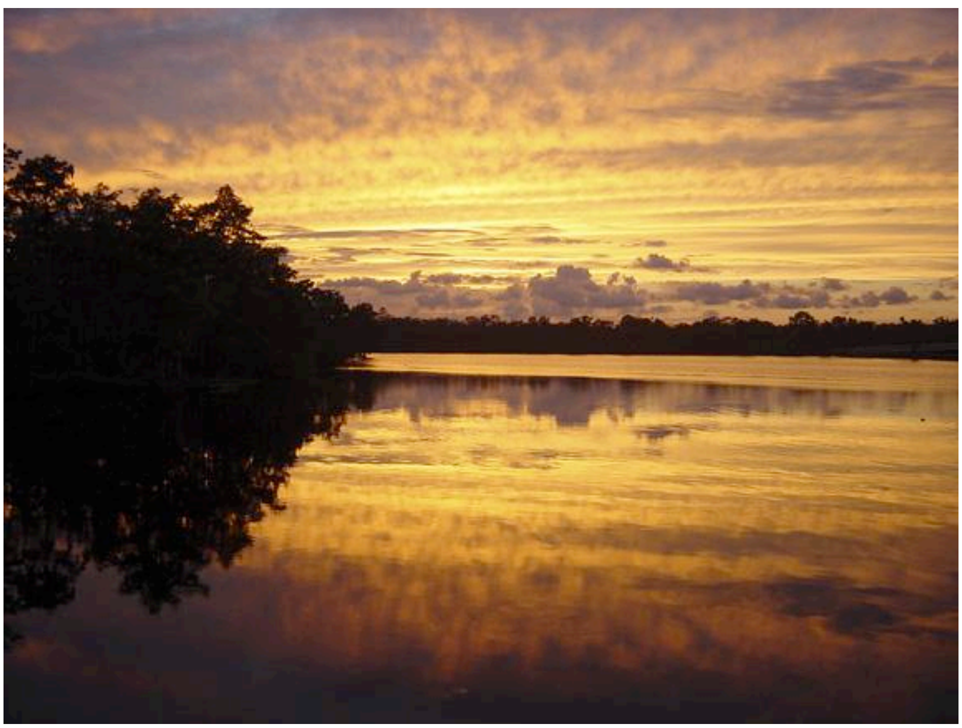
Climate Change and Conservation: A Primer for Assessing Impacts and Advancing Ecosystem-based Adaptation in The Nature Conservancy

March 2010



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Cover: Albemarle Peninsula, North Carolina (Christopher E. Zganjar © The Nature Conservancy). On the Albemarle Peninsula, TNC staff members are working with the U.S. Fish and Wildlife Service and other partners on the Alligator National Wildlife Refuge to implement a comprehensive set of strategies to mitigate the effects of rising sea level including hydrological restoration, land conservation, reforestation, oyster reef restoration, and shoreline restoration. Such efforts will help sustain important natural communities and important ecosystem services such as clean water and ocean and forest products.

PREFACE

The Conservation Leadership Team of The Nature Conservancy has established climate change as one of four strategic focal areas for The Nature Conservancy. Within the Climate Change focal area, the Conservancy is engaged on many fronts related to both mitigation of greenhouse gas emissions and adaptation to the impacts of climate change on natural and human communities. In the adaptation arena, our vision of success is:

Ecosystem-based adaptation strategies are widely used by public and private institutions as an effective way to sustain essential human needs like water, food and natural resources, and protect against natural hazards like coastal and river flooding, drought and fire while preserving biodiversity. We will realize this vision by showing how ecosystem-based adaptation works in real places, empowering others to act by sharing what we know, and leveraging our knowledge and relationships to align policies and incentives and to create public/private partnerships that can deliver benefits at scale.

As climate change continues, the risks to people and to The Nature Conservancy's conservation mission grow larger and more severe. Our conservation mission and commitment to delivering long-term benefits for both nature and people give us a direct stake in developing and implementing strategies that can sustain nature in the face of unavoidable impacts. At the recent Copenhagen Climate Conference, billions of dollars were pledged to support adaptation actions. The Conservancy's challenge is to turn those resources into tangible global impact that benefit both people and nature with science-based, field-tested climate adaptation solutions.

The Global Climate Change Program is focused on four principal strategies to advance ecosystem-based adaptation:

- **Making the case** and setting global priorities for ecosystem-based adaptation by clearly defining what ecosystem-based adaptation is and is not, and showing where and what the needs and opportunities are.
- **Building the know-how and can-do** among practitioners and partners by supporting priority demonstration projects, facilitating learning, and developing tools and methods that others can use.
- **Cultivating commitment, funding and capacity** for ecosystem-based adaptation in other institutions like government agencies, development agencies, humanitarian/aid NGOs.
- **Promoting public/private partnerships** for ecosystem-based adaptation that deliver large-scale benefits for people and nature.

The Global Climate Change Program will be working closely with each of TNC's regions and focal area teams to achieve the vision of ecosystem-based adaptation. As an organization we will be most effective in working towards this vision when staff members across the Conservancy have a sufficient appreciation of climate change impacts, an understanding of how to analyze and predict those impacts, an awareness of ongoing efforts in and outside of TNC on adaptation, and the tools to design and implement strategies to abate and mitigate these impacts for both nature and people. This primer, aimed toward a TNC audience, is designed to help meet these ends.

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TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY

Scarcely a day passes when we don't hear or read about a new impact of climate change on the environment. Conservancy scientists, practitioners, and managers now find themselves wrestling with how to best adapt our conservation work to a changing climate. Not long ago, many environmental and conservation organizations were reluctant to focus on adaptation over concerns that they would risk drawing attention away from mitigation efforts. This is no longer the case. There is an enormous amount of attention now being paid to adaptation as evidenced by a proliferation of web sites, scientific publications, books, and conferences that address the topic. At the same time, knowledge about impact assessments and adaptation, especially ecosystem-based adaptation, is highly variable across The Nature Conservancy, and even in the best staffed programs, this is a difficult field with which to stay up-to-date. This primer is intended to provide all Conservancy staff with an introduction to climate impacts and ecosystem-based adaptation, a review of basic definitions, updates on new conservation planning approaches that incorporate adaptation, tools and resources to assist in impact analyses and strategy identification, an overview of ecosystem-based adaptation in the policy arena, and summary information on adaptation approaches.

Ecosystem-based adaptation is a term whose history can be traced to the international climate policy arena. At its core, it refers to taking conservation actions that will benefit both nature and people in the face of climate change impacts. The Conservancy is currently involved in hundreds of conservation projects across the organization, many of which will be impacted by climate change. Some of these projects work closely with local (human) communities while others are only involved more secondarily or indirectly with people. Although our strategic emphasis in the future will be on adaptation strategies that benefit both nature (biodiversity) and people, the methods, tools, approaches, and resources outlined in this primer should be helpful to all conservation projects, regardless of the degree of emphasis on human well-being. Moreover, our methods, tools, and approaches for better incorporating the people side of the equation in adaptation work will clearly be improved in future editions of this primer as well as other guidance materials.

As a result of the Conservancy's 2009 Climate Adaptation Clinic, new guidance is available on incorporating adaptation strategies into Conservation Action Planning (CAP). A parallel effort is now complete for incorporating impact analyses and adaptation considerations into ecoregional and regional-scale assessments. Many additional tools are described which can assist Conservancy practitioners in incorporating adaptation considerations into our conservation work at all levels of the organization. Chief among these tools is the Climate Wizard - a Web-based, interactive, mapping tool that analyzes historic and projected future data on temperature and precipitation changes at a variety of scales relevant to the Conservancy's work. Learning networks and an adaptation projects database are among several other useful tools that we describe.

As necessary as it is to incorporate impact assessments and adaptation strategies into our own conservation work, there is also much to be gained for advocating for ecosystem-based adaptation in the US and international policy arena such as the recently held Climate Conference in Copenhagen. Ecosystem-based adaptation, or using restoration or management of functioning natural systems to help minimize negative impacts of climate change on people and biodiversity, is a natural extension of our work on ecosystem services and multi-stakeholder driven conservation planning. With an understanding that even the most successful policies that mitigate for elevated greenhouse gases in the atmosphere won't be sufficient, Conservancy scientists and government relations staff have diligently advocated for years to increase funding for and implementation of adaptation strategies, particularly in the developing world. This primer provides a summary of some of the Conservancy's most important work on adaptation in the policy arena.

An understanding of the likely direct and indirect effects of climate change on conservation targets, key ecosystem processes, and human communities is critical to the Conservancy's work. This primer provides frameworks, methods, and case studies for conducting impact assessments to obtain this critical information. The goal of these impact assessments is to evaluate exposure of natural and human communities to changes in climate, and to link this exposure with sensitive aspects of species' life histories or key processes that shape ecosystems. Understanding exposure to *and* sensitivity to climate change allows us to evaluate vulnerability, and develop priorities with respect to implementing adaptation actions.

Several good syntheses of adaptation strategies and approaches are now available and referenced in this primer. Yet, as a general rule, the conservation community is only now gaining on-the-ground experience in conservation projects that will enable us to eventually provide more specific guidance on how, when, and where to implement adaptation strategies. At the same time, many conservation practitioners inside and outside the Conservancy increasingly recognize that they already have many of the methods, tools, and strategies at their disposal to mitigate to some degree the most deleterious effects of climate change, especially reducing existing stressors to ecosystems (e.g., invasive species, altered fire and flow regimes). In many cases, we simply need to do a better job of explaining how what we are doing contributes to adaptation, how we are updating our strategies to make our contribution to adaption even stronger, and most importantly – disseminate best practices in adaptation across the conservation community as quickly and efficiently as possible. The primer reviews many of the existing strategies that we can put to use now, and identifies several new mechanisms by which conservation practitioners can learn about the best practices of their colleagues.

Climate change projections and responses by species and systems to this change are both associated with many forms of uncertainty. This uncertainty is best addressed through consistent use of an adaptive management framework in the implementation of adaptation strategies. Fortunately, the concept of adaptive management is well integrated within and being advanced by the Conservancy's efforts to better evaluate the effectiveness of its strategies and actions through its Conservation Measures Initiative.

2.0 INTRODUCTION

On nearly a weekly basis there is a new web site, announcement of a conference, or a new report or scientific paper on climate change and adaptation. At the same time, there is much work underway in The Nature Conservancy that focuses directly or indirectly on adaptation – the September 2009 Climate Clinic, our international policy work on ecosystem-based adaptation, and numerous on-the-ground adaptation projects are just a few examples. From the perspective of any one operating unit of the Conservancy, it is difficult to stay current on all of these developments.

In this introductory section, we aim to outline the more detailed objectives of this primer, acquaint the reader with some of the observed and projected impacts of climate change, review some commonly used terminology related to climate change and adaptation, and provide a brief overview of some important concepts related to the modeling of climate change impacts and uncertainty associated with that modeling.

2.1 Objectives of Primer

The purpose of this primer is to provide our field operating units, regional programs, and appropriate Worldwide Office programs with up-to-date information on important developments inside and outside the Conservancy that could help us be more effective in confronting the impacts of climate change and adapting our strategies as needed. More specifically, we intend for this primer to:

- Provide an introduction to climate change and the observed and predicted impacts of these changes on biodiversity.
- Identify a set of frequently-asked questions that TNC managers, scientists, and project directors need to be able to answer to effectively address the challenge of climate change.
- Define commonly used terminology in the climate change community.
- Outline proposed guidance to incorporate climate change considerations in the Conservancy's conservation planning methods.
- Inform staff of tools (e.g., Climate Wizard), web mapping services (e.g., Coastal Resilience), data (e.g., general circulation models or GCMs), toolkits and learning networks (e.g., Reef Resilience), and other resources (web sites, reports, scientific papers), and international policy work that are collectively advancing efforts to design, implement, and promote ecosystem-based adaptation practices.
- Provide an understanding of how and when to conduct impact and vulnerability analyses and an overview of the wide array of ecosystem-based adaptation strategies that can potentially address climate change impacts.

Most conservation practitioners and managers are just beginning to broach the issue of climate change in the context of their already complex jobs. In doing so, a plethora of questions often come to mind. Based on recent informal surveys of managers and scientists in the Conservancy, we have compiled a set of questions (Box 1) that are often asked by practitioners starting to grapple with the issue. This primer is intended to shed some light on these questions and point readers to existing resources where further guidance may be found.

Box 1. Frequently Asked Questions about Climate Change and Adaptation in TNC addressed in this Primer

1. Do we need to revise our ecoregional assessments or conservation action plans (CAP) in the face of climate change? What sort of guidance is available to do these revisions?
2. Should we focus on adaptation or mitigation (and what's the difference)?
3. What is the state of the knowledge on climate models (e.g., temperature, precipitation) and ecological response models (e.g., dynamic vegetation models, species distribution models)?
    a. Are model outputs available at the spatial scale of interest to most managers (e.g., preserve, ecoregion, state, country)?
    b. How should we deal with "model uncertainty?" Will better models be available soon?
4. Should we conduct an assessment of impacts or vulnerability?
    a. If so, what are the best approaches to these assessments?
    b. What level of conservation target should I focus on - species, ecosystems, or processes? What is the appropriate temporal and spatial scale?
    c. How does an assessment inform conservation and management priorities (e.g., should we focus attention on the most vulnerable places or species, or the least vulnerable?)
5. What are examples of climate change adaptation strategies?
    a. Will managing for resilience be adequate for the pace of change expected? (And what is resilience – we hear it used in a variety of ways?)
    b. How do we evaluate the risk of being wrong and ensure that we learn from our mistakes?
    c. How do we balance resources allocated toward specific action based on "best guesses" versus actions designed to hedge our bets in the face of uncertainty?
6. How does adaptation planning relate to how we implement adaptive management?
7. Are our project or program-level conservation goals achievable and relevant in the face of climate change?
8. What are the ways in which people will be most affected by climate-related changes in ecosystems?
    a. How do we most effectively deal with the impacts of climate change on people and the communities with which we work, and anticipate adaptive responses by people that may stress biodiversity?
    b. How can our adaptation efforts most efficiently support the needs of both people and nature?

2.2 Changing Climate

The Earth's terrestrial, freshwater, and marine habitats face an uncertain climatic future. Although climate has changed repeatedly over past millennia, for a variety of reasons, anticipated human-driven changes are likely to be unusually fast and large (Houghton et al. 2001). Global mean annual temperatures have already increased by 0.75 °C (1.3 ºF) between 1901 and 2002, and are projected to increase by another 2 to 4°C (3.6 to 7.2°F) before 2100 with considerable changes in the timing and distribution of precipitation (IPCC 2007a). However, these changes in temperature and precipitation are occurring at different rates around the world (Girvetz et al. 2009).

While 0.75 °C rise in the global mean temperature may seem a small change, this increase has already had a demonstrable impact on natural resources as maximum high temperatures and droughts have become more pronounced and acute over the last 100 years. This trend is projected to continue over the next 100 years (Christensen et al. 2007). While the public generally appreciates that a world of rapidly changing climate is not desirable for nature or for people, most do not understand the gravity of the situation and the need to act now to mitigate emissions and adapt our conservation actions to a changing climate. If we remain on the current greenhouse gas emission trajectory, we are committed to no less than a global mean temperature increase of 3 ºC (5.4 ºF) (Figure 1).

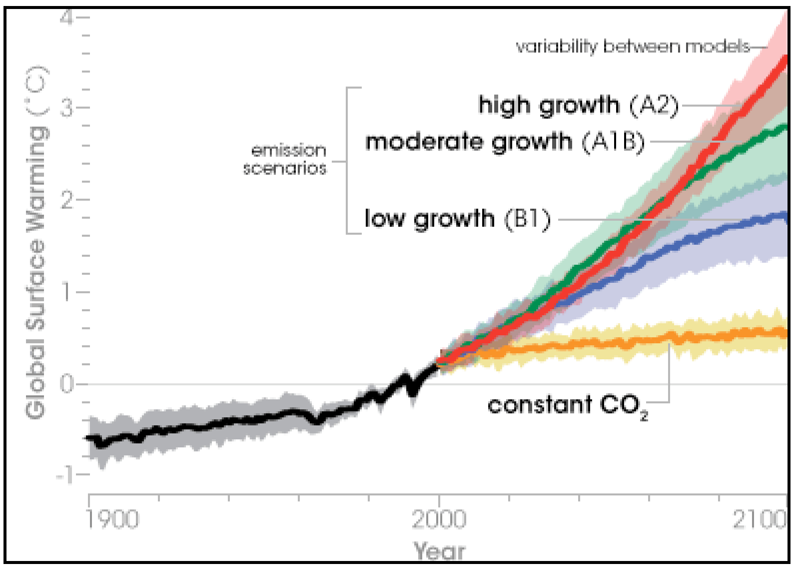


Figure 1.Projected increases in global surface temperature as predicted by different models of the Intergovernmental Panel on Climate Change (IPCC). More information on emission scenarios and IPCC models is provided in Section 2.6 of this primer.
Source: http://www.epa.gov/climatechange/science/futuretc.html Based on IPCC Fourth Assessment Report (2007).

The rate at which these temperature changes are occurring suggests that many, if not most, wild species will experience climate change as a stressor that reduces survival and/or reproduction, and thus has strong potential to lead to population declines, or even extinction. The most recent Intergovernmental Panel on Climate Change (IPCC) report, which represents the consensus view of a team of hundreds of scientists from across the globe, suggests that 15-40 percent of species will be at increasingly high risk of extinction as global mean temperatures reach 2 to 3ºC above pre-industrial (or 1.2 to 2.2ºC above current) levels (Field et al. 2007, based on work in Thomas et al. 2004).

2.3 Observed Impacts of Climate Change

Impacts of climate change have been well-documented for terrestrial, aquatic, and marine ecosystems. Although readers of this primer will undoubtedly be aware of the more well publicized impacts of climate change such as sea level rise, ocean acidification, insect outbreaks, coral reef bleaching, and melting of sea ice and permafrost, there are many less obvious ecological impacts on ecosystems across the globe. These include changes in the length of the growing season and stratification period in lakes, in the timing of seasonal events (phenology), in patterns of primary production, and in species distributions and diversity (Peñuelas and Filella 2001, Walther 2002, Parmesan and Yohe 2003, Root et al. 2006, Austin and Coleman 2007, Field et al. 2007). Mismatched changes in seasonal timing of interacting species have been documented in terrestrial, aquatic, and marine ecosystems (e.g., Winder and Schindler 2004, Both et al. 2009, Thackeray et al. 2010), and have serious implications for the life cycles and competitive abilities of numerous species. Similarly, as species vary widely in their abilities to shift location in response to climate change, we can expect impacts from disruptions in key species interactions, and additional stress on species from both native and non-native species, and disease vectors that shift into new locations. Researchers have begun to explore the implications of these changes for the provisions of ecosystem services (*sensu* Millennium Ecosystem Assessment 2005). Many of the most pernicious impacts on biodiversity will not be direct but come as a result of altered species interactions (e.g., Pounds et al. 2006).

Examples of different ecological effects in Europe and North America include shifts in spring events such as budburst, floral abundance, egg laying, bird migration, and the hatching of caterpillars occurring earlier over the course of the last 30 years (Menzel et al. 2006; Schwartz et al. 2006; van Asch and Visser 2007; Inouye 2008). Evidence from two comprehensive analyses and a synthesis on a broad array of species and ecosystems suggests that there is a significant impact of recent climatic warming in the form of long-term, large-scale alteration of animal and plant populations (Parmesan and Yohe 2003; Root et al. 2003, Parmesan 2006). Figure 2 summarizes the complexity of effects on species we can anticipate from predicted climate changes.

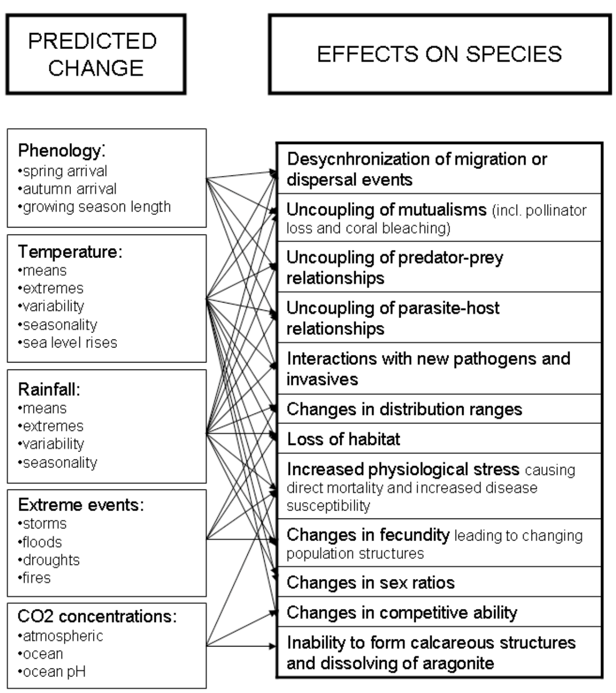


Figure 2. Climate change impacts and their predicted effects on species. Used by permission from Foden et al. 2008.

2.4 Projected Impacts of Climate Change

Climate change is likely to exacerbate further the loss of ecosystems and the services they support and on which humans depend. While ecosystems have always changed over time, the ecosystem effects of climate change are likely to be made more severe by the dramatic loss of natural areas we have experienced in the last half century. Natural area loss is a primary factor leading to the decline in many important ecosystem services worldwide (Millennium Ecosystem Assessment 2005), particularly the loss of terrestrial biodiversity (Wilcove et al. 1998). The amount of land and water currently under conservation status is insufficient to sustain biodiversity, to adequately protect ecosystem services for people into the future, or to facilitate the natural adaptation of the earth's species. Additional stresses to species and ecological systems are also likely to come from increased invasions from non-native species, more frequent high-intensity fires, increased drought stress, changes in the relative competitive advantage of species as conditions change, and from new barriers to migration that arise as humans change their environment to promote their own adaptation.

In rivers and streams, low and high temperature changes will likely cause isolation of nearby wetlands and a loss of habitat for wetland dependent fish. A decrease in the snow pack will yield a weaker spring flood, threatening freshwater wetlands and floodplains which depend on this seasonal inundation. Key wetland services, like the assimilation of nutrients and storage of sediment may also be affected by the changing hydrologic regimes (Grubin et al. 2007). Under pressure from climate change and the full array of stressors, these ecosystems, including the distinctive species associated with these places, will necessarily respond and change. As a result, it is likely that many species and ecosystems, and the direct value we derive from them via ecosystem services will also be altered dramatically.

2.5 Climate Change and Adaptation Terminology

To conduct or understand climate change impact analyses or develop adaptation strategies, it is necessary to have a basic understanding of the terminology associated with this body of work. Although far from exhaustive, in the following section we have defined some of the more commonly used terms in the rapidly growing adaptation literature.

To begin with, this primer is focused on **Ecosystem-based Adaptation** which is not synonymous with the broader term of **adaptation**. As defined by the Second Ad-hoc Technical Expert Group on Biodiversity and Climate Change[1] (AHTEG 2009),

> **"Ecosystem-based adaptation is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change.** Ecosystem-based adaptation uses the range of opportunities for the sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change. It aims to maintain and increase the resilience and reduce the vulnerability of ecosystems and

[1] AHTEG is a group established by the Secretariat's office on the Convention on Biological Diversity (CBD) to provide biodiversity-related information to the United Nations Framework Convention on Climate Change (UNFCCC).

people in the face of the adverse effects of climate change. Ecosystem-based adaptation is most appropriately integrated into broader adaptation and development strategies."

Adaptation as used by the IPCC (Schneider et al. 2007) is a broader term defined as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. From this perspective, adaptation is the whole range of activities that society will undertake in response to climate change. Some of these will involve the use of natural ecosystems (e.g., conserving mangroves for flood control) while others will not (e.g., building sea walls). Although The Nature Conservancy and its staff will need to be aware of and in many cases respond to the variety of forms of societal adaptation, our primary focus will be working with natural ecosystems and advancing ecosystem-based adaptation. We acknowledge that many of these ecosystems will change in species composition and function over time under the influence of climate change and that our ecosystem-based strategies will need to account for such changes.

Although the Conservancy is moving in a direction of advancing adaptation projects that will benefit both people and biodiversity, we are also engaged in many long-running conservation projects in which our primary interest remains biodiversity conservation and only secondarily or indirectly involve working with human communities. Even though the balance of adaptation projects focused primarily on biodiversity targets versus those aiming to benefit both people and biodiversity may shift in the future, most of the methods, tools, analyses, resources, and strategies outlined in this primer should prove helpful regardless of that emphasis. Even under the umbrella of ecosystem-based adaptation, this first edition of the primer is largely aimed at adaptation activities and strategies within natural ecosystems. At the same time, we acknowledge that we are already engaged in numerous projects to promote "green infrastructure" across a variety of human-dominated and natural ecosystems including, for example, reducing impacts of agricultural practices on freshwater ecosystems in the Midwestern U.S.

Vulnerability is a concept that appears repeatedly in the adaptation literature. The IPCC (2007b) defines vulnerability as the degree to which a system (either a natural system or a human dominated one) is susceptible to and unable to cope with adverse effects of climate change, including climate variability and extremes. Although these concepts are primarily being applied to ecological systems, they could be applied to human-dominated systems as well. Operationally, vulnerability can also be defined as:

Vulnerability = Exposure + Sensitivity – Adaptive Capacity

With:

Exposure = general degree, duration, and/or extent in which a system is in contact with a perturbation (Adger 2006) (perturbation in this sense is related to the character, magnitude, duration, and variability of climate change)

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., change in crop yield due to change in temperature) or indirect (e.g., damage caused by increased frequency of coastal flooding due to sea-level rise).

Adaptive Capacity = the ability of a system (including natural and human-dominated systems) to adjust to climate change including climate variability and extremes to moderate potential damages, to take advantage of opportunities, or to cope with consequences

Finally, no discussion of adaptation would be complete without mention of the concept of resilience. The IPCC defines **resilience** as "the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and function, the capacity for self-organization, and the capacity to adapt to stress and change." Although we consider this to be a useful definition, Conservancy staff should be aware that resilience can be a confusing term with a wide range of interpretations in the ecological literature.

The complete glossary of climate change and adaptation terms from the Working Group II Contribution to the Fourth Assessment Report of the IPCC (Climate Change 2007: Impacts, Adaptation, and Vulnerability) can be downloaded from the IPCC web site: http://www.ipcc.ch/pdf/glossary/ar4-wg2.pdf

The terms presented in this section will be used with examples in several places in this primer. In addition, Section 6 of this primer (Evaluating Impacts and Advancing Adaptation Strategies) will define and use some additional terms related to adaptation frameworks.

2.6 Interpreting and Using Climate Change Projections and Related Models

Climate modelers have applied different greenhouse gas emissions (GHG) scenarios to simulations using general circulation models or GCMs (Figure 3) which calculate the interrelationships of the Earth's elements (i.e., solar input, changes in hydrological cycle, land use changes, changes in atmosphere, and so forth) to project future climate trends (IPCC 2007a, Krapp and Scholze 2009). General circulation models are computer models that divide the Earth into grid cells and then calculate, with the aid of supercomputers, the climatic state for each cell. For the latest IPCC report, 23 different GCMs were taken into consideration, each differing by grid cell resolution and the emphasis placed on various physical processes.

The direct outputs of these GCMs are typically not very useful to managers because they lack the resolution at local and regional scales where environmental impacts relevant for natural resource management can be evaluated. As a result, finer-scale models which take into consideration local features such as mountains, lakes, and cities have been developed. The general technique for developing these finer-scale climate models is referred to as downscaling and there are several different methodological approaches to downscaling projections from general circulation models (e.g., Salathé, Jr., 2003, Wood et al. 2004, IPCC 2007a). The three main approaches are: 1) dynamic downscaling (often referred to as regional climate modeling); 2) statistical downscaling; 3) downscaling using weather generators (for more information see: http://www.climate-decisions.org/2_Downscaling%20Climate%20Data.htm)

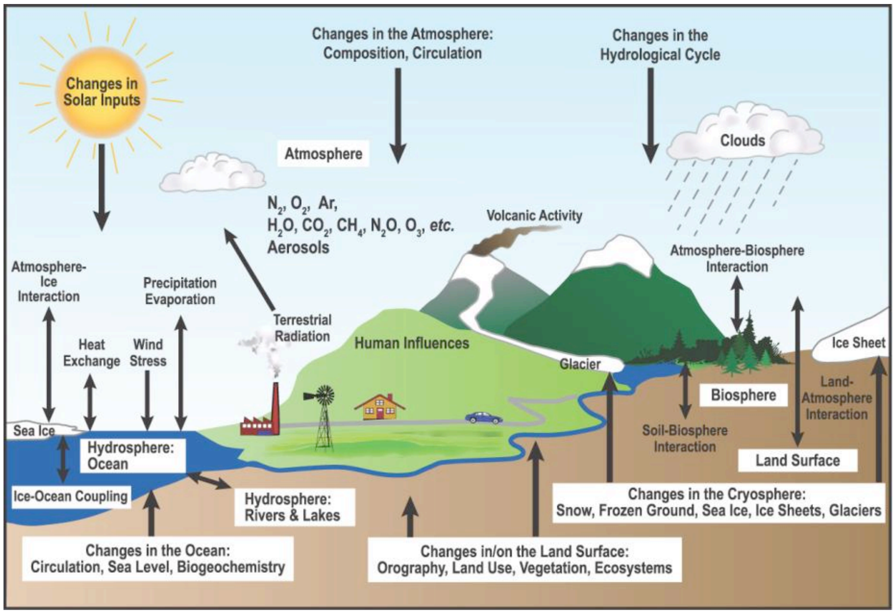


Figure 3. Important factors taken into consideration in the development of General Circulation Models or GCMs. Source: IPCC, http://www.ipcc.ch/graphics/ar4-wg1/jpg/faq-1-2-fig-1.jpg

Using any of these different techniques, model outputs from GCMs derived at the coarse grid scales of 2.5° x 3.25° (roughly 200–500 km^2, depending on latitude) can be downscaled to make climate projections at resolutions of 10-50 km. Results of these downscaled or regional climate models can be used to make predictions about local areas that are likely to get hotter or colder or wetter or drier over specified time periods due to changes in climate. These predictions can then serve as input into additional models and analyses that can predict, for example, shifts in vegetation (e.g., dynamic vegetation models, see http://en.wikipedia.org/wiki/Dynamic_global_vegetation_model) or changes in individual plant and animal distributions (e.g., climate envelope models - Hijmans and Graham 2006, Lawler et al. 2009). Figure 4 provides an overview of the relationship among emission scenarios, GCMs, regional climate models, and impact analyses.

There are many sources of uncertainty in predicting future climate change as well as the impacts of those changes on biological and human communities. We can distill these uncertainties down to three types: climate uncertainties (how will the climate change?), ecological uncertainties (how will ecological systems respond to climate change?), and human uncertainties (how will human systems change in response to climate and ecological change?). General circulation models themselves are full of uncertainties as they are essentially trying to represent the complexity of the Earth's set of physical systems and processes. And these uncertainties are further amplified with the application of these climate projections to various ecological impact models mentioned previously (e.g., dynamic vegetation models). In addition, the outputs of global and regional climate models are focused on changes in average temperature and precipitation regimes while it is often the changes in the frequency, timing, and magnitude of extreme weather events which climate scientists are not able to reliably predict that are imposing the most severe stress on species and ecosystems.   In their guidance on climate change and regional assessments, Conservancy scientist Edward Game and colleagues provide additional discussion about uncertainty in climate change analyses (see Section 3.2 of this primer below).

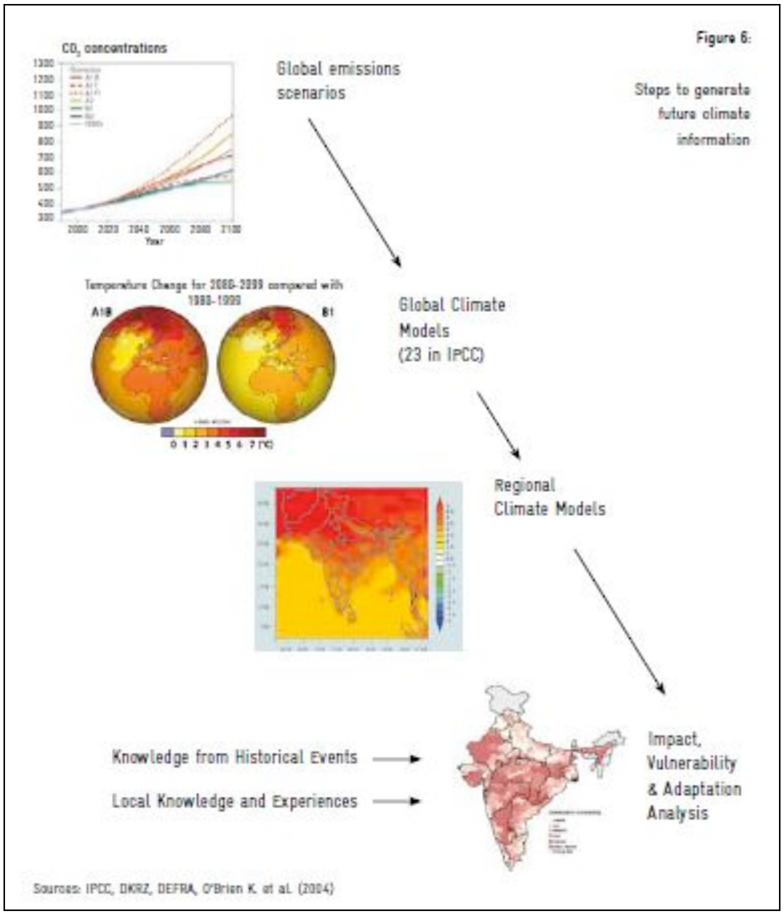
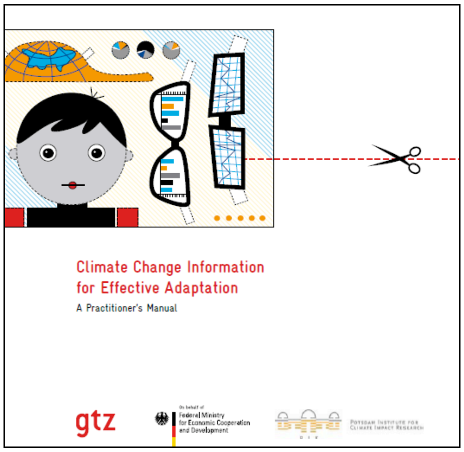


Figure 4. Steps involved in climate impact and vulnerability assessments from generation of emission scenarios to downscaling of General Circulation Models into Regional Climate Models. Used by permission from Kropp and Scholze (2009).

The high degree of uncertainty inherent in assessments of climate change impacts on natural resources can make it difficult for a manager to translate results from those assessments into practical management action. By working with a range of possible futures rather than a single projection (see Figure 1), managers can focus on developing the most appropriate responses based on that range rather than on a "most likely" outcome. Seen through this lens, uncertainty is not the same thing as lack of information—it simply means that there is more than one outcome possible as a result of climate change. The challenge for natural resource managers and conservationists is to manage this uncertainty, not overcome it.

In addition to exploring a range of alternative future climate scenarios, there are other approaches that we can take to help manage uncertainty. For example, in many local and regional situations, some physical or ecological systems may be sufficiently well understood that expert panels may be able to reduce uncertainties in how these systems are most likely to respond to climate change. Longer-term decisions with regard to adaptation strategies can be broken into a series of shorter-term decisions with a greater emphasis on monitoring and learning how ecological and human systems are responding to climate change. Finally, we can attempt to deploy robust adaptation strategies that do not rely on specific climatic futures but are likely to prove beneficial for conservation under a range of possible climate futures. In the remaining sections of this primer, we will recommend conservation planning approaches and explore case studies that consider various approaches to reducing uncertainty.



Readers interested in additional information about emissions scenarios, climate models, uncertainty, and adaptation in a broad sense may want to consult this handbook. It's available from: http://www2.gtz.de/dokumente/bib/gtz2009-0175en-climate-change-information.pdf

3.0. Climate Change, Adaptation, and Conservation Planning

The Nature Conservancy has traditionally conducted two different types of conservation planning:

1. Strategic conservation plans known as CAPs or Conservation Action Plans at the scale of conservation projects
2. Ecoregional or regional assessments which have primarily been prepared for the purpose of addressing what biodiversity we should try to conserve, where we should work in a region or ecoregion to conserve this biodiversity, and which of these places are highest priority.

Two separate efforts were initiated in 2009 to develop guidelines for conservation planning in the context of climate change for Conservation Action Plans and Ecoregional Assessments, respectively. These efforts and their guidance are described below.

3.1 Climate Clinic and CAP Adaptation Guidance

From September 1-3, 2009, The Nature Conservancy sponsored a Climate Adaptation Clinic. This 3-day event brought together 200 project staff, external partners, facilitators and climate science and policy experts for an Efroymson-style peer review workshop to help 20 conservation projects amend their existing conservation plans and develop specific, actionable climate adaptation strategies. Prior to the clinic, project teams were expected to understand the potential impacts of climate change on their project, especially on the conservation targets. In addition, each team was asked to develop specific "hypotheses of change" (Figure 5, Table 1) for their conservation targets over the next 50 years. In essence, project teams came to the clinic with their existing strategies and left with "climate-adapted" targets, strategies, and actions.

Detailed guidance for revising Conservation Action Plans in the face of climate change was provided to all Clinic participants. Based on lessons learned at the Clinic, this guidance has now been revised and is available to all conservation practitioners in TNC (Box 2). More detailed information about the Climate Clinic can be found at http://conserveonline.org/workspaces/climateadaptation/documents/climate-clinic

Box 2. CAP Guidance for Adaptation Projects

Clinic participants were expected to have already completed a CAP or Conservation Action Plan for their project prior to the Climate Clinic. Specific guidance was then provided to each project attending the Clinic for revising their CAP. The key steps in this guidance are:

Step 1 – Understand the Potential Ecological Impacts of Climate Change
Step 2 – Formulate Specific Ecological Hypotheses of Change
Step 3 – Explore Potential Human Responses to Climate Change
Step 4 – Determine which Climate-induced Threats are Most Critical to Address
Step 5 – Evaluate if Potential Climate Impacts Fundamentally Change the Project
Step 6 – Develop Adaptation Strategies and Evaluate their Feasibility and Cost
Step 7 – Develop Measures, Implement, Adapt, and Learn

Detailed guidance for each of these steps along with tips and tools for using the guidance are provided in "Conservation Action Planning Guidelines for Developing Strategies in the Face of Climate Change" October 2009. The Nature Conservancy. Available at: http://conserveonline.org/workspaces/climateadaptation/documents/climate-change-project-level-guidance

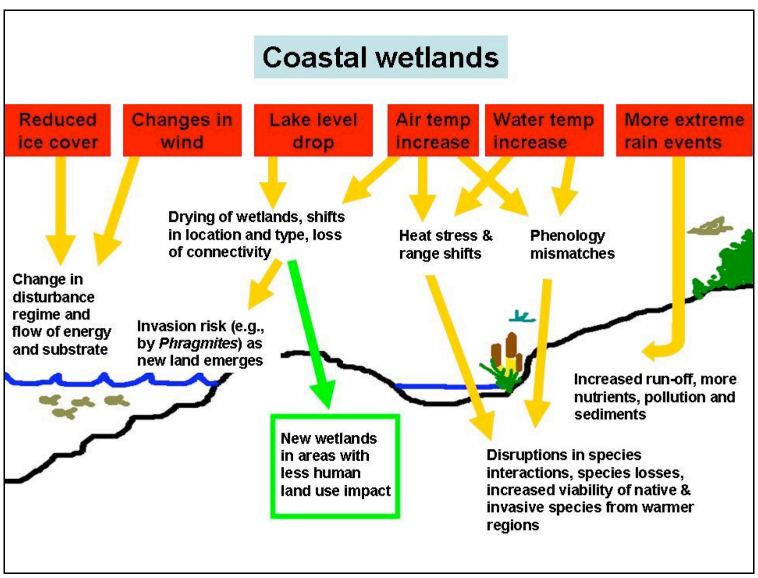


Figure 5. Example of a diagram designed to illustrate the suite of climate change impacts that may lead to stresses on a conservation target (Great Lakes coastal wetlands, from the Lake Huron/Lake Ontario CAP team at the Climate Clinic).

Table 1. Example of Hypotheses of Change used at the TNC Climate Adaptation Clinic.

Conservation Target	**Climate Factors**	**Likelihood of Climate Factor Change**	**Key Ecological Attribute**	**Hypothesis of Change**	**Likelihood of Ecological Change**
Mangrove ecosystem	Sea level rise (+x-y meters)	Virtually certain	Erosion-deposition sediment regime	Predicted increase in sea level will accelerate *erosion-deposition regime* moving mangrove ecosystem into adjacent upslope areas.	Virtually certain
Patch coral reef ecosystem	Ocean temperature (+2-4 degrees C)	Very likely	Live coral cover	Predicted increase in ocean temperatures will reduce live coral cover for patch coral reef ecosystem.	Very likely
Riparian ecosystem	Snowmelt (-20-40%)	Uncertain	Hydrologic flow regime	Significantly reduced winter snow pack will alter the spring and summer *hydrologic flow regime* for riparian ecosystem.	Virtually certain
Wet meadows	Temperature (+3-4 degrees C mean annual)	Uncertain	% cover and composition of species	Hotter annual temperatures will reduce soil moisture and thus significantly impair *% cover and composition of species* in wet meadows.	Likely
Tropical dry forest ecosystem	Temperature (+x-y degrees C) & precipitation (+number of dry months)	Very Likely	Intensity, frequency, and extent of fires (i.e., fire regime)	Higher mean annual and summer temperatures and lower and/or unequally distributed precipitation will increase *intensity, frequency and extent of fires* for tropical dry forest ecosystem.	Likely
Rare, endemic amphibian species	Temperature (+2-5 degrees C) & precipitation (-10-20% average summer)	Likely	Extent of summer breeding habitat	Increased temperature and decreased precipitation will significantly reduce the *extent of summer breeding habitat* of rare, endemic amphibian species in temperate life zones.	Uncertain

3.2. Incorporating Climate Change Adaptation into Regional Conservation Assessments

The climate change adaptation and ecoregional assessment (ERA) working group, led by Edward Game (egame@tnc.org) of the Conservation Methods and Learning team, has produced a draft guidance document to assist field programs with incorporating considerations of climate change impact and adaptation into ecoregional and regional-scale assessments: (http://conserveonline.org/workspaces/climateadaptation/documents/incorporating-cc-adaptation-into-regional).

This guidance is aimed at three scenarios: new conservation assessments, reviewing and updating existing assessments, and prioritizing among conservation areas within an existing assessment. It focuses on five adaptation approaches (Box 3) that are best applied at regional and ecoregional scales. Given the uncertainty surrounding climate change, these approaches are likely to help the Conservancy reach its conservation objectives regardless of whether climate change impacts occur as expected. The guidance presents information on assumptions and tradeoffs in using each approach and detailed methods are provided in an appendix.

4.0 Overview of Helpful Tools and Resources related to Ecosystem-based Adaptation

There are many efforts underway within the Conservancy to provide our staff with guidance, tools, and information systems for assessing impacts from climate change and developing and implementing adaptation strategies. In this section, we highlight the most important efforts.

4.1 Adaptation Projects Database

Many Conservancy programs are already developing and implementing ecosystem-based adaptation strategies on a range of projects. We are building an adaptation projects database to disseminate up-to-date information about these projects. The database is meant to help conservation practitioners identify projects and project contacts who may be working on similar adaptation issues so they can exchange ideas and promote peer-to-peer learning. Project examples range from assessing potential climate impacts on individual species to designing strategies for larger systems such as coral reefs in the Coral Triangle and Mesoamerica. Project issues include coastal erosion and inundation on North Carolina's Albemarle Peninsula, sea-level rise on Long Island, receding glaciers in China's Meili Snow Mountains, declining water flows in the northern Andes and pinyon forest die back in New Mexico. More than 70 TNC projects have been included in the database at this time. Because more projects are being launched, the database may not be entirely up-to-date at any particular moment, but it is upgraded as new projects come online. If you know projects that are not included, please contact the climate adaptation staff at: adaptation@tnc.org. The database can be found at the Climate Adaptation Workspace in ConserveOnline: http://conserveonline.org/workspaces/climateadaptation

Box 3. Five Adaptation Approaches for Ecoregional and Regional Conservation Assessments.

1. Identifying Robust and Poor Conservation Investments: Identifying these investments primarily involves determining where biodiversity is least likely to be impacted by climate change (climate refugia).
2. Conserving the Geophysical Stage: In many parts of the world, the physical environment such as soils, bedrock geology, slope, elevation, and aspect are major drivers of species distributions. Conservation planners have typically paid more attention to patterns of biodiversity than patterns of the physical environment but climate change suggests we need to pay more attention to conserving the evolutionary stage (the physical environment) than the actors (the biodiversity) themselves (Anderson and Feree 2010, Beier and Brost 2010).
3. Enhancing Regional Connectivity: Improving connectivity is the most commonly recommended adaptation approach (Heller and Zavaleta 2009). It can be accomplished by consideration of size, placement, and number of conservation areas; by considering the shape and orientation of conservation areas, and through conservation management of the intervening matrix. The greatest challenge often is determining what connectivity patterns are needed where.
4. Sustaining Ecosystem Process and Function: Conservation planners and practitioners have long focused more attention on the patterns of biodiversity than the underlying ecological processes that support it. Although understanding processes is still an emerging science, this approach to adaptation suggests that we need to increasingly focus efforts on conserving processes (e.g., ecological flow regimes) and places that support these processes.
5. Taking Advantage of Emerging Opportunities: As society responds to climate change, there will be opportunities to improve the cost effectiveness and efficiency of conservation. One example is REDD (Costenbader 2009) –a policy for Reduced Emissions from Deforestation and Degradation. REDD is a climate change mitigation activity, but its implementation may provide the added benefit of conserving forest biodiversity in the tropics. Biodiversity offsets, renewable energy, and conserving other ecosystem services represent other emerging opportunities for adaptation.

4.2. Decision Support Tools

4.2.1. Climate Wizard

Climate Wizard is an online, interactive, map-based tool that delivers historic and projected future data about temperature and precipitation to your desktop. It was developed by TNC in collaboration with the University of Washington and the University of Southern Mississippi. Users select a region, state, or country to view, and can then explore maps and time series graphs of historic and future projected temperature and precipitation (Figure 6). The Wizard brings authoritative global climate data to the desktop through an easy-to-use, web-mapping interface. Options include projections based on multiple climate models and emissions scenarios, and the ability to parse data by season or month. Experienced users can download the underlying GIS data for further analysis and overlay with other data layers. Explore the

Climate Wizard at: www.climatewizard.org. For more information on the Climate Wizard, see Girvetz et al. 2009 or contact climatewizard@tnc.org.

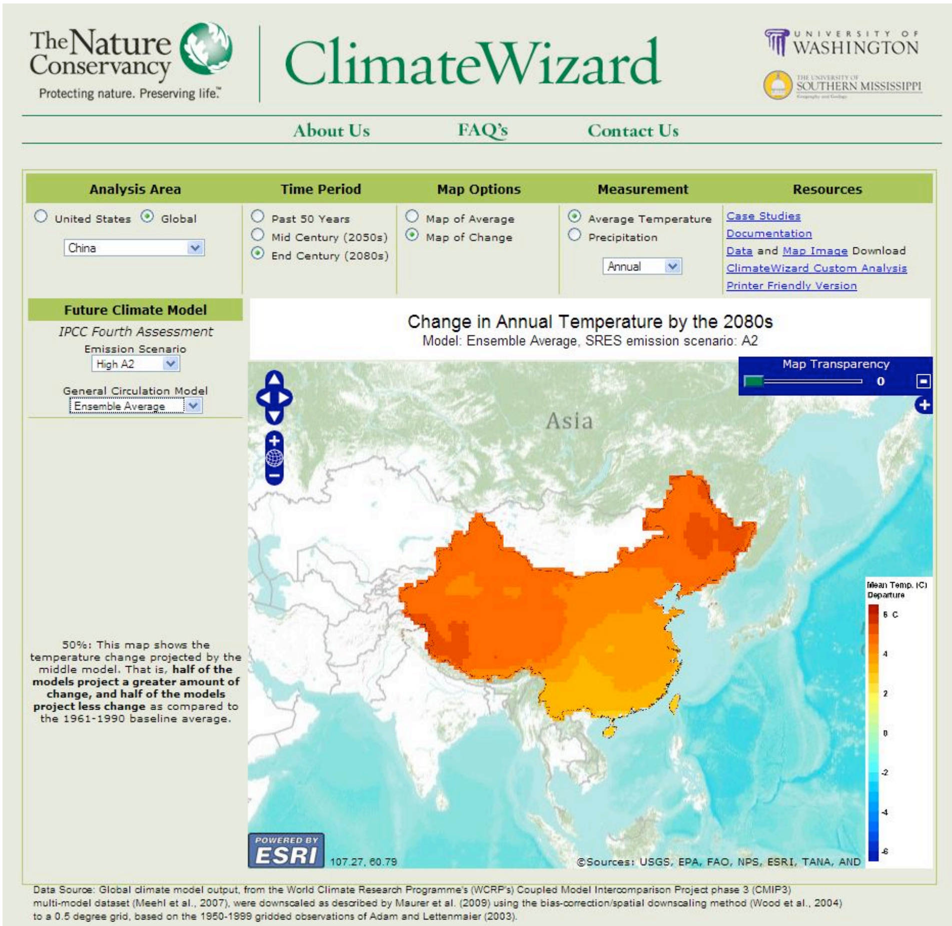


Figure 6. The Climate Wizard is a desktop application that allows users to explore historic and projected changes in temperature and precipitation for different parts of the world. See www.climatewizard.org for more details.

4.2.2. Coastal Resilience - Long Island: Adapting Natural and Human Communities to Sea Level Rise and Coastal Hazards

Coastal resilience describes the ability of coastal communities to respond to and recover from stressors. The Coastal Resilience Long Island project explores flooding scenarios resulting from sea level rise and storm surge for the south shore of Long Island, New York, to help stakeholders understand and incorporate these stressors in their decision-making. The Long Island coastline has both highly developed lands and valuable marine resources in the coastal zone. The costs of coastal hazards are increasing as investments in coastal development swell. Much of Long Island's private property is only inches above sea level, placing millions of dollars in public and private funds at risk.

The project's interactive web mapping application, the Future Scenarios Mapper, www.coastalresilience.org/future-scenarios.html helps users visualize flooding given a range of sea level rise and storm scenarios, presenting these in a user-friendly framework that can inform decision making. This tool demonstrates that mutually beneficial solutions for human and natural communities can be created by combining hazard mitigation and biodiversity conservation in coastal zones.

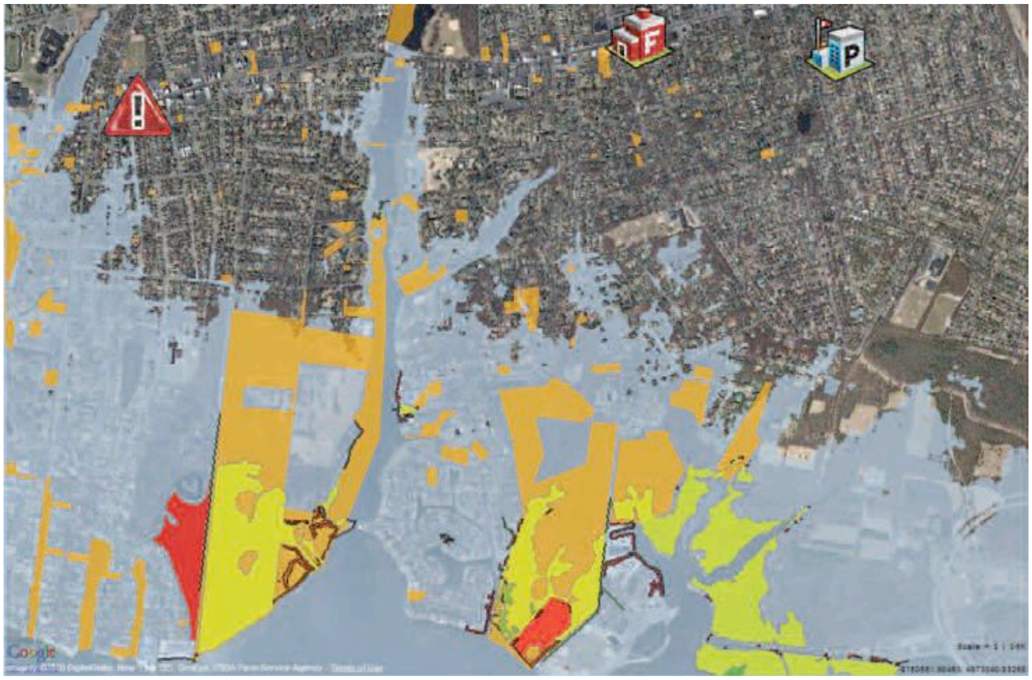


Figure 7. The Coastal Resilience decision support system (DSS) at **www.coastalresilience.org** allows users to examine reasonable future flooding scenarios from sea level rise and storms; to examine the ecological, social, and economical vulnerability; and to identify solutions. The image is an example screen shot from the online, interactive, future scenarios mapper. The map is zoomed in to a portion of the existing project area on the southern shores of Long Island. The map illustrates the flooding and inundation from a moderate emissions scenario (IPCC A2 projection) coupled with a flooding event with a 20% likelihood annually. A few of the ecological and socio-economic data layers are activated to show some of the information that decision makers can access.

The Future Scenarios Mapper allows users to examine current ecological, biological, socioeconomic, and management information alongside inundation scenarios of sea level rise and storm circumstances developed from widely accepted climate and hazard models. This helps the user visualize and better understand vulnerabilities, and when combined with the project website's information on context and policy information, helps communities take action to achieve both ecological and socioeconomic objectives. Use of the Future Scenarios Mapper is now being expanded to other coastal resilience projects beyond Long Island.

The Coastal Resilience framework (see Box 4 for coastal resilience principles) incorporates information on biodiversity and coastal hazards to assist coastal managers in visualizing and managing for climate change. The primary objectives of the project included:

- Building a spatial database and interactive map server that provides decision support for jointly meeting biodiversity and hazard mitigation objectives;

- Conducting workshops with local (town councils and boards) and state (NY Department of State and the NY Ocean and Great Lakes Ecosystem Conservation Council) officials on the utility of the database and interactive decision support.
- Constructing a website (www.coastalresilience.org) that explains TNC's approach around ecosystem-based adaptation to climate change.
- Identifying viable alternatives that reduce losses and vulnerability of coastal communities for people and ecosystems.

4.3 Online Knowledge Base

To make information, data and other resources easier to access and share with others, the Global Climate Change Program has established an online knowledge base. The knowledge base presently includes the Climate Wizard, the Climate Adaptation Clinic, a database of TNC adaptation projects, and links to important external resources about climate change such as the Intergovernmental Panel of Climate Change (IPCC) reports. The knowledge base will continually be built by gathering and synthesizing ongoing developments regarding ecosystem-based climate adaptation. The knowledge base is available at: www.conserveonline.org/workspaces/climateadaptation

4.4 Learning Networks related to Climate Change and Adaptation

There are numerous learning networks in The Nature Conservancy, but two of them in particular offer guidance related to various aspects of climate change and adaptation:

- **Reef Resilience Network**. Led by Stephanie Wear (swear@tnc.org), the network delivers information about building resilience into coral reef management strategies through regional workshops and a toolkit available on DVD or on their website: www.reefresilience.org/Toolkit.html

- **Fire Learning Network**. Led by Lynn Decker (ldecker@tnc.org), a cooperative project of The Nature Conservancy, Interior Departments and the USDA Forest Service, the network was created in 2002. Part of the larger joint program - Fire, Landscapes and People: A Conservation Partnership - the Network operates at both national and local levels to overcome barriers to reducing hazardous fuels build-up and restoring fire-dependent ecosystems. The Fire Learning Network is working on adjusting to the implications that arise as climate change influences fire regime factors. www.home.tnc/conservation_initiatives/fire/

- **CAKE – Climate Adaptation Knowledge Exchange, Island Press**. CAKE is a cooperative effort of Island Press and EcoAdapt (www.islandpress.org/cake) to "create a community of practice on climate change adaptation." CAKE is intended to be launch in July 2010 and will contain detailed case studies of adaptation efforts (including several contributed by TNC), a directory of individuals involved in adaptation, a library of resources, links to other tools and resources, and postings about important meetings, workshops, and other events.

Box 4. Principles of Coastal Resilience: Five Step Program for Sea Level Rise Adaptation by Sarah Newkirk and Mike Beck (more detailed information on these principles is available at www.coastalresilience.org)

Step 1: Move Vulnerable Public Structures

There are a number of significant public structures that are threatened, in the immediate term, by sea level rise and more intense coastal storms. The regulatory agencies overseeing these structures have taken a variety of approaches to protecting them, including building revetments and other walls to try to keep the ocean at bay. However, these approaches impede natural coastal processes, and so damage coastal ecosystems. They also sometimes prove ineffective. Accordingly, the federal government, states and local municipalities should adopt a policy of realignment of public structures, whenever possible. This policy both sends an appropriate message to private landowners regarding the feasibility of retreat from the coast, and provides the most effective protection of our important public landmarks.

Step 2: Voluntary Land Acquisition

The state and federal governments should provide significant financial rewards to local governments that implement strong coastal programs to buy out willing coastal landowners who choose to proactively get out of harm's way. The objectives of such programs of voluntary land acquisition would be to protect human life and permit natural, sustaining processes to occur in the coastal zone. Land acquisition along the coast is often thought to be prohibitively expensive. However, a variety of tools are available to facilitate voluntary acquisition of vulnerable coastal property at less-than-fee-simple cost including land exchanges, retained use and occupancy, purchase of development rights or PDR, and transfer of development rights or TDR.

Step 3: Post-storm Redevelopment Planning

Permitting unwise and inadequately protected development in locations known to involve serious risks from natural hazards amounts to a failure of planning to serve one of its most vital public functions. Nonetheless, only half the states, in their planning enabling statutes, mention natural hazards at all as a concern that should or may be addressed in comprehensive plans. An effective post disaster recovery plan could include some or all of the following components: hazard area identification, prohibitions against rebuilding in hazard areas, special tax district in high hazard areas, negotiated acquisition process or mandatory mediation.

Step 4: Natural Habitat Restoration

Healthy, properly functioning natural shorelines and tidal marshes provide buffers that mitigate storm damage and dampen the impact of tidal surges. Investing in the restoration of natural ecosystems will provide a return of important ecosystem services and increased shoreline protection and erosion control.

Step 5: Amend Key Laws

The federal government, as well as each state, has a variety of shoreline management laws that predate the current period of awareness of sea level rise and global warming. At the federal level, the Coastal Zone Management Act, the National Flood Insurance Program, and the various FEMA Hazard Mitigation Programs all require amendment to reflect the realities of sea level rise, and the need to plan for and fund the activities listed in Steps 1-4 above. At the state level, most coastal states have Coastal Zone Management Programs, wetlands protection statutes, shoreline protection programs, and other coastal policies. State programs need to be remodeled to provide for regulations and development standards that address sensitive habitat protection and restoration, restricted shoreline development, buffers, and post-storm redevelopment planning.

4.5 CRiSTAL – International Tool for Integrating Climate Change Risk and Adaptation into Development Projects (www.cristaltool.org)

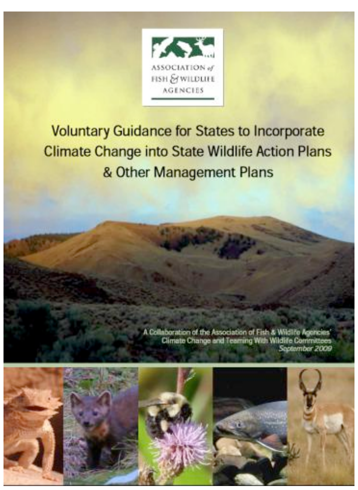
Many organizations around the world are piloting adaptation activities, including activities that could be described as ecosystem-based adaptation and/or community-based adaptation. One assessment tool that has been used at the community level to enable the inclusion of climate change considerations into development projects is CRiSTAL (Community-based Risk Screening Tool – Adaptation & Livelihoods), a project planning and management tool developed by IUCN, the International Institute for Sustainable Development (IISD), and the Stockholm Environmental Institute's US Center (SEI-US). Conservancy staff working in developing countries may find CRiSTAL to be a useful tool. It seeks to help project planners and managers integrate risk reduction and climate change adaptation into community-level projects. Although the tool is strong in providing support for participatory approaches to community-based adaptation, it relies almost exclusively on community knowledge for determining what the likely impacts of climate change are on resources and could be more user-friendly and reliable if this type of information were supplied more readily.

4.6. U. S. Federal Natural Resource and Land Management Agency Efforts on Adaptation

Many efforts are underway in the United States government to conduct climate impact analyses, synthesize known and projected impacts, and outline adaptation strategies. We highlight a few of the most relevant efforts in Appendix A.

4.7. State Wildlife Action Plans/Association of Fish and Wildlife Agencies (AFWA)

Over half of the Conservancy's state chapters were involved in development of State Wildlife Action Plans or SWAPS (www.wildlifeactionplans.org) completed for all U.S. states and territories in 2005. These plans now offer an excellent framework for state wildlife agencies and key partners such as the Conservancy to fine tune state investments in adaptation strategies for climate change and to communicate these efforts to the wildlife conservation community.



A working group facilitated by The Association of Fish and Wildlife Agencies (an umbrella organization for state wildlife agencies – see www.fishwildlife.org) and in which the Conservancy participated has published guidelines for incorporating climate change considerations into SWAPS (AFWA 2009). The guidance document consists of three major chapters: 1) approaches and concepts for developing adaptation strategies, 2) adaptation toolbox with recommendations for conducting a vulnerability assessments (for key species and habitats), implementing adaptive management, and conducting targeted monitoring of the impacts of climate change and the effectiveness of adaptation strategies, and 3) specific recommendations for revising a SWAP in the context of climate change relative to the eight elements that were originally required by Congress for the development of these plans (e.g., species distribution and abundance, location and condition of key habitats were two of the original eight elements). The AFWA guidance document includes six case studies on how states are revising their SWAPs relative to climate change and a helpful list of resources and references on adaptation as well. For Conservancy state programs working closely with their wildlife agencies on climate changes, this guidance is essential reading. It can be downloaded from: www.ncseonline.org/00/Batch/WHPRP/Boulder%20Presentations/Climate%20Change%20Guidance%20Document_FINAL_Sept%2021.pdf

4.8 NatureServe's Vulnerability Index

NatureServe has led an effort to develop a tool to predict the vulnerability of individual plant and animal species to climate change. The index uses four sets of information to assign species to a vulnerability category: exposure to local climate change as predicted by the Climate Wizard, indirect exposure through means such as sea-level rise or barriers to dispersal, species-specific sensitivities such as dispersal ability, and documented responses to climate change by individual species. The main audience for the index is state agency personnel tasked with updating SWAPs to incorporate climate change as a stressor on species of concern. An Excel workbook allows practitioners to apply the index to individual species, evaluate uncertainty in species response information, and store the results. For more information on the Vulnerability Index including the downloadable software and guidelines for its use, see: http://www.natureserve.org/prodServices/climatechange/ClimateChange.jsp. The development of the index, and a case study application for the state of Nevada is described in Young et al. (in press). Kim Hall (kimberly_hall@tnc.org) is a co-author of the index and can provide more information and contacts with other index users.

Three Useful Websites - There are many websites with information on adaptation to climate change. Three of the most useful for conservation scientists and practitioners are:
www.climate-decisions.org maintained by the University of British Columbia

www.conservationclimatechangeclearinghouse.net maintained by Charles Chester

www.wires.wiley.com maintained by Wiley publishing company.

5.0 Advancing Ecosystem-based Adaptation in the Policy Arena

Just as there are already many efforts underway in the Conservancy to revise conservation plans, projects, and strategies in the face of climate change, there is an equally important effort to advance ecosystem-based adaptation in the international policy arena. In this section of the primer, we highlight the key international policy efforts related to adaptation, provide brief but pertinent background information on this policy work, and summarize the outcome of the U. N. Climate Change Conference in Copenhagen (COP 15, December 2009).

5.1 The Context of the UNFCCC and the Bali Action Plan

The United Nations Framework Convention on Climate Change (UNFCCC - www.unfccc.int) is one of the three major conventions adopted by the global community at the landmark Rio Summit in 1992, the others being the Convention on Biological Diversity (www.cbd.int) and the

UN Convention to Combat Desertification. (www.unccd.int). The stated objective of the UNFCCC is worth noting:

"The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."

Key insights that may be gleaned from this objective are: 1) at the time of adopting the UNFCCC, the parties (nations) to the convention were focused on mitigation actions that would avoid the progressive impacts of climate change and buy time for adaptation to take place naturally, and 2) the relevance and relationship between ecosystem functioning, food production and sustainable economic development was highlighted from the outset. The UNFCCC therefore sets the scene for adaptation to be considered as a holistic set of activities that would maintain the essential links between ecosystem conservation and human health and welfare.

Spurred on by the improved scientific understanding of the rate and impacts of climate change, the Parties to the UNFCCC (those countries formally and legally agreeing to implement the UNFCCC) adopted the Bali Action Plan in 2007, including its four pillars:

- **Mitigation**, including developed country commitments for emissions reductions and developing country actions towards low-carbon development pathways.
- **Adaptation**, reducing the impact of climate change on the most vulnerable countries.
- **Technology development and transfer** to support action on mitigation and adaptation.
- **Provision of financial resources** and investment to support action on mitigation and adaptation and technology cooperation.

The Bali Road Map, as it is called, required the Parties to the UNFCCC to adopt a new climate change agreement at the 15th Conference of the Parties (aka U.N. Climate Change Conference) in Copenhagen in December 2009 (see Box 5 for information on the Copenhagen Conference) that would come into effect in 2012 (often referred to as the Post-2012 climate agreement). Until 2012, the Kyoto protocol (signed in December 2007 in Kyoto, Japan) remains in effect - an international agreement linked to the United Nations Framework Convention on Climate Change that sets binding targets for 37 industrialized countries and the European community for reducing greenhouse gas (GHG) emissions.

Box 5. Ensuring that the Post-2012 Climate Change Agreement Incorporates Ecosystem-based Adaptation – Results from the U.N. Copenhagen Climate Change Conference.

Throughout 2009, the Conservancy's international climate policy team worked with other international conservation and development organizations as well as national governments to ensure that ecosystem-based approaches were included in the climate change negotiations. The Conservancy outlined its preferred policy outcomes in an important position paper on adaptation available at:
http://www.nature.org/initiatives/climatechange/files/adaptation_position_paper_updated_10_29_09_low_res.pdf

By the end of the discussions in Copenhagen, the parties (nations) had put some important principles and options on the table. Although a far cry from a clear-cut call for ecosystem-based adaptation, the final language of the Copenhagen Accord calls for:

"Enhanced action and international cooperation on adaptation is urgently required to ensure the implementation of the Convention by enabling and supporting the implementation of adaptation actions aimed at reducing vulnerability and building resilience in developing countries, especially in those that are particularly vulnerable, especially least-developed countries, small-island developing States and Africa. We agree that developed countries shall provide adequate, predictable and sustainable financial resources, technology and capacity-building to support the implementation of adaptation action in developing countries." More detailed information on the Accord, including proposed agreements to cut global emissions, can be found at:
http://unfccc.int/2860.php .

The World Bank also presented a report estimating that the cost of adaptation (and their emphasis was purely on infrastructure) would be in the order of $100 billion per annum. Even if only a small percentage of that is spent on options that explicitly consider natural capital and the use of nature-based solutions, this could be an important outcome of these negotiations.

Reaching a post-2012 climate change agreement was not achieved in Copenhagen. Negotiations to reach a legally binding climate change agreement have been extended until December 2010, the scheduled next meeting of the Conference of Parties for the UNFCCC in Mexico. The TNC team is figuring out how to leverage the best influence.

One certain outcome – good field projects that demonstrate how we can address adaptation from a social, ecological and economic perspective are essential if we are going to achieve tangible progress on ecosystem-based adaptation.

5.2 Climate Change Adaptation and the Convention on Biological Diversity (the *Other* CBD)

Several programs and thematic issues related to the Convention on Biological Diversity can positively influence the world's ability to adapt to climate change. One of these is known as the Programme of Work on Protected Areas that was agreed to by most countries under the

Convention on Biological Diversity in 2004.[2] The Programme of Work is a comprehensive program to put in place representative, effectively managed and sustainably financed systems of protected areas that will help the world achieve the biodiversity target adopted by the United Nations as part of the Millennium Development Goals (a set of eight goals that respond to the world's main development challenges). Goal 7 includes the 2010 biodiversity target of reducing the rate of loss of biodiversity (www.undp.org/mdg/basics.shtml).

Even though this Programme of Work was adopted a mere five years ago, there is only one reference to climate change in it, indicating a lack of awareness of the significance of this threat at that time. By 2008, however, concern over climate change and its impact on protected areas had deepened and a formal meeting of the Parties for the Convention on Biological Diversity (known as Conference of the Parties or COP 9) made a number of key decisions to address the issue (due in part to efforts by TNC country programs and national/international policy teams). These decisions included: 1) exploring funding opportunities for protected area design, establishment and effective management in the context of efforts to address climate change, 2) urging multilateral donors, non-governmental organizations, and other funders to support projects in developing countries that demonstrate the role that protected areas play in addressing climate change, 3) inviting the Global Environmental Facility (GEF)[3] (www.thegef.org) to consider support for proposals that demonstrate the role-protected areas play in addressing climate change, and 4) encouraging Parties to enhance research and awareness of the role that connected networks of protected area networks can play in addressing climate change. Several Conservancy country programs work with their national governments to undertake activities related to the Programme of Work on Protected Areas. Other Programmes of Work under the CBD are also moving to address climate change, including the Inland Waters and the Marine and Coastal Programmes of Work.

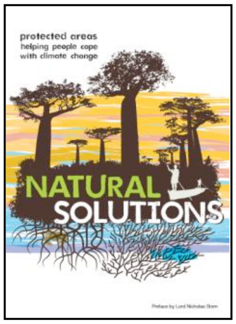
5.3 Protected Areas and Climate Turnaroud 2020 Initiative (PACT 2020)

Building on our involvement with the CBD Programme of Work on Protected Areas, The Nature Conservancy in collaboration with the IUCN World Commission on Protected Areas and other major conservation organizations, has developed and co-financed a project known as PACT 2020 (Protected Areas and Climate Turnaround). The primary objective of PACT 2020 is to ensure that

[2] Note that 168 countries are signatories to the Convention on Biological Diversity. By signing and ratifying the Convention, countries are legally obligated to undertake a set of activities related to conserving biological diversity including those related to establishing and maintaining a system of protected areas. The United States is the only major developed nation in the world that has not ratified this Convention. biological diversity including those related to establishing and maintaining a system of protected areas. The United States is the only major developed nation in the world that has not ratified this Convention.

[3] The Global Environment Facility (GEF) is a global partnership among 178 countries, international institutions, non-governmental organizations (NGOs), and the private sector to address global environmental issues while supporting national sustainable development initiatives. It provides grants for projects related to six focal areas: biodiversity, climate change, international waters, land degradation, the ozone layer, and persistent organic pollutants. The GEF is also the designated financial mechanism for a number of multilateral environmental agreements (MEAs) or conventions; as such the GEF assists countries in meeting their obligations under the conventions that they have signed and ratified.

protected areas and protected area systems are recognized as an important contribution to climate change adaptation/mitigation strategies for biodiversity and human livelihoods. The two most important products of the PACT 2020 partnership have been the commissioning of a key report on the value of protected areas for mitigation and adaptation:



Natural Solutions - Protected Areas: Helping People Cope with Climate Change *(Dudley et al. 2009)*
(The report and an English, French and Spanish summary can be downloaded at:
http://cmsdata.iucn.org/downloads/natural_solutions.pdf

And in collaboration with the Andalucian government of Spain, convening a Summit meeting on Protected Areas and Climate Change, in preparation for the Copenhagen Climate Conference. A summary of recommendations from this Summit is available at:
www.iucn.org/about/union/commissions/wcpa/wcpa_events/wcpa_climatepasummit/

More information on PACT 2020 can be found at:
www.iucn.org/about/union/commissions/wcpa/wcpa_events/wcpa_climatepasummit/wcpa_pact2020

5.4 The Ad Hoc Technical Expert Group on Climate Change and Biodiversity (AHTEG) & Ecosystem-based Adaptation (EBA)

The AHTEG was established by the Secretariat of the Convention on Biological Diversity to provide biodiversity-related information to the United Nations Framework Convention on Climate Change (UNFCCC) through the provision of scientific and technical advice on the integration of the conservation and sustainable use of biodiversity into climate change mitigation and adaptation activities.

The importance of AHTEG is that it provided guidance on adaptation for the parties participating in the December 2009 Copenhagen Climate Conference. The report of the second AHTEG (convened in October 2008 by the CBD) – *Connecting Biodiversity and Climate Change Mitigation and Adaptation* – contained eight key messages, two of which are most relevant to adaptation:

- The resilience of biodiversity to climate change can be enhanced by reducing non-climatic stresses in combination with conservation, restoration, and sustainable management strategies (this message will be explored in more detail in the final section (6) of this primer).
- Ecosystem-based adaptation, which integrates the use of biodiversity and ecosystem services into an overall adaptation strategy, can be cost-effective and generate social, economic, and cultural co-benefits and contribute to the conservation of biodiversity.

The full AHTEG report can be downloaded at:

http://www.cbd.int/doc/publications/cbd-ts-41-en.pdf

6.0. Evaluating Impacts and Advancing Adaptation Strategies

State, country, and regional programs of The Nature Conservancy need flexible, practical, and often low-cost approaches to evaluating the impacts of climate change and developing adaptation strategies. Depending on program resources and anticipated severity of impacts, these assessments can range from being quite simple (literature searches and expert panels) to more in-depth analyses. In this final section of the primer, we outline some of the considerations for conducting climate change impact and vulnerability assessments, introduce the wide array of adaptation strategies being deployed or envisioned, provide resources for obtaining more information on these assessments and strategies, and illustrate both with a few case studies. The considerations outlined in this section build upon and provide more detail for the basic CAP and regional conservation planning guidance previously discussed in Section 3.

6.1 Assessing Climate Change Impacts and Vulnerabilities of Conservation Targets

The primary impetus for conducting an impact assessment typically relates to the question: *"What are the physical impacts and ecological consequences of climate change relative to the resources that I manage or want to conserve?"* A conservation planner or project director from a TNC field office might ask the same question in a slightly different way: *"What are the implications of climate change for conservation priorities identified in my ecoregional portfolio or for a large landscape or watershed project?* Looking forward, and in anticipation of the increasing emphasis that we are placing on the human benefits of adaptation, we may slightly reframe this question to be: *"What are the implications of climate change for the priority conservation projects in my regions and the stakeholders and constituents that will be engaged with these projects?"*

To answer these questions, a typical first step is to assess the physical effects of climate change on a given geography or ecological target of interest. This involves identifying the physical environmental impacts resulting from changing temperature and precipitation regimes and then assessing how these drive changes in the landscape processes that shape ecological systems and, ultimately, affect the distribution and status of conservation targets. The guidance on adaptation and regional conservation assessments (Game et al. 2010) outlined in Section 3 of this primer evaluates some of the different ways to examine climate data and determine these physical impacts. The Climate Wizard (Girvetz et al. 2009 – see Section 4) is one of the most useful tools available for Conservancy practitioners and scientists to examine these physical effects and impacts. Utilizing the Internet to develop web mapping applications significantly increases our ability to examine alternative future scenarios of climate change. The Coastal Resilience project (www.coastalresilience.org/future-scenarios.html), also discussed in Section 4, is an example of how these alternative scenarios can be brought down to the local level through participatory stakeholder workshops .

At a larger regional scale, the New Mexico chapter of the Conservancy has completed an initial assessment of the potential environmental changes resulting from climate change, and a synopsis of that assessment is provided in Appendix B-1. That state assessment has now been expanded into a Southwest Climate Change Initiative that involves four state TNC programs (AZ, NM, CO, UT), academic institutions, the US Forest Service, and state agencies. Contact initiative leader Patrick McCarthy (pmccarthy@tnc.org) for more information. Along similar lines, the California TNC program has recently developed a *Climate Stress Index* that is designed to synthesize observed past and projected future climate data into an intuitive and actionable metric for all conservation landscapes in California. A brief summary of their approach is provided in Appendix B-2.

A variety of frameworks exist for assessing climate change impacts ranging from that of the IPCC (2007b) outlined in Figure 8 to frameworks specifically focused on coupled human-environment systems (Turner et al. 2003, Schroter et al. 2005), individual sectors such as reservoir operations risk (Brekke et al. 2009), or natural resource management (Kareiva et al. 2008). Depending on the motivating goals and objectives of the assessment, issues of scale, the specific data sets used to evaluate climate, and the audience for which the assessment is prepared, assessments can have varying outputs and outcomes. Furthermore, the variety of terms used related to these assessments can be confusing. For example, in some contexts climate change impacts may refer primarily to the physical impacts of exposure (e.g., Game et al. 2010) while in other frameworks such as the IPCC, these impacts clearly have a broader meaning (Figure 8).

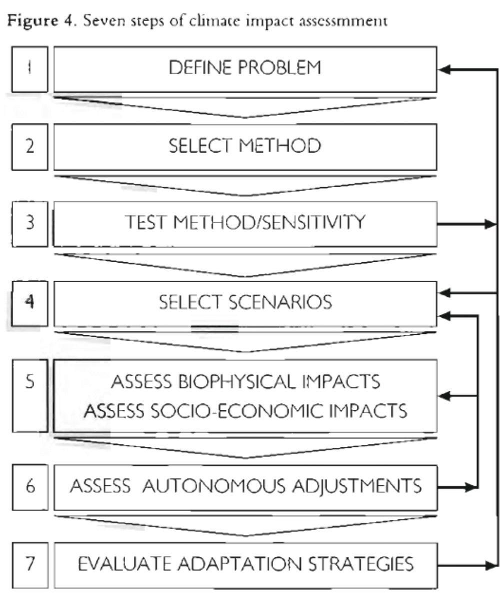


Figure 8. Seven Steps of Impacts Assessment from IPCC (2007b).

Impact assessments are not to be confused with vulnerability assessments. The United Nations Framework Convention on Climate Change's (UNFCCC – see section 5.1 in this primer) approach shows some hierarchical distinction between these terms, where the overall impacts assessment is broken into sub-steps that include biophysical impacts and socio-economic impacts, leading to a determination of vulnerability (UNFCCC 2006, Figure 9).

Recall that in Section 2.5, we defined vulnerability as equal to Exposure + Sensitivity – Adaptive Capacity. Ideally, a vulnerability assessment would consider all three of these components (Adger 2006, Game et al. 2010). In the adaptation and regional assessment guidance (Section 3), we suggest that there are four reasons for conducting a vulnerability assessment:

- Vulnerability has a strong regional context
- To support decisions about the selection of conservation targets and TNC investment in them. (i.e., setting conservation priorities).
- To understand regional requirements for the conservation of high value targets.
- To raise public awareness of climate change threats to biodiversity.

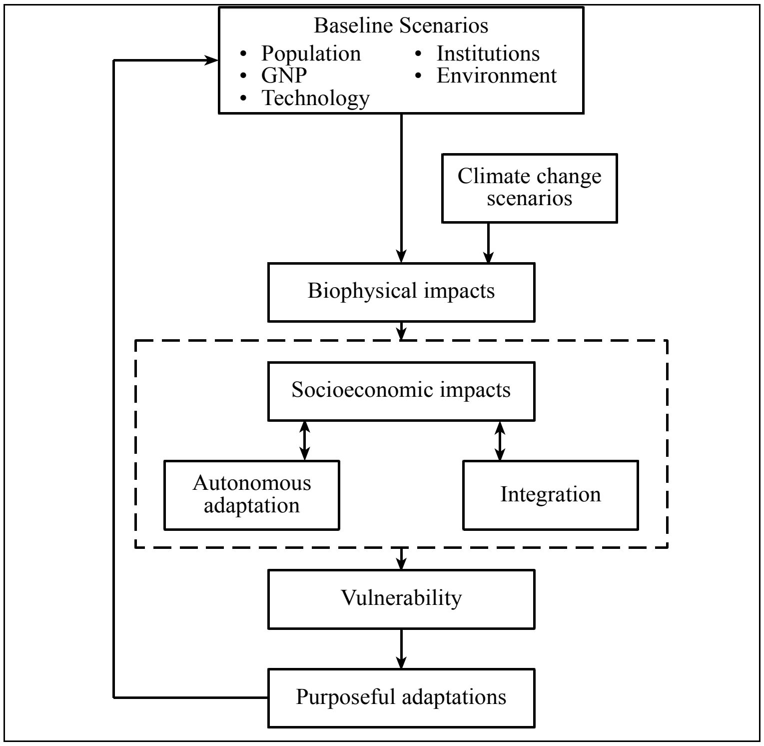


Figure 9. UNFCCC conceptual framework for climate impact assessment.

From the standpoint of impact assessments and regional or project-level conservation plans, there are two important points to keep in mind about vulnerability assessments. First, ecological change attributed to climate change does not necessarily equate to vulnerability. Conservation targets may not necessarily be vulnerable to change. For example, the integrity of a coral reef or a freshwater system may remain intact despite some turnover in species composition. Second, vulnerability assessments are not necessarily a prerequisite to implementing adaptation strategies. Many of the broad adaptation strategies outlined in the regional conservation planning guidance in Section 3 - Box 3 can be implemented without conducting a vulnerability assessment. That said, there is clearly valuable information that can be gained from a vulnerability assessment that can inform adaptation strategies. Box 6 provides more detailed information on how to conduct such an assessment. An example of an ongoing vulnerability assessment being conducted by the University of Washington in collaboration with the Washington TNC program is summarized in Appendix B-3.

Whether or not a particular operating unit or program of the Conservancy is engaged in a more limited analysis of climate change impacts or a more in-depth one that might also include an assessment of vulnerability, such analyses should trigger a re-examination of both regional priorities and project-level conservation goals. For example, in the California TNC chapter's approach to adaptation (Appendix B-4), they routinely re-evaluate whether a project can continue to meet is original goals and objectives under different climate change scenarios and whether it is necessary to modify those goals even with adaptation strategies in place.

Ideally, the Conservancy and other organizations will have access to a spectrum of assessment approaches and tools that can be tailored to an operating unit's needs, timeline, and capacity and to those of key partners. Climate data and climate models are complex. In many cases, it will make most sense for TNC state, country, or regional programs to develop collaborations with academic or government research institutions to conduct impact and vulnerability assessments. Examples of such collaborations are provided in the case studies below.

Box 6. Vulnerability Assessment as a Tool to Safeguard Fish, Wildlife, and Natural Resources in a Warming World.

The National Wildlife Federation (Patty Glick, Naomi Edelson, Bruce Stein) is leading a multi-institutional working group in the development of guidelines for conducting a vulnerability assessment. These guidelines will discuss the basics of vulnerability assessments (sensitivity, exposure, adaptive capacity) and define the objectives and goals of doing such an assessment. Guidelines will incorporate stakeholder engagement, analytical techniques of climate modeling, and species, habitat, and ecosystem-specific elements related to sensitivity, exposure, and adaptive capacity. Sections on dealing with uncertainty and case studies will help make these guidelines user friendly and easier to apply. Key working group members include Molly Cross of the Wildlife Conservation Society, Josh Lawler of the University of Washington, Linda Joyce of the US Forest Service, Jenny Hoffman of EcoAdapt, Evan Girvetz of TNC, and Hector Galbraith of the Manomet Center for Conservation Science. Guidelines are expected to be released in Spring 2010. Contact Bruce Stein (SteinB@nwf.org) for more information.

6.2. Adaptation Approaches

Adaptation strategies can come in many forms. Millar and colleagues (2007) identified three different adaptive approaches to climate change – resistance, resilience, and response options. In certain situations, defending resources against change (resistance) may be an appropriate, albeit short-term and often expensive strategy. Some circumstances may warrant this approach such as when dealing with legally challenging endangered species issues or responding to extreme drought or storm situations that have been exacerbated by climate change. Management actions that propose to improve a species or ecosystem's ability to respond to a climate-change related disturbance and return to a pre-disturbance state are referred to as a resilience strategy. For example, restoring riparian areas along streams that are experiencing climate-related intensity of drought may help in retaining more overall water quality and quantity in the ecosystem. Finally, responsive options are those that help facilitate the transition of ecosystems from current to new conditions. An example of such a strategy is improving habitat connectivity to facilitate species that are shifting in their range of distribution. Climate scientist and ecologist Dr. Erika Zavaleta, in a recent address to TNC staff at the Climate Clinic, has referred to these three broad strategies as resistance, resilience, and transformation (i.e., "responsive" approach from Millar et al.) (Figure 10) and noted that over the last 25 years that the conservation community is moving from resistance-oriented management actions to transformative ones. Although Conservancy practitioners may use any one or all three types of adaptation strategies, we anticipate that transformative actions aimed will be the most successful and cost-effective over the long term.

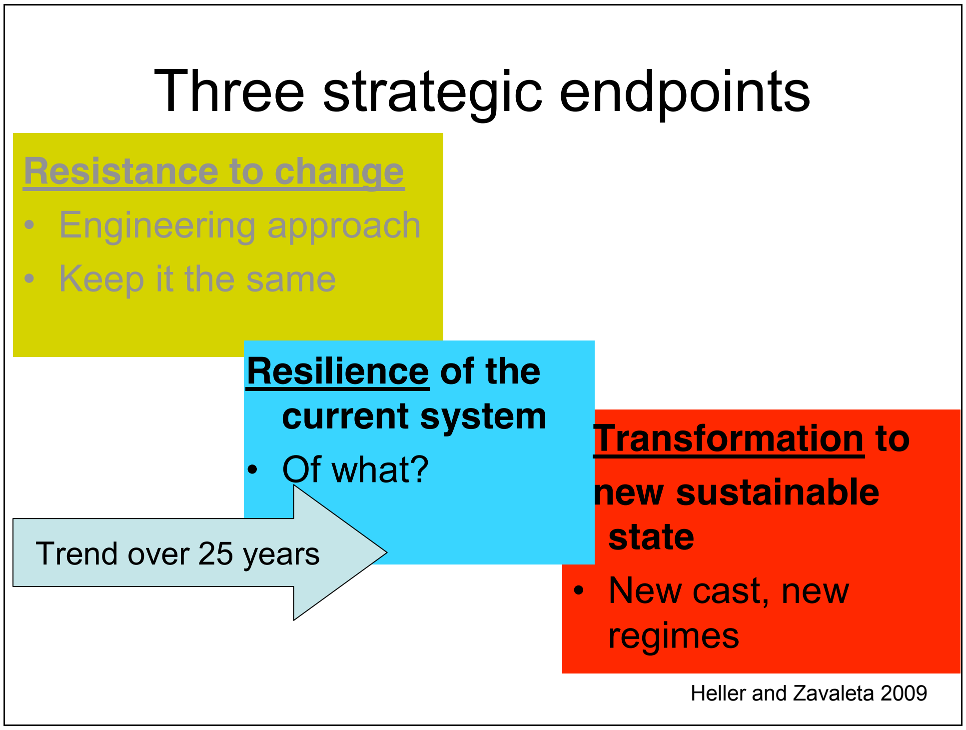


Figure 10. Three strategic approaches to adaptation as outlined by Dr. Erika Zavlaeta in a presentation to Nature Conservancy staff at the Climate Adaptation Clinic 2009.

The development and implementation of adaptation strategies is in its infancy and will be challenging on several fronts. First, it is hard to synthesize all of the potential impacts of climate change on the systems and species that we care about, and prioritize a set of actions that will help them adapt. As identified in a recent report from the US National Research Council, a key need for our organization and others engaged in adaptation is better tools for managing, linking, and integrating information to support decision-making (National Research Council 2009). A second contributor to "adaptation paralysis" is the fact that most of the recommendations to date on adaptation remain broad and somewhat limited in use (e.g., improve connectivity among conservation areas to help facilitate changes in range).

However, many of the stewardship actions taken at our reserves, or work that we influence through our collaboration with partners, can be viewed as either promoting adaptation or as strategies and actions from which we can learn to promote adaptation. For example, actions that promote system resilience, such as returning fire to the landscape, reconnecting rivers, removing non-native species, and promoting ecologically sound principles of forest management all have benefits in terms of climate change adaptation. Our key challenges are to ensure that we are learning from the actions that we are already engaged in, that our approaches and plans are anticipating changes in climate (e.g., flooding risk is estimated using projected precipitation ranges, not just historic), that we are doing the best we can to implement this work in the places where it will have the most benefit, and that what we learn about adaptation strategies and actions is disseminated across the Conservancy so that the entire organization benefits from this knowledge.

In some situations, adaptation actions for human communities and natural communities may not be well linked and could undermine efforts to facilitate adaptation in natural systems. In other situations, particularly in the more economically poorer countries and regions where TNC works, there may not be adequate social adaptive capacity to implement adaptation strategies and the necessary capacity must first be built (McClanahan et al. 2008). Finally, we will likely encounter a few cases where actions related to adaptation and mitigation may run counter to each other. Below, we suggest how better linkages can be made between community-based and ecosystem-based adaptation strategies, discuss the relationship between mitigation and adaptation efforts, and outline ideas for implementing several of the more prominent adaptation strategies.

6.2.1 Linkages between Community-based and Ecosystem-based Adaptation Efforts

As sea levels rise, the number of drought-stricken regions increase, and other impacts of climate change impinge upon human communities around the globe, society will be forced to take actions to mitigate these impacts. Undoubtedly, some of these actions (e.g., placing sandbags along coastal shorelines) will be detrimental to biodiversity and ecosystem services. In any discussion of climate adaptation, a false dichotomy can easily be created between actions that benefit nature conservation versus local communities or cities. At one extreme would be those who are concerned mostly with securing the resilience or transformation of ecosystems, and who might advocate that if these are assured, then societal adaptation would necessarily follow. At the other extreme are those who are most concerned with the impacts of climate change on people, in part because climate change is predicted to have its greatest impacts on the most marginalized people who are often dependent on natural resources for their livelihoods and exposed to natural hazards (Mani et al. 2007). From these perspectives, the challenge for organizations like the Conservancy is to help ensure that in regions where we work, as many of these adaptation actions as possible are in the best interests of both human and natural communities (i.e., ecosystem-based adaptation).

The World Resources Institute (McGray et al. 2007), in a comparison of adaptation and development processes, has outlined a framework in which community-based and ecosystem-based adaptation could be profiled along a continuum of approaches. They identify two factors that shape the adaptation responses of human communities: 1) the existing capacity of the affected community, and 2) the level of information about projected climate impacts. Their rationale suggests that the response of these communities will be guided by their understanding of climate change impacts and how these impacts will affect the resources with which they work. For example, knowledge of the projected loss of grazing resources for pastoralism or of potential changes in dry season surface water distribution will likely have a strong influence on a local community's response to such changes and loss.

A better understanding of the underlying ecosystem structure and function, of the ecosystem services that are generated, and of the community dependency on these services will allow a more thoughtful impact assessment to be conducted, not only on the resources themselves but on the communities that depend on these resources. In the example given above, ecosystem-based adaptation options might include altering stocking densities of herbivores to take account of resource constraints at particular times, augmented storage of fodder for over-wintering feed supplies, or altering the fire management regime to avoid the denudation of soils as a result of changes in precipitation patterns. By taking into consideration impacts to both human and ecological communities and concurrently considering a range of adaptation approaches for these two communities (e.g., maintaining ecosystem function while diversifying livelihoods), our overall conservation efforts are more likely to succeed.

6.2.2. The Interplay of Adaptation and Mitigation

While this first edition of the primer focuses primarily on ecosystem-based adaptation, it is essential that the world act to address the root cause of climate change – the increased concentration of greenhouse gases in the atmosphere. Mitigation strategies are those that limit the extent of climate change by reducing emissions across all sectors of society – from industrial to the ecological including transportation, urban, agriculture, forestry, ranching, energy, flood management, health, tourism and recreation. It is these strategies that were the over-arching focus of the recent Climate Change Conference in Copenhagen in December 2009 (see Box 5).

In addition to specific emission reduction strategies, examples of other mitigation approaches include conserving or restoring forests (15% of greenhouse gas emissions worldwide come from the clearing and burning of forests), increasing energy efficiency, and developing renewable energy, all of which serve to decrease greenhouse gas emissions. In a similar vein, adaptation strategies can span multiple sectors of society and can be "built" strategies such as raising levees to deal with increased flooding and sea level rise to "natural" strategies (also referred to as "green infrastructure") such as restoring wetlands and degraded watersheds to address the same threats. Well-planned natural adaptation strategies can have a positive impact on the mitigation of greenhouse gas emissions. Likewise, for natural systems, well-planned mitigation strategies can have a positive effect on the adaptation of the species, habitats and ecosystems for which we seek to facilitate adaptation. For example, protection of forests and wetlands can make significant contributions to carbon sequestration while protecting habitat and building climate resilience for multiple species.

The IPCC Fourth Assessment Report (IPCC 2007b) identifies four types of interactions between adaptation and mitigation:

- Adaptation actions that have consequences for mitigation.
- Mitigation actions that have consequences for adaptation.
- Decisions that include trade-offs or synergies between adaptation and mitigation.
- Processes that have consequences for both adaptation and mitigation.

To date, there is little detailed information regarding the array of potential synergies and trade-offs between mitigation and adaptation strategies (Klein et al. 2007). Most analyses have focused on either adaptation or mitigation, but not both, and most have a single-sector focus with very few analyzing the secondary synergies and/or trade-offs within or across sectors (Adger et al. 2007). Clearly, adaptation of species, habitats and ecosystems could be enhanced or undermined by adaptation and mitigation measures in other sectors such as transportation, urban, agriculture, forestry, ranching, energy, water management, health, tourism and recreation (Berry et al. 2008, 2009). Paterson and colleagues (2009) provided a preliminary synthesis of the sectoral impacts of climate change mitigation and adaptation strategies and have identified those strategies which are most likely to have significant potential for beneficial impacts on biodiversity. This study highlights that many mitigation and adaptation measures are complementary, but their application needs to be well-integrated across temporal and spatial scales.

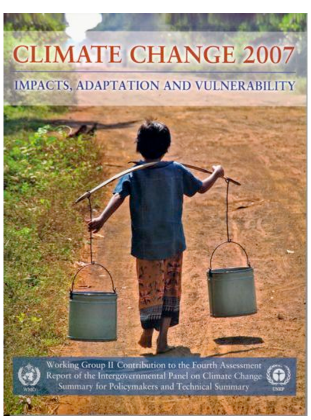
What is needed now is a comprehensive accounting of synergies and trade-offs among mitigation and adaptation strategies across all sectors to ensure that desired climate change goals are achieved within a reasonable timeframe to allow for the adaptation of species, habitats and ecosystem and the services they provide in support of human health and well-being. Without this information, developing climate policies are likely to fundamentally decouple mitigation and adaptation strategies with a diminished capacity to achieve both mitigation and adaptation goals.

6.3 Identifying and Implementing Adaptation Strategies

There is no shortage of written recommendations on adaptation strategies for species and ecosystems. Two recent reviews in biodiversity conservation journals outline the range of possible strategies. Heller and Zavaleta (2009) reviewed 22 years of scientific articles that focus on recommendations related to climate-change adaptation and biodiversity conservation. They condensed 524 recommendations into 113 recommendation categories with detailed references for each category. Broadly speaking, they suggested these recommendations could be applied in three major ways: 1) through changes in regional policy and planning, 2) through site or project-scale management actions, and 3) through adapting existing conservation plans. Importantly, their review also acknowledged that most recommendations lacked specifics about who, where, and how these adaptation recommendations should be implemented.

In a second review, Mawdsley and colleagues (2009) examined both scientific literature and public policy documents to identify 16 broad adaptation strategies for wildlife management and biodiversity conservation in the US, Canada, Mexico, England, and South Africa. They grouped their 16 strategies under the broad topics of land and water protection, direct species management, monitoring and planning, and law and policy. They concluded that most of the tools for implementing these strategies (e.g., increase protected areas, translocate species) are already available to managers and conservation practitioners. In fact, many practitioners in TNC are arriving at similar conclusions. Although we may not be able to predict the severity of impacts, we have many of the tools and strategies in place to take actions now that will almost certainly mitigate to some degree the deleterious effects of climate change on our conservation projects (see Box 7 for advice on freshwater adaptation strategies). In many cases, we need to do a better job of explaining how what we are doing contributes to adaptation, and how we are updating our strategies to make our contribution to adaption even stronger.

Two recent publications provide a more in-depth examination of adaptation options.



The first of these is Working Group II's Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2007b, www.ipcc.ch/ipccreports/ar4-wg2.htm), a detailed report on impacts, adaptation, and vulnerability that is cited numerous times in this primer. In addition to detailed analyses on impacts and vulnerabilities, this publication examines practices, costs, constraints, and opportunities for adaptation on a continent by continent basis.

Box 7: Freshwater Adaptation Approaches

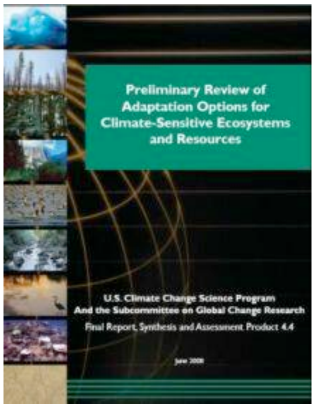
Adaptation approaches to enable aquatic ecosystems to provide for human and wildlife needs in the face of a changing climate include:

- Design water-supply systems that are flexible to both short- and long-term changes in streamflow patterns including increased floods, droughts and rising temperatures.
- Adopt comprehensive basin-wide approaches to water accounting and management to preserve the flexibility of the water system to adapt to change – all water management plans should give due consideration to environmental flows needed to sustain healthy freshwater ecosystems.
- Manage existing water infrastructure in a manner that both meets human needs for water and sustains healthy freshwater ecosystems. This includes providing appropriate environmental flow releases from dams.
- Restore floodplains and wetlands that can provide needed flood storage and help to recharge aquifers, while freeing up valuable storage space previously allocated to flood control (see below).
- Remove barriers, such as unnecessary dams and road culverts that constrain the ability of fish and other aquatic organisms to move to cooler waters as the climate warms.
- Invest in applied research on the impacts of climate change on specific ecosystems and link adaptation strategies to this research.

Floodplains: an EBA example

Floodplain conservation—including protection of existing floodplains or reconnection of currently disconnected floodplains—provides a strong example of ecosystem-based adaptation. Most climate forecasts suggest that the frequency and magnitude of flooding will increase and even without climate change, flood risks are rising in much of the world due to changing land-use patterns (e.g., draining of wetlands, increase in impervious surfaces), increases in population and development within flood-prone areas, and aging infrastructure and insufficient maintenance (e.g., eroding levees). Rather than trying to stay ahead of this flood risk through expanded grey infrastructure (dams, levees, floodwalls), large-scale reconnection of floodplains can act as green infrastructure that reduces flood risk. Levees can be set back from the river in strategic locations to allow floodplains to store and convey floodwaters and reduce risk for nearby areas (Opperman et al. 2009).

Climate models suggest an increase of hydrological extremes—the increase in flood frequency as described above and an increase in the frequency of droughts. Thus some parts of the world may experience a change in how precipitation is distributed through the year, with more falling in short intense events with longer dry periods in between. This pattern will exacerbate management challenges for multipurpose dams that strive to provide both flood control—which requires empty or partially empty reservoirs to capture floodwaters—and a range of purposes that benefit from full reservoirs (water supply, hydropower, environmental flows to support downstream rivers). Large-scale reconnection of floodplains can shift some of the floodwater storage from the reservoir to the floodplain, liberating an additional increment of storage in the reservoir that can be used for water supply, irrigation, hydropower or environmental flows. In summary, restoring the important ecosystem of a connected floodplain can increase the provision of important benefits from multipurpose reservoirs, serve as a hedge against hydrological uncertainty due to climate change, and increase the resiliency of water management systems. In the developing world context, this same approach can be applied to the protection of existing connected floodplains.



The second publication with a more in-depth look at adaptation options is a review of climate sensitive ecosystems and resources in the United States that was commissioned by the US Climate Change Science Program, a body responsible for coordinating and integrating research on climate change conducted by 13 federal agencies (http://www.globalchange.gov/publications/reports/scientific-assessments). This review, published by the Environmental Protection Agency in 2008 (many of the chapters were just published in a 2010 volume of the journal *Environmental Management*), features chapters on impacts and adaptation responses for national forests, national wildlife refuges, marine protected areas, wild and scenic rivers, national estuaries, and national parks. The synthesis and conclusions chapter (Kareiva et al. 2008) details best practices, barriers, and opportunities for adaptation. That chapter also outlines seven important principles for adaptation:

1) Protection of key ecosystem features
2) Reduction of anthropogenic stresses that erode resilience
3) Representation – increase representation of genotypes, species, and communities under conservation management
4) Replication – increase the number of replicates of each ecosystem type under conservation
5) Restoration – of ecosystems that have been lost or severely degraded
6) Refugia – identify and conserve areas that are refuges from climate change impacts
7) Relocation – relocate species to appropriate habitats.

Earlier in this primer (Box 3, Section 3), we mentioned five broad strategies for Conservancy practitioners and planners to consider when incorporating adaptation and climate change into regional and ecoregional assessments. Although best applied at regional scales, these broad strategies are likely to be applicable to many of the Conservancy's landscape and seascape level projects and strategies. In addition to outlining these broad strategies, the guidance on adaptation and regional assessments (Game et al. 2010) also provides detailed information on the tools and data necessary to implement them. For additional and more specific guidance on identifying and implementing strategies at the project level, we suggest examining one or more of several recent syntheses and summaries on adaptation strategies (Box 8).

Although we previously mentioned the dearth of applications of adaptation strategies, several Conservancy projects are beginning to accumulate a wealth of experience in implementing adaptation strategies. The adaptation projects database mentioned in Section 4 of this primer highlights many of these projects. Two of the more significant Conservancy project-level investments on climate change adaptation are the Albemarle (Peninsula) Climate Adaptation Project in North Carolina (Appendix B-5) and the Great Lakes Climate Adaptation Project (Appendix B-6).

Implementing any adaptation strategy will have uncertain results. Those strategies that are tied to specific predictions of future climate changes will have even greater uncertainty due to the difficulty of predicting future climate changes (Lawler et al. 2010). Acting in the face of this

Box 8. Review and Synthesis Articles on Adaptation Strategies

- Glick, P., A. Staudt, and B. Stein. 2009. A new era for conservation: a review of climate change adaptation literature. National Wildlife Federation. Available from: http://www.nwf.org/globalwarming/pdfs/NWFClimateChangeAdaptationLiteratureReview.pdf

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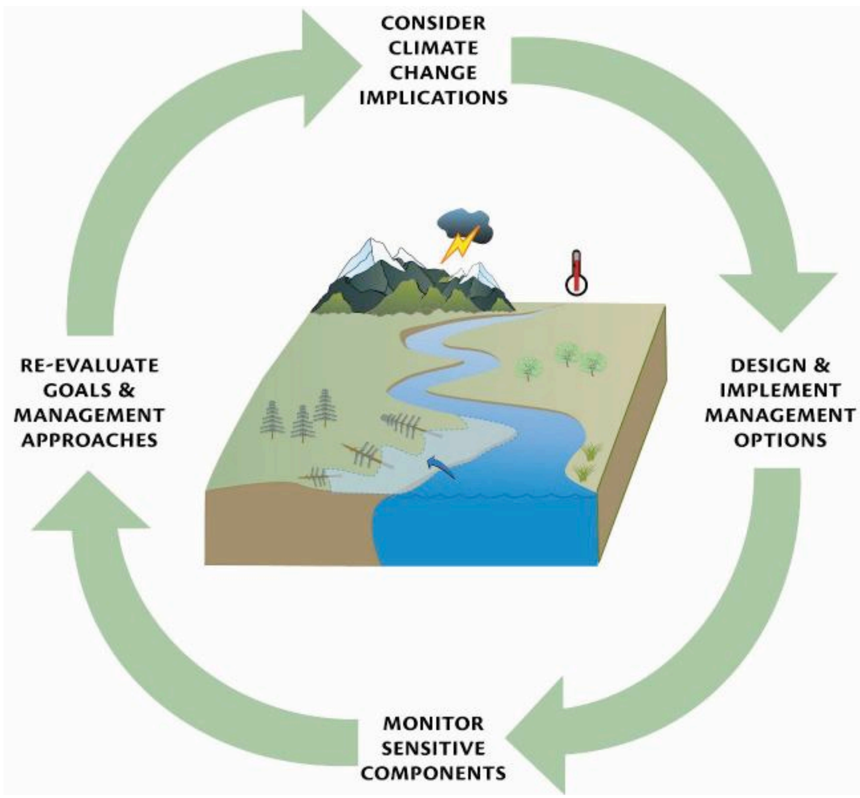

Figure 11. An adaptive management cycle for a conservation project or strategy that is taking adaptation actions.

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8.0 APPENDICES

APPENDIX A: Climate Change and Adaptation Resources in US Federal Agencies

U.S. D. A. Forest Service (USFS)

The U.S. Forest Service maintains several web sites focused on climate change, but http://www.fs.fed.us/ccrc the Climate Change Resource Center (CRCC) is likely the most useful site for TNC scientists and practitioners. In their words, the CRCC "addresses the manager's question "What can I do about climate change?" by providing information about basic climate sciences and compiling knowledge resources and support for adaptation and mitigation strategies. The site offers educational information, including basic science modules that explain climate and climate impacts, decision-support models, maps, simulations, case studies, and toolkits." The CRCC provides an array of resources including a primer on climate change, short papers on impacts on different taxonomic groups and environmental features, an overall Forest Service climate change strategy, a news section with the latest developments and projects related to climate change across a variety of federal agencies, and an excellent section on management options (http://www.fs.fed.us/ccrc/topics/natural-resource.shtml) including the 5-R strategy of increase resistance to change, promote resilience to change, enable ecosystems to respond to change, reduce greenhouse gases, and realign conditions to current and future dynamics.

U. S. Geological Survey (USGS)

The USGS maintains a home page on climate change known as the Office of Global Change (http://www.usgs.gov/global_change/). It is one of the most comprehensive climate change web sites within the federal natural resource agencies. There are sections on frequently asked questions, fact sheets, podcasts, a variety of topical reports on climate change impacts on various sectors, links to USGS research reports (e.g., new report on climate change impacts on polar bears) spanning a range of climate-related research topics, and the Climate Change Science Program's Synthesis and Assessment Product – a series of 21 reports to be produced by 13 participating agencies on such topics as climate change in the High Arctic and Thresholds for Climate Change in Ecosystems (http://www.usgs.gov/global_change/sap.asp). A USGS Circular on Climate Change and Water Resources Management: A Federal Perspective can be found at http://pubs.usgs.gov/circ/1331/. The site includes a report on Global Climate Change Impacts in the United States, with sections on each region of the country and broken into various sectors, including ecosystems and water resources (http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts). For a summary of ongoing climate change research in all federal agencies, see http://www.globalchange.gov/.

Environmental Protection Agency (EPA)

The Environmental Protection Agency maintains the most comprehensive information on climate change and adaptation in the US government (http://www.epa.gov/climatechange/index.html). It covers the science of impacts, greenhouse gas emissions, climate policy, health and environmental effects, economic analyses, and information on regulations related to climate change. The section on adaptation is particularly strong (http://www.epa.gov/climatechange/effects/adaptation.html) with advice, recommendations, and reports across multiple sectors (e.g., agriculture, forestry, water resources, energy, coastal areas).

US Fish and Wildlife Service (USFWS)

The USFWS maintains a climate change web site as well (http://www.fws.gov/home/climatechange/). Although much of the material and information located here is not specific to the USFWS and can be located through other web sites, TNC practitioners may find the new Climate Change, Wildlife and Wildlands Toolkit for formal and informal educators to be particularly useful. "The kit contains materials that will help classroom teachers and informal educators in parks, refuges, forest lands, nature centers, zoos, aquariums, science centers, and other venues teach middle school students about how climate change is affecting our nation's wildlife and public lands and how everyone—including kids—can become "climate stewards."" There are also links to what the USFWS is doing in terms of adaptation and climate change in its different administrative regions as well as a strategic plan for how the USFWS intends to respond to climate change overall.

National Oceanic and Atmospheric Administration (NOAA)

NOAA has recently consolidated its climate change-related web presence to a single point-of-entry known as the NOAA Climate Portal (www.climate.gov). The site is designed to address the needs of five broadly-defined user groups: decision makers and policy leaders, scientists and applications-oriented data users, educators, business users, and the public. Highlights of the portal include an interactive "climate dashboard" that lets users see a range of constantly updating climate datasets (e.g., temperature, carbon dioxide concentration and sea level) over adjustable time scales and a new climate science magazine called ClimateWatch, featuring videos and articles of scientists discussing their recent climate research and topics, in addition to an array of data products and educational resources.

Appendix B. TNC Case Studies on Impact Assessments and Adaptation

B-1. New Mexico

In an analysis designed to support New Mexico's state wildlife action plan, Enquist and Gori (2008) used historical 4-km^2 PRISM data to map recent changes in climate. They found that over 95% of the state had experienced mean temperature increases of varying magnitude between 1991-2005 compared to an earlier baseline period (1960-1990). This was also true during a recent severe drought period (2000-2005) relative to the baseline. Precipitation changes were more variable than temperature, with over half the state tending toward wetter conditions between 1991 and 2005. However, nearly three quarters of the state experienced drier conditions during the 2000-2005 period. The study then evaluated New Mexico's network of conservation areas (or, ecoregional portfolio) relative to the level of recent climate exposure, measured by the degree of climate departure or anomaly from the baseline time period. High impact areas represented areas where recent climate exposure has been particularly extreme (i.e., warmer-drier conditions or greater variability in temperature and precipitation) and lower impact areas indicate areas where recent climate departure has shown little change (i.e., smaller increases in temperature coupled with small decreases in precipitation, no change or increased precipitation) (Figure 12). Target species occurring in these high impact conservation areas were subsequently assessed for drought sensitivity through a new rapid vulnerability protocol.

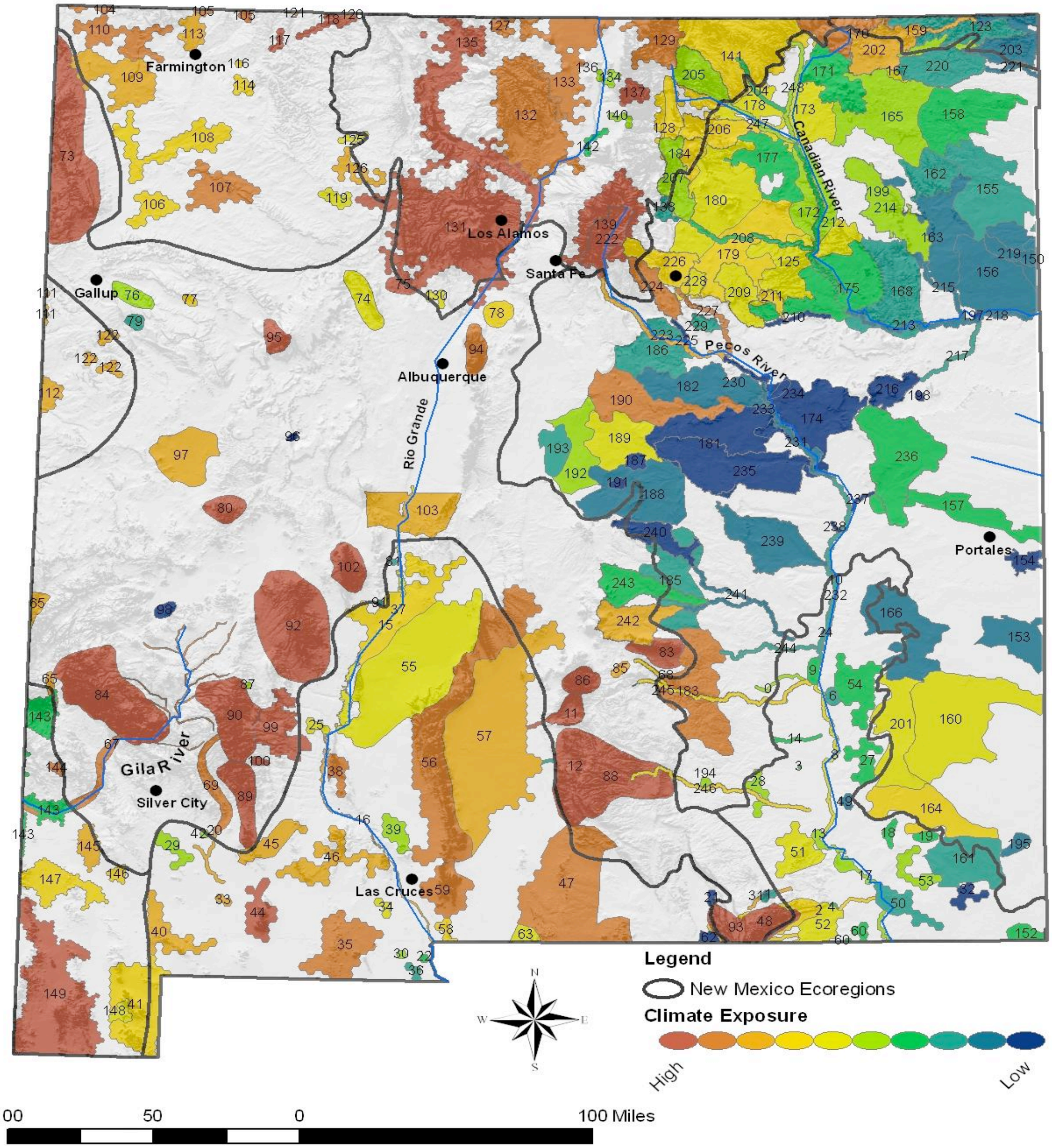


Figure 12. Map of New Mexico's key conservation areas ranked by climate exposure, or climate departures, experienced in the past two decades. High impact areas are those where exposure has been particularly extreme (i.e., warmer-drier conditions) and lower impact areas are those where climate has shown little change.

In a second suite of analyses, Enquist et al. (2008) used the Climate Wizard toolbox to map and analyze long-term trends (1970-2006) in a variable that combines temperature and precipitation and can be used to indicate potential biological moisture stress. Trends in moisture stress were summarized by USGS HUC-8 watersheds in New Mexico to shed light on recent patterns in water availability, which not only has implications for vegetation structure and distribution, but for the capacity of natural systems to provide critical services for humans (Millennium Ecosystem Assessment 2005). The moisture stress exposure metric was then related to available spatial data estimating the number of species identified as important for conservation by watershed. In doing so, Enquist et al. (2008) were able to demonstrate a method that resource-limited conservation practitioners and managers can use to rapidly prioritize watersheds for near-term adaptation action. Full reports of all the New Mexico worked described here can be found at: www.nmconservation.org.

B-2. California

California has recently developed a *Climate Stress Index* that is designed to synthesize observed past and projected future climate data into an intuitive and actionable metric for all landscapes in California. Resulting maps present the *Drought Stress Index* and *Heat Stress Index* for the entire state (Figure 13). These maps were generated by comparing future projections from a mean of 15 general circulation models (GCMs) run under the IPCC A2 emissions scenario – the most probable emission scenario - to observed climate data from the 20th century. The uncertainty is low if there is substantial agreement among the 15 GCMs, and high if not.

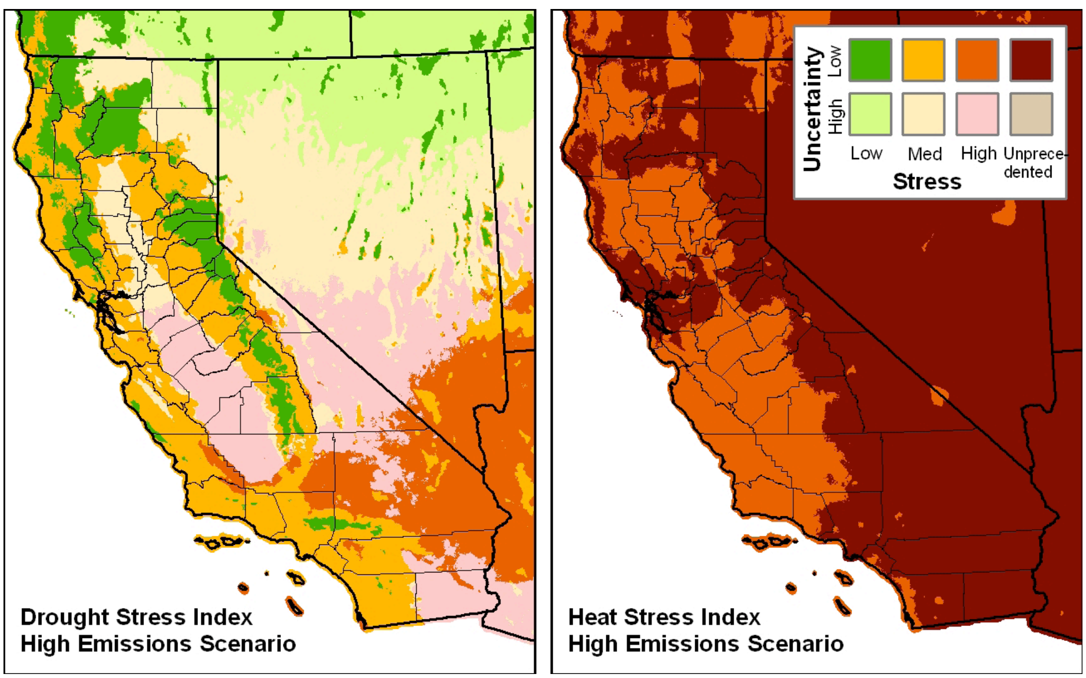


Figure 13. Results of applying a drought stress and heat stress index to California.

The observed climate data are from the PRISM climate layers from 1900-1999 at 800m resolution. The future climate projection summaries were generated from 15 general circulation models (GCMs) run to support the International Panel on Climate Change (IPCC) Forth

Assessment Report. The GCM data were converted and downscaled to match the 800m resolution of the PRISM data. The Drought Stress Index is calculated by comparing the future (2070-2099) 30-year mean projection of annual precipitation for every 800m pixel to the observed annual precipitation values between 1900 and 1999. The index is calculated based on the number of observed years that are greater than the future projection. Thus, a value of 70 means that the future projection is drier than 70 of the 100 years between 1900 and 1999. These values were classified into the following categories: 0-50 is low, 50-66 is medium, 66-99 is high, and 100 is unprecedented. Values were calculated for all 15 of the GCMs.

B-3. Washington State Vulnerability Assessment

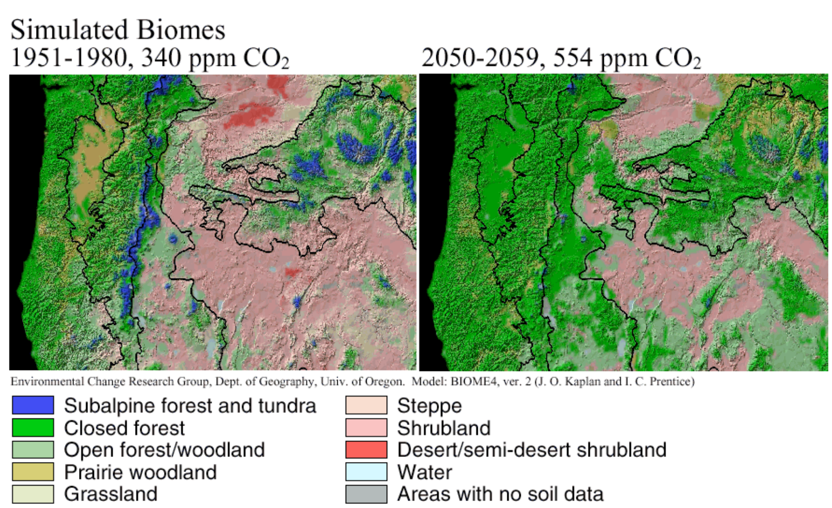
Conservation practitioners, managers and decision-makers need detailed information on which species and systems are most susceptible to climate change and how we should adapt our strategies to be most effective in light of climate change impacts. The Washington Chapter is spearheading a comprehensive approach to address climate change impacts in the Pacific Northwest and is currently working with partners from the University of Washington, the US Geological Survey, the Washington Department of Fish and Wildlife, the University of Idaho, and the Idaho Department of Fish and Game to meet the following objectives:

- Assess climate impacts on species and ecosystems
- Determine the impacts to conservation and managed lands
- Use this information to facilitate smart strategy development for climate change adaptation

There are five parts to this work:

Part I - Future Climate Projections
Fine spatial resolution analyses of climate-change impacts are particularly important for mountainous regions, such as the Pacific Northwest, where large changes in species and community composition can occur over relatively short distances. We are creating 30 different future climate change scenarios (downscaled to 1 km^2) based on ten global circulation models and three emission scenarios. In addition to basic climate variables such as mean annual temperature and total annual precipitation, we will calculate bioclimatic variables representing important physiological limits of species. The bioclimatic variables will be used for simulating future species distributions.

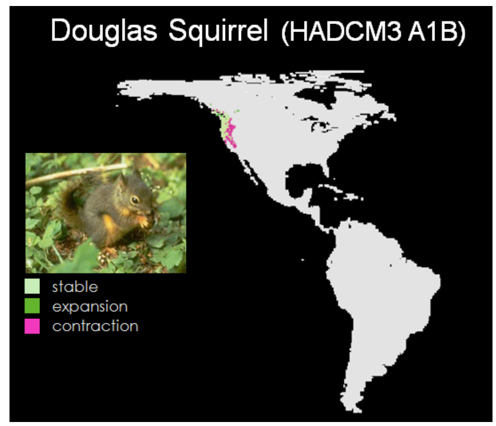
Part II - Future Vegetation Projections
Future climate changes will alter vegetation both directly via changes in climate and indirectly via changes in climate-driven disturbance regimes. We will simulate future vegetation responses to climate change in the Pacific Northwest using the climate data produced in *Part I* as input to a dynamic global vegetation model. The vegetation data, in combination with the climate data, will be evaluated for evidence of potential future changes in climatic conditions that will alter the frequency and



severity of drought and wildfires, which are explicitly simulated by these models.

Part III - Climate Sensitivity Database
We are developing a digital web-based database of inherent climate-change sensitivities for hundreds of species of concern in the Pacific Northwest. The database will provide park managers and decision makers with some of the most basic and most important information about how species and systems are likely to respond to climate change.

Part IV - Animal Range Shift Projections
We are using a hierarchical modeling approach to project changes in future species distributions for key species in the region. The species we are modeling are being selected in conjunction with state wildlife managers based on their conservation status, potential sensitivity to climate change, and the degree to which they are representative of important habitats.



Part V - Comprehensive Assessment
We will use the data from *Parts I-IV* to provide a synthesis of climate impacts to species and ecosystems and to identify climate change refugia (i.e., areas predicted to experience relatively small and/or slow future changes). We also will compare impacts to current conservation and managed lands. Specifically, we will integrate the downscaled climate projections, projected vegetation changes, and projected range shifts to assess the relative vulnerability to climate change across the region and within the three types of managed lands: national parks, state and federal fish and wildlife refuges, and Conservancy (TNC) owned and managed sites.

Products
A variety of products will be created from our work, including

- A searchable and spatially referenced climate change sensitivity database for species
- Projected change maps for climate, vegetation and species
- Analysis of likely climate change impacts to conservation and managed lands
- Uncertainty maps and documentation
- Web access to products and information
- Peer-reviewed journal articles

For more information on this project, contact Elizabeth Gray, TNC WA Director of Science (egray@tnc.org).

B-4. TNC CALIFORNIA CLIMATE CHANGE ADAPTATION APPROACH (JULY, 2009)

The California chapter of the Conservancy is developing an adaptation approach to incorporate climate change impacts at the scale of conservation action. This approach includes developing five year plans in the context of 50 year change, a partnership between scientists and practitioners for adaptive learning, a commitment to monitor change and to reassess our priorities as new information becomes available and, ultimately, to assess whether our goals are achievable in the long-term. The adaptation model outlined in Figure 14 and the analyses summarized in Table 2 capture the heart of TNC California's approach to adaptation. The approach incorporates a series of methodologies to link regional and local analyses on impact, resilience, vulnerability, and adaptation and mitigation potential over the next fifty years.
Climate Change Adaptation Model The regional- and project- level impact, resilience and vulnerability analyses are placed into a modified adaptation model that incorporates Conservation Action Planning. After impact, resilience and vulnerability assessments are completed, we conduct a climate-sensitive CAP, assess our ability to achieve our current goals within the project boundaries given current policy frameworks, assess the opportunity for achieving those goals outside the project boundaries, identify climate-adapted strategies and assess costs, and review opportunities for policy change to support adaptation. The final product is an adaptation plan for implementing no-regrets strategies for achieving project goals within the region. Once project plans are complete, a review of their viability in context of the statewide analyses will be done. Finally, the interaction between human and natural systems will be critical in determining the protection of the state's biodiversity. As such, we will continue to conduct analyses of the impact of climate change on ecosystems services and human adaptation responses and modify our strategies as appropriate.

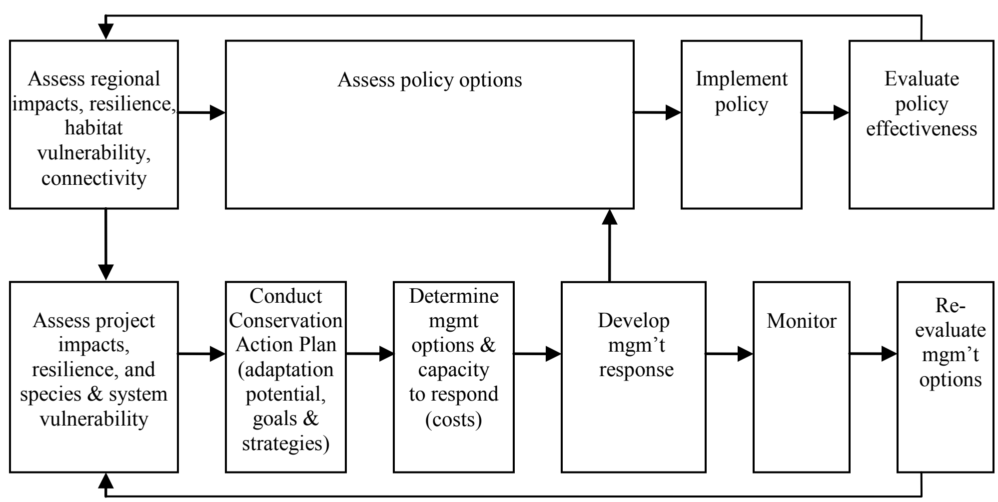


Figure 14: Climate change adaptation planning model for California TNC.

Table 2. List of analyses for adaptation plan

	Regional Scale	Project Scale
Impacts	• Climate Stress Index	• Climate Stress Index
Resilience	• Landscape Resilience Index	• Microclimate Resilience Assessment
Vulnerability	• Habitat Stress Index • Aquatic Stress Index • Coastal & Marine Stress Index	• Species Vulnerability Assessments • Systems vulnerability Assessments (aquatic, marine
Adaptation potential	• Protected Area Climate Stability Assessment (to identify refugia) • Velocity of Change Index (to identify connectivity)	• Goal and Strategy Assessment • Strategy cost Assessment
Mitigation potential	• Carbon Storage Change Index	• Mitigation/adaptation strategy assessment
Adaptation Plan	• Statewide and Project Adaptation Plans with Policy Option	

For more information on TNC California's approach to adaptation, contact Rebecca Shaw, TNC CA Director of Conservation Programs (rshaw@tnc.org).

B-5. North Carolina - Albemarle Climate Adaptation Project

More than 540,000 acres (1,334, 340 ha) on the Albemarle Peninsula are currently under conservation protection as National Wildlife Refuges, Wildlife Resources Commission Game Lands, Department of Defense lands, and Coastal Reserves. Millions of dollars in state, federal, and private funds have been invested in land acquisitions and other conservation activities. The effects of climate change threaten the decades-long work of The Nature Conservancy and our partners on the Albemarle -Pamlico Peninsula. Among landscapes vulnerable to the effects of climate change, few are in as precarious a position as North Carolina's Albemarle-Pamlico Peninsula. The effects of climate change are already visible on the Peninsula: the region's peat soils are degrading quickly and natural communities are in retreat from saltwater intrusion. Rapidly rising seas threaten to forever change this complex ecosystem of estuaries, swamp forests, marshes and meandering rivers. The current rate of relative sea level rise in the Albemarle region is nearly two inches every decade, with the rate of rise expected to double in 50 to 100 years. A 2008 study by the University of Maryland identified North Carolina's coast as one of the country's most vulnerable areas to climate change. High-resolution models developed for The Nature Conservancy show that up to 469,000 acres on the Albemarle-Pamlico Peninsula could be flooded by as little as a 12-inch (30 cm) increase in sea level.

As part of the Albemarle Climate Adaptation Project, TNC representatives are planning and implementing a comprehensive set of strategies on the Alligator River National Wildlife Refuge to abate the effects of climate disruption on this rich complex of coastal ecosystems. Through land conservation, hydrologic restoration, reforestation, oyster reef restoration, and shoreline transition and restoration the project will help ensure that today's Albemarle ecosystems are transformed into ecosystems that still support many species and complex natural communities, sequester large volumes of carbon, and provide human ecosystem services such as clean air and water, ocean and forest products and outstanding outdoor recreation opportunities. The project will also help secure the availability of natural corridors to facilitate the inland and upland migration of organisms as waters begin to submerge lowlands. Efforts will be undertaken in an experimental context to test the efficacy of different strategies in a way that encourages agencies and other land managers to employ coastal adaptation strategies at a much larger scale.

For more information on the Albemarle project, contact Jeff DeBlieu (jdeblieu@tnc.org) of the Global Climate Change Program.

B-6. Climate Change Adaptation in the Great Lakes Region

The Problem. Climate change will bring warmer temperatures to the Great Lakes region, with greatest increases expected in summer maximum and winter minimum temperatures. Currently, summer surface water temperatures in the upper Great Lakes are warming even faster than air temperatures, and ice cover is declining. Both warmer temperatures and reduced ice cover promote evaporation, and most models suggest that drops in average water levels in the Great Lakes are likely. Of special concern in the region, where a major threat to freshwater systems is pollution and sedimentation from storm run-off, is the prediction of more extreme storms. Even in places where changes in precipitation do not pose a direct risk, infrastructure built by human society to manage these storm events, or increased failures of existing water-handling infrastructure (e.g., combined sewage and storm water handling systems) could have significant negative impacts on aquatic systems and biodiversity.

The Nature Conservancy's Climate Change Adaptation Program is a central strategy of the organization's Great Lakes Project. The Great Lakes Project is governed by the state directors of the eight state programs in the region, and the Ontario director of Nature Conservancy of Canada. The Climate Change strategy is closely tied to The Great Lakes Project's other focal strategy areas (Coastal Zones, Forests, Watersheds, Invasive Species), and much our work on the climate side focuses on ensuring that work in the other priority areas is "climate smart".

The first phase of the Great Lakes adaptation work focused on synthesizing existing Great Lakes climate change research, advancing our knowledge base of threats and impacts from climate change in the Great Lakes, and exploring potential adaptation approaches that can be employed at both local and regional scales (e.g., efforts to coordinate and maximize the benefits of site-scale actions). We further "jump-started" our work on ecosystem-based adaptation by holding a workshop in February 2009 in which we convened regional scientists and experts to help prioritize our work on climate change, and brainstorm on key adaptation strategies.

Climate Clinics. Last September, a team from the Great Lakes region attended The Nature Conservancy's first ever Climate Clinic in which Conservancy staff and partners peer-reviewed work on assessing impacts of climate change, and updated key strategies to make them "climate smart." Building on the design and lessons learned from this first global clinic, one of the Great Lakes Project's objectives is to host climate clinics for Conservancy staff and partners at a regional and local level. The goal is to develop, and through practice, refine a systematic approach to convening projects with similar conservation concerns and strategies, and take project teams through a process of evaluating climate change impacts, assessing vulnerabilities, and identifying how key strategies need to be "adapted" and/or re-prioritized in light of climate change. Local and regional climate clinics will not only serve to build a stronger knowledge base for adaptation practices in the Great Lakes, but also will be an efficient and essential means of informing effective policy and decision-making.

Place-based Adaptation Projects. Successful climate adaptation requires application of conservation techniques not just for a specific area's resident natural communities but also for the benefit of larger-scale functions and services, such as carbon storage, and protection of groundwater. To foster this "ecosystem services" approach, the Great Lakes Project is developing tools and decision-making approaches that frame localized actions in a watershed context. What follows is a closer look at three of early investments in climate change adaptation projects in ecosystems that are vulnerable to rapid climate change.

Forests. The northern portion of the Great Lakes basin remains largely a forested landscape, albeit a fundamentally different forest than what was present several centuries ago. These forests now are managed working landscapes that not only provide wood products to society, but also provide a suite of other important values such as wildlife habitat, clean water, carbon sequestration and recreational opportunities. In response to the new challenges presented by climate change, we are engaged in several forest modeling projects to understand how climate change may influence forest species composition, forest structure, and the impacts of changes in key stressors like drought stress and increased abundance of forest pests under future conditions. At the same time, we are actively piloting production-scale forest-management approaches that we expect will help to restore and maintain resilient forests in the face of climate change.

Freshwater Adaptation in Agricultural Watersheds. Throughout the southern portion of the Great Lakes basin, aquatic systems are embedded in working, agricultural landscapes. These systems not only support regionally important flora and fauna, they also provide important services to society including abundant and clean water supplies, flood abatement, water filtration and recreational opportunities. The Great Lakes Project is focusing on projects in Michigan, Indiana, Ohio and New York as part of a hydrologic restoration strategy that incorporates adaptation to climate change. For example, in Michigan's Paw Paw River watershed The Nature Conservancy is partnering with Michigan State University's Institute of Water Research to inform not only *where* to focus adaptation and conservation efforts for the greatest outcome and return on investment, but also *how much* land must be conserved to successfully protect the watershed. Two key aspects for developing strategies that abate the effects of extreme precipitation on sensitive aquatic systems involve, first, learning to predict how much flow alteration can be tolerated by different aquatic communities and, second, understanding what can be done on the land to reduce the "flashiness" of these flows.

Promoting Ecosystem-based Adaptation in Urban settings: Chicago Wilderness. In 2008, the City of Chicago released a Climate Action Plan that outlines five science-based strategies for mitigating greenhouse gas emissions and adapting city services to a warmer future. In response, The Nature Conservancy developed "The Climate Action Plan for Nature" to complement Chicago's plan for the human community by including conservation of native species, natural areas, and ecosystem services as part of the solution. The Plan for Nature expands its geographic scope beyond Chicago city boundaries to include the Chicago Wilderness area—and ultimately to influence climate adaptation in urban settings throughout the Great Lakes basin.

For more information on the Great Lakes adaptation project, contact Kimberly Hall, Great Lakes Climate Change ecologist (Kimberly_Hall@tnc.org).