the U.S. National Park Service Climate Change Response Program has been using scenario planning to train its staff to plan for climate change, holding at least eight scenario planning workshops for their parks as of this writing (NPS 2011).<sup>53</sup> The goal of these workshops is to “explore future impacts of global climate change, management policies, and societal attitudes on national parks” (Ibid).<sup>54</sup>

At present, scenario planning is being used by the NPS in an informal planning context and in the form of staff training exercises; the next phase of use is expected to involve more formal

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<sup>53</sup> This section's content (Section 3.4.1) is based on personal discussions with NPS Climate Change Response Program staff Leigh Welling (Climate Change Response Manager) and Matt Rose (Natural Resource Specialist) in October 2010 and August 2011 (Matt Rose), with the subsection on the Joshua Tree prototype workshop mainly based on discussions with Paul DePrey, former Chief of Resources at Joshua Tree National Park (acting as such during the time of the 2007 scenario planning workshop) in June 2011, and Joe Zarki, Chief Interpreter at Joshua Tree National Park (a participant at the 2007 workshop) in August 2011. Additional input came from a consultation with Joshua Tree National Park staff Andrea Compton, current Chief of Resources, and Josh Hoines, Vegetation Branch Chief, in August 2011.

<sup>54</sup> See Section 3.3.1 *Scenario Planning* for more on the scenario planning tool outside the NPS context.

planning (M. Rose, personal communication, August 2011). Scenario planning workshops have been held by the NPS to address the climate change planning needs of the following places:

- Joshua Tree National Park and Kaloko-Honokohau National Historical Park (prototype workshop 2007);
- Assateague Island National Seashore and Wind Cave National Park (2009);
- Crown of the Continent Ecosystem: multi-jurisdictional workshop including Glacier National Park, northern Montana, southeast British Columbia, and Southwest Alberta (2010);
- Southwest Coastal Alaska and Arctic Alaska Bioregions (2010);
- Great Lakes and Atlantic Coast (2010);
- Urban Landscapes and Eastern Forests (2010);
- Western Mountains, Pacific Islands (small cultural parks), and Arid Lands (Mojave Desert) (2011);
- Alaska (ongoing scenario planning projects on bioregional basis, 2010–2012).

The NPS climate change scenario planning workshops typically convene a small number of people (15–20) representing two national parks at a time for three days, 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 (in recent workshops using facilitators from the Global Business Network<sup>55</sup>) and climate scientists are recruited to help workshop participants (e.g., via a webinar) interpret downscaled climate model outputs<sup>56</sup> to identify and describe the most important climate variables driving change in the region of concern, such as temperature and precipitation. Ten to fifteen variables, including climatic (e.g., temperature, precipitation) and climate-driven environmental (e.g., storm intensity, sea level rise) variables, are considered. 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.

Participants devise scenarios based on these drivers, and select (by majority rule) three to five scenarios to discuss in depth. For each scenario participants select a title, create a timeline of significant events and headlines, and brainstorm action steps. The main output of the workshop is a set of action steps that is appropriate for multiple scenarios.

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<sup>55</sup> The Global Business Network (GBN), also known as GBN/Monitor, is a consulting firm specialized in scenario planning, founded in 1987 by one of the original purveyors of the scenario planning tool in the business community, Peter Schwartz (Schwartz 1991). Also credited on the GBN website as company founders are scenario planning experts Jay Ogilvy, Lawrence Wilkinson, Stewart Brand, and Napier Collyns. For more information: <http://www.gbn.com>.

<sup>56</sup> The climate model outputs most often used by the NPS to inform its planning scenarios are those of the IPCC's A1B (medium) emissions scenario (M. Rose, personal communication, August 2011).

At present, the scenario planning exercises are not generally coordinated with the General Management Plan revision process at the national parks. In the case of Assateague Island National Seashore, information on sea level rise and storm frequency generated during its scenario planning workshop informed the most recent revision of its General Management Plan. Staff members from Alaska's National Parks, having been trained in scenario planning by the NPS Climate Change Response Program, have held at least three successive workshops, revisiting and refining their scenarios. They are working without outside facilitation, developing lower level management plans at the park scale. Sequoia Kings Canyon National Park is also using the scenario planning model to develop fire management plans, also without outside facilitation, working on the scale of a single park (M. Rose, personal communication, August 2011).<sup>57</sup>

Because the scenario planning exercises have thus far been aimed at training individuals how to use scenario planning to think about the problem of climate change, not to develop specific actions, it is still early to compare the NPS scenario planning effort with other efforts (such as those described in some of the other planning examples below), which are intended to create specific action plans. In the future, the NPS may implement scenario planning as a tool in the way it is used by the business sector, e.g., iteratively, revising or replacing scenarios as new evidence is gathered. However, at present, the NPS has not repeated a scenario planning exercise in order to improve the plausibility of scenarios in a particular case, and so the exercises have principally been beneficial as way to initiate a climate change planning discussion, not necessarily to create or inform concrete action plans.

The scenario planning workshops are primarily intended to train NPS staff, and are closed to the general public (though efforts are made to strategically include non-NPS participants representing a variety of outside perspectives<sup>58</sup>). The workshops are not systematically documented for the public. If the workshops were to be adapted for use in a concrete action-oriented planning process, federal government transparency requirements would demand a stakeholder involvement process and thorough documentation of the proceedings (P. DePrey, personal communication, June 2011).

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<sup>57</sup> For more information on how scenario planning is being used in the National Parks and other NPS climate change adaptation work, see the two recent Special Issues of *Park Science* on climate change adaptation, in particular Weeks, Malone, and Welling (2011), "Climate change scenario planning: A tool for managing parks into uncertain futures" (accessed September 1, 2011): <http://www.nature.nps.gov/ParkScience/index.cfm?ArticleID=475>.

<sup>58</sup> In different NPS scenario planning workshops, participants included staff from other government agencies, as well as from universities, tribal governments, and in one case—the Crown of the Continent workshop—staff from the Canadian park service. (M. Rose, personal communication, August 2011).

In September 2010, the NPS released a Climate Change Response Strategy elucidating six Principles for Effective Decision Making in a Changing Climate:<sup>59</sup>

- Principle 1. Begin with managers' needs.
- Principle 2. Give priority to process as well as product.
- Principle 3. Link information providers and users.
- Principle 4. Build connections across disciplines and organizations.
- Principle 5. Enhance institutional capacity.
- Principle 6. Design for learning.

This 2010 strategy sets out 15 goals for the NPS in terms of science, adaptation, mitigation, and communication. The **science** goals include the following:

Goal One: Use the best available scientific data and knowledge to inform decision making about climate change.

Goal Three: Inventory and monitor key attributes of the natural systems, cultural resources, and visitor experiences likely to be affected by climate change.

The strategy's **adaptation** goals consist of the following:

Goal Five: Incorporate climate change considerations and responses in all levels of NPS planning. One of the points under this goal is Objective 5.4: *Conduct scenario planning to explore the range of potential conditions that parks may experience and the possible consequences associated with particular actions.*

Goal Six: Implement adaptation strategies that promote ecosystem resilience and enhance restoration, conservation, and preservation of park resources.

Goal Seven: Develop, prioritize, and implement management strategies to preserve climate-sensitive cultural resources.

Goal Eight: Enhance the sustainable design, construction, and maintenance of park infrastructure.

A more fully developed implementation plan for these 15 goals is due out in 2012. Meanwhile, NPS scenario planning workshops continue to be developed.

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<sup>59</sup> See all 15 goals of the NPS Climate Change Response Strategy here (accessed February 13, 2012): [http://www.nps.gov/climatechange/docs/NPS\\_CCRS.pdf](http://www.nps.gov/climatechange/docs/NPS_CCRS.pdf).

### *3.4.1.1 Scenario Planning in Joshua Tree National Park and Kaloko-Honokohau National Historical Park (prototype workshop 2007)*

In 2007, 15 staff members from the Joshua Tree National Park and the Kaloko-Honokohau National Historical Park (Hawaii) were convened by the NPS Climate Change Response Program for the park service's first climate change scenario planning workshops (NPS 2007; Waser 2009b).<sup>60</sup> The variables selected for defining three scenarios for Joshua Tree National Park were the seasonal timing of precipitation and the quantity of precipitation, corresponding with three different IPCC emissions projections (B1, A1B, A1F).<sup>61</sup> Vegetation changes were a focus of concern. In the "Dune" scenario there is a complete loss of vegetative cover, in "Summer Soaker" most vegetation would move upslope and Joshua Trees would be isolated or lost, and in "When it Rains it Pours" the park would become grassland.

Paul DePrey, the Chief of Resources at Joshua Tree National Park at the time of the workshop, describes the result of the workshop as an "in-house brainstorm" (personal communication, June 2011). Chief Interpreter at the park (at the time of the workshop and presently) Joe Zarki said that it was a "great experience," and was particularly useful as an opportunity to interact with climate scientists, making an abstract problem more concrete, but he concurred with DePrey in saying that it stopped short of informing planning processes, in part because at the time of the workshop "the ground was not ready for concrete action" (personal communication, August 2011). According to DePrey, previous to the workshop, the park staff was researching climate change impacts on the park in a generalized way, with an emphasis on the iconic Joshua Tree and other species of concern; after discussion of the precipitation-defined scenarios, the staff began focusing on one location in the park that is especially vulnerable to climate change impacts (at the edge of the Sonoran and Mojave deserts). They began planning to establish baseline data for that location, to allow the park to monitor changing conditions (though funding for this monitoring is still pending, per communication with current park Resource Chief A. Compton). Staff also began planning how to message the possible loss of Joshua Trees in the park as a result of climate change.

DePrey reports that he would like to see the workshop repeated at Joshua Tree National Park, to improve on the original scenarios, but he would like to see it done with some changes. It would be helpful, according to DePrey, to include more people, both from the park and from other stakeholder groups (such as the Bureau of Land Management, Department of Defense, county and city governments, as well as more scientists and other experts on climate change). He would also like to see it linked to action, through regulation or research, or otherwise

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<sup>60</sup> While the workshop addressed the concerns of two parks (a Hawaiian and a Californian park), this summary description focuses on Joshua Tree National Park for its relevance to the greater Californian context.

<sup>61</sup> The B1, A1B, A1F scenarios correspond with some of the emission scenarios used as a basis for impact projections in the IPCC Fourth Assessment Report (IPCC 2008b). B1 is a low-emissions scenario, A1B is a medium-emissions scenario, and A1F represents the scenario with the sharpest rate of increase in emissions (Lenart 2008; Waser 2009b).

through links to concrete planning processes. Zarki noted that the 2007 workshop was weighted toward representatives of the science fields and that it would be helpful to include people representing the economic perspective.

At present, the limited resources for climate change planning at the NPS appear to constrain the scenario planning workshops to in-house brainstorming. At Joshua Tree National Park, concrete next steps for the park to adapt to climate change have not been defined, though managers are interested in continuing the planning process (Waser 2009b; personal communication with A. Compton and J. Hoines, August 2011). The park's Current Chief of Resources Andrea Compton notes that the park staff are presently engaged in monitoring and narrowing the focus of research. Park Vegetation Branch Chief Josh Hoines indicates that one of the park's next steps is a climate vulnerability assessment. Hoines has begun to classify species in the park as "strivers" (will likely expand on their own regardless of climate change), "survivors" (having a wider distribution, has already survived subtle climate shifts), and "divers" (not likely to do well under climate change). The park is also participating in the California Phenology Project, monitoring the timing of plant and animal life cycle changes, currently focused on six pilot parks in the National Park system.<sup>62</sup>

At present the NPS Climate Change Response Program is not planning on revisiting Joshua Tree National Park to revise the 2007 scenarios (personal communication with M. Rose, August 2011). On the question of how to potentially include scenario planning in future park planning processes in an iterative way, Hoines suggests that an annual climate change planning exercise might not be feasible, but it might be feasible and useful to do an annual planning exercise for the park that includes climate change as a factor (personal communication, August 2011).

### 3.4.2 The MFPP's Climate Solutions University

In 2009, the Model Forest Policy Program (MFPP) came together with the Tennessee-based Cumberland River Compact to create Climate Solutions University (CSU), a teaching forum to support rural U.S. communities to prepare for climate change, focusing on communities dependent on natural resources, especially forests and rivers.<sup>63</sup> Nancy Gillam of MFPP and Gwen Griffith of the Cumberland River Compact noticed that most climate change planning in the United States was taking place in cities and mostly concerned reducing greenhouse gas emissions, while rural communities were already detecting changes to the climate and worrying about how to prepare (G. Griffith, personal communication, June 2011). Adapting the city-focused "Preparing for Climate Change: A Handbook for Local, Regional, and State

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<sup>62</sup> For more information on the California Phenology Project, see its profile on Facebook (<https://www.facebook.com/pages/California-Phenology-Project/167737189945018?sk=info>) or on the National Phenology Network website (<http://www.usanpn.org/cpp>).

<sup>63</sup> This section is based on conversations with CSU's Gwen Griffith (Director of Curriculum) in June 2011, Jeff Morris (Director of Communications and Community Coordinator) of Climate Solutions University in April 2011, and Lindsay Taylor, Program Coordinator of the Nooksack Salmon Enhancement Association in April 2011.

Governments” (ICLE, King County and Climate Impacts Group 2007) for a rural context, they created a distance-learning curriculum to facilitate rural community-based climate change planning.<sup>64</sup> Gillam and Griffith piloted the CSU curriculum with two communities in Idaho and Tennessee (communities with which they were already associated), and then moved on to select communities through a competitive application process. CSU selected six communities in 2010, and another six in 2011, to be led through the curriculum with a goal to creating local climate change adaptation plans and supporting the implementation of the plans. Each selected participant community receives \$10,000 to support paid staff time and gains access to ten modules taught using remote learning tools over a period of 10 months.

The curriculum is taught by consultants located around the country. This differs from the approach typical of private consulting organizations, where a team of experts flies in to create an adaptation plan in a one-time workshop over a period of a few days: the CSU curriculum takes more time and relies more on local leadership. The CSU approach emphasizes localization, both of the community adaptation plan and the science on which the plan is based. For example, CSU helps communities access academic support for climate model downscaling.

The curriculum is separated into four basic steps:

1. Forming a multi-stakeholder team;
2. Assessing the risks (localized current and projected risks, focusing on water, forest, climate, and economic risks);
3. Synthesizing the story of risks and opportunities/strategizing for action;
4. Finalizing a plan and identifying tools for implementation.

CSU provides implementation support for two years following the completion of the 10-module curriculum. At present, they are able to offer opportunities for all 12 communities in the program from 2010 and 2011 to benefit from each other’s experiences and give peer support where they find overlap in climatic and institutional challenges. Overall, CSU is focused on creating action plans collaboratively with community members in rural places vulnerable to climate change. It is an entry-level, process-oriented approach to climate change preparation.

The CSU curriculum currently does not include a scenario planning component, basing its alternatives for action exclusively on a risk assessment covering water, forest, climate, and economics.

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<sup>64</sup> Read “Preparing for Climate Change: A Handbook for Local, Regional, and State Governments” (Snover et al. 2007, accessed June 29, 2011) here: <http://www.icleiusa.org/action-center/planning/adaptation-guidebook/>.

Also, see Section 3.4.5 for more on ICLEI- Local Governments for Sustainability, and Appendix J for more adaptation planning support tools from ICLEI.

### *3.4.2.1 CSU in Bellingham, Washington, with the Nooksack Salmon Enhancement Association*

Bellingham, Washington, was one of the six communities that completed Climate Solution University's 2010 curriculum. It is currently moving into the implementation stage of its climate change adaptation plan. The applicant organization that facilitated Bellingham's participation in CSU is the Nooksack Salmon Enhancement Association (N-SEA).

Lindsay Taylor of N-SEA was the staff member charged with coordinating the 2010 project (L. Taylor, personal communication, April 2011). The main result of the project was a county (Whatcom County) and watershed-wide (Nooksack River watershed) model climate change adaptation plan which launched Bellingham into working on climate change adaptation (personal communication with L. Taylor, April 2011). The county and city had both already created a greenhouse gas reduction plan (supported by ICLEI - Local Governments for Sustainability),<sup>65</sup> but it had not begun planning for climate change impacts.

The Nooksack River watershed has a multi-stakeholder Salmon Recovery Board that is acting as the body working on prioritizing adaptation actions and carrying out implementation of the model adaptation plan. N-SEA is working on education and outreach to support the implementation. The Watershed Management Board is also involved in planning and organizing implementation. The model adaptation plan is based on localized climate impacts analyses from sources including the Climate Impacts Group at the University of Washington.

Feedback from participants in the adaptation planning process thus far includes observations about the amount of work involved and the types of information used. CSU requires a community-based team to be created at the start of the project, and in this community, that first step proved to be the most laborious. After climate model projections for the community were formulated participation in the team became easier to solicit: by the end of the process of describing climate impacts, the reason for concern became evident to the major planning groups, and they were willing to be involved. However, there was also concern about the climate impact projections. N-SEA emphasized to participants that the model outputs were useful for painting a picture of a possible future, but were not intended to be predictive. Participants wanted to see past trend data to show existing changes, so as not to rely too heavily on future projections.

The economic decline of recent years caused climate change planning to stall, but it is now gaining traction. At present, the City of Bellingham is using the CSU-facilitated model adaptation plan as a starting point for the city's adaptation plan. Also, N-SEA is gathering feedback to inform the ongoing planning process through a survey of participants in the Whatcom County Climate Adaptation Symposium, a community gathering hosted by N-SEA in April 2011 in partnership with the City of Bellingham, Western Washington University, and the Washington State University Whatcom County Extension.

An overarching problem in planning for climate change in this community is a combination of distrust in the government and climate change skepticism outside the city of Bellingham. Thus

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<sup>65</sup> For more information on ICLEI see Section 3.4.5.

far, no official local policies have changed to address climate change. The CSU approach seems to be helpful at launching a broad-based climate change planning effort; it may be too soon to say whether it provides sufficient support to carry the effort forward to the point of changing government policies.

### 3.4.3 The Southwest Climate Change Initiative

The Southwest Climate Change Initiative (SWCCI) is preparing for climate change impacts on natural resources in Utah, Colorado, Arizona, and New Mexico.<sup>66</sup> It is currently coordinated by Patrick McCarthy (the Nature Conservancy of New Mexico). This area is a focus of climate change adaptation because it is the epicenter of climate change impacts in the lower forty-eight states (McCarthy 2011). The goal of the SWCCI is to provide tools and information, assess impacts, take action, document actions, and share the results. There are four demonstration landscapes in the SWCCI: Bear River Basin (Utah/ Wyoming), Four Forests (Arizona), the Jemez Mountains (New Mexico), and Gunnison Basin (Colorado). The collaboration involves 190 people from 43 organizations. SWCCI adaptation actions in these sites are being planned on the basis of a climate change vulnerability assessment completed in January 2011 which identifies habitats and species of concern based on temperature and hydrological change without a sensitivity analysis for individual species of concern (assuming equal sensitivity to impacts).

According to McCarthy, the current recommendations for management resulting from the vulnerability analysis and pilot site planning processes include the following:

- Consider conservation goals to be a moving target, reevaluating and modifying goals in light of climate change;
- Coordinate management across jurisdictions;
- Step up the use of monitoring and make sure it informs management plans (testing assumptions about the impacts of climate change and evaluating the effectiveness of adaptation actions).

The SWCCI has conducted climate change planning workshops for its demonstration sites, using the Adaptation for Conservation Targets Framework developed by Molly Cross (see Section 3.3.3). 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. McCarthy states that the ACT Framework workshops have been useful for starting positive conversations: it helps getting people “past despair” to action.

### 3.4.4 The Sierra Nevada Alliance

In March 2011 the Sierra Nevada Alliance (SNA), located in South Lake Tahoe, California, published the third edition of its “Sierra Climate Change Toolkit: Planning ahead to protect

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<sup>66</sup> This section is 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.

Sierra natural resources and rural communities.”<sup>67,68</sup> This toolkit is intended to help a wide variety of stakeholders begin taking action in response to climate change within existing planning processes (M. Gee, personal communication, April 2011). It presents information on climate change impacts (in the Sierra, in California, and at broader scales), and frameworks, strategies and case studies about preparing for climate change within existing planning processes in the Sierra. It also presents communication tools to build support for action.

The toolkit includes the Sierra Nevada Alliance Climate Change Adaptation Principles for Planning:

1. Educate ourselves and others on the impacts of climate change.
2. Identify future change through modeling and forecasting.
3. Develop and implement adaptive management strategies.<sup>69</sup>
4. Monitor and track changes in weather, hydrology, ecosystems, and communities.
5. Promote the resiliency of Sierra ecosystems, communities, and economies, and minimize non-climate stressors.
6. Prioritize projects that will succeed under multiple scenarios.
7. Integrate and coordinate local efforts.

The Sierra Nevada Alliance has also published three editions of case studies highlighting how resource planners have addressed climate change emission reduction and adaptation in the Sierra and other regions.<sup>70</sup>

According to the current Interim Regional Climate Change Program Director at the organization, Marion Gee,<sup>71</sup> one of the emphases of the SNA’s climate change adaptation work is the Integrated Regional Water Management (IRWM) planning and funding process in the Sierras (M. Gee, personal communication, April 2011). The IRWM process is a state-wide grant program administered by the California Department of Water Resources (DWR) to support regional planning that integrates water supply, water quality, flood management, and ecosystem health objectives. IRWM plans are required to address greenhouse gas reduction and

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<sup>67</sup> This section is based on a conversation with Marion Gee, Interim Regional Climate Change Program Director at the Sierra Nevada Alliance in April 2011.

<sup>68</sup> Read the 2011 edition of the SNA toolkit here (accessed June 29, 2011):  
[http://www.sierranevadaalliance.org/publications/db/pics/1303760072\\_12034.f\\_pdf.pdf](http://www.sierranevadaalliance.org/publications/db/pics/1303760072_12034.f_pdf.pdf).

<sup>69</sup> Adaptive management emphasizes learning from experience, including engaging in deliberate experimentation and monitoring (BCMFR 2011).

<sup>70</sup> For more information see SNA’s Regional Climate Change Program Blog (accessed February 15, 2012):  
<http://snalliance.wordpress.com/category/regional-climate-change/>.

<sup>71</sup> At the time of writing (2011) Marion Gee was the interim Regional Climate Change Program Director at SNA; at the time of publishing (2012) Craig Breon (craig@sierranevadaalliance.org) is the Regional Climate Change Program Director at SNA.

climate change adaptation objectives. IRWM regions are in the process of conducting analyses to understand their vulnerabilities to climate change and account for these in planning. They are employing various methodologies, which may include scenario planning. Read an assessment of the approaches to climate change planning being undertaken in IRWM regions on the DWR Climate Change Program website (Conrad 2012).<sup>72</sup>

The IRWM provides an opportunity to develop a nuanced, multi-stakeholder approach to water management under climate change that is attached to a concrete statewide planning process through the California Department of Water Resources.

### 3.4.5 ICLEI Local Governments for Sustainability

ICLEI-Local Governments for Sustainability<sup>73</sup> is an international association of local, regional, and nation-wide local government organizations committed to sustainable development (ICLEI 2008). Its programs include ICLEI USA Climate Resilient Communities.<sup>74</sup> This program supports local governments preparing for climate change using an on-line teaching module: Adaptation Database and Planning Tool (ADAPT) (ICLEI USA 2011). ICLEI partner communities include Keene, New Hampshire; Anchorage, Alaska; Dade-County, Florida; Homer, Alaska; and Fort Collins, Colorado. ICLEI bases its Climate Resilient Communities work on five milestones.

ICLEI's Five Milestones for Climate Change Adaptation:

1. Conduct a Climate Resiliency Study.
2. Set Preparedness Goals.
3. Develop a Climate Preparedness Plan.
4. Publish and Implement the Preparedness Plan.
5. Monitor and Reevaluate Resiliency.

This five-part plan was piloted in the United States in 2007 in Washington's King County, encompassing the City of Seattle. The ICLEI/ King County handbook,<sup>75</sup> developed as part of

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<sup>72</sup> Read E. Conrad's 2012 report on regional IRWM climate change planning in California (accessed August 12, 2012) here: [http://www.water.ca.gov/climatechange/docs/IRWM\\_CCReport\\_Final\\_June2012\\_EConrad\\_UCBerkeley.pdf](http://www.water.ca.gov/climatechange/docs/IRWM_CCReport_Final_June2012_EConrad_UCBerkeley.pdf).

<sup>73</sup> Founded in 1990, the official name of the organization since 2003 has been ICLEI- Local Governments for Sustainability; "ICLEI" formerly was an acronym for the International Council for Local Environmental Initiatives (ICLEI 2008).

<sup>74</sup> Read more about ICLEI adaptation projects such as the ICLEI USA Climate Resilient Communities initiative here (accessed February 15, 2012): <http://www.iclei.org/index.php?id=10832>. See Appendix J for more ICLEI resources for climate change planning.

<sup>75</sup> See Footnote 64 for more on "Preparing for Climate Change: A Handbook for Local, Regional, and State Governments" (Snover et al.).

that pilot program, is a reference document used in local and state adaptation processes around the United States.

ICLEI's assistance with adaptation planning is contingent on formal membership (ICLEI 2008). Membership is offered to local governments and associations of local governments, and requires annual membership dues which vary according to Gross National Income and population. Even with a sliding-scale, membership fees might prove prohibitive for small governments; given that, ICLEI might be best suited to assist larger cities.

### 3.4.6 The Geos Institute and the ClimateWise<sup>®</sup> Process

The Geos Institute, formerly the National Center for Conservation Science and Policy, is a private non-profit consulting firm based in Ashland, Oregon, that "uses science to help people predict, reduce, and prepare for climate change" (Geos Institute 2010). In California in 2010 the Geos Institute supported the development of climate adaptation plans for two California counties, Fresno<sup>76</sup> and San Luis Obispo<sup>77</sup>, working in partnership with the Local Government Commission (LGC). The LGC is a non-profit, nonpartisan membership organization of local government officials and community leaders, based in Sacramento, California, that specializes in assisting local governments "in developing and implementing policies and program that help establish more livable, healthy, prosperous and resource-efficient communities" (LGC 2010). Geos employs a system trademarked by the organization as the "ClimateWise" process.

ClimateWise was developed by the Geos Institute together with the Climate Leadership Initiative (now the Resource Innovation Group)<sup>78</sup> and piloted at sites selected for their ability to provide "a collective diversity of expected climate change impacts as well as local features such as land use patterns, cultural traditions, economic drivers, biological diversity, rural vs. urban percentages, and political climate." Pilot sites were also selected to represent a variety of geographic scales, including sites as large as the Klamath Basin watershed and the relatively small San Luis Obispo County (Koopman and Journet 2011). A feature of more recent projects is the selection of a convening organization to be the local primary point of contact and convene a steering committee for the project (Ibid). The steering committee, comprised of 10–15 representatives from the site's critical socioeconomic and natural sectors, is responsible for identifying opportunities for adaptation action and also funding (Ibid). The Geos Institute prepares two reports for each site: a climate projections report and a socio-economic report (Ibid). A workshop is held, convening 60–80 community leaders and experts to review the impacts information and begin to develop strategies to reduce vulnerability. Participants at the

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<sup>76</sup> For more information on Fresno's adaptation plan (accessed February 15, 2012): <http://www.geosinstitute.org/completed-climatewise-projects/climate-change-adaptation-planning-fresno-county.html>.

<sup>77</sup> For more information on San Luis Obispo's adaptation plan (accessed February 15, 2012): <http://www.lgc.org/adaptation/slo/docs/SLOClimateWiseFinal.pdf>.

<sup>78</sup> For more information on the Climate Leadership Initiative/Resource Innovation Group: <http://www.theresourceinnovationgroup.org/>.

workshop are broken up by expertise into focus groups to identify and rank risk factors which contribute to vulnerability (Ibid). Next, participants are broken up into groups intended to include representatives of different expertise sectors and asked to discuss the highest-ranked risks identified by the expertise-specific focus groups. Strategies are developed and ranked according to criteria such as feasibility, funding, and political constraints (Ibid). Workshop results are presented to community leaders at a dinner event, and then the steering committee is responsible for developing strategies to execute the actions recommended through the workshop (Ibid).

The feedback on the Futures of Wild Marin scenario planning workshop (discussed in Section 4) included the recommendation of incorporating an opportunity for workshop participants to divide by expertise and discuss strategies, a step included in the ClimateWise process. However, the recommendation was specifically for the strategies to be first devised in interdisciplinary groups, to benefit from outside perspectives and cross-pollination of management approaches, and then have the details of application developed by expertise-specific groups, to benefit from the reality check on the practicability of possibly nontraditional approaches.

In the ClimateWise process, strategy development proceeds in the reverse order: expertise-specific groups devise the strategies and then interdisciplinary groups develop them. With this order of operations, strategies are likely to resemble business-as-usual management practices, possibly missing innovative opportunities that may come from an interdisciplinary strategy session. However, the familiar practices may be the most feasible—or only feasible—way to advance climate change preparedness in some contexts.

As of late 2010, the ClimateWise projects currently underway are in Missoula County, Montana, and in Oregon: the Deschutes Basin Project (Deschutes, Jefferson, and Lincoln Counties), and the Rogue Valley Project (Jackson and Josephine Counties) (Geos Institute 2011). The Rogue Valley Project was the institute's first climate change planning project, completed in 2008; in 2010 the institute began Phase II of the project, working with the Rogue Valley Council of Governments on a greenhouse gas emissions reduction plan.

### 3.4.7 The Columbia Basin Trust Adaptation Initiative

Since 2008, the Columbia Basin Trust (CBT) Adaptation Initiative, British Columbia, Canada, has been supporting climate change adaptation planning in two communities: Kimberley<sup>79</sup> and Elkford,<sup>80</sup> British Columbia (CBT 2009).<sup>81</sup> The CBT was formed as a result of negotiations in 1995

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<sup>79</sup> For more information on the Kimberley planning process (accessed February 15, 2012): <http://cbtadaptation.squarespace.com/kimberley-bc/>.

<sup>80</sup> For more information on the Elkford planning process (accessed February 15, 2012): <http://cbtadaptation.squarespace.com/elkford-bc/>.

<sup>81</sup> For more information on the CBT adaptation planning process download a PowerPoint presentation by J. Zukiwsky (2010), "Assessments in Rural Mountain Communities in the Columbia Basin Region of

between the Province of British Columbia, leaders from First Nations (indigenous communities in Canada), and local communities to strengthen the local voice in the execution of the Columbia River Treaty (CBT 2008; Clark and Grant 2011). The CBT funds its work, including its climate change adaptation activities, through income earned from the investment of an endowment from the province of \$321 million Canadian dollars (Ibid).

CBT provides technical resources and assists the communities in gaining access to experts. It promotes a six-step adaptation planning process:

1. Make a commitment, determine desired outcomes and objectives, and develop a work plan.
2. Learn about climate change through local observations and research of historical and future data/models. Use these findings to effectively communicate the science.
3. Identify priority areas for action by investigating potential impacts and utilizing existing planning documents.
4. Assess vulnerability and risk.<sup>82</sup>
5. Develop adaptation strategies and goals to determine proper action.
6. Implement and continually monitor for new strategies. Continue community outreach.

In recent years, this six-step process has been used in other Columbia Basin cities, including Castlegar, Rossland, and the Regional District of Central Kootenay Area D/ the Village of Kaslo (CBT 2009).

An innovation of the CBT process is the use of a one-day rapid action planning workshop<sup>83</sup> to *thin-slice*, or streamline, the planning process for climate change. It is designed to get a small group of key decision makers to their next step in a particular planning process based on identified risks and vulnerabilities, referencing the experience of the cities and villages that have already completed the six-step CBT planning process.

### 3.4.8 The USFS Climate Change Roadmap and Scorecard

In 2011, the U.S. Forest Service published a roadmap and scorecard intended for systematic implementation by Forest Service units to help them prepare for climate change (USFS 2011a, USFS 2011b). This is a national-level effort, involving National Forests and Grasslands—more than 35 million acres of wilderness (Ibid). Although the USFS is not implementing a multi-

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Canada” (accessed July 30, 2011): <http://www.slideshare.net/uhi/conducting-climate-change-risk-and-vulnerability-assessments-in-rural-mountain-communities-in-the-columbia-basin-region-of-canada-jeff-zukiwsky>.

<sup>82</sup> CBT cites a five-step process for vulnerability assessment available here (accessed February 15, 2012): <http://cses.washington.edu/db/pdf/snoveretalgb574ch8.pdf>.

<sup>83</sup> For more information on CBT’s rapid action planning process (accessed February 15, 2012): <http://adaptationresourcekit.squarespace.com/rapid-action-planning/>.

stakeholder planning process, the initiative does involve Forest Service units managing for a variety of uses, including (though not exclusively) resource protection. The scorecard is intended to guide units toward a goal of completing seven out of ten of the listed tasks by fiscal year 2015. Each unit will designate a Climate Change Coordinator or Team to promote progress on these tasks through annual performance reviews. The scorecard consists of a one-page list of ten yes/no questions separated into four categories: organizational capacity, engagement (partnerships and education), adaptation, and mitigation. The questions under “adaptation” consist of:

- Has the Unit engaged in developing relevant information about the vulnerability of key resources, such as human communities and ecosystem elements, to the impacts of climate change?
- Does the Unit conduct management actions that reduce the vulnerability of resources and places to climate change?
- Is monitoring being conducted to track climate change impacts and the effectiveness of adaptation activities? (USFS 2011b, p. 9)

The scorecard is intended to move the units forward on the goals of the USFS National Roadmap for Responding to Climate Change, a 28-page document which describes the four categories of activity in greater detail.

It is too early in the implementation of the scorecard initiative to speculate on its strengths and weaknesses.<sup>84</sup>

### 3.4.9 The Southern Sierra Conservation Cooperative

In 2008, a collaboration of scientists and federal land managers launched an effort to support climate change adaptation in the Southern Sierra Nevada ecoregion (located in eastern central California) (Nydick and Sydoriak 2011a). The collaboration was formalized in a 2008 Memorandum of Understanding (MOU) signed by federal agency authorities, followed by a symposium to elucidate a research agenda based on the MOU.<sup>85</sup> The MOU reads, in part:

The parties to this agreement recognize and agree to collaboratively develop a program of research, resources management, and public education to help mitigate the impacts from and adapt to climate change effects on ecosystems of the southern Sierra Nevada. (2008 MOU, p. 1)

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<sup>84</sup> For more on the Forest Service’s work on climate change adaptation, see its Climate Change Resource Center website (accessed February 13, 2012): <http://www.fs.fed.us/ccrc/>.

<sup>85</sup> Read the 2008 “Memorandum of Understanding between United States Department of Interior Sequoia/Kings Canyon National Parks, United States Department of Interior U.S. Geological Survey – Western Ecological Research Center, United States Department of Agriculture Forest Service – Pacific Southwest Research Station and United States Department of Agriculture Forest Service Sequoia National Forest/Giant Sequoia National Monument” here (accessed February 13, 2012): [http://www.fs.fed.us/psw/southernsciencence/MOU\\_final\\_global\\_climate\\_change.pdf](http://www.fs.fed.us/psw/southernsciencence/MOU_final_global_climate_change.pdf).

In 2009, based on the symposium's output, the MOU participants published *A Strategic Framework for Science in Support of Management in the Southern Sierra Nevada Ecoregion: A Collaboratively Developed Approach* (Ibid).<sup>86</sup> The following year, the MOU participants met several times, expanding involvement to include non-governmental organizations; thereafter the group began calling itself the Southern Sierra Conservation Cooperative (SSCC) (Ibid). In 2011, a second MOU was signed by 10 parties specifically to bring the cooperative into alignment with a mission to work together to make the best use of each partner's resources and efforts to conserve the regional native biodiversity and key ecosystem functions within the Southern Sierra Nevada ecoregion in the face of accelerated local and global agents of change (personal communication with K. Nydick, February 2012).

The starting goal of this cooperative is information-sharing:

To avoid jurisdictional conflicts, the cooperative will not make resource management decisions or forward an agenda of any particular management action. Rather the cooperative will provide and exchange information to better inform decision makers. (Nydick and Sydoriak 2011a, p. 1)

The cooperative's main tools for information-sharing are annual workshops and periodic conference calls, with an on-line information clearinghouse in the works (personal communication with K. Nydick, February 2012). The 2009 *Strategic Framework* also points to a goal of hiring a coordinator: this was satisfied with the assignment of the Science Coordinator for SEKI, Koren Nydick, to support the work of the cooperative.

The cooperative is currently planning an interagency symposium, slated for early 2013, involving a broader audience to share information on climate projections, tools, and possible courses of action (personal communication with K. Nydick, February 2012). Also, some of the partners in the cooperative are working on a climate change adaptation project: an ecoregional fire management exercise based on plausible future scenarios which uses a hybrid approach incorporating both scenario planning and a geospatial vulnerability assessment (Ibid; Nydick and Sydoriak 2011b).

The intent of the cooperative is to encourage inclusive, broad dialogue and shared science-based learning between governmental and non-governmental agencies, organizations, and institutions that share the cooperative's mission. Currently, due to the different capacities of the members, the cooperative is primarily driven by federal agencies, with non-governmental information sharing coming through the involvement of a coalition of non-governmental organizations called the Southern Sierra Partnership (personal communication with K. Nydick, February 14, 2012).<sup>87</sup> The State of California, through the Sierra Nevada Conservancy, takes part

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<sup>86</sup> Read 2009 *Strategic Framework for Science in Support of Management in the Southern Sierra Nevada Ecoregion: A Collaboratively Developed Approach* here (accessed February 13, 2012): <http://www.nps.gov/seki/naturescience/upload/strategic-framework.pdf>.

<sup>87</sup> Read more about the Southern Sierra Partnership at the Nature Conservancy's page of resources on the coalition (accessed February 14, 2012): <http://conserveonline.org/workspaces/climateadaptation/documents/southern-sierra-partnership-ca-0>.

as an observer (participating in meetings, though not a party to the MOU at this time). This type of federal/non-governmental collaboration presents opportunities and challenges: it is important to acknowledge that this kind of partnership is made more challenging when partner staff time and resources are stretched thin, such as under the current conditions of economic downturn (Ibid). Another important factor for collaborative work in the Southern Sierra is geography: partners are separated not only by differences in capacity to participate, but also spatial distance (Ibid). Therefore, the highest priority of the cooperative for the present will continue to be information-sharing, capitalizing on what can be most easily achieved under conditions of scarce resources and infrequent opportunities to meet in person (Ibid). At the same time, the cooperative is looking to the future, and has developed and is seeking funding for several new projects (Ibid).

### 3.5 Measuring Effectiveness: What is Successful Adaptation?

All climate change interventions should be designed with an evaluation mechanism. But what are the criteria for successful adaptation? Climate change is an ongoing process, preventing a true ex post facto (outcome) evaluation of effectiveness of intervention, e.g., sea level will be rising for hundreds of years after greenhouse gases are stabilized in the atmosphere (Hedger et al. 2008). The outcome of a certain intervention can be measured against observable impacts at a given point in time, but the intervention's ultimate effectiveness cannot be known. Still, for the sake of efficiency, evaluation criteria and associated indicators must be selected, if not measuring the *ultimate* outcome, then the design, process, outputs, and provisional outcomes of an intervention.<sup>88</sup>

As important as it is to design for evaluation, evaluation for evaluation's sake should be avoided: evaluation should only be done in a way to improve outcomes (George et al. 2003). Evaluation of project success might only be required according to the needs of funding sources, but resource managers should consider evaluating their progress according to the schedule that will best inform project decisions to improve outcomes.

It is beyond the scope of this study to identify or synthesize findings of empirical testing of the effectiveness of different criteria for the evaluation of climate change interventions.<sup>89</sup> The field

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<sup>88</sup> Outputs are a measure of volume of activity (e.g., number of attendees at an event); outcomes are the consequences of that activity (e.g., increased awareness of the topic discussed at the event); indicators are observable characteristics, actions or conditions which demonstrate whether a desired change has happened (e.g., the number of attendees who can accurately answer questions on the topic discussed at the event) (Motylewski and Horn 2002).

<sup>89</sup> For further reading on the evaluation of adaptation indicators, see Hedger et al. (2008), especially Table A5, "An assessment of the advantages and disadvantages of indicators used in the GEF (Global Environment Facility) database, with respect to CCAI (Climate Change Adaptation Interventions)." This table gives the pros and cons of each indicator for usefulness in evaluating adaptation actions. For example, the indicator "Stakeholder access to meteorological data" has the drawback that "stakeholders do not know how to use information."

of impact evaluation for climate change adaptation interventions is relatively young, and the evidence base is minimal (Prowse and Snilstveit 2010). To date, there have only been a few quasi-experimental evaluations of climate change adaptation interventions for conservation targets in which impact evaluation<sup>90</sup> techniques were used to estimate outcomes (Ibid). Meanwhile, the evaluation of climate change interventions continues to be an essential way both to determine which adaptation actions are the most cost-effective, and support arguments for their funding.

### 3.5.1 On Adaptive Management and Climate Change Intervention Evaluation

The theory of an *adaptive management* approach to natural resource management, developed in the 1970s, can be understood as a “systematic, rigorous approach for deliberately learning from management actions with the intent to improve subsequent management policy or practice” (BCMFR 2011). See Figure 5 (Section 3.3.3) for an illustration of the six basic steps of adaptive management: assess the problem; design an intervention; implement it; monitor it; evaluate it; and adjust the intervention on that basis (returning then to “assess the problem”). The implementation of an experimental climate change adaptation intervention within the context of adaptive management, which is built for the experimental approach, should facilitate the intervention’s ability to be systematically evaluated and improved.

However, there are barriers to the adaptive management approach. Peterson states: “Despite being widely advocated in the last decade, and being initially proposed more than 25 years ago, adaptive management has not been widely practiced” (Peterson 2005, p. 383). Barriers to adaptive management include the reluctance of managers or decision makers to engage directly with uncertainty (especially in the presence of the frequent assumption that admission of uncertainty is the same as an admission of weakness, and an admission of weakness will result in inaction or an ineffective compromise in policy); the vested interests’ motivation to avoid the change that might result from experimentation; and the cost of monitoring and experimentation (Walters 1997). Walters asserts:

[I]t is easy to see various reasons why the simple, attractive idea of treating management as experimentation has been so difficult to put into practice. Objections to large-scale experiments range from faith in our ability to purchase answers through process research and modeling, to concerns about ecological side effects and risks of experimental policies. These objections provide a rich set of excuses to delay decisive action by those who can profit from, or find protection in, such delays. ... The critical need today is not better ammunition for rational debate, but creative thinking about how to make management experimentation an irresistible opportunity, rather than a threat to various established interests. (Walters 1997, p. 1, Conclusions and Questions)

The discussion of ways to overcome barriers to adaptive management is beyond the scope of this present study. However, the existence of these barriers is important to keep in mind when

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<sup>90</sup> For more information on impact evaluation techniques, see the World Bank’s series of fourteen reports: “Doing Impact Evaluation” (2006–2009) (accessed July 31, 2011): <http://go.worldbank.org/OZLH1R1QV0>.

selecting criteria for evaluation of climate change adaptation. Resource managers have practical limitations on their ability to do experimentation and systematically evaluate it, even more in the case of the wicked problem of climate change. Criteria selected for evaluation must be realistic within this context.

### 3.5.2 Examples of Criteria for Evaluation of Climate Change Interventions

The following examples of criteria for evaluation of a climate change intervention are intended for discussion within a variety of resource management contexts and are not intended to represent the full range of possible good criteria for adaptation evaluation. The values of the implementing institution or individuals will dictate both the criteria and the weight given to different criteria (which might represent conflicting values, such as effectiveness versus cost) (Bardach 2005). See Appendix G for examples of criteria for climate change adaptation actions from a sampling of government adaptation policy documents, and Appendix I for suggestions of possible indicators for measuring the success of climate change adaptation actions.

In the following sets of criteria, the most universal are flexibility (robustness), cost-effectiveness (efficiency) and having co-benefits (benefitting goals beyond climate change preparedness). Before looking at more specific criteria for climate change interventions, first consider the following criteria for interventions in more “tame” problems. In a relatively straightforward policy intervention, some commonly used criteria for evaluation include the following (Bardach 2005):

- Efficiency/cost-effectiveness
- Equity (defined variously, including equitable allocations of risk and benefit across populations [Schlosberg 2007]; and/or equity across sectors, regions and societies [Hedger et al. 2008])
- Process values (e.g., transparency, accessibility, incorporating collaboration)
- Legality
- Political acceptability
- Robustness under conditions of administrative implementation
- Improvability

In a relatively straightforward *conservation* intervention, some recommended criteria for evaluation of conservation strategies and methods include the following (CMP 2007):

For strategies:

- Likelihood of success
- Cost
- Degree of linkage to critical factors (in the context of the conservation target)
- Specificity of focus

For methods (e.g., of data collection):

- Accuracy
- Reliability/ repeatability
- Cost-effectiveness

For both strategies and methods

- Feasibility
- Appropriateness (within site-specific cultural, social and biological norms)

A passage on criteria for *climate change adaptation in a general public planning context* from a consultant to the UK Office of the Deputy Prime Minister in “The Planning Response to Climate Change: Advice on Better Practice” reads:

The criteria should include constraints such as the need to conform to national planning policy guidance and environmental legislation and to avoid imposing unreasonable costs on developers. Adaptation to climate change may be only one objective of the policy. Other policy objectives will also provide criteria. It may be necessary to revisit the criteria after carrying out the preliminary risk assessment and options appraisal. (CAG 2004, p. 22)

Another set of criteria suggested for use in planning for climate change in a general public planning context in the Netherlands (de Bruin et al. 2009) include the following:

- The importance of the option in terms of the expected gross benefits (avoided damages)
- The urgency of the option, reflecting the need to act sooner than later
- The no-regret characteristics of the option (it is beneficial irrespective of climate change)
- The co-benefits to other sectors (producing benefits for both adaptation goals and goals unrelated to climate change)
- The effect on climate change mitigation (e.g., causing land use change that changes greenhouse gas emissions)

Another set of criteria was recommended by James Titus, a U.S. Environmental Protection Agency project manager for sea level rise, for use in climate change adaptation interventions in a public planning context (Titus 1990, p. 4):

- Economic Efficiency: Will the initiative yield benefits substantially greater than if the resources were applied elsewhere?
- Flexibility: Is the strategy reasonable for the entire range of possible changes in temperatures, precipitation, and sea level?
- Urgency: Would the strategy be successful if implementation were delayed ten or twenty years?
- Low Cost: Does the strategy require minimal resources?
- Equity: Does the strategy unfairly benefit some at the expense of other regions, generations, or economic classes?
- Institutional feasibility: Is the strategy acceptable to the public? Can it be implemented with existing institutions under existing laws?
- Unique or Critical Resources: Would the strategy decrease the risk of losing unique environmental or cultural resources?
- Health and Safety: Would the proposed strategy increase or decrease the risk of disease or injury?
- Consistency: Does the policy support other national state, community, or private goals?

- Private v. Public Sector: Does the strategy minimize governmental interference with decisions best made by the private sector?

Some criteria recommended for use in *climate change adaptation interventions that address both resource conservation and economic development* include the following (Hedger et al. 2008):

- Effectiveness
- Flexibility (considering climate change uncertainty and the evolving base of knowledge)
- Equity
- Efficiency
- Sustainability

As stated above, the appropriate criteria for any given adaptation intervention will depend on the values of the implementing institution or individuals. These represent only a sampling of criteria suggested by the literature from a range of sectors. The resource management sector can look to the public planning and sustainable development sectors for inspiration when modifying conservation intervention criteria for the purposes of climate change adaptation, just as it can look to the military, business, medical and disaster response sectors for decision-making tools.

For more information on ways to do cost-benefit analyses and other forms of economic evaluation of climate change adaptation interventions in the natural resource management context, see the World Bank's 2010 report *Mainstreaming Adaptation to Climate Change in Agriculture and Natural Resources Management Projects*, especially Guidance Note 7: Evaluate via economic analysis, and Guidance Note 8: Monitor and evaluate activities.<sup>91</sup>

For discussion and webinars regarding climate change adaptation evaluation, visit Climate-Eval,<sup>92</sup> a resource launched in 2010 by the Global Environment Facility<sup>93</sup> to exchange information on effective evaluation practices in the field of climate change and sustainable development.

### **3.6 Ecosystem-Based Adaptation**

Natural resource management under climate change draws resource managers into planning processes in other sectors, such as transportation and public works. These interactions with other sectors bring an opportunity to find ways to simultaneously reduce impacts on both

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<sup>91</sup> Read the 2010 World Bank report "Mainstreaming Adaptation to Climate Change in Agriculture and Natural Resources Management Projects" (accessed July 31, 2011):

<http://climatechange.worldbank.org/climatechange/content/mainstreaming-adaptation-climate-change-agriculture-and-natural-resources-management-project>.

<sup>92</sup> For more information on Climate-Eval (accessed February 15, 2012): <http://climate-eval.org/>.

<sup>93</sup> For more information on the GEF (accessed February 15, 2012): <http://www.thegef.org/gef/whatisgef>.

ecosystems and human communities. *Ecosystem-based* adaptation is an approach which seeks to do both.

The following quote from a July 29, 2011, article “Rough Waters for Sea Level Rise Planning” distills a central argument behind the ecosystem-based climate change adaptation approach:

“Wetlands are wonderful for dealing with climate change,” said [Will] Travis [Executive Director of the Bay Conservation and Development Commission]. “Wetlands soak up flood water. So the wider the wetland in the front, the lower the levee can be in the back.” (Sommer 2011, p. 1)

Ecosystem-based adaptation is the use of sustainable ecosystem management to support societal adaptation (CBD[1] 2009). In this case, a San Francisco resource management agency is promoting wetlands as a way to reduce the risk to society from climate change-driven floods. This ecosystem-based approach puts the value of healthy natural systems at the center of adaptation.

Ecosystem-based adaptation is contrasted with traditional “hard” engineered approaches that create surfaces resistant to change, such as a sea wall, which may be faster to implement, but more short-term in efficacy and expensive to maintain than ecosystem-based measures (ENCA-BfN 2010; PEDRR 2010). Compared with hard approaches, ecosystem-based approaches in some cases can be relatively more cost-effective and more affordable to communities (Ibid). However, in some cases, a portfolio of different approaches will be needed to sufficiently prepare for climate change impacts, including the use of technology, engineering, community capacity building, and behavioral change as along with sustainable ecosystem management (Ibid). An example of a hybrid approach, combining both ecosystem-based and hard approaches, might be when wetlands are used to reduce wave impact to protect levees from storm surges, increasing the effectiveness and lifespan of levees (PEDRR 2010).

There are trade-offs between the two approaches. Hard approaches to climate change adaptation may be infeasible because of high cost or technological requirements, while maintaining and restoring ecosystems as natural infrastructure may be more cost-effective, especially when taking into account the full range of benefits provided by ecosystems (PEDRR 2010). In other cases, natural buffers may be infeasible because of biological limitations, space constraints, or incompatibility with priority land uses, while hard infrastructure may be the only effective way to provide sufficient protection from climate impacts (Ibid). Resource managers weighing these two approaches should take into account some other drawbacks possible with traditional engineering approaches. In addition to high cost and technological requirements, hard approaches may generate new negative environmental impacts, provide a false sense of security, or fail in ways that greatly amplify natural disaster damage (Ibid).

Where possible, resource managers working in collaboration with planners from other sectors should seek to create adaptation plans that support sustainable ecosystem management, conservation, and restoration of key systems (such as wetlands) to help people adapt to climate change. Examples of current ecosystem-based adaptation projects include the following:

- Vietnam: An investment of \$1.1 million restoring nearly 12,000 hectares of mangroves in Vietnam is estimated to have saved \$7.3 million per year in dike maintenance, while providing protection to human communities and fisheries (UNEP 2010).
- Kiribati: In 2011 over 37,000 mangrove seedlings were planted on the islands of Aranuka, Butaritari, Maiana, and Makin and in North and South Tarawa, Kiribati, with the support of the World Bank, the Global Environment Facility (GEF), AusAID, and the New Zealand Aid Programme, to reduce Kiribati's vulnerability to sea level rise and other impacts (World Bank 2011).
- Mexico: In 2009–2010 the World Bank financed the first stages of a pilot project to restore wetlands and mangroves in the Gulf of Mexico to prepare for sea level rise (UNEP 2010; Fernández 2010).

## SECTION 4: Case Study: The Futures of Wild Marin

A central component of the present study was a one-day scenario planning<sup>94</sup> workshop, the Futures of Wild Marin, held in January 2011, to help bridge the gap between climate change science and resource management decisions and to field-test the scenario planning tool, a key adaptation planning tool emerging from our literature review. Scenario planning is recommended as a tool when decision makers have little control over major influencing factors and uncertainty is high (see Section 3.3.1.1. for more on its optimal use). Scenario planning is only one tool, and would be more useful in most planning circumstances when combined with other tools, such as mathematical and physical modeling (see Section 3.2.1.1 for more on the optimal uses of modeling).

In the context of this paper, the Futures of Wild Marin workshop provides a concrete example of the ways in which vulnerability assessment information can be combined with field knowledge and planning tools to identify and prioritize robust adaptation actions to manage natural resources under climate change. Our workshop was a one-time event held over the course of one day: this should be considered the absolute minimum amount of time needed to produce a useful scenario planning exercise. As discussed later, having more time and a process for reconvening participants to improve the scenarios would make the exercise more useful.

Also, as described in Section 3.4., there are many examples of different levels of engagement for resource management planning under climate change (as with any planning process), from one-time local pilot workshops such as Futures of Wild Marin to multi-year national efforts such as the U.S. Forest Service scorecard initiative. In between these are iterative training processes, from basic to intensive, from general environmental topics to resource or natural-object-specific, targeting a broad audience or a select team of decision makers. The format of the present one-day workshop is not expected to be the most useful format in all planning efforts across California; different geographic scales, with different planning horizons and conservation targets, will need to employ different formats for climate change planning.

Our workshop was held with 35 resource managers and scientists working in the protected areas of West Marin County. The intent of the workshop was two-fold:

- To test scenario planning as a tool for developing concrete action steps to help resource managers at a case study site prepare for multiple plausible scenarios of the future, and
- To evaluate the scenario planning tool to make recommendations for its use in other California resource management contexts.

We chose the scenario planning tool as the focus for our case study in part because of its new, systematic, widespread deployment for climate change planning by the National Park Service.<sup>95</sup> Before being adopted by the NPS, the scenario planning tool was primarily used to plan for the

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<sup>94</sup> See Section 3.3.1 for a description of the scenario planning tool.

<sup>95</sup> See Section 3.4.1 for a description of the National Park Service scenario planning workshops.

future under uncertainty in the military and business sectors. The NPS has been using scenario planning to plan for climate change since 2006 applying an approach that starts with examining available climate change projections and then incorporates other factors important to decision-making, both qualitative and quantitative. Our workshop was modeled on the NPS Climate Change Response Program<sup>96</sup> scenario planning workshops, and was facilitated by the same consultant used by the NPS from the Global Business Network.<sup>97</sup>

For more details on the Futures of Wild Marin workshop, see Appendices B through G:

- Appendix B: Futures of Wild Marin Workshop - Participants List
- Appendix C: Map of Case Study Area
- Appendix D: Selection of the Case Study Site
- Appendix E: Workshop Agenda
- Appendix F: Transcription of Workshop’s Scenario Descriptions
- Appendix G: Draft Statement of Agreement for Workshop Participants

What follows is a summary of how we selected the case study site and collaboratively planned and staged the workshop. Also following is a summary of the workshop activities themselves, their rationales, and the subsequent outcomes and short-term evaluation of its success. Figure 6 presents the main steps involved in the planning of the workshop.



**Figure 6: Summary of Workshop Planning Process**

<sup>96</sup> For more information on the NPS Climate Change Response Program (accessed February 15, 2012): <http://www.nps.gov/climatechange/>.

<sup>97</sup> For more information on the Global Business Network, see Footnote 55.

## 4.1 Case Study Site Selection

Before selecting a case study site, the authors assembled a list of potential sites in California and evaluated them against a set of criteria:

- High feasibility
- Good climate data
- Significance<sup>98</sup> to the state (i.e., familiarity to most Californians, iconic species, etc.)
- Interaction of human and natural systems (e.g., recreational site and lake)
- A mix of land use types (though not necessarily mixed land cover)
- A mix of land management jurisdictions
- Land located one-hundred percent within the state (this excluded Lake Tahoe)
- Land covering minimally one square mile (with no maximum size)
- Mainly terrestrial landscapes (this excluded marine protected areas)
- State Parks located within the site (this was included because the target audience for the research is at the state agency level, and also because the ecosystem section of the vulnerability assessment emphasized a focus on protected areas)

The criteria were not weighted in advance, but in the decision-making process feasibility and the presence of a mix of land management jurisdictions carried relatively more weight. Feasibility came to be more important as we evaluated our budget and staff restrictions, and the mix of jurisdictions became more important because we realized the importance of examining the possible pros and cons of an inter-agency approach.

After an evaluation of 13 sites suggested by the lead scientists of the ecosystem section of the State Vulnerability and Adaptation Study, we selected the protected areas of West Marin County as our case study site. We defined this site as including the following protected areas: the Bolinas Lagoon, the Marin Municipal Water District, Point Reyes National Seashore, Muir Woods National Monument, Mount Tamalpais State Park, and Samuel P. Taylor State Park. The site as thus defined was highly feasible, being in relatively close proximity to the workshop organizer, and including local, county, water district-level, state, and federal protected areas.

See Appendix D for an expanded description of the case study site criteria, the evaluation of our selected site along these criteria, and the list of candidate sites for this project. See Appendix C for a map of Marin County, California.

## 4.2 Workshop Participant Selection

After selecting our case study site, participants were identified utilizing personal and professional networks. Forty academic researchers, scientists and resource managers working on climate change planning in the case study site were consulted in depth by phone, in addition to briefer consultations with others via e-mail and through attendance at public education

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<sup>98</sup> “Significance” here was measured by the authors’ speculation on public perception, a subjective measure.

events and conferences. The general criteria for participant recruitment were that the person, at the time of recruitment, works or worked in the case study site, is involved in long-term planning within their agency or organization, consumes or produces climate change data for decision-making,<sup>99</sup> and is available in January 2011. If the person met these criteria strongly, s/he was recruited for the scenario planning team, which met in advance of the workshop. For this level of participation, there was an additional criterion: the person had to be available for three one-hour phone calls in November and December 2010, and in early January 2011, as well as the January workshop. See Appendix B for the final list of workshop participants, including name, title, organization, and role in the workshop.

Based on the advice of NPS scenario planning organizers, the size of the workshop was limited. We targeted a maximum size of 40 participants with a minimum of 30 resource managers, or 75 percent of attendees. Among invitees we had a goal of including at least one manager from each component protected area in the case study site was recruited, at least one representative from each level of management (sub-county, county, water district, state, federal), and at least one specialist with expertise in each major resource of concern (vegetation, marine/sea level rise, forest/fire, salmonids, fresh water supply, avian species), and at least one representative each from a non-government stakeholder group and a non-government conservation group. We loosely targeted having a minimum of 50 percent female participants, acknowledging the different ways men and women use public space for discussion (Baxter 2006).<sup>100</sup>

Forty-two representatives from 15 agencies and organizations were invited to the workshop. Of these, 35 representatives of 14 agencies and organizations attended.<sup>101</sup> We attained most of our

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<sup>99</sup> “Consumes or produces climate change data for decision making:” this criterion necessarily biased selection toward people who already had climate change on their agenda. This might not be realistic as a criterion in other resource management planning contexts around California, where a scenario planning exercise such as this might need to be preceded by an multi-institutional educational effort, perhaps requiring the involvement of climate change communication specialists. In some contexts, a planning exercise might be possible only after an educational program making the case for climate change as a real phenomenon requiring human response.

<sup>100</sup> Criteria regarding participants’ socio-economic status and ethnicity were not used in recruitment for this workshop: it was infeasible in this case, given the small size of the candidate pool and lack of any systemic way to screen for these characteristics. However, in any climate change planning process (or, any planning process) it is important to gauge the feasibility of incorporating diverse participation along these variables, and doing so when possible. Climate change impacts, as with any public problem, affect different sectors of society differently, so incorporating diverse perspectives on the problem will lead to more robust solutions.

<sup>101</sup> The following invitees were prevented from attending the workshop due to unforeseeable circumstances: Jay Chamberlin, Chief, Natural Resources Division, California State Parks; Rick Rayburn, Former Chief of Natural Resources, California State Parks; Tom Gardali, Assoc. Dir. Terrestrial Ecology Division, Point Reyes Bird Observatory; Jennifer Blackman, General Manager, Bolinas Community Public Utility District; Torri Estrada, Program Director, Environment, Marin Community Foundation; and Nancy Scolari, Executive Director, Marin Resource Conservation District.

goals for the composition of workshop attendees: all levels of management and key areas of expertise were represented and we attained our gender goal (at 60 percent female). However, only 60 percent of the participants were resource managers, falling short of the 75 percent goal.

The format of a one-day workshop was selected due to the limited resources available. The NPS workshop on which this was principally modeled<sup>102</sup> was held over three days, with the scenarios being developed by all participants together during the workshop itself. Our abbreviated format required the scenarios to be developed by a subset of ten participants in advance of the workshop to allow time for discussion at the workshop. This group was called the scenario development team. Again, see Appendix B for the participant list, which denotes the 10 members of the scenario development team. Organizations represented include the NPS Coast and Oceans Program, the Golden Gate National Recreation Area, California Early Detection Networks, California State Parks - Marin District, the Marin Municipal Water District, the Marin County Planning Department, the Pepperwood Preserve, and PRBO Conservation Science.

During three conference calls, the team devised the basic elements for the workshop. Before developing the scenarios, the team reviewed background documents on the scenario planning tool and the primary projected impacts according to available climate change science for the area of West Marin. Then, the team set goals for the workshop and for adaptation in general. Next, the team began the process of developing the scenarios for the workshop.

### **4.3 Scenario Development Process**

The scenarios were developed over three conference calls involving the ten members of the scenario development team.

#### **4.3.1 Preliminary Steps: Background on Scenario Planning and Local Climate Change Projections**

Prior to meeting via conference call, the scenario development team reviewed background documents on the scenario planning tool, including:

- 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.
- 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)*.
- 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.

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<sup>102</sup> The Futures of Wild Marin workshop was modeled principally on the NPS Joshua Tree National Park and Kaloko-Honokohau National Historical Park prototype scenario planning workshop held in 2007 (NPS 2007).

- 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.

The team also considered the main impacts projected for West Marin according to available climate change science documentation.<sup>103</sup> The main sources used as the bases for our presumptions about climate change in West Marin include:

- Flint, A. and L. Flint (2010). USGS climate projections (PRISM climate layers downscaled to 270 meters).
- Micheli, L., A. Flint, L. Flint, et al. (in prep. 2011), North Bay Watershed hydrological projections.
- Cornwell, W., et al. (in prep. 2011). Vegetation projections. UC Berkeley.
- Largier, L., 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.
- Johnstone, J., and T. Dawson (2010). Context and ecological implications of summer fog decline in the coast redwood region. *Proceedings of the National Academy of Sciences (PNAS)*, 107(10): 4533–4538.

#### 4.3.2 First Scenario Development Team Call: Goal and Planning Horizon Setting

The first call concerned participants’ different planning horizons and organizational goals, and the workshop’s planning horizon (how far into the future do we want look?), workshop goals (what do we want to get out of this exercise?), and provisional adaptation goals (what can we agree on for the purposes of this workshop as basic goals for climate change preparation?).

The planning horizons determined to be the most useful for participants’ planning processes were identified as 20, 50, and 100 years, with an iterative planning process assumed. Within the workshop, discussion concerned short-, mid-, and long-term planning, discussing near-term actions as those occurring between the present and 2031, mid-term by 2061, and long-term by 2111.

The workshop’s goal was defined as the use of scenarios to determine action steps for multiple plausible climate futures for different adaptation goals (to be useful to a range of different agencies), and, in the process to identify a common vision for what constitutes good adaptation; who is doing what (in terms of adaptation planning); resources available to support adaptation planning; what’s needed for a comprehensive regional adaptation plan; and ways to network as we go forward.

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<sup>103</sup> See Section 3.2.1.1 for more on the strengths and weaknesses of climate models as planning tools.

Regarding goals for adaptation, the scenario development team decided that climate change adaptation actions should (with wording carefully chosen by team participants):

- **Maintain key ecosystem functions** (to provide the benefits of nature to human populations)
- **Facilitate a gentler transition** under climate change, based on natural systems
- **Maintain bioregional native biodiversity**<sup>104</sup>

#### 4.3.3 Second Scenario Development Team Call: Brainstorming Drivers of Change

On the second call, the scenario development team identified the most important drivers of change in the resource management realm. Each driver was assigned a certainty, either relatively more certain or more uncertain (more probable or less probable).

First, we identified the following climate factors and climate-driven (environmental) factors as relatively high consequence and **relatively probable**, to be considered as part of any scenario of the future:

Relatively Probable Climate Factors:

- Temperature will rise.
- There will be more extreme heat events.
- Sea temperature will rise.

Relatively Probable Climate-Driven (Environmental) Factors:

- Sea level will rise.
- Salinity will rise in wetlands systems and other places where freshwater and ocean systems interact.
- Snowpack will decrease.
- Risk associated with fire intensity will go up.
- Pressure from biological invaders will go up.
- The fire season will be longer.
- Native species and invasive species will move to cooler climates, higher altitudes. Coastal redwoods and Douglas fir will retract.
- Groundwater supplies will decrease. Creeks will be drier.
- Soil will be drier.
- Waves will be bigger and more frequent with associated increased wave damage. Storm surges will be more frequent. Both will accelerate erosion and cause more frequent landslides.
- More erosion will cause introduction of more toxins from old dumps, mercury mines, non-point source runoff, etc.

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<sup>104</sup> These adaptation goals incorporate actions which could be called *resistance*, *resilience*, and *response* actions, both more and less novel approaches. The participants were willing to consider both traditional and unprecedented, experimental interventions.

- There will be more extreme weather events.
- Wind speed will be more variable, and more extreme.
- Ocean acidification will increase.

#### Other Relatively Probable Factors:

Non-climatic, non-environmental factors were also considered among the more certain drivers of change, including the following economic, political, social and technological factors:

- Budget restrictions will be as bad or worse in the future. (One participant said, “We will never have enough money to do the work that needs to be done.”)
- Social competition for freshwater resources will go up.
- Human populations will be facing more tensions (interactions between subpopulations aggravated by changing demographics, economics, etc.).
- The human response to sea level rise will not be adequate.
- Infrastructure will be undermined along the coast, particularly where coastal soils are highly erosive.
- There will be more loss of human lives due to extreme weather events, wave height, storm surges, etc.
- The movement of species will lead to loss of contact with species by visitors of protected areas (or, loss of customary contact with traditionally valued species).
- Tools for habitat restoration will improve.

After considering the certainties, we discussed the **relatively uncertain** factors. To identify the most uncertain, highest consequence factors, scenario development team members were asked to imagine what factors they would ask about if they were able to meet a local resource manager from the future, or, what resource management problems kept them up at night.

The factors determined to have the highest uncertainty and highest consequence for resource management included climate factors and climate-driven (environmental) factors:

#### Relatively Uncertain Climate Factors:

- Precipitation will change (timing and/or amount).
- The length of the dry season will change.
- The frequency of wet springs will change. (More wet springs fueling Sudden Oak Death.)
- High pressure systems will be more or less frequent (onshore and/or offshore).
- The fog regime will change.

#### Relatively Uncertain Climate-Driven (Environmental) Factors:

- Upwelling will change.
- The fire regime will change.

- The flood regime will change.
- As native species retract, other species will take advantage: which species will become dominant is unknown.
- Phenology will change (relationships and interactions between species will change).
- Natural systems will adapt passively to changes in ways we cannot predict.

Other Relatively Uncertain Factors:

Non-climatic, non-environmental factors were also considered among the more uncertain drivers of change, including the following economic, political, social, and technological factors:

- Political willingness to act (towards adaptation) may change.
- The political system may become better or worse at responding to long-range climate threats.
- Public support/ societal commitment for adaptation may change.
- Funding for adaptation may change.
- Human communities may change how they manage for biological invaders (better or worse).
- Human communities may change how they manage wildfires (better or worse).
- Human demographics will change.
- Communities will respond to climate change, but it is uncertain whether they will use sustainable and effective methods to adapt. (One participant asked, “Will we just build bigger sea walls?”)
- Emergency response plans will be developed, but it is uncertain how natural resource managers will be involved in those planning efforts.

#### 4.3.4 Third and Final Scenario Development Team Call: Selection of Highest Consequence Factors

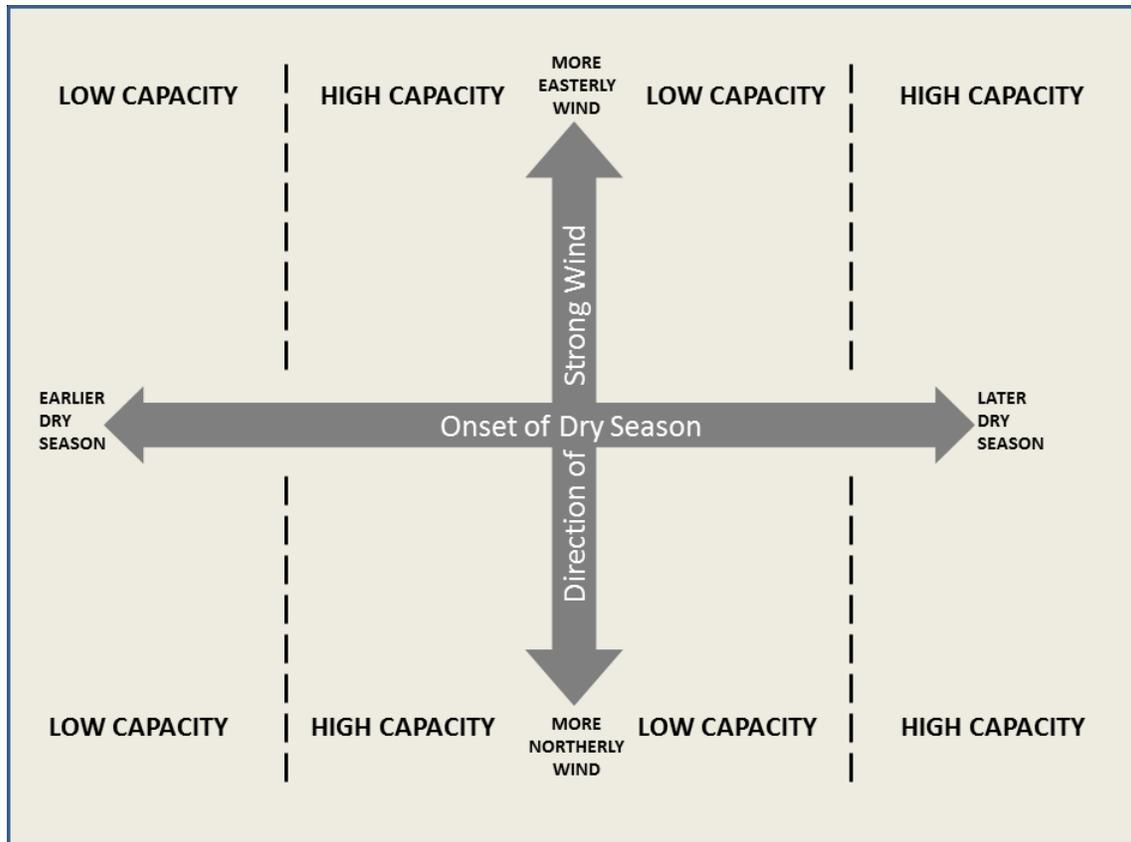
On the third call members of the scenario development team discussed the above factors and attempted to distill the top-most high consequence certain and uncertain factors to use to define our scenarios.

The group agreed on the following relative probabilities to include in all scenarios: sea level rising, temperature rising, biological diversity declining with biological invaders increasing, and seasonal extremes increasing.

The group decided on the following relative uncertainties to use to differentiate unique scenarios:

- Onset of the dry season (earlier or later)
- Direction of strong wind (more easterly or more northerly)
- Capacity to respond in a resource management realm (same/lesser or significantly greater)

The interaction of the three uncertain variables selected by the scenario development team resulted in eight scenarios to discuss at the one-day workshop (see Figure 7).

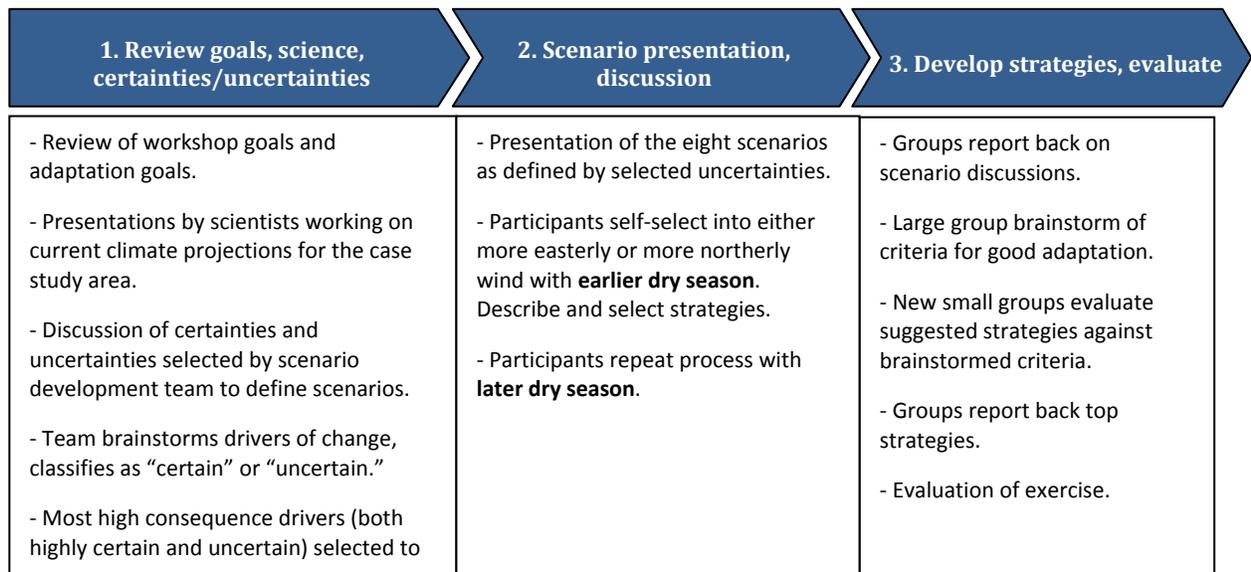


**Figure 7: Futures of Wild Marin: Eight Scenarios**

In Figure 7 the axes divide “future space” into quadrants, each characterized by the climate changing with regards to the dry season onset and the direction of strong wind: either earlier or later dry season and more easterly or more northerly winds. Then each quadrant is split into low-capacity-to-respond and high-capacity-to-respond futures (wherein institutional capacity to respond in a resource management context is either the same or less, or significantly greater). Each eighth of the future space defines one of the eight possible future scenarios under consideration, e.g., the bottom-right/right scenario is a future where, in addition to relatively certain trends such as increasing temperatures and sea level and decreasing biodiversity, winds are more northerly, the onset of the dry season is later, and the institutional capacity to respond to these changes is significantly greater. Eight scenarios were discussed at the workshop.

## 4.4 Resource Manager Workshop Structure and Results

The workshop was structured such that the first part of the day included a presentation of workshop goals, adaptation goals, the scenario planning tool, the factors selected to define the scenarios, and two presentations about current ongoing studies of climate change impacts for Marin. Figure 8 briefly describes the structure of the day. See Appendix E for the full workshop agenda.



**Figure 8: Workshop Structure**

### 4.4.1 Scenario Discussions: Dry Season Onset (Earlier or Later) plus Wind Direction (Easterly or Northerly)

For the first set of scenario discussions, participants self-selected into two groups to discuss the scenarios involving the earlier onset of the dry season: one group talked about an early dry season with stronger easterly winds, and the other early dry season with stronger northerly winds. After discussing the interaction of the two climatic factors, each group split again into two smaller groups to discuss each of the two climatic scenarios in the context of the same or less capacity to act, and significantly greater capacity to act. The goal of this step was for each group to describe short-, mid-, and long-term characteristics of each climate future, and then divide by different capacities; each sub-group was to name each scenario, giving it a narrative, describing headlines and major events and management responses of the short-, mid-, and long-term in that future.

In the second half of the day, participants repeated the process, first describing short-, mid-, and long-term characteristics of each climate future for the scenarios with a later dry season in the context of stronger easterly or northerly winds. Again, the groups broke into smaller groups to discuss each climatic future in the context of the different capacities to act. In each scenario discussion group, the scenarios were again given memorable names, then described in terms of

headlines and major events, and then in terms of short-, mid-, and long-term management response actions. These are summarized in Figure 9. See Appendix F for the full transcription of descriptions of the four climatic scenarios, and brainstormed headlines/events and management response actions for each of the eight scenarios.

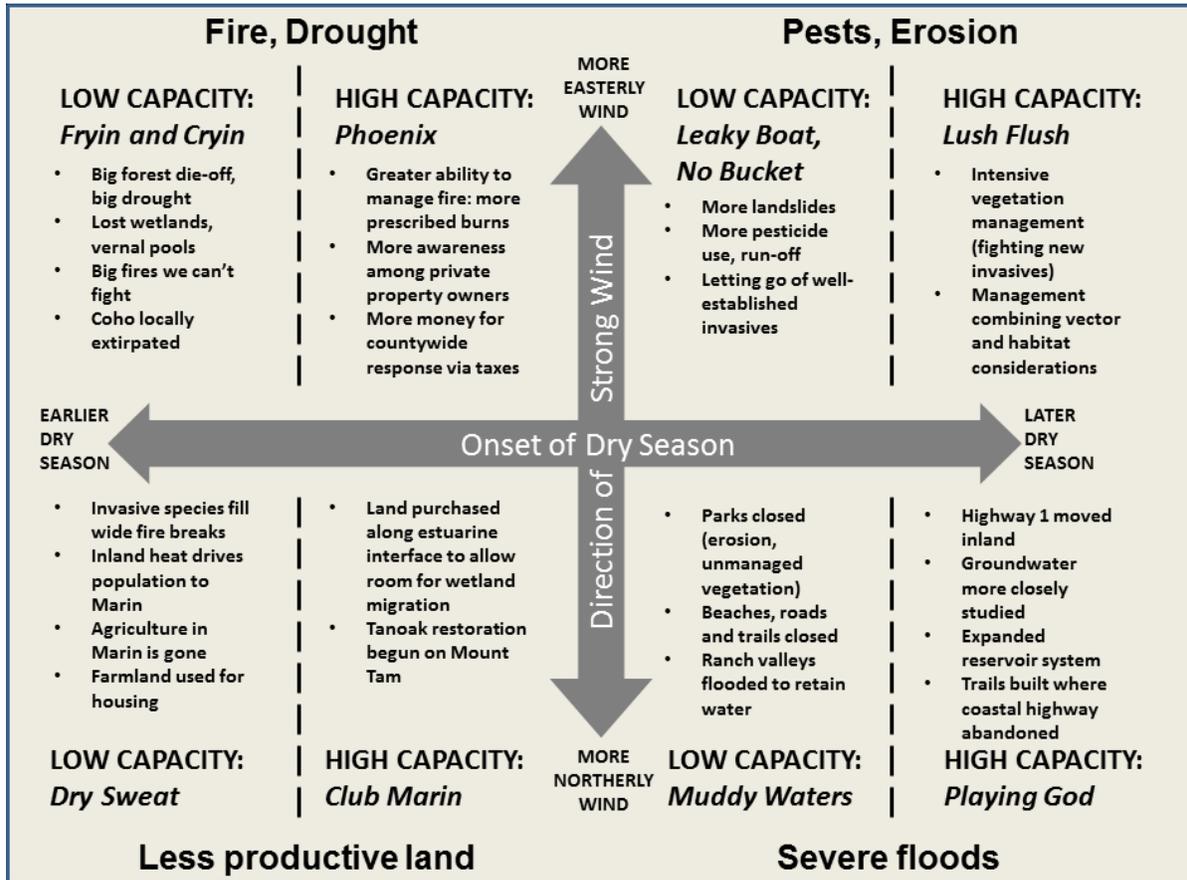


Figure 9: Futures of Wild Marin: Eight Scenarios with Titles and Descriptions

#### 4.4.2 Developing and Evaluating Strategies

The format for discussing the climatic scenarios mirrored the NPS scenario planning workshop format (see Section 3.4.1 for more on the NPS scenario workshops). We described and discussed each scenario, brainstorming responses, and then reported back three management responses for each of eight scenarios to the large group. However, the next step was an innovation, departing from the NPS model: a discussion and selection of **criteria** for prioritizing climate change adaptation actions.

The workshop packets contained a set of sample criteria from 13 recent government policy documents on climate change adaptation from around the North Pacific (see Appendix H).

Considering this sampling of criteria and the particular context of adaptation in West Marin's protected areas, participants brainstormed criteria for prioritization of actions.

The initial brainstorm produced the following criteria for vetting and prioritizing adaptation actions. An adaptation action should:

- Be robust to a variety of future climate states;
- Be sustainable in terms of resources (can be kept going);
- Address multiple management goals;
- Be designed at the scale of the problem (spatial and temporal scales);
- Be collaborative, not duplicating efforts;
- Be transparent in process;
- Demonstrate results towards resource management goals, producing measurable results that inform planning;
- Integrate across silos towards an effective outcome;
- Be able to be piloted (it will not be scaled up before testing);
- Implement full adaptive management cycle (identify stressors, identify solutions, evaluate results, modify according to the evaluation);
- Be flexible;
- Be based on the best science;
- Be cost-effective;
- Have a clear design for the purposes of garnering support.

We summarized these in 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.**<sup>105</sup>

Next, workshop participants met in new small groups (composed by counting off by fives) to discuss the action steps proposed for the eight scenarios in the context of our criteria for prioritization. Some groups effectively put aside the criteria and continued to work on developing concrete ideas for adaptation actions, while others systematically evaluated their top priority actions along the criteria. This activity was followed by a large group discussion of the top actions recommended by each small discussion group, and then summarized into 10 main action steps.

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<sup>105</sup> See Section 3.5.2 *Examples of Criteria for Evaluation of Climate Change Interventions* to compare the criteria selected here with the criteria suggested by the literature on the subject of policy/ intervention evaluation. The criteria of using adaptive management and having clarity of design are not mentioned in the selected examples, while flexibility, cost-effectiveness, and having a collaborative approach are mentioned. Noticeably absent from the selected criteria here is *feasibility* (see Section 1.2 for a brief discussion of the context for this absence).

#### 4.4.3 Selection of Top Strategies and Next Steps

The following adaptation actions steps were identified as meeting the criteria for prioritization and being appropriate for all eight scenarios discussed in this workshop:

1. Regional collaborative climate change adaptation planning efforts.
2. Collaborative fire and water management efforts.
3. Early detection and rapid response to biological invaders.
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<sup>106</sup> 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.
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<sup>107</sup> 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.

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<sup>106</sup> See Section 3.3.4 on the “Prepare for Surprises” approach to climate change decision making.

<sup>107</sup> See Section 3.3.2 on the triage approach to climate change decision making.

After agreeing on the above priority adaptation actions, participants engaged in an evaluation of the day and a discussion of next steps.

Two concrete next steps were agreed upon by workshop participants: (1) preparing an informal statement of agreement for participants to sign on to as a way of supporting future coordination around adaptation actions, and (2) working on a Marin County vulnerability analysis.

See Appendix G for the draft Statement of Agreement between workshop participants (current as of April 2011). This document is temporarily (as of August 2011) under the stewardship of Janet Klein, the Vegetation Ecologist of the Marin Municipal Water District.

## **4.5 Post-Workshop Analysis of Results**

### **4.5.1 On-Site Initial Evaluation**

The initial evaluation discussion at the end of the one-day workshop was intended to get first impressions of how the workshop was useful, how it might be made more useful, or how it might be useful in other contexts.

In both the initial evaluation and subsequent evaluation, participants generally agreed that the scenario planning tool was useful, but would be more useful if scenarios were built on factors that were validated by climate scientists and given more time for deeper discussion.

Scenario planning for climate change, as modeled by the NPS, is *idea-driven* and *science-informed*: the general tenor of feedback at the workshop was that the scenarios needed to be more science-informed, in particular more informed by specific information about how projected changes or uncertainties might impact conservation targets.

However, conditions discussed in the present workshop (severe fire, severe flood, the challenges to maintaining a healthy agricultural sector and threats to public safety, including pests and erosion, etc.) were sufficiently relevant to both immediate and future management concerns to make the scenarios useful. Also, it was noted that simply getting representatives of the 14 agencies present at the workshop to spend a day discussing climate change planning made the workshop a success.

Subsequent evaluation resulted in more thorough feedback on the strengths and weaknesses of this workshop and the scenario planning tool.

### **4.5.2 Off-Site Subsequent Evaluation**

After the workshop, the scenario development team held a final conference call to discuss the workshop results, and a sampling of participants was contacted for more in-depth feedback via phone. A total of 18 of 35 participants (just over 50 percent of the workshop participants), representing a range of jurisdictions and expertise areas, gave input on the following questions:

1. Did the workshop meet your expectations? Did you find the scenarios helpful?
2. Were there any surprises or “aha” moments?
3. What would you do differently next time or in another context?

4. What were the pros and cons of having an inter-agency approach? Would it have been better to only have representatives from one agency? Was the presence of non-governmental organization representatives helpful?
5. Where would you like to see this kind of workshop done next?

#### *4.5.2.1 Were Expectations Met? Were the Scenarios Helpful?*

All those consulted said that the workshop met or exceeded her/his expectations. Comments included that the workshop was “fascinating,” and one participant said she was “pleasantly surprised” by how productive it was. One said it was “a good first cut.”

All found the scenarios helpful, if only as a structure within which to have more general conversations about climate change planning. Even if some participants found the workshop’s scenarios questionable (in terms of plausibility/probability), the exercise required them to go through the helpful process of thinking about what climate scenarios *would* be most useful for their planning. One participant said it was useful how scenarios “take you out of the everyday.” Another said it was useful to make climate change less abstract, to picture what it would be like and “paint it onto our landscape.”

Those who work with climate modeling were noting the benefit of using scenarios as a way to offset the risk of only using climate models for planning: models do not necessarily capture biologically important factors (e.g., the new “coldest night” instead of average or most frequent coldest night), interactions or secondary impacts.<sup>108</sup> Participants with climate science backgrounds were worried to observe that some non-scientists were relying on climate model outputs as facts rather than speculations: “we can’t predict how things will unravel,” “...we need to be prepared for the unexpected.”

#### *4.5.2.2 Were There Surprises?*

The following represents a selection of comments by workshop participants regarding things that surprised them at the workshop. All surprises reported were either positive or neutral.

- It was surprising to realize the importance of building scenarios on multidirectional variables (e.g., a wetter versus drier springtime) instead of unidirectional variables with thresholds delineated (e.g., one meter of sea level rise versus three meters of sea level rise). Thresholds are different for different resources or landscapes. Also, they are mentally hard to grasp. It is hard to visualize “big change” versus “really big change,” so the differences between thresholds become functionally irrelevant.
- The workshop had an impressive amount of engagement overall and good attendance, and participants had an impressive ability to focus (including on the scoring of actions by criteria at the end of the day).
- One participant reported an “epiphany” when discussion turned to the idea that a lot of current practices are preparing us for the coming crisis: we could do better, but a lot of

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<sup>108</sup> See Section 3.2.1.1 on climate models, including their strengths and weaknesses as planning tools.

good practices are in place. Changes may be acute, but they have also been in process for a while, so agencies are already engaged with climate change (regardless of how it is currently framed in agency work plans).

- The workshop convened a mix of people who otherwise may never have a chance to sit together and discuss natural resource management plans.

#### 4.5.2.3 Things to Do Differently

The following represents a selection of comments by workshop participants regarding things that they would like to see done differently if the workshop were repeated.

- Participants could have used **more time with the scenarios**: they mostly just had time to identify problems without sufficient time to develop responses. At least two days are necessary to have a meaningful discussion of both the individual variables (certain and uncertain) and the resulting scenarios. Some participants' lack of buy-in to the scenarios was related to not having enough time to think about them. Time constraints also fed a tendency by those with less climate change expertise to let those with more expertise dominate discussion.
- The range of organizational missions and management goals at this workshop made the time shortage even more difficult: **a multi-stakeholder workshop should be given more time than a single-organization workshop.**
- **There should be a one to two-hour "Adaptation 101" webinar prior to the workshop** to bring participants up to speed on basic information about climate change and current management responses.
- One participant critiqued, "uncertainties soaked up most of the energy." There was an appetite in the room for discussing climatic *certainties* more: these variables provide a rich new base case ("the new normal," with new averages) that begs discussion. **After discussing the certainties, then factor in each climatic uncertainty (non-average or extreme conditions) one at a time, and then layer it all together.**
- Those who helped select the defining variables were invested in them; those who did not help select them did not fully buy into them. It is important to somehow **incorporate all workshop participants in the selection of the variables which define your scenarios.**
- The climatic uncertainties defining the scenarios were "mushy": especially the variable concerning the direction of strong wind was complex with non-intuitive axes endpoints.<sup>109</sup> **Define scenarios by factors with two directions of change that are easy to grasp for all participants.**

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<sup>109</sup> The variable concerning the direction of strong wind was sufficiently difficult to grasp that some discussion groups discarded it in favor of increased El Niño and La Niña conditions for "more northerly strong wind" and "more easterly strong wind," respectively. In both cases the relationship of these

- **There should be a “climate science team” that has an opportunity to respond to the factors (certain and uncertain) designated as high consequence by resource managers,** providing a brief evaluation of how consequential the factors might be (e.g., projected timing and severity of impacts). This should take place before the scenarios are developed on the basis of those factors. Scenarios are not intended to be the most probable futures, only plausible futures-of-concern, but maximizing the science informing the scenarios could maximize their probability and therefore usefulness.
- **After the interdisciplinary brainstorming of management responses by scenario, participants should separate into expertise/impact groups** (e.g., fire, flood, heat, etc.) to develop specific management responses based on the brainstormed actions.<sup>110</sup>
- **In the evaluation of actions by criteria, have accurate summaries of the actions on a scorecard,** or some other instrument to facilitate the evaluation.

#### 4.5.2.4 *The Value of an Inter-Agency Approach*

The following represents a selection of comments by workshop participants in response to being asked the pros and cons of the workshop’s inter-agency approach to climate change planning. All comments reflect the sentiment that such an approach is not only positive but *necessary*.

- One participant stated that it is impossible to separate out one agency when talking about climate change planning: “we are inextricably linked in our work now” (e.g., including non-governmental and governmental organizations).
- The presence of academic scientists in the workshop was helpful to provide the climate change research frame, but it’s important to keep discussion focused on the actual decisions of field practitioners.
- Those working outside the “government mode,” especially non-governmental organization representatives, found it useful to learn more about the importance of institutional constraints in government decision-making.
- Those coming from the government perspective observed that non-governmental organization representatives have more flexibility in what they can say. Also, it was observed that although they might “over-interpret” science (given their advocacy

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conditions to changes in marine upwelling was poorly understood by most participants, given its complexity and specificity as a marine phenomenon and the fact that most participants were focused on terrestrial systems. It was suggested that managers would find it helpful to see a white paper explaining how climate change appears to be affecting upwelling and what that might mean for terrestrial resource managers.

<sup>110</sup> See Section 3.4.6 on the Geos Institute’s approach to climate change planning, which involves strategizing in expertise-specific groups, but in a different order in the process from how it is suggested here. The Geos Institute process starts with expertise-specific groups identifying strategies which are then developed by interdisciplinary groups.

stances) it is very important to include their perspective. It is “super-important” to maintain connections with non-governmental organizations. “We are a community.”

- The correct scale of response for climate change goes beyond the jurisdiction of any one agency: consideration of large-scale systems and utilization of multi-institutional approaches are necessary.

#### *4.5.2.5 Where Else Should the Workshop Be Held? What Should Happen Next?*

The following represents a selection of responses by workshop participants regarding where they would like to see a scenario planning workshop held next, or other next steps they would recommend.

- Continue to build on this work in Marin County by incorporating agricultural/private land owner groups more, and also agency heads and policy makers (to help generate political will); developing the statement of agreement to help keep adaptation actions on the agenda; developing better climate change data for the area, including downscaled impact maps identifying most vulnerable sites; and mainstreaming climate change planning into all sectors and all projects.
- Look at the role of resource managers in disaster response and see where coordination is possible.
- Take the scenario planning tool to places where different resource management actors are in contention over climate impacts and responses, such as in the San Joaquin River Valley. That example was cited as a good place to use scenarios because river restoration and salmon conservation organizers are planning for only one future avenue of action, putting “all their money on one horse.” Several participants mentioned the usefulness of taking this workshop inland to more rural places where there is higher skepticism about climate change impacts as a way to get people to face the reality of climate change and the difficult trade-offs it requires.

Participants generally agreed that the scenario planning tool was useful, but that it would be more useful if scenarios were built on factors that were validated by climate scientists and given more time for deeper discussion.

It is hard to qualitatively compare this workshop with other climate change planning workshops to determine the relative usefulness of the scenario planning tool, partly because of the scarcity of those workshops and their widely varying units of analysis (e.g., “oceans,” “California coast,” or “Fresno County”). Indicators of success are also unclear: is a successful workshop one that produces a concrete adaptation action plan, or one that results in adaptation actions being taken on the ground (regardless of planning documents)? Or is it the one with the most practical networking opportunities (often mentioned as one of the workshop’s most useful aspects)?

An instance of the workshop changing resource management planning in the present was mentioned by one participating resource manager. She indicated that walking through the different climate scenarios with professional peers was useful for envisioning the potential

future landscape and specifically useful for helping reevaluate the location of a red-legged frog pond restoration project. The project was planned to be sited near a wetland. After the workshop, she changed the plans, having realized the wetlands were going to migrate with sea level rise and inundate the planned frog pond. This workshop participant might have made that change to her plans based only on looking at sea level rise maps, but it is possible that the interactive discussion of multiple climate futures, with sea level rise taken as a constant in all futures, helped her realize the relative certainty of that impact and saved her the cost of a restoration project that may not be sustainable over the long term.

#### 4.5.3 Questions Going Forward

In addition to feedback on the Futures of Wild Marin workshop, consultations with participants yielded a set of general questions and concerns about climate change planning for natural resource managers in the future:

- How do resource managers prepare themselves for **collaboration around disaster**?<sup>111</sup>
- At what point does a land manager tell the Department of Fish and Game and Department of Fish and Wildlife that restoring landscapes by planting “**in kind and in place**” is **no longer appropriate**?
- **How can we prevent natural resource agencies from making conflicting trade-offs?** We need an analysis of where contradictions/conflicts in agency management goals occur and how to overcome them.
- **What are the management tools that both enable and constrain action on climate change adaptation?** We need an analysis of how the Endangered Species Act and the California Environmental Quality Act can help and hinder adaptation action.<sup>112</sup>
  - What will happen to management strategies that are built around the leverage provided by the ESA after the endangered species is locally extirpated?
- **What is the best way to export lessons from this workshop to state agencies working on larger scales?** At what other geographic scales of analysis would this kind of workshop be useful?

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<sup>111</sup> A note on “collaboration:” Going forward, while promoting the idea of inter-agency collaboration, it’s important to note that there is no standard definition of the term. Inviting people to attend a meeting is one kind of collaboration, but it may not be the most productive, depending on the goal. There is a body of literature on cross-sectoral and multi-stakeholder planning processes which can be consulted for help deciding the best kind of collaboration for a given institutional context. Some titles to consider include “Conceptual issues in inter-agency collaboration,” by Ranade and Hudson (2003); or “Environmental decision making in multi-stakeholder contexts” by Thabrew, Wiek, and Ries (2008); or the “Pulling Together” tool for facilitating interagency collaboration, available at the website of the National Association of County and City Health Officials (accessed February 14, 2012): <http://www.naccho.org/topics/environmental/pullingtogether/default.cfm>.

<sup>112</sup> See Section 1.2.4.1 on the need to use traditional conservation tools differently under climate change, including suggestions regarding use of the ESA and CEQA.

- A level of analysis larger than the county level would be unwieldy for the scenario planning tool. The larger the scale, the more it becomes a public education exercise and the less it can produce concrete action steps.
- What is too small a geographic scale for scenarios to be useful? It was speculated that it would be interesting to experiment with very small-scale analyses (e.g., a part of a creek) to see if there is a minimum scale for scenario planning to be useful.
- **What sources of funding can be identified to support similar scenario planning workshops?**
  - This workshop required three months of planning by one full-time employee, and \$10,000 in venue rental, supplies, and facilitation costs. Is this affordable for agencies and institutions that are most in need of this kind of planning tool?

Some concluding observations from workshop participants:

- The **vulnerability assessment** that stems from this workshop could be the first one that is guided and structured by the strategies that are intuitive for resource managers. It could be more useful than those structured by scientists guided by their own research questions.
- The **statement of agreement** that stems from this workshop could be a template for building inter-agency bridges at the state level, not just within the California Natural Resources Agency, but across departments, such as with CalTrans, Public Health, Planning, etc.
- It would be helpful to **build another set of scenarios after more climate data from scientists is available** so we are better able to isolate the highest consequence, most uncertain variables.

## SECTION 5: Recommendations

The goal of this study was to present information on tools available to natural resource managers for decision-making for climate change adaptation. This information is based on a literature review and a case study involving a climate change scenario planning exercise. Our hope is that this research will help resource managers utilize climate change impact and vulnerability information to create concrete action plans to reduce climate threats to their conservation and management targets. Scenario planning and other tools and analytical approaches presented in this paper can help resource managers combine their field knowledge with climate change impact and vulnerability information to plan effectively for climate change.

The following are the main recommendations of this paper with regard to the **design** of climate change adaptation actions in a resource management context:

- Adaptation actions should be designed within a framework of **accepted best practices for resource conservation and management**, including ecosystem-based adaptation options where possible, to avoid decisions that are maladaptive or otherwise harmful. Traditional conservation practices in many cases may be sufficient to prepare appropriately for climate change. However, traditional tools should be reevaluated, and in some cases used differently under climate change, and available climate science projections should be incorporated when possible, keeping in mind its limitations.
- Adaptation actions should be **robust to a range of alternative futures**, given the uncertainty about the complex systems involved in climate science, climate change impacts (both primary and secondary), threshold effects, and interaction effects with demographics, economic conditions, land use practices, political and cultural attitudes toward climate change, and other critical non-climate factors.
- Adaptation actions should **follow the practices of adaptive management**, involving the setting of criteria for good adaptation, and the monitoring of decision-critical indicators which informs the ongoing evaluation and improvement of actions. Where possible, pilot projects should precede large-scale deployment of adaptation actions. Actions should be designed to do no harm, be flexible (maintaining the ability to reverse mistakes), and address the areas of greatest need, effectively minimizing negative climate impacts on biodiversity and natural resources.

This study has examined the potential usefulness of the scenario planning tool in the resource management context. Based on that research, this paper recommends the following regarding **robust climate change planning** under uncertainty in the resource management or any sector:

- Climate change planning should involve: (1) a **vulnerability assessment** supported by impact information from an ensemble of **climate change model outputs**; (2) **scenario planning**, informed by the climate model outputs but **driven by ideas** that allow for planning outside the climate trends to include extremes, interactions, and secondary impacts; and (3) **an iterative process** of planning, testing, and improving theories of change (and revising the scenarios accordingly before using them to test policies). This

iterative process should be informed by the monitoring of key indicators, according to the principles of adaptive management.

The main recommendations of this paper for the employment of **scenario planning exercises** for climate change planning in the resource management sector are the following:

- The exercise should **incorporate scientific input on the critical variables defining the scenarios** (e.g., provide an opportunity for climate scientists to review and comment on the variables chosen by resource managers).
- Exercise participants should be given an initial, basic presentation on local climate impacts and existing resource management responses to climate change—an **“Adaptation 101”**—either in advance of the workshop or at its beginning, describing the climate models used and their projections and any available vulnerability information.
- The exercise should be **longer than one day**, at minimum two days, to allow time for sufficient discussion of the critical variables, their interactions, and the resulting scenarios.
- The exercise should involve **a range of representatives** from agencies and organizations appropriate to the scale of local resource management, avoiding a single-agency approach to climate change planning.
- **All exercise participants** should be given an opportunity to collaborate in **selecting the decision-critical factors** defining the scenarios.
- Scenarios ideally should be defined using variables which are **bi-directional** (e.g., “more rain or less rain,” as opposed to “a little more rain and a lot more rain,” where the critical threshold will vary depending on the target), and, when graphed, have **axes endpoints with clear meaning** to all participants regardless of area of expertise (“wetter/drier,” as opposed to something more arcane, like “more upwelling/less upwelling”).
- After an interdisciplinary brainstorm of strategies that are robust to multiple scenarios, participants should have an opportunity to discuss the top adaptation strategies in **expertise/climate impact-specific groups** (e.g., vegetation/fire, coasts/erosion) to develop specific parameters for action.
- After the development of specific parameters for action by the expertise/impact-specific groups, participants should **define criteria** for prioritizing action, and **evaluate the top adaptation strategies** by those criteria, utilizing an evaluation instrument with clear descriptions of the proposed strategies (e.g., a prepared scorecard).

In addition to the above recommendations regarding climate change adaptation planning, we offer final recommendations on **climate change planning in the context of California’s perennial state budget crisis**:

- California’s resource managers should maximize the potential for climate change preparedness in a time of fiscal scarcity by seeking and promoting **low-cost**

**opportunities for inter-agency collaboration** to enable climate change planning to proceed despite the lack of institutional capacity.

- Resource managers should use the opportunities created by cross-sectoral climate change planning to **promote the understanding and utilization of efficient, effective and cost-effective ecosystem-based adaptation solutions as alternatives to “hard” engineered solutions** that may be appealing to planners for their short-term benefits, but costlier in the long run.

The challenge of planning for climate change impacts is similar to current and past challenges of planning under great uncertainty. Resource managers already have many of the tools they need to prepare appropriately for climate change. However, action is often delayed due to climate science uncertainties, lack of political will, or lack of capacity; meanwhile, the cost of inaction grows. Hopefully this paper can help bridge the gap between science and management to facilitate timely and effective action to protect California’s natural resources from the impacts of climate change.

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# Glossary

ACT Framework	Adaptation for Conservation Targets Framework
ADAPT	Adaptation Database and Planning Tool
AMAT	Assisted Migration Adaptation Trial
BAEDN	Bay Area Early Detection Network
BC	British Columbia
CBT	Columbia Basin Trust
CCVA	California Climate Vulnerability Assessment
CEQA	California Environmental Quality Act
CSU	Climate Solutions University
DWR	Department of Water Resources
ESA	Endangered Species Act
FWS	U.S. Fish and Wildlife Service
GCM	global climate model
ICLEI	ICLEI – Local Governments for Sustainability
ICS	Incident Command System
IPCC	Intergovernmental Panel on Climate Change
IRWM	Integrated Regional Water Management
LGC	Local Government Commission
MFPP	Model Forest Policy Program
MOU	Memorandum of Understanding
MST	Mountain Areas Safety Taskforce
MMWD	Marin Municipal Water District
NEPA	National Environmental Policy Act
NPS	National Park Service
N-SEA	Nooksack Salmon Enhancement Association
OPEC	Organization of Petroleum Exporting Countries
PIER	Public Interest Energy Research

SB	Senate Bill
SNA	Sierra Nevada Alliance
SPAWN	Salmon Protection and Watershed Network
SSCC	Southern Sierra Conservation Cooperative
SWCCI	Southwest Climate Change Initiative
UC	University of California
USFS	U.S. Forest Service
USACE	U.S. Army Corps of Engineers
WWCI	Westwide Climate Initiative

# APPENDIX A: Definition of Terms

This appendix gives the definitions of terms important to this paper. Multiple definitions, where provided, are intended to illustrate the diversity of ways the terminology of climate change adaptation is used in the literature, and give a foundation for understanding its use in this paper.

## Adaptation

Adaptation (1): Adjustments in individual, group, and institutional behavior in order to reduce society's vulnerabilities to climate. (Pielke 1998, p. 159)

Adaptation (2): Actions to realize gains from opportunities or to reduce the damages that result from climate change (Agrawala and Fankhauser 2008, p. 11).

Adaptation (3): 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.**

Note: Adaptation planners need to differentiate between *proactive, anticipatory, planned* adaptation (adaptation done in advance using policy decisions), and *autonomous* adaptation (adaptation that takes place regardless of any intention to adapt). These are defined by the IPCC:

Anticipatory adaptation: Adaptation that takes place before impacts of climate change are observed. Also referred to as *proactive adaptation*. Similar term: *Planned adaptation*: Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state. (IPCC Fourth Assessment Report 2007)

Autonomous adaptation: Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. Also referred to as *spontaneous* adaptation. (IPCC Fourth Assessment Report 2007)

Adaptation Assessment: The practice of identifying options to adapt to climate change and evaluating them in terms of criteria such as availability, benefits. (IPCC Fourth Assessment Report 2007)

Adaptation Strategy: A plan to prepare for climate change impacts. It may include guiding principles, goals and action steps designed to facilitate adaptation.

See under Ecosystem for Ecosystem Adaptation and Ecosystem-Based Adaptation.

### **Adaptive Capacity**

**Adaptive Capacity:** The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. (IPCC Fourth Assessment Report 2007, from Glossary of Terms)

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

### **Climate Change**

**Climate Change:** Any change in climate over time, whether due to natural variability or as a result of human activity. (IPCC Fourth Assessment Report 2007)

**Climate Change Scenario:** A plausible, coherent and internally-consistent description of the change in climate by a certain time in the future using assumptions about factors that influence climate. (Waser 2009a; NPS 2007; Schwartz 1991)

**Climate Projection:** The calculated response of the climate system to emissions or concentration scenarios of greenhouse gases and aerosols, or radiative forcing scenarios, often based on simulations by climate models. Climate projections are distinguished from climate *predictions*, in that the former critically depend on the emissions/ concentration/ radiative forcing scenario used, and therefore on highly uncertain assumptions of future socio-economic and technological development. (Italics added by author, IPCC Fourth Assessment Report 2007, from Glossary of Terms)

**Climate-Vulnerable:** Describes the state of having particularly acute vulnerability to present and forecasted climatic changes (Burkett 2009). The Intergovernmental Panel on Climate Change ('IPCC') defines vulnerability as "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes" (IPCC, 'Summary for Policymakers' in Working Group II, IPCC, Climate Change 2007: Impacts, Adaptation and Vulnerability, IPCC Fourth Assessment Report, 2007). Here, the 'climate vulnerable' describes those communities or nation-states that have a particularly acute vulnerability to present and forecasted climatic changes. Antonym: *Climate-Resilient*.

### **Ecosystem**

**Ecosystem:** "A system of interacting living organisms together with their physical environment." (U.S. Climate Change Science Program 2008)

**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[1] 2009, p. 10).

*Ecosystem Adaptation and Ecosystem-Based Adaptation* compared: Ecosystem adaptation specifically addresses the adaptation of natural systems; ecosystem-based adaptation may address any aspect of adaptation (poverty, migration, access to clean water, heat events).

Ecosystem Services: The conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life. (U.S. Climate Change Science Program 2008)

**Impact Assessment:** A systematic evaluation of predicted or observed changes caused by an event or process.

**Maladaptation:** (Also: maladaptive practices) Actions or processes that increase vulnerability to climate change. (UNDP 2010)

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

### **Resilience**

Resilience: The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change. (IPCC Fourth Assessment Report 2007)

Note on the use of the term “resilience” in adaptation planning: A human or natural system or community may be resilient, but its *essential function* or *basic structure and ways of functioning* may need to change in order for it to survive a climate impact. Ability for decision makers to take risks and innovate in order to survive/conservate resources is not measured by resilience. Also, the definition of a system’s essential function or basic structure and ways of functioning is highly subjective.

**Resistance:** The engineering approach to ecosystem management, with the goal of preventing change.

*Resilience* and *Resistance* compared: Resilience measures try to improve a system’s capacity to return to original functioning after a disturbance; resistance measures try to anticipate and stop disturbances. *Resistance* measures may be part of a *resilience* strategy, and vice versa. The two approaches are similar in that they both are aimed at preserving the existing system as-is (e.g., maintaining the same flora and fauna in the same place). These measures will not work in a scenario where a particular system is expected to change its function permanently in unprecedented ways. For example, resilience and resistance strategies will not be successful in the case of an agricultural region that is expected to become a desert, or a lowland area that is expected to be flooded.

**Sensitivity:** The degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise). (IPCC Fourth Assessment Report 2007)

**Transformation:** Creation of a new, sustainable state.

*Resilience, Resistance and Transformation* compared: Resilience/ resistance approaches try to conserve resources in one place, whereas transformation approaches allow that a place may be transformed beyond recognition. For example, a transformation approach may be successful in the case of an agricultural region that is expected to become a desert. (Chapin and Zavaleta 2010).

## **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 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, IPCC Third Assessment Report 2001)

End Point Vulnerability: A residual of climate change impacts minus adaptation; in this sense, a means to grasp net climate change impacts after the fact. (O'Brien et al. 2004)

Starting Point Vulnerability: A state generated by multiple environmental and social processes exacerbated by climate change; in this sense, a means to grasp the distribution of climate change impacts, primarily to identify measures to reduce vulnerability in advance of impacts. (O'Brien et al. 2004)

Vulnerability Assessment: A systematic evaluation of predicted or observed areas of particular exposure to negative impacts from an event or process.

*Impact Assessment and Vulnerability Assessment* compared: An impact assessment may but does not necessarily point to areas of particular exposure (as in, relative to other areas of exposure). An impact assessment may list but not prioritize impacts along a continuum of vulnerability.

**For the purposes of this paper, vulnerability can be understood to be a condition consisting of three component factors: physical or social exposure to impacts, sensitivity to impacts, and lack of capacity to adapt to climate change.**

## APPENDIX B: Futures of Wild Marin Workshop - Participants List

	Name (Alpha by Last Name)		Title	Organization	Workshop Role
1.	Sarah	<b>Allen</b>	Coast and Oceans Program Lead, Regional Office	NPS	Scenario Development Team
2.	Greg	<b>Andrew</b>	Fisheries Biologist	Marin Municipal Water District - MMWD	
3.	Brian	<b>Aviles</b>	Landscape Architect/ Senior Planner	GGNRA	
4.	Ben	<b>Becker</b>	Director, Pacific Coast Science and Learning Center	Point Reyes NS	
5.	Erin	<b>Chappell</b>	Staff Environmental Scientist / Climate Change Program Member	Department of Water Resources - North Central Region Office	
6.	Ellie	<b>Cohen</b>	Executive Director	Point Reyes Bird Observatory - PRBO	
7.	Amy	<b>Concilio</b>	Ph.D. Candidate	UC Santa Cruz	Workshop Note Taker
8.	Mick	<b>Costigan</b>	Practitioner	Global Business Network - GBN	Workshop Facilitator
9.	Angee	<b>Doerr</b>	PhD candidate	UC Davis	Workshop Presenter
10.	Julie	<b>Ekstrom</b>	Postdoctoral Researcher: Climate Change Vulnerability & Adaptation Initiative	University of California, Berkeley,  Center for Law, Energy & the Environment	
11.	Will	<b>Elder</b>	Park Ranger	NPS/ GGNRA	

12.	Eric	<b>Ettlinger</b>	Aquatic Ecologist	Marin Municipal Water District - MMWD	
13.	Sue	<b>Fritzke</b>	Supervisory Vegetation Ecologist	GGNRA	Scenario Development Team
14.	Natalie	<b>Gates</b>	Chief of Natural Resources Management	Point Reyes NS	
15.	Dan	<b>Gluesenkamp</b>	Director of Habitat Protection and Restoration	Audubon Canyon Ranch	Scenario Development Team
16.	Bree	<b>Hardcastle</b>	Environmental Scientist	California State Parks - Marin District	Scenario Development Team
17.	Daphne	<b>Hatch</b>	Chief of Natural Resources Management & Research	GGNRA	
18.	Patricia	<b>Hickey</b>	Stewardship Director	Marin Agricultural Land Trust - MALT	
19.	Elise	<b>Holland</b>	Planning & Resources Chief	Marin County Parks and Open Space	
20.	Kent	<b>Julin</b>	Forester	Marin County Fire Department	
21.	Janet	<b>Klein</b>	Resource Manager / Vegetation Ecologist	Marin Municipal Water District - MMWD	Scenario Development Team
22.	Gary	<b>Knoblock</b>	Program Officer- SF Bay Area	Gordon & Betty Moore Foundation	
23.	Jack	<b>Liebster</b>	Principal Planner	Marin County Planning Department	Scenario Development Team
24.	Mischon	<b>Martin</b>	Natural Resources Program Manager	Marin County Parks and Open Space	
25.	Lisa	<b>Micheli</b>	Executive Director	Pepperwood Preserve	Scenario Development Team
26.	Sara	<b>Moore</b>	Assistant Specialist, Climate Change Adaptation Policy	UC Santa Cruz	Workshop Organizer

27.	Joanna	<b>Nelson</b>	Ph.D. Candidate	UC Santa Cruz	Workshop Note Taker
28.	Lorraine	<b>Parsons</b>	Wetland Ecologist; Project Manager, Giacomini Wetland Restoration	Point Reyes NS	
29.	Isaac	<b>Pearlman</b>	Sea Grant Fellow	California State Parks	
30.	Nat	<b>Seavy</b>	Research Director, Terrestrial Ecology Division	Point Reyes Bird Observatory - PRBO	Scenario Development Team
31.	Rebecca	<b>Shaw</b>	Director of Science	The Nature Conservancy - California - TNC	PIER Study Principal Investigator (2)
32.	Jonathan	<b>Star</b>	Senior Practitioner	Global Business Network - GBN	Workshop Facilitator
33.	Mike	<b>Swezy</b>	Watershed Manager	Marin Municipal Water District - MMWD	Scenario Development Team
34.	Andrea	<b>Williams</b>	Vegetation Ecologist	Marin Municipal Water District - MMWD	
35.	Erika	<b>Zavaleta</b>	Assistant Professor	UC Santa Cruz	PIER Study Principal Investigator (1)

The following accepted invitations but could not attend:

1. Jennifer **Blackman**, Bolinas Community Public Utility District, General Manager
2. Jay **Chamberlin**, Chief, Natural Resources Division, California State Parks
3. Torri **Estrada**, Program Director, Environment, Marin Community Foundation
4. Tom **Gardali**, Assoc. Dir. Terrestrial Ecology Division, Point Reyes Bird Observatory
5. Rick **Rayburn**, Former Chief of Natural Resources, California State Parks
6. Nancy **Scolari**, Executive Director, Marin Resource Conservation District
7. Gail **Seymour**, Senior Environmental Scientist, Fisheries and Watershed Restoration, Bay Delta Region, California Department of Fish and Game

## APPENDIX C: Map of Case Study Area

Map A: Location of Marin County in the State of California (D. Benbennick 2006, copyright Wikimedia Commons).<sup>113</sup>



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<sup>113</sup> Marin/California map accessed September 2, 2011, here:  
[http://en.wikipedia.org/wiki/File:Map\\_of\\_California\\_highlighting\\_Marin\\_County.svg](http://en.wikipedia.org/wiki/File:Map_of_California_highlighting_Marin_County.svg).

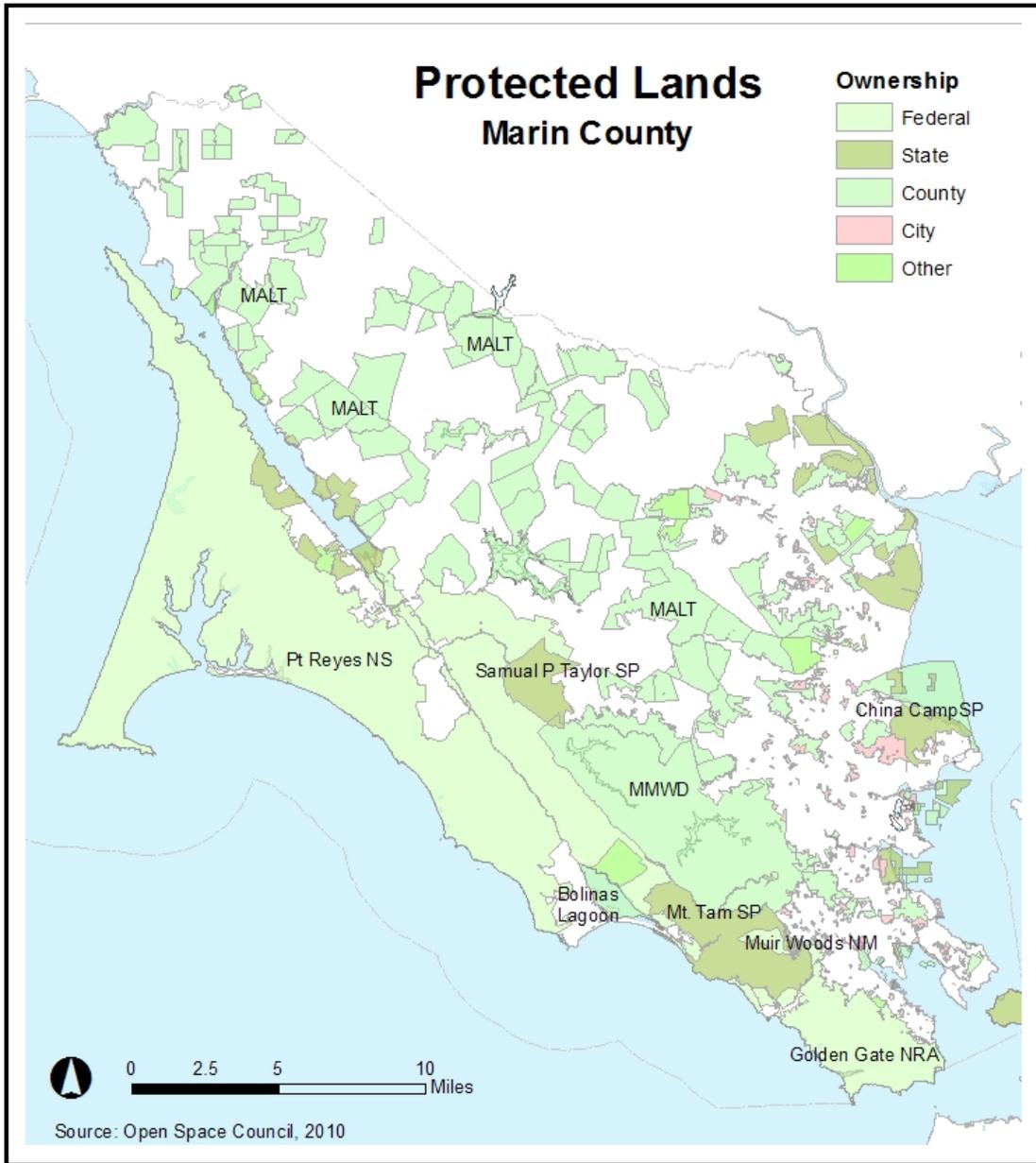
Map B: Map of Marin County (County of Marin 2004).<sup>114</sup>



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<sup>114</sup> Marin County map accessed December 17, 2010, here:  
<http://www.co.marin.ca.us/depts/IS/main/CountyMap.cfm>.

**Map C: Map of Marin County Protected Lands** (Open Space Council 2010). The protected lands selected for this paper’s case study site are labeled below: the Bolinas Lagoon, the Marin Watershed (labeled as MMWD), Mount Tamalpais State Park (labeled as Mt. Tam SP), Muir Woods National Monument, Point Reyes National Seashore, and Samuel P. Taylor State Park. Lands labeled “MALT” are owned by the Marin Agricultural Land Trust.



## APPENDIX D: Selection of the Case Study Site

The following criteria were used to select the case study site of West Marin County's protected areas (the Bolinas Lagoon, the Marin Watershed, Mount Tamalpais State Park, Muir Woods National Monument, Point Reyes National Seashore, and Samuel P. Taylor State Park):

- Feasible: can be used as a case study within the practical constraints of our study.
  - The study's main researcher lived in relative proximity to the selected case study site.
- Has good climate change data: there is sufficient climate data to make projections about impacts, and the data is sufficiently synthesized in an impact assessment with sufficient validity (i.e., has buy-in from the end users of our case study).
  - The 2010 report published by Largier, Cheng and Higgason, "Climate Change Impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries," was not an impact assessment of West Marin, but provided a good starting set of data and projections for the area. Also, Marin County is included in the nine counties of the Bay Area case study that is a part of the 2011 California Energy Commission Climate Change Vulnerability Assessment, providing access to new findings about climate impact projections for the area.
- Significant to California: is a place of concern to people with identified vulnerability to climate change, but not necessarily something we could scale up, or representative of the state's climate issues.
  - Our site included Muir Woods National Monument, an iconic place for Californians, host to hundreds of thousands of tourists annually (779,880 in 2009).<sup>115</sup>
- Has an interaction of human and natural systems (not specifying systems), e.g., ranchers and prairie, backpackers and lake.
  - Our site included protected areas which are heavily used for recreation.
- Has mixed land use types (though not necessarily mixed land cover), i.e., mix of working landscapes and protected lands.
  - Our site included Point Reyes National Seashore, which mixes protected land and working landscapes.

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<sup>115</sup> Muir Woods NM annual visitation statistics (accessed August 12, 2012): <http://www.nature.nps.gov/stats/park.cfm?parkid=587>.

- Has mix of land management jurisdictions, in order to sample institutional challenges.
  - Our site included a mix of lands managed by the county, the water district, the state, and federal-level staff.
- 100 percent within State of California: could include federal lands, should not include Tribal lands, disputed lands, or lands where central landscape unit crosses state boundary.
  - This criterion precluded using Lake Tahoe as a site. West Marin is fully within the state.
- Minimum of one square mile, with no absolute size constraints.
  - The case study site is a 100,000-plus-acre territory, sufficiently large enough to encompass a variety of ecosystems and climate change challenges.
- Mainly terrestrial.
  - The workshop goals and design were discussed with staff working in the National Marine Sanctuary off the coast of West Marin, but participants were selected with a focus on those with expertise on terrestrial systems.
- Has significant protected areas, including state park land.
  - The site included Mount Tamalpais State Park and Samuel P. Taylor State Park.
- Our work would be value-added there (not duplicative).
  - Another scenario planning exercise was done in this geographic area with some of our targeted participants, held by the Center for Ocean Solutions on February 22–26, 2010.<sup>116</sup> Based on feedback about that workshop, our workshop was designed to be more action-oriented and grounded in climate change impact data with a greater mix of institutional representation.

Case study site candidates were solicited from Lee Hannah (UC Santa Barbara), Patrick Roehrdanz (UC Santa Barbara), David Ackerly (UC Berkeley), and Rebecca Shaw (The Nature Conservancy of California [2010]). These are the sites from which we selected the protected areas of West Marin:

1. The San Francisco Bay National Wildlife Refuge
2. The Golden Gate National Recreation Area

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<sup>116</sup> See the workshop agenda and other materials here (accessed August 12, 2012): <http://centerforoceansolutions.org/climate/solutions/adaptation/>.

3. Irvine Ranch
4. Lake Tahoe
5. The Marin Watershed District
6. Mount Hamilton
7. Mount Tamalpais State Park
8. Napa County
9. Point Reyes National Seashore
10. Santa Ynez
11. Sonoma County
12. Tehachapi/ Southern Sierra / Tejon
13. Yosemite

Other sites we considered may be facing more acute climate impacts, or may represent areas with greater importance to the state's natural assets (wildlife biodiversity, water supply, etc.), but the area we selected best fit our criteria, as explained above.

# APPENDIX E: Workshop Agenda

**Futures of Wild Marin**  
**January 28, 2011, the Headlands Institute**  
**Sausalito, California**

A climate change scenario planning workshop for resource managers concerned with the protected areas of West Marin.



Graphic: Red-Legged Frogs. Photo: John Sullivan/Rabbit Photography

## GOALS

### Workshop Goal:

The goal of this workshop is to use scenarios to determine action steps for multiple plausible climate futures for different adaptation goals (to be useful to a range of different agencies), and in the process 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.

### Draft Adaptation Goals: Climate change adaptation actions 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;
- Maintain bioregional native biodiversity.

## AGENDA

9:00 to 9:20	<b>Welcome</b> (Erika Zavaleta, Sara Moore, Jonathan Star, Mick Costigan) A brief background on this project and scenario planning as a tool.
9:20 to 9:40	<b>Quantifying Uncertainties</b> (Lisa Micheli) Findings from the North Bay Watershed downscaled hydrology study; framing presumptions about local climate change.
9:40 to 10:00	<b>Introduction to Point Reyes Vulnerability Assessment</b> (Angela Doerr, UC Davis) Methodology and findings from a UC Davis research team (Angela Doerr, Sarah Hameed, Jill Baty, Katie Holzer) doing a climate change vulnerability assessment for Point Reyes National Seashore.
10:00 to 10:30	<b>Questions and Discussion of Drivers of Change</b> (Sara Moore, Jonathan Star, Mick Costigan) Presentation of variables considered for local climate scenarios.
10:30	<b>Coffee Break</b> (10 min)

10:40 to 11:15	<b>Presentation of Scenarios</b> (Sara Moore, Jonathan Star, Mick Costigan) Presentation of variables selected, eight scenarios developed: discuss and select four for discussion, assign two to each group (one to discuss before lunch, one to discuss after).
11:15 to 12:30	<b>Break into Two Groups: One Scenario Each: Action steps?</b> <i>Please self-select into one of two groups to discuss the scenario that would be most helpful to you. Each group will be asked to brainstorm three action steps to prepare for each scenario. Before lunch: earlier dry season. Upstairs: more easterly strong winds Downstairs: more northerly strong winds.</i>
12:30 to 1:20	<b>Lunch Break</b>
1:20 to 2:30	<b>Break into Two Groups: A Second Scenario: Action steps?</b> <i>After lunch: later dry season. Upstairs: more easterly strong winds Downstairs: more northerly strong winds.</i>
2:30 to 3:15	<b>Groups report back</b> One person from each group, with the group's facilitator, will describe their scenarios and top action steps.
3:15	<b>Coffee Break</b> (10 min)
3:25 to 3:45	<b>Discussion of Criteria for Adaptation Actions</b> What are the top criteria for prioritizing adaptation actions (cost, cost-effectiveness, feasibility, flexibility, etc.)?
3:45 to 4:30	<b>Small Groups: Evaluate Action Steps</b> Discussion of the action steps proposed, rating them along the criteria. <i>Please select three top priority actions.</i>
4:30 to 5:00	<b>Next Steps: Presentation of top priority actions by small groups, and (if possible) assignment of lead people / agencies for those actions</b>
5:00 to 5:50	<b>Evaluation of the Planning Exercise</b>
5:50	<b>Thank You</b> (Erika Zavaleta and Sara Moore)

# APPENDIX F: Transcription of Workshop's Scenario Descriptions

The following consists of transcriptions of the group discussion worksheets describing the four climate scenarios envisioned in the Futures of Wild Marin Workshop on January 28, 2011, and the descriptions of the eight scenarios which combined the climate factors with the capacity to act. The two most uncertain climate factors of top concern by which the scenarios were defined were the timing of the onset of the dry season (earlier, later) and the direction of strong wind (increasingly easterly or northerly). The capacity to act was envisioned to be either the same or less, or much greater, here below labeled (A) LOW CAPACITY or (B) HIGH CAPACITY.

## F.1. Four Plausible Climatic Futures of Concern

1. Earlier dry season, stronger easterly winds (interpreted in some groups as increased La Niña conditions)

### *Descriptive terms*

- Super dry
- Catastrophic fire
- Water wars
- Less fog
- Competitive

### *Underlying trends*

- Demographic transition to coasts
- Resource competition
- Water stresses
- Marin versus other areas in California

### *Key events and headlines*

Ordered by nearer term/ present to far future (one hundred years from now):

- Lower incidence of sudden oak death (SOD): but, others? (Goldback ferns transport SOD, so SOD may decrease in this scenario)
- More extensive salt water marshes and estuaries
- More salinity in freshwater environments
- Seasonal freshwater wetlands decline
- Salmon season shuts down
- Increase in water quality issues
- More intense water competition (vineyards)
- Increase agricultural pressure on wild lands (especially vineyard changes)
- Planning for major transition to coasts
- More beach visitors: greater development pressure on coastal communities

- More invasive aquatic species: more sunlight, warmer winds
  - Effects on salmon habitats, etc.
  - Reduced in-stream flows
  - Grasslands not grazed: loss of some grassland species
  - Increase in grassland wildlife species which are mobile
  - Fewer mosquitoes: less standing water
  - Decline in extent of Redwoods - forest to shrub
  - Fires: more frequent and intense in the short term, but maybe less intense over time
  - San Rafael Burns to the Ocean
  - Vegetation converts to invasive species: high disturbance
  - Stronger easterly winds: fires change the vegetation structure over 50 years
  - Amphibians: more bullfrogs? Or not? Restricted breed in habitat: dispersal.
2. Earlier dry season, stronger northerly winds (interpreted in some groups as increased El Niño conditions)

*Descriptive terms*

- Dry windy
- Colder
- Less extreme fire behavior

*Underlying trends*

- Mismatch in the time between pollination
- Lifecycle dependencies between species broken

*Key events and headlines*

Ordered by nearer term/ present to far future (one hundred years from now):

- More ignitions but shorter fires
- Coho Salmon - None in Sight
- Desalination Slakes Marin's Thirst
- More persistent drought
- Muir Woods Burns
- Extreme fire lasts only three hours
- Nick's Cove Swept Away
- San Anselmo Floods Again, 7th Time Again
- More recreational use of Marin County
- Last Dairy Closes
- Sea level rise: Highway 1 Bolinas Road cut off
- Giacomini Wetlands Restored Again
- Mission Blue Butterfly Extinct

- Pt. Reyes surfing hotspot - Mavericks Moves North
  - Farallones Rookeries Fail Again
  - Eel grass and kelp forests decrease
  - Point Reyes an Island (and New Bridge Built)
  - Coast Oak on the Way Out
  - Lose some rare annual plants
  - Beach Layia Gone (endangered herb species)
3. Later dry season, stronger easterly winds (interpreted in some groups as increased La Niña conditions)

*Descriptive terms*

- Lush
- More fuel
- Invasive species
- Stormy
- Variable

*Key events and headlines*

Ordered by nearer term/ present to far future (one hundred years from now):

- Explosions of high biomass weeds
- Invasive booms
- Phenological shifts: late blooms?
- Sudden Oak Death: oaks disappear
- Mosquitoes: West Nile, invasives
- Really big annual grasses
- Fungal pathogens
- Increased forage, better for grazing
- Poor for water storage: evaporation
- Deeply-rooted species do not do so well
- Difficult for sea birds: marine food webs messed up
- More extremes: wetter spring, drier summer
- Ocean effects: non-survivorship
- Better chances for fish, amphibians, etc. (...but...)
- Higher energy storms
- Tropical storms
- Saturated soils: floods and landslides
- Floods: greater erosion
- Fire season beginning will be later, but still high intensity

4. Later dry season, stronger northerly winds (interpreted in some groups as increased El Niño conditions)

*Descriptive terms*

- More flooding

*Underlying trends*

- Later demand for irrigation
- Least fire prone scenario
- Oh, the landslides!
- Longer period for establishment of invasive species
- More vegetation to burn
- Warmer waters offshore

*Key events and headlines*

Ordered by nearer term/ present to far future (one hundred years from now):

- More erosion and sedimentation
- Erosion creating new pollution
- Tourism falls off
- Coastal highway collapses from flooding
- More rainwater harvest possible
- Sir Francis Drake Bypass Approved (to avoid landslide)
- Desalination plant not required for 20 years
- Accelerated Sudden Oak Death
- Houses in Corte Madera washed away
- More harmful algae blooms
- Shorter management window (between time when rains end and fire danger too high to use equipment)
- New fish in commercial fisheries
- Good times for cows! More forage (but less nutritious forage?)
- Bishop Pine returns.... and then later: Bishop Pine dies of disease
- Jellyfish drive people away from beaches (jellies dominate)
- Redwood retraction (chaparral moves)
- More disease in general
- Coho gone from Marin (but disappearance delayed compared to other scenarios)
- Trout fishing in Marin!
- Reservoir debates re-emerge

## F.2. Eight Plausible Futures: Combining Climate with Capacity to Act

1. (A) Earlier dry season, stronger easterly winds (interpreted in some groups as increased La Niña conditions), LOW CAPACITY: *Fryin and Cryin*

### *Top Actions Reported Back to Group*

- Institutional coordination, consolidation, shared priorities
- Mandatory water conservation rationing
- Communication campaign/ public education/ volunteer science

### *Brainstormed Key Events and Headlines*

Nearer term (by 2021) to longer term (by 2081):

- Big forest die-off on Mount Tam, big drought
- Increased sense of insecurity, water infrastructure/ desalination projects/ storage
- Lost wetlands (vernal pools)
- State Parks lose funding, big fires (we can't fight), increased land and water use: conflicts with conservation
- Reactive, short-term management takes over
- Emphasis more social than environmental
- Endangered Species Act suspended, Coho locally extirpated

### *Brainstormed Actions*

Short-Term/ Today:

- Fight against "hard" fixes (levees, etc.) today because there will be little capacity to change in the future
- Identify today which resources are expected to be most impacted and prioritize/triage
- Identify, focus on priority areas, species, processes
- Build really effective invasive species detection and best management eradication
- Build regional coordination with other land managers

Mid-Term:

- Flexibility and mechanisms to develop shared priorities, change institutions: get on the same page, structure
- Increase coordination and resource sharing for first degree actions
- Prioritize critical habitats to be maintained versus given over for infrastructure
- Maintain some critical habitat corridors
- Identify shared core values across agencies (and align)
- Increase ability to partner with other organizations to share resources
- Focus on government streamlining and integration: low cost, high impact

- Emphasize ecological benefits to people’s well-being
- More public education
- Develop communication campaign (today/mid-term)
- Focus on volunteer, citizen-science, restoration efforts (today/mid-term)
- Shift management for functions versus species
- Let landscapes convert to super-arid vegetation
- Accept transition to fire-driven ecosystems
- Fight really ugly invasive species, plan for intervention after catastrophic fires
- Mandatory water conservation rationing

Long-Term:

- Give up on levees, let them break to create buffer
- Understand trade-offs, acceptance
- Limit population growth

2. (B) Earlier dry season, stronger easterly winds (interpreted in some groups as increased La Niña conditions), HIGH CAPACITY: *Phoenix*

*Top Actions Reported Back to Group*

- Integrate restoration with infrastructure
- Improve fire management (new taxation to fund)
- Buying habitat for refugia and corridors
- Bay Area Early Detection Network-style approach (early detection)

*Brainstormed Key Events and Headlines*

Nearer term (by 2021) to longer term (by 2081):

- Increased awareness of private property owners. (More conservation, decreased lawns and inappropriate use of chemicals)
- Greater ability to manage fire: more prescribed burns, etc.
- Increased volunteerism
- Land managers develop cohesive landscape vision across management boundaries
- Increased private money donations
- Increased money for countywide response through taxes
- Amendments to laws (Endangered Species Act, etc.) to allow more flexibility to protect ecosystems and habitats: “waiver for white hat projects”<sup>117</sup>

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<sup>117</sup> Dan Gluesenkamp, a member of this discussion group, clarified that “waiver for white hat projects” refers to creating systems for expediting environmentally beneficial projects, such as environmental compliance fast-tracking, CEQA waivers, etc.

*Brainstormed Actions*

Short-Term/ Today:

- Big fire: Develop a special district to pay for fire protection, weed control - based on science; decommission bad fuel breaks.
- Integrate restoration with infrastructure projects (roads as solutions rather than impacts)
- Use Soulajule Reservoir water for resource purposes
- Buy up habitat that can serve as refugia or corridors for species retention and migration
- Increased money and resources for restoration of lands already impacted (to increase resilience)
- Increased Marine Protected Areas and increase enforcement
- Increased cohesiveness amongst land managers to share techniques and increase restoration efficiencies

Mid-Term:

- Change infrastructure to allow for sea level rise, allow the inland migration of wetlands
- Create more water retention structures at sub-watershed level
- More money to manage protected lands (Marin Agricultural Land Trust lands)
- Effective monitoring and control of invasive species (Bay Area Early Detection Network-style approach)

Long-Term:

- Marin desalination plant(s) to allow for land-water retention for native habitat
- Countywide moratorium on lawns

3. (A) Earlier dry season, stronger northerly winds (interpreted in some groups as increased El Niño conditions), LOW CAPACITY: *Dry Sweat*

*Top Actions Reported Back to Group*

- Triage
- Reactive enforcement
- Regulatory reform

*Brainstormed Key Events and Headlines*

Nearer term (by 2021) to longer term (by 2081):

- Beaches full of jellyfish
- Invasive species fill wide fire breaks
- Human community needs trump ecosystem services needs
- Inland heat drives population to Marin

- Agriculture in Marin is gone
- Farmland used for housing
- New markets will be created around changing needs

*Brainstormed Actions*

Short-Term/ Today:

- Delay new fuel break construction where there's no way to maintain it properly (near-term, ongoing)
- Stem tide of invasive species with early detection and rapid response
- Conservation: penalties for overuse of water
- Decouple the water rate structure (so that reducing use of water doesn't de-fund water district)
- Increase permit fees
- Enforce building codes around fire
- Reactive enforcement after overuse or fire loss

Mid-Term:

- Triage (Give up Deer Park and Phoenix watersheds to invasive species; let go some species, such as dune species; let animals go first [more expensive])
- Regulatory reform: collapse of Coho releases the need for some regulation
- Roll out the herbicides
- No Jacuzzis unless used for rainwater catchment

Long-Term:

- Concept of endangered species becomes endangered
- Rainwater harvesting by communities (through private action, non-governmental organizing)

4. (B) Earlier dry season, stronger northerly winds (interpreted in some groups as increased El Niño conditions), HIGH CAPACITY: *Club Marin*

*Top Actions Reported Back to Group*

- Monitoring
- Interagency cooperation
- Incentives for public-private partnership

*Brainstormed Key Events and Headlines*

Nearer term (by 2021) to longer term (by 2081):

- Gray whales calf in Tomales Bay

- Lagunitas hatchery opens
- Elephant seals breeding in downtown Stinson
- NPS/State Parks surfing schools open classes for Chinese visitors
- Upland Habitat Goals purchases “next millionth” area
- Land purchases along estuarine interface to allow room for wetland migration
- Corridors for elk and black bears between Marin and Sonoma counties
- Tanoak restoration project begins on Mount Tam
- Bridge to Point Reyes Island
- Pampas grass a thing of the past
- Massive expansion of habitat restoration of all riparian corridors in Marin
- Bio-climate monitoring in every neighborhood
- Highway 1 re-routed into tunnel
- Biospheres for rare species created in hot spots of biodiversity
- Marin Municipal Water District raises dams, broom flooded
- New species: Alpine Piranha

*Brainstormed Actions*

Short-Term/ Today:

- Multi-species conservation prioritizes process, not species
- Pull parking lots off of great beaches
- Incentives for private owners to preserve corridors
- Highway 1 viaduct opens north of Stinson Beach
- New fire stations open in Mill Valley
- Shelter-in-place communities

Mid-Term:

- More trails to protect processes
- More floodplain
- Region-wide information hub: central portal
- Solar panels on every roof
- All cars are electric
- Engage social scientists and integrated scientists in process
- Prevention and early detection/ rapid response incorporated into all management and planning processes

Long-Term:

- Comprehensive natural indicator (physical and biological) monitoring programs

- More interagency collaboration (BAECCC, UHS, BAEDN<sup>118</sup>): groups staffed and funded
- Private lands incentive programs pay to protect water, carbon
- Expand carbon credits and incentives for soil sequestration on rangelands

5. (A) Later dry season, stronger easterly winds (interpreted in some groups as increased La Niña conditions), **LOW CAPACITY: *Leaky Boat, No Bucket***

*Top Actions Reported Back to Group*

- Increase water storage, carbon sequestration
- Retrench fire protection
- Prioritization, protection and acquisition of lands

*Brainstormed Key Events and Headlines*

Nearer term (by 2021) to longer term (by 2081):

- Increased pesticide use, run-off
- Rainy season visitors: erosion
- People are more focused on their own properties: less focus on open spaces and resources
- Socratically oriented resource management<sup>119</sup>
- Big fire
- More landslides

*Brainstormed Actions*

Short-Term/ Today:

- More emphasis on early detection and rapid response of new invasive species - Early Detection Network: Support collaboration, Share limited resources, Find problems early, Fix problems while cheap
- Let go of well-established invasive species

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<sup>118</sup> Bay Area Ecosystems Climate Change Consortium (BAECCC), Upland Habitat Goals (UHG), Bay Area Early Detection Network (BAEDN)

<sup>119</sup> Clarification from Dan Gluesenkamp, a member of this discussion group: “We used [the] term [Socratically oriented resource management] for bad ideas coming out of smart people. For example, we talked about the tendency to come up with generalizations based on logic, and not experience or reality, e.g., actions proposed on the basis of functional groups instead of real species. Some academics have suggested that maybe we should plant invasive perennial grasses because they are in the same functional group as native perennial grasses. The land managers then ask, what is a ‘functional group’? What do you mean when you talk about ‘ecosystem function’? Get outside and get to know the species and you’d never propose such an idea.” (personal communication)

- Market brand: “Visit nice cool Marin”
- Close Highway 1 between Muir Beach and Stinson Beach
- Close down entire areas to public access
- Develop private volunteer foundation to support all parks (\$)
- See fire break plan from first scenario (this refers to earlier dry season onset, easterly winds, high capacity: Phoenix)<sup>120</sup>
- Reduce number of fire roads to help decrease sediment
- Re-evaluate current fire lines/ fuel breaks; reconfigure for better effectiveness
- Resource sharing and collaboration among managers

Mid-Term:

- Prioritize increasing productivity “source” areas and selectively manage them
- Vegetation communities that are resilient (from past climate change): find them and protect them
- Enforcement of current Marine Protected Area regulations
- Increase visitor use fees
- Increase water storage capacity

Long-Term:

- Carbon sequestration market

6. (B) Later dry season, stronger easterly winds (interpreted in some groups as increased La Niña conditions), HIGH CAPACITY: *Lush Flush*

*Top Actions Reported Back to Group*

- Ready to go restoration teams
- Invasive protection and response
- Fuel load management

*Brainstormed Key Events and Headlines*

Nearer term (by 2021) to longer term (by 2081):

- Species die off
- New climate adaptation agency announced
- Catastrophic fire: Muir Woods burns
- Dengue and malaria

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<sup>120</sup> Ibid: “We liked the idea of revising the fuel break systems in light of good science, closing some and realigning fire roads, etc. We thought this could be funded by special district assessments, to revise the system and then fund fuel management and wildland urban interface invasive plant management.” (personal communication)

- New exotics take over!
- Flooding - Highway 1 is shut down
- Levees break in Delta
- Public health crisis
- Muir Woods die off
- Towns burn

*Brainstormed Actions*

Short-Term/ Today:

- Purchase land for future coastal wetlands and wildlife corridors
- Establish and protect corridors and networks of protected areas
- Sequester carbon
- Marin County Adaptation Plan 2013
- Increased public education
- Intensive vegetation management
- More short-term preventative management to avoid invasive infestations
- Decrease fuels between communities
- Management combining vector and habitat consideration
- Organize and coordinate to prevent duplicating efforts
- Monitor and manage adaptively
- Comprehensive and implemented climate adaptation plan
- Anticipate what to do after catastrophic fire

Mid-Term:

- Control invasive species and fuel load
- Early detection: rapid response and containment for fungal pathogens, exotics
- Manage streams for peak flow and sediment input
- Enhance groundwater recharge – urban areas
- Water Redwoods
- Mobilize invasive species controls
- Detection and rapid response
- Spring controlled-burn program
- Wildlife-friendly agriculture
- Climate hazard prediction and response team/ agency
- Have response plans ready to go
- Increase fire suppression capacity

Long-Term:

- Re-engineer ecosystems
- Invest in rapid response infrastructure for restoration
- Manage more intensively to speed shifts in veg. community

- Be prepared for directed post-fire restoration
7. (A) Later dry season, stronger northerly winds (interpreted in some groups as increased El Niño conditions): LOW CAPACITY: *Muddy Waters*

*Top Actions Reported Back to Group*

- Change in land use policies
- Public-private partnerships
- Triage areas and focus on core programs

*Brainstormed Key Events and Headlines*

Nearer term (by 2021) to longer term (by 2081):

- Parks close (erosion, unmanaged vegetation)
- Beaches closed for more periods of time
- Agencies merge
- Roads and trails close!
- Public lands expand but aren't maintained
- Global pandemic!
- Ranch valleys flooded to retain water
- FEMA office in Marin manages devastated lands

*Brainstormed Actions*

Short-Term/ Today:

- Prevention and early detection, rapid response for weeds instead of ongoing control (BAEDN, incorporating prevention into CEQA).
- Siting new and rebuilt infrastructure out of harm's way.
- Expanding private fundraising partnerships.
- Piggyback ecological and recreational planning on larger infrastructure and public safety projects.

Mid-Term:

- Staff reorganization and restructuring.
- Increase labor available for conservation and fuels management through local volunteer programs (or Bureau of Prisons).

Long-Term:

- Increase public-private lands partnerships.
- Triage areas for management and reduce management burden, focus on core programs.

- Change land use policies to minimize habitat impacts.
8. (B) Later dry season, stronger northerly winds (interpreted in some groups as increased El Niño conditions): HIGH CAPACITY: *Playing God*

*Top Actions Reported Back to Group*

- New habitat creation
- Land acquisition
- Better monitoring all around

*Brainstormed Key Events and Headlines*

Nearer term (by 2021) to longer term (by 2081):

- Don't need ridge top fire breaks
- Highway 1 collapse: abandoned, losing battle
- "Parkland" becomes protected (after collapse of highway)
- Highway 1 becomes a popular trail between Stinson Beach and Muir Beach

*Brainstormed Actions*

Short-Term/ Today:

- Landscape scale prevention, early detection and rapid response
- Monitoring: all around better monitoring
- Study ground water
- Instead of growing tax base, protecting natural resources: infill growth only

Mid-Term:

- Elevate Highway 1 on a trestle/ move it inland (where?)
- Expand tank and reservoir system
- Land acquisition: where? Corridors for plants and wildlife, places where infrastructure most at risk: Buy out flood zones (Corte Madera), Seadrift turned into a wetland

Long-Term:

- Build trails where coastal highway abandoned
- New habitat creation: experimentation, assisted migration, "playing God"

# APPENDIX G: Draft Statement of Agreement for Workshop Participants

## Statement of Agreement

Regarding Principles of Resource Management for Climate Change Adaptation in

Marin County, California

DRAFT April 6, 2011

Recognizing the harm that climate change is expected to cause Marin County's natural systems and the need to work collaboratively to maximally reduce this harm, and also take maximum advantage of opportunities created by climate change, we the undersigned express our agreement with the following principles of resource management for climate change adaptation in Marin County, California.

### 1. Climate change is expected to cause significant impacts over time including:

- Air temperature increasing;
- Sea level rising;
- Seasonal extremes increasing; and
- Biodiversity declining.

### 2. Actions which prepare natural systems for the impacts of climate change (adaptation actions) should be done with the following goals:

- Maintaining key ecosystem functions (to provide the benefits of nature to human populations);
- Facilitating a gentler transition under climate change, based on natural systems; and
- Maintaining bioregional native biodiversity.

### 3. Priority should be given to adaptation actions which:

- Are flexible/robust under multiple scenarios;
- Are collaborative and coordinate efforts to avoid duplication;
- Use adaptive management, e.g., monitoring, correct scale of design, best science, pilot programs (before scaling up), and an iterative process;
- Are cost-effective and otherwise sustainable;
- Have clarity of design and transparency of implementation process;
- Address the most urgent impacts – and provide the greatest long-term benefits – to ecosystems;
- Are feasible within current resource constraints.

**4. The following adaptation actions which are already being undertaken should be maintained and improved:**

- Regional collaborative climate change adaptation planning efforts;
- Collaborative fire and water management efforts;
- Early detection and rapid response to biological invaders;
- Increasing connectivity between protected lands, given projections of species migration under climate change;
- Riparian restoration (as part of improving water management and connectivity);
- Coastal wetland restoration (as a buffer for sea level rise and extreme storms, and to provide carbon sequestration);
- Restoration of connectivity between upland and coastal areas, such as restoring floodplain function;
- 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.

**5. The following adaptation measures which build on current efforts may be developed collaboratively and implemented as they become necessary:**

- 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.
- 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).
- Development of a triage framework to give guidance on resource allocation within a financially constrained environment;
- Development of public-private partnerships to support adaptation actions along the Natural Resources Conservation Service model.

**6. Every six months, beginning in July 2011, a representative of the signatory agency will participate in a conference call to report on adaptation actions related to this agreement.**

**7. Every two years, beginning in 2013, a representative of the signatory agency will participate in a meeting to revise the agreement according to changing climate change information and management priorities, and to reconfirm the agency’s participation in the agreement.**

## APPENDIX H: Sample Criteria for Climate Change Adaptation Actions

The following are criteria used by government planners in fourteen current policy documents on climate change adaptation. These are taken from a study of climate change policy documents from around the North Pacific.<sup>121</sup> These criteria are variously being used to design, evaluate, or prioritize climate change actions.

The most commonly used criteria include feasibility, flexibility, and effectiveness at enhancing the ability to adapt. Other interesting criteria include clarity of policy, urgency, and ability to bring adaptation into the mainstream (of government functioning).

### Canada

**Canada:** *From Impacts to Adaptation: Canada in a Changing Climate 2007* (2008).

In deciding what adaptation option is most appropriate for a particular situation, attention must be paid to feasibility, likelihood and mechanisms for uptake.

**British Columbia:** *Preparing for Climate Change: British Columbia's Adaptation Strategy* (February 2010).

Defining Positions: To achieve our vision, we need to:

1. Build a strong foundation of knowledge and tools to help public and private decision-makers across British Columbia prepare for a changing climate.
2. Make adaptation a part of the Government of British Columbia's business, ensuring that climate change impacts are considered in planning and decision-making across government.
3. Assess risks and implement priority adaptation actions in key climate sensitive sectors.

**Yukon:** *Yukon Government Climate Change Action Plan* (February 2009).

1. Enabling effective adaptation,
2. Responding to public needs, and
3. Forging partnerships for a coordinated response.

### China

**The People's Republic of China:** *China's National Climate Change Programme* (June 2007).

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<sup>121</sup> Sara S. Moore (2010). *Emerging Climate Change Adaptation Policy: A North Pacific Analysis*. UC Berkeley Master's Thesis.

To address climate change and to make further contributions to protect global climate, China will be guided by the following:

1. To give full effect to the Scientific Approach of Development;
2. To promote the construction of socialist harmonious society;
3. To advance the fundamental national policy of resources conservation and environmental protection;
4. To control GHG emission and enhance sustainable development capacity;
5. To secure economic development;
6. To conserve energy, to optimize energy structure, and to strengthen ecological preservation and construction;
7. To rely on the advancement of science and technology;
8. To enhance the capacity to address climate change.

## Japan

**Japan:** *Wise Adaptation to Climate Change* (June 2008).

1. Promotion of regional vulnerability assessments;
2. Monitoring, and adoption of early warning systems that utilize monitoring;
3. Utilization of a diverse range of options;
4. Utilization of both long-term and short-term perspectives;
5. Utilization of observation results, and introduction of adaptation measures that ensure a certain degree of clearance ('margin for error');
6. Mainstreaming adaptation;
7. Effective and efficient realization of low vulnerability "flexible and responsive systems;"
8. Promotion of co-benefit type adaptation;
9. Improvement of society-wide adaptive capacity by utilizing insurance and other economic systems;
10. Development of systems of cooperation and alliance with relevant organizations;
11. Promotion of voluntary initiatives through entities that allow for a detailed approach at the coalface ('by local actors who could implement finely-tuned efforts on site');
12. Development of human resources.

## Russia

**The Russian Federation:** *Climate Doctrine of the Russian Federation* (December 2009).

(Presented in the policy document without explanation of how these principles would be used to prioritize actions.)

1. The global scope of the interests of the Russian Federation concerning climate change and its effects;
2. The priority of national interests in the development and implementation of climate policy;

3. The clarity and informational transparency of climate policy;
4. The recognition of the need for domestic as well as international equal partnership actions of the Russian Federation in the framework of international research programs and projects concerning climate change;
5. The comprehensive consideration of potential losses and advantages related to climate change;
6. The prudential planning and implementation of measures intended to protect human beings, economy and State from the adverse effects of climate change.

## **The U.S.A.**

**The United States of America:** *Progress Report of the Interagency Climate Change Adaptation Task Force* (March 2010).

Good adaptation measures will use:

1. Planning and preparation with the engagement of stakeholders, including States, Tribes, local governments, the private sector and non-government institutions, and understanding and accommodating differing vulnerabilities across people and places.
2. A systematic approach to the problem, considering how a range of risks and opportunities interact, as well as how existing and potential stresses reduce or amplify these risks and opportunities.
3. An environmentally sustainable approach, as well as an approach coordinated with also critical greenhouse gas mitigation efforts.

**Alaska:** *Alaska's Climate Change Strategy: Addressing Impacts in Alaska* (January 2010).

1. Significance: Magnitude/extent of economic/ sectoral impacts, irreversibility of impacts.
2. Benefits and Effectiveness: Effectiveness of recommended option in adapting to climate change by reducing adverse impacts or taking advantage of opportunities, as well as producing other, ancillary benefits.
3. Costs: Magnitude of public and private sector costs relative to benefits (initial costs and costs over time).
4. Feasibility: Realistic to implement (within state authority; legal, administrative, financial, technical and other resources exist)?
5. Timing: How urgent is adaptive action, given timing of impacts, planning and implementation periods for action, and other factors?
6. Adaptive Capacity: How well can natural and human systems adapt to climate change in the absence of the recommended action?

**California:** *2009 California Climate Adaptation Strategy* (December 2009).

1. Use the best available science in identifying climate change risks and adaptation strategies.

2. Understand that data continues to be collected and that knowledge about climate change is still evolving. As such, an effective adaptation strategy is “living” and will itself be adapted to account for new science.
3. Involve all relevant stakeholders in identifying, reviewing, and refining the state’s adaptation strategy.
4. Establish and retain strong partnerships with federal, state, and local governments, tribes, private business and landowners, and non-governmental organizations to develop and implement adaptation strategy recommendations over time.
5. Give priority to adaptation strategies that initiate, foster, and enhance existing efforts that improve economic and social well-being, public safety and security, public health, environmental justice, species and habitat protection, and ecological function.
6. When possible, give priority to adaptation strategies that modify and enhance existing policies rather than solutions that require new funding and new staffing.
7. Understand the need for adaptation policies that are effective and flexible enough for circumstances that may not yet be fully predictable.
8. Ensure that climate change adaptation strategies are coordinated with the California Air Resources Board’s AB 32 Scoping Plan process when appropriate, as well as with other local, state, national and international efforts to reduce GHG emissions.

**California: Oakland:** *City of Oakland Draft Energy and Climate Action Plan (ECAP)* (April 2010).

Taken from a planning document for the draft ECAP:

1. Greenhouse Gas Reduction Potential
2. Implementation Cost and Access to Funding
3. Financial Rate of Return
4. Greenhouse Gas Reduction Cost Effectiveness
5. Economic Development Potential
6. Creation of Significant Social Equity Benefits
7. Feasibility and Speed of Implementation
8. Leveraging Partnerships
9. Longevity of Benefits

**Hawaii:** *A Framework for Climate Change Adaptation in Hawaii* (November 2009).

1. Flexibility,
2. An iterative process,
3. Cost,
4. Timeliness,
5. Equitability.

**Oregon:** *Final Report to the Governor: A Framework for Addressing Rapid Climate Change* (January 2008).

These are intended to cover both mitigation and adaptation sections of the policy document.

1. Reduce our carbon “footprint” through increased energy, water and materials efficiency and reliance on renewable energy sources, cap and trade policies and other approaches.
2. Prepare for and build resilience in our natural, built, and human systems while managing risks that might have catastrophic or irreversible consequences.
3. Capture the social and economic opportunities that climate change presents.

**Washington:** *Leading the Way on Climate Change: The Challenge of Our Time* (February 2008).

1. Degree to which the measure is actionable,
2. Degree to which it has near-term importance in improving preparation or adaptation in each given topic area.

**Washington: King County:** *King County 2009 Climate Report* (February 2010).

A good adaptation measure would use:

1. A mainstreaming approach, and;
2. A collaborative process.

# APPENDIX I: Possible Indicators for the Evaluation of Climate Change Adaptation Interventions

The following are possible indicators suggested by the literature for measuring the success of climate change adaptation interventions. Indicators are observable characteristics, actions or conditions which demonstrate whether a desired change has happened (e.g., the number of attendees who can accurately answer questions on the topic discussed at the event) (Motylewski and Horn 2002). Indicators may be design, process, output, or outcome indicators, or a combination of these.

## Design

- Length of planning horizon (sufficient to cover timing of projected onset of worst impacts).
- Feedback loops (iterativeness) to incorporate new information, evaluation information.
- Variety of kinds and scales of information considered when assembling evidence about problem (beyond climate model projections), historical and projected.
  - Deep historical changes.
  - Continental scale changes.
  - Indigenous/community knowledge, including traditional responses to climate variability during past instances of extreme weather.
  - Institutional factors: culture of decision-making, decision-making points (e.g., budgeting cycles, electoral cycles).
  - Demographic changes.

## Process

- Cost.
- Level of stakeholder participation (invitee/attendance ratio of meetings, numbers of organizations represented, numbers of individuals attending, etc.).
- Thoroughness of planning documents (length, level of detail and specificity about action).
- Number of new reports or other forms of new evidence incorporated into feedback process when monitoring and modifying project.
- Participants in a volunteer science program, households in an energy/water efficiency program, hours logged by participants in an invasive species identification and mapping program, etc.

## Output

- Number of individuals surviving an extreme weather or climate event in a target population.
- Number of acres restored after climate-related negative impact (outbreak of disease, wildfire, etc.).

- Miles of riparian corridors restored and width of buffer zone created.
- Number of water-rationing days in a dry season and levels in reservoirs.
- Cost per unit of output (efficiency).

**Outcome**

- Survival of minimum critical number of individuals (for species survival) in target population over defined planning period.
- Adequate minimum supply of clean water provided to target population over defined planning period.
- Retention of minimum number of acres/ riparian miles in critical habitat for target species or natural process over defined planning period.

## APPENDIX J: Climate Change Planning Resources

- **Academic Resources:** academic articles, tools and reports useful to natural resource managers planning for climate change.
  - 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:  
<http://www.vcccar.org.au/files/vcccar/Jones%20scenarios%20presentation%2011-11-10.pdf>
  - Lawler, J. J., T. Tear, C. R. Pyke, R. Shaw, P. Gonzalez, P. Kareiva, L. Hansen, L. Hannah, K. Klausmeyer, A. Aldous, C. Bienz, and S. Pearsall (2009). **Resource management in a changing and uncertain climate.** *Frontiers in Ecology and the Environment*, 7. This is an influential (and brief) article that nicely summarizes many of the main themes of this report. It also presents synopses of three case studies of ecosystem adaptation strategies, including one in the Central Valley of California concerning tiger salamanders and fairy shrimp: <http://faculty.washington.edu/jlawler/pages/PDFS/gcc-managers-eview.pdf>
  - Peterson, G. D., G. S. Cumming, and S. R. Carpenter (2003). **Scenario planning: a tool for conservation in an uncertain world.** *Conservation Biology* 17, no. 2 (2003): 358–366. Another influential and brief article that gives specific recommendations about using scenarios for conservation planning:  
<http://technologyforge.net/STMWarsaw/ScenarioPlanning/ENMA291STReferences/Processes/ToolsForConservation.pdf>
  - University of Washington Urban Ecology Research Laboratory (2010). **Puget Sound Future Scenarios.** A report on a project wherein scenarios were developed based on input by over 100 experts to examine the implications of climate change on Puget Sound and the nearshore ecosystem: [http://www.urbaneco.washington.edu/R\\_scenarios.html](http://www.urbaneco.washington.edu/R_scenarios.html)
  - **U-Plan Urban Growth Model.** This tool, developed at University of California, Davis, is a mapping tool being used for components of the California State Climate Vulnerability Assessment: <http://ice.ucdavis.edu/project/uplan>
- **Adaptability** – The Climate Adaptation Network. A community on LinkedIn for professionals working in the adaptation field.  
<http://www.linkedin.com/groups?mostPopular=&gid=934207>
- **Australian Government Resources:**
  - The Australian Government: the National Climate Change Adaptation Research Facility’s (NCCARF) **Adaptation Research Networks.** The NCCARF facilitates interdisciplinary research on climate change. The site includes a large collection of relevant video

seminars, and contacts for eight sector-specific networks:

<http://www.nccarf.edu.au/adaptation-research-networks>

- Government of Western Australia, Department of Environment and Conservation, **Adaptation Links**. This list includes links to a variety of local government Australian adaptation vulnerability assessments and plans.

<http://www.dec.wa.gov.au/content/view/5170/2188/1/1/>

- **Californian Government Resources:**

- **Cal-Adapt**, an on-line climate change impact mapping tool:

<http://www.climatechange.ca.gov/adaptation/cal-adapt.html>

- **California Department of Water Resources(DWR) “Current Perspectives”** Climate Change Blog: <http://www.water.ca.gov/climatechange/blog/>

- DWR Climate News Digest:

<http://www.water.ca.gov/climatechange/news.cfm>

- **Canadian Government Resources:**

- Natural Resources Canada: **Climate Change Impacts and Adaptation Division – CCIAD**: [http://adaptation.nrcan.gc.ca/index\\_e.php](http://adaptation.nrcan.gc.ca/index_e.php)

- Natural Resources Canada: **Tools for Adaptation**:

[http://adaptation.nrcan.gc.ca/tools/abosuj\\_e.php](http://adaptation.nrcan.gc.ca/tools/abosuj_e.php)

- Natural Resources Canada (2010). **Adapting to Climate Change: A Risk Based Guide for Local Governments in British Columbia**:

[http://adaptation.nrcan.gc.ca/projdb/pdf/212\\_e.pdf](http://adaptation.nrcan.gc.ca/projdb/pdf/212_e.pdf)

- Canadian Climate Impacts and Adaptation Research Network - C-CIARN (2006). **Adapting to Climate Change: An Introduction for Canadian Municipalities**. A good basic guide with case studies including Vancouver, BC.

<http://www.gnb.ca/0009/0369/0018/0006-e.pdf>

- **Other C-CIARN research products** from the network’s period of activity (2001–2007) are available at CCIAD. Includes reports on land, water, coastal management under climate change: [http://adaptation.nrcan.gc.ca/site\\_e.php?p=1](http://adaptation.nrcan.gc.ca/site_e.php?p=1)

- **Regional climate change impacts posters** (1999–2002). Still excellent examples of climate impact communication tools: [http://adaptation.nrcan.gc.ca/posters/index\\_e.php](http://adaptation.nrcan.gc.ca/posters/index_e.php)

- **The Center for Clean Air Policy’s Urban Leaders Initiative**. This project has partnered with ten North American cities, including San Francisco, to support governments as they face infrastructure and land-use decisions that affect local climate adaptation efforts: <http://www.ccap.org/index.php?component=issues&id=20>

- **Lessons learned** on local climate adaptation from the urban leaders adaptation initiative (2011):

[http://www.ccap.org/docs/resources/988/Urban\\_Leaders\\_Lessons\\_Learned\\_FINAL.pdf](http://www.ccap.org/docs/resources/988/Urban_Leaders_Lessons_Learned_FINAL.pdf)

- **Climate Adaptation Knowledge Exchange (CAKE).** Natural resource management and conservation resources, maintained by EcoAdapt and Island Press.  
<http://www.cakex.org/category/type-adaptation-actionstrategy/natural-resource-management/conservation>
  - **EcoAdapt.** The site includes links to an adaptation advice column, funding and employment opportunities, and the blog “Adaptation Nation.” <http://ecoadapt.org/>
- **Climate Impacts Group (CIG) Resources:**
  - **CASES (Climate Adaptation caSE Studies) database and adaptation library.** An online database of state and local adaptation planning efforts:  
<http://cses.washington.edu/cig/cases>
  - **CIG Presentations.** A collection of PowerPoint presentations presented by CIG researchers on climate change in the U.S. West/ Pacific Northwest (including California, Washington, and the Columbia Basin) and resource management planning for climate change in general:  
<http://cses.washington.edu/cig/outreach/presentations.shtml>
- **Climate Solutions University (CSU) curriculum.** This curriculum is designed to guide rural, natural resource-dependent U.S. communities through the development of a model climate change adaptation plan: <http://www.mfpp.org/csu/>
  - **The model adaptation plan for Whatcom County, Washington,** developed in 2010 with CSU and the Nooksack Salmon Enhancement Association (NSEA):  
<http://www.mfpp.org/?p=713>
- **Cooperative Extension: Climate Change Adaptation for Forests.** This page summarizes the main points of Millar, Stephenson and Stephens (2007), with sidebar links to a wide assortment of related article summaries, including “Basics of Climate Models” and “Interpreting Climate Data for Land Management”:  
<http://www.extension.org/pages/33704/climate-change-adaptation-for-forests>
- **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 scenario planning process for the NPS: <http://www.nps.gov/climatechange/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”):

[http://www.fws.gov/northeast/climatechange/conference/pdf/330pm\\_carl\\_zimmerman.pdf](http://www.fws.gov/northeast/climatechange/conference/pdf/330pm_carl_zimmerman.pdf)

- **ICLEI –Local Governments for Sustainability Resources:**

- Snover, A. K., L. Whitely Binder, J. Lopez, E. Willmott, J. Kay, D. Howell, and J. Simmonds (2007). **Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments**. In association with and published by ICLEI. The writing team for this guidebook included individuals from the Climate Impacts Group, a research center at the University of Washington, Seattle; the King County Government, Seattle, Washington; and ICLEI – Local Governments for Sustainability. This guide is written very accessibly, like a textbook for policy makers, and is in use by city and state governments around the U.S. for adaptation planning:  
<http://www.icleiusa.org/action-center/action-center/planning/climate-adaptation-planning-resources/adaptation-guidebook>
- **ICLEI Canada Local Governments for Sustainability (2010). Changing Climates, Changing Communities: Municipal Climate Adaptation Guide and Workbook**. This guide was drafted based on workshops that vetted the ICLEI framework from the 2007 King County guide (above) in communities around Canada, updating the tools and modifying them for a Canadian context  
<http://www.iclei.org/index.php?id=8708>
- **ICLEI USA Adaptation Database and Planning Tool (ADAPT)**. This tool walks the user through the ICLEI milestone framework from the 2007 King County Guide. Log-in is only for ICLEI members, but the webpage provides other information, including a link to the ADAPT user guide.  
[http://www.icleiusa.org/programs/climate/Climate\\_Adaptation/adaptation-database-and-planning-tool-adapt](http://www.icleiusa.org/programs/climate/Climate_Adaptation/adaptation-database-and-planning-tool-adapt)
- **ICLEI USA - Local Governments for Sustainability: Climate Adaptation Planning Resources:**  
<http://www.icleiusa.org/action-center/planning/climate-adaptation-planning-resources>

- **The Nature Conservancy’s Knowledge Base for Climate Change Adaptation:**

<http://conserveonline.org/workspaces/climateadaptation/>

Also at: <http://naturepeoplefuture.org>

- The “**Climate Wizard**,” a tool for mapping climate impacts created by the Nature Conservancy. <http://www.climatewizard.org/>

- **Northern Periphery Programme Climate Change Adaptation Resources**. A well-organized set of selected resources for use by planners involved in this 2007–2013 European program for cooperative sustainable development across the northern reaches of Norway, Finland, Sweden, Iceland, Scotland, etc.

<http://www.climatechangeadaptation.info/training-resource/developing-adaptation-strategies/reports/>

- **San Francisco Planning and Urban Research Association - SPUR (2011). Climate Change Hits Home.** This report that makes recommendations on how local and regional agencies can begin minimizing the San Francisco Bay Area's climate vulnerabilities. <http://spur.org/publications/library/report/climate-change-hits-home>
- **Southwest Climate Change Network: Adaptation.** (Different from the Southwest Climate Change *Initiative*.) An excellent, well-organized, accessibly written site with numerous articles explaining the concepts and tools involved in climate change adaptation. Most articles are from 2009: <http://www.southwestclimatechange.org/solutions/adaptation>
- **Southwest Climate Change Initiative.** (Different from the Southwest Climate Change *Network*.) This is the most current site (as of August 2011) for information on SCCI's work in Arizona, Colorado, New Mexico and Utah: <http://conserveonline.org/workspaces/climateadaptation/documents/southwest-climate-change-initiative-0/view.html>
- **Tribal Government Resources.** These are resources either produced by tribal governments, or for the use of tribal governments (whose constituents may be referred to variously, depending partly on geography, as Alaska Natives, American Indians/ Native Americans, First Nations People, and other designations).
  - **Alaska:** four coastal Native Alaskan tribal communities are working on relocation plans.
    - **Kivalina**—an Inupiaq (Inupiat) community—filed a lawsuit against major oil companies for the cost of relocation, and is working with the U.S. Army Corps of Engineers to plan for relocation.
      - **City of Kivalina climate change blog:** <http://www.kivalinacity.com/climatechange.html>
      - **Kivalina v. ExxonMobil Corporation:** summary article on Wikipedia: [http://en.wikipedia.org/wiki/Kivalina\\_v.\\_ExxonMobil\\_Corp.,\\_Et\\_al](http://en.wikipedia.org/wiki/Kivalina_v._ExxonMobil_Corp.,_Et_al).
      - **U.S. Army Corps of Engineers Kivalina Relocation Master Plan (2006):** <http://www.poa.usace.army.mil/en/cw/Kivalina/Kivalina.html>
    - **Newtok**—a Yup'ik community—is moving to an island the community has named Mertarvik. The Newtok Planning Group was formed in 2006 to plan for relocation, including representatives of Alaskan state and federal government agencies and regional non-profit organizations: [http://www.dced.state.ak.us/dca/planning/npg/Newtok\\_Planning\\_Group.htm](http://www.dced.state.ak.us/dca/planning/npg/Newtok_Planning_Group.htm)
    - **Shishmaref**—an Inupiaq (Inupiat) community—has created an Erosion and Relocation Coalition: <http://www.shishmarefrelocation.com/>
  - **Centre for Indigenous Environmental Resources (CIER): Climate Change Planning Tools for First Nations Guidebooks (2006).** A great set of starting-point guides for any

small/ rural community starting the climate change planning process, on tribal lands or anywhere. Includes specific examples of adaptation actions.

<http://www.cier.ca/information-and-resources/publications-and-products.aspx?id=412>

- **Columbia Basin Trust (CBT) Communities Adapting to Climate Change Initiative (CACCI).** The CBT is not exclusively a First Nations organization, but was formed as a result of negotiations between British Columbia, First Nations leaders and local communities to strengthen the local voice in the execution of the Columbia River Treaty (CBT 2008, Clark and Grant 2011).
  - **CBT Climate Change Initiative** (an overview of efforts):  
[http://www.cbt.org/Initiatives/Climate\\_Change/](http://www.cbt.org/Initiatives/Climate_Change/)
  - **CBT Adapting to Climate Change.** Includes links to case study documentation on the CBT's adaptation planning work in Castlegar, RDCK Area D/ Kaslo, Rossland, Kimberley, and Elkford communities.  
[http://www.cbt.org/Initiatives/Climate\\_Change/?Adapting\\_to\\_Climate\\_Change](http://www.cbt.org/Initiatives/Climate_Change/?Adapting_to_Climate_Change)
  - **CBT Adaptation Resource Kit.** Provides good examples of planning efforts at the local level involving multiple groups of stakeholders.  
<http://adaptationresourcekit.squarespace.com/>
- **Institute for Tribal Environmental Professionals (ITEP) Tribes and Climate Change Program:**
  - **ITEP Adaptation Planning Resources.** An extensive list of reports and resources potentially useful to tribes in planning for climate change:  
<http://www4.nau.edu/tribalclimatechange/resources/adaptation.asp>
  - **ITEP Policy References and Resources.** Includes policy statements from coalitions of tribal governments and international indigenous groups on climate change:  
<http://www4.nau.edu/tribalclimatechange/resources/policies.asp>
  - **ITEP Tribal Climate Change Adaptation Plan Template** (March 2011). Available by request in Word format. The template provides guidelines for creating a plan, including key terms and examples. Contact Sue Wotkyns, ITEP's Climate Change Program Manager, with your name, tribe or organization, and contact information: susan.wotkyns "at" nau.edu
- **National Tribal Air Association** (December 2009). **Impacts of Climate Change on Tribes in the United States.** A brief compilation of comments submitted to the U.S. Environmental Protection Agency and National Tribal Air Association by representatives of over 65 Tribal Nations. Impacts are classified by region. Includes a set of tribal government contacts (e.g., environmental directors and other relevant professionals), and references on tribal climate change impacts and planning resources:  
<http://www.epa.gov/oar/tribal/pdfs/Impacts%20of%20Climate%20Change%20on%20Tribes%20in%20the%20United%20States.pdf>

- **Pacific Northwest Tribal Climate Change Network**, hosted by the Tribal Climate Change Project of the University of Oregon Environmental Studies Program/ USDA Forest Service – PNW Research Station:  
<http://tribalclimate.uoregon.edu/network/>
- **Swinomish Office of Planning and Community Development Climate Change Initiative**. The Swinomish Tribe may be the first lower-48 tribe to create a tribal adaptation plan. According to Ed Knight, the Senior Planner responsible for guiding the tribe’s adaptation planning process, a series of bad storms affecting the coastal tribe (in the Puget Sound area of Washington State) led to a 2007 resolution on creating a climate change adaptation plan (personal communication, September 2011). Read the “Proclamation of the Swinomish Indian Senate on a Swinomish Climate Change Initiative” here: [http://www.swinomish-nsn.gov/climate\\_change/Docs/Swinomish%20Climate%20Change%20Proclamation.pdf](http://www.swinomish-nsn.gov/climate_change/Docs/Swinomish%20Climate%20Change%20Proclamation.pdf)
  - **Swinomish climate change planning efforts as summarized by the Institute for Tribal Environmental Professionals:**  
[http://www4.nau.edu/tribalclimatechange/tribes/northwest\\_swinomish.asp](http://www4.nau.edu/tribalclimatechange/tribes/northwest_swinomish.asp)
  - **Swinomish climate change impact and adaptation reports** (2009 and 2010 respectively):  
[http://www.swinomish-nsn.gov/climate\\_change/project/reports.html](http://www.swinomish-nsn.gov/climate_change/project/reports.html)
- **United Kingdom Government Resources:**
  - **UK Climate Impacts Programme (UKCIP) “Tools”** webpage, directed at local governments, principally links to vulnerability assessment tools, including an “Adaptation Wizard”: <http://www.ukcip.org.uk/tools/>
  - **UKCIP (2008). Identifying Adaptation Options**. Like the Snover et al. (2007) guidebook produced by ICLEI, this is another good “how-to” written accessibly for government policy practitioners. *Appendix 1* presents a useful list of specific examples of adaptation actions currently in use. They are divided into two main categories: *building adaptive capacity* (research, monitoring, changing regulations, internal organizational development, awareness-raising, and working in partnership) or *delivering adaptation actions* (living with and bearing losses or risk, sharing responsibility for losses or risk, risk prevention or avoidance, and exploiting opportunities).  
[http://www.ukcip.org.uk/wordpress/wp-content/PDFs/ID\\_Adapt\\_options.pdf](http://www.ukcip.org.uk/wordpress/wp-content/PDFs/ID_Adapt_options.pdf)
- **United Nations Development Programme (UNDP) Resources:**
  - **Climate-Eval**. This is a site created by the UNDP’s Global Environment Facility to provide networking and other support for those working on the evaluation of climate change and economic development interventions. It includes information on ways to evaluate both adaptation and mitigation interventions.  
<http://www.esdevaluation.org/gefeo/>

- **Adaptation Policy Frameworks for Climate Change.** Published in 2004, this represents some of the first “how-to” guidance to help governments begin thinking about adaptation policy.<sup>122</sup> <http://www.undp.org/climatechange/adapt/apf.html>
- **U.S. Government Resources:**
  - **U.S. Department of the Interior Climate Change Adaptation and Decision Support Tools:** <http://www.doi.gov/whatwedo/climate/adaptation.cfm>
  - **U.S. Environmental Protection Agency’s Climate Ready Water Utilities Toolbox.** This highlights some top resources (shown by category), and has others searchable by geographic region, water utility type and size, water resources, climate change impact, and climate change response strategies: <http://www.epa.gov/safewater/watersecurity/climate/toolbox.html>
  - **U.S. Forest Service Climate Change Resource Center (2009). Adapting to Climate Change: A Short Course for Land Managers.** Featuring: Furniss, M. J.; Millar, C. I.; Peterson, D. L.; Joyce, L. A.; Neilson, R. P.; Halofsky, J. E.; Kerns, B. K. DVD available, or streaming videos viewable here: <http://www.fs.fed.us/ccrc/hjar/>
  - **U.S. National Park Service Climate Change Response Program “Useful Resources and Links.”** This list includes links to many individual parks’ climate change webpages, as well as key scientific research centers: <http://www.nature.nps.gov/climatechange/resources.cfm>
  - **The White House Council on Environmental Quality/Interagency Climate Change Adaptation Agency Working Group: Federal Agency Climate Change Adaptation Planning: Support Document, 2011 (on CAKE):** <http://www.cakex.org/virtual-library/3221>
- **World Wildlife Fund (WWF) – U.S. (September 2011). “Some of My Favorite Climate Change Adaptation Resources,”** by S. Martin, Managing Director of Conservation Leadership and Capacity Building. This is a brief, annotated list of resources to assist in adaptation planning: <http://www.climateprep.org/2011/09/09/some-of-my-favorite-climate-change-adaptation->

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<sup>122</sup> It bears mentioning that this adaptation policy framework was developed by a team of highly accomplished thinkers in the climate change policy field. Edited by Bo Lim, then Senior Technical Advisor at UNDP’s Global Environment Facility (now UNDP’s Special Advisor for Development and Climate Change Adaptation), and Erika Spanger-Siegfried, then Associate Scientist with the Stockholm Environment Institute – Boston Center (now a senior analyst at the Union of Concerned Scientists), and co-authored by Ian Burton, Scientist Emeritus with the Meteorological Service of Canada (the lead author on the chapter “Moving Forward on Adaptation” in Natural Resource Canada’s national climate change impact assessment *From Impacts to Adaptation: Canada in a Changing Climate 2007*); Elizabeth Malone, a Senior Research Scientist at Battelle Washington Operations; and Saleemul Huq, then Executive Director of the Bangladesh Centre for Advanced Studies (also a leading author on equity in climate change planning, now a senior fellow at the International Institute for Environment and Development).

[resources/?utm\\_source=feedburner&utm\\_medium=email&utm\\_campaign=Feed%3A+ClimatePrep+%28Climate+Prep%29](resources/?utm_source=feedburner&utm_medium=email&utm_campaign=Feed%3A+ClimatePrep+%28Climate+Prep%29)

His list includes the Snover et al. (2007) guidebook produced by ICLEI and the following:

- **Climate Change Information for Effective Adaptation: a Practitioner's Manual** by Dr. Juergen Kropp and Michael Scholze (2009):  
<http://ccsl.iccip.net/gtz2009-0175en-climate-change-information.pdf>
- **Climate Change Glossary** at Reegle.info (no copyright date on site, developed by the Austria-based Renewable Energy & Energy Efficiency Partnership):  
<http://www.reegle.info/glossary>
- **The Psychology of Climate Change Communication** by the Center for Research on Environmental Decisions (CRED) at Columbia University (2009):  
<http://www.cred.columbia.edu/guide/>