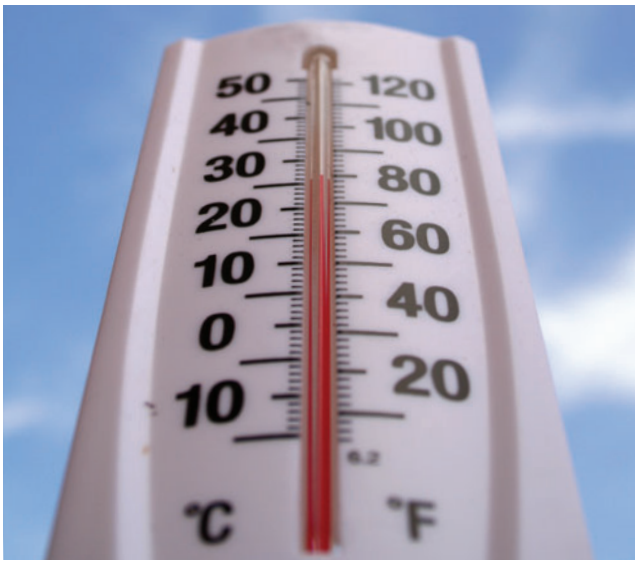
PREPARING FOR CLIMATE CHANGE

A Guidebook for Local, Regional, and State Governments



Written by
Center for Science in the Earth System (The Climate Impacts Group)
Joint Institute for the Study of the Atmosphere and Ocean
University of Washington

King County, Washington

With an introduction by King County Executive Ron Sims

King County

CLIMATE IMPACTS GROUP

In association with

I·C·L·E·I
Local Governments for Sustainability

Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments

Written by

Center for Science in the Earth System (The Climate Impacts Group)
Joint Institute for the Study of the Atmosphere and Ocean
University of Washington
and
King County, Washington

In association with

ICLEI – Local Governments for Sustainability

With an introduction by King County Executive Ron Sims

September 2007

acknowledgements

The writing team for this guidebook consisted of the following individuals at the Climate Impacts Group, King County, Washington, and ICLEI – Local Governments for Sustainability.

Climate Impacts Group:

Dr. Amy K. Snover, Research Scientist and Assistant Director to the Center for Science in the Earth System

Lara C. Whitely Binder, Outreach Specialist

Dr. Jennifer Kay, postdoctoral research fellow, Climate and Global Dynamics (CGD) division of the National Center for Atmospheric Research (NCAR)

King County, Washington:

Ron Sims, Executive, King County, Washington

Jim Lopez, Deputy Chief of Staff, King County Executive Office

Elizabeth Willmott, Global Warming Coordinator, King County Executive Office

ICLEI – Local Governments for Sustainability:

Michelle Wyman, Executive Director of ICLEI – Local Governments for Sustainability – USA

Margit Hentschel, Regional Director, Western States, ICLEI – Local Governments for Sustainability – USA

Annie Strickler, Communications Director of ICLEI – Local Governments for Sustainability – USA

Special thanks to: Josh Foster and the National Oceanic and Atmospheric Administration's Climate Program Office for funding that has made this collaboration possible; Bruce Laing, Kurt Triplett, Pam Bissonnette, Don Theiler, Bob Burns, and many others in King County government whose public service over the years has provided the foundation for this guidebook; Dr. Edward Miles for his role in establishing the Climate Impacts Group as an internationally recognized institution of climate science and public policy advice; Doug Howell, Washington State Senator Erik Poulsen, and Jim Simmonds for their early contributions to the guidebook; Becky Spithill and Sheila Roehm for their editorial suggestions and support; Rich Hoey, Danielle Harrington, Vince McGowan and Dorothy Craig, staff and consultants from the City of Olympia, Washington, for a summary of Olympia's activities related to climate change; Dr. Jennifer Penney of Toronto's Clean Air Partnership for an adapted version of that organization's report, *Cities Preparing for Climate Change: A Study of Six Urban Regions;* and Wendy Gable Collins of King County's Department of Natural Resources and Parks for design and layout.

The writing team is indebted to all of the reviewers listed below. This list includes the officials and staff of local, regional, and state governments who are on the front lines of preparing for climate change impacts, and climate science experts at NOAA-funded Regional Integrated Systems Assessment (RISA) branches across the United States.

Reviewers:

Dr. Cheryl L Anderson, Director, Hazards, Climate & Environment Program, University of Hawaii Social Science Research Institute

Anne Biklé, Environmental Planner, Seattle-King County Department of Public Health

Dr. Kirstin Dow, Associate Professor, Department of Geography, University of South Carolina

Dr. Greg Carbone, Associate Professor, Department of Geography, University of South Carolina

Amanda Eichel, Climate Protection Advisor, City of Seattle Office of Sustainability and the Environment

Mikaela L. Engert, City Planner, City of Keene, New Hampshire

Paul Fleming, Seattle Public Utilities

Matthew M. Fontaine, Civil / Environmental Engineer, Herrera Environmental Consultants

Nancy Gilliam, Executive Director, Model Forest Policy Program

Angela Grout, Oceanographer, King County Department of Natural Resources and Parks

Dr. Holly Hartmann, Acting Program Manager, Climate Assessment for the Southwest (CLIMAS), Institute for the Study of Planet Earth, University of Arizona

Kathy Jacobs, Executive Director, Arizona Water Institute

Dr. Melanie Lenart, Research Associate, University of Arizona Institute for the Study of Planet Earth

Karl Pepple, Director of Environmental Programming, Mayor's Office, City of Houston, Texas

Eric Rosenberg, Research Assistant, Department of Civil and Environmental Engineering, University of Washington

Dave Monthie, Regional Water Policy Analyst, King County Department of Natural Resources and Parks

Dr. Philip Mote, Research Scientist for the Climate Impacts Group and Washington State Climatologist

David Noble, Principal, 2degreesC

Linda Giannelli Pratt, Office of Environmental Protection and Sustainability Chief, City of San Diego Environmental Services Department

Jill Simmons, Climate Protection Program Manager, City of Seattle Office of Sustainability and the Environment

Eileen L. Shea, Director, NOAA Integrated Data and Environmental Applications Center and Member, Pacific Islands RISA Team, East-West Center, University of Hawaii

Carl Spector, Executive Director, Boston Air Pollution Control Commission

Dr. Anne C. Steinemann, Professor, Department of Civil and Environmental Engineering and the Evans School of Public Affairs, University of Washington

Clinton E. Trammel, Education Director, Model Forest Policy Program

Brad Udall, Director, Western Water Assessment, University of Colorado at Boulder

Bud Watson, Research Director, Model Forest Policy Program

Emily Young, Associate Vice President, San Diego Foundation

Suggested format for citing this publication:

Snover, A.K., L. Whitely Binder, J. Lopez, E. Willmott, J. Kay, D. Howell, and J. Simmonds. 2007. *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*. In association with and published by ICLEI – Local Governments for Sustainability, Oakland, CA.

about the authors and the climate resilient communities program™

The Climate Impacts Group at the University of Washington

The Climate Impacts Group (CIG) is an interdisciplinary research group studying the impacts of natural climate variability and global climate change ("global warming") on the U.S. Pacific Northwest. Through research and interaction with regional stakeholders, the CIG works to increase the resilience of the Pacific Northwest to fluctuations in climate. The CIG is unique in its focus on the intersection of climate science and public policy. The group performs fundamental research on climate impacts and works with Pacific Northwest planners and policy makers to apply this information to regional decision making processes.

The CIG is part of the Center for Science in the Earth System at the University of Washington's Joint Institute for the Study of the Atmosphere and Ocean, and is one of eight Regional Integrated Sciences and Assessment (RISA) teams studying regional impacts of climate variability and climate change in the United States. The RISA program is funded by the National Oceanic and Atmospheric Administration's Climate Program Office. CIG also receives additional financial and technical support from the University of Washington.

King County, Washington

Located on Puget Sound in Washington State and covering an area of 2,134 square miles, King County is nearly twice as large as the average county in the United States. With almost 1.8 million people, it also ranks as the 14th most populous county in the nation.

King County's terrain ranges from farmland and the Cascade Mountains on the east side to Puget Sound and urban coastline on the west side. King County's rural and metropolitan areas are vulnerable to many projected climate change impacts, including declining mountain snowpack (which is directly linked to water supplies), increased risk of drought, sea level rise, and increased flooding in coastal and freshwater river systems.

King County provides regional services to all residents of the county, including people who live in cities. These include courts and related legal services, public health services, the county jail, records and elections, property tax appraisals and regional parks and facilities, including the King County International Airport (Boeing Field). The county government also has responsibility for public transit and sewage disposal. The King County Executive is the elected executive officer of county government, and the Metropolitan King County Council is the elected legislative body of county government.

Now in his third term as King County Executive, Ron Sims has built his career in public service around the progressive principles of environmental stewardship, social justice, and good government. He has a national reputation for boldness and vision, and has an established record of environmental protection. In early 2007, under his leadership, King County's Executive Action Group on Climate Change released its inaugural climate plan, which included aggressive strategies to reduce greenhouse gas emissions from government operations and the region, as well as practical steps to make the region more resilient to projected climate change impacts. He has been honored with the Sierra Club's prestigious 2006 Edgar Wayburn Award, which celebrates outstanding service to the environment by a person in government, *Governing Magazine's* 2006 national Public Official of the Year award, and the United States Environmental Protection Agency's 2007 Climate Protector Award.

ICLEI – Local Governments for Sustainability and the Climate Resilient Communities Program™

ICLEI – Local Governments for Sustainability is an international association of almost 1,000 local governments worldwide and more than 250 in the United States that have made commitments to sustainable development and climate protection. ICLEI, founded in 1990 as the International Council on Local Environmental Initiatives and now known officially as ICLEI – Local Governments for Sustainability, strives to advance solutions to global climate change through cumulative local action. ICLEI provides technical and policy assistance, software training, climate expertise, information services and peer networking to help members build capacity, share knowledge and implement sustainable development and climate protection at the local level.

In 1993, ICLEI launched its Cities for Climate Protection Campaign© to assist local and regional governments in adopting policies and implementing quantifiable measures to reduce local greenhouse gas emissions, improve air quality, and enhance urban livability and sustainability. More than 800 local governments participate in the Cities for Climate Protection Campaign and have begun to integrate sustainability and climate change mitigation into their decision-making processes. ICLEI runs this highly successful and widely recognized campaign either regionally or nationally in Australia, Canada, Europe, Japan, Latin America, Mexico, New Zealand, South Africa, South Asia, Southeast Asia, and the United States. The campaign is based on an innovative performance framework structured around five milestones that local governments commit to undertake. The milestones allow local governments to understand how municipal decisions affect energy use and how these decisions can be used to mitigate global climate change while improving community quality of life.

In fall 2005, ICLEI launched its Climate Resilient Communities Program with funding from the National Oceanic and Atmospheric Administration (NOAA) to help local governments throughout the United States improve their resiliency to climate change impacts. The Climate Resilient Communities Program helps local governments develop tools to protect their communities from the impacts and costs associated with climate change. Program participants learn to use tools and develop strategies that reduce hazards and manage risks related to regulations, planning, urban design, and investments. The program also helps communities identify and pursue creative opportunities that arise from change. Early partners have included: Keene, New Hampshire; Fort Collins, Colorado; Anchorage, Alaska; Miami-Dade County, Florida; and Homer, Alaska.

As in the Cities for Climate Protection Campaign framework, local and regional governments in the Climate Resilient Communities Program can measure their progress according to five milestones of preparedness. The Five Milestones – 1) Initiate a climate resiliency effort, 2) Conduct a climate resiliency study, 3) Set preparedness goals and develop your preparedness plan, 4) Implement your preparedness plan, and 5) Measure your progress and update your plan – are consistent with the material of this guidebook.

In addition to making this guidebook available to its members and local government leaders, ICLEI is ready to assist any municipalities that want to implement the milestones, strategies and recommendations of the guidebook. ICLEI is a leading resource for cities, towns and counties on climate mitigation and adaptation, and its growing peer network of members is an excellent venue for municipalities to communicate with one another, share best practices, and address the challenge of climate change together at the local level. To learn more about ICLEI or the Climate Resilient Communities program and to become a member, please visit *http://www.iclei.org*.

table of contents

Figures

Tables

Boxes

executive summary

Humans are altering the earth's atmosphere, causing changes in global climate that will affect our environment and communities for centuries to come. There are many indications that these changes are already underway: temperatures are increasing, glaciers are retreating, snowpack is disappearing, spring is arriving earlier, the ranges of plants and animals are shifting, and seas are rising. Within a handful of decades, climate in many parts of the United States is expected to be significantly warmer than even the warmest years of the 20th century, increasing the risk of drought, flooding, forest fires, disease, and other impacts across many regions.

Public decision-makers have a critical opportunity – and a need – to start preparing today for the impacts of climate change, even as we collectively continue the important work of reducing current and future greenhouse gas emissions. If we wait until climate change impacts are clear to develop preparedness plans, we risk being poorly equipped to manage the economic and ecological consequences, and to take advantage of any potential benefits.

Preparing for climate change is not a "one size fits all" process. Just as the impacts of climate change will vary from place to place, the combination of institutions and legal and political tools available to public decision-makers are unique from region to region. Preparedness actions will need to be tailored to the circumstances of different communities. It is therefore necessary that local, regional, and state government decision-makers take an active role in preparing for climate change, because it is in their jurisdictions that climate change impacts are felt and understood most clearly.

The purpose of *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments* is to help you as a decision-maker in a local, regional, or state government prepare for climate change by recommending a detailed, easy-to-understand process for climate change preparedness based on familiar resources and tools. The content of this guidebook was developed from reviews of scientific literature, the Climate Impacts Group's experience working with U.S. Pacific Northwest decision-makers on preparing for climate change, and King County, Washington's experience developing and implementing a climate change preparedness plan. ICLEI – Local Governments for Sustainability has also provided guidance based on its Climate Resilient Communities Program, its Five Milestones process for climate change adaptation, and its extensive experience with local and regional governments.

The guidebook begins with an introduction (Chapter 1) from King County Executive Ron Sims, which highlights both the urgent responsibility and opportunity for public decision-makers to prepare for climate change now and in the coming decades. Chapter 2 provides a short overview of the science of global climate change and its projected national and regional consequences. Chapter 3 offers reasons why local, regional, and state decision-makers should prepare proactively for the impacts of climate change to their communities.

This guidebook is for you if your primary area of concern includes the following:

- ensuring safe and reliable public services
- ensuring environmental quality or compliance
- economic development
- land use planning and zoning
- fiscal responsibility and risk management
- capital investments
- emergency response
- water resources management
- public health
- coastal zone management
- port management
- ecosystem management
- transportation infrastructure
- simply making sure that your community is planning for climate change

Chapter 4 through 7 provide suggestions on the critical steps to take to initiate your climate resiliency effort. Specifically, these chapters recommend how to:

- scope the climate change impacts to your major ***sectors*** (Chapter 4)
- build and maintain support among your stakeholders to prepare for climate change (Chapter 5)
- build your climate change preparedness team (Chapter 6)
- identify your ***planning areas*** relevant to climate change impacts (Chapter 7).

Words in ***bold italics*** indicate the first use of key terms defined in the "Key Terms" section on pages 5–6.

At the completion of these chapters, you should have: an understanding of climate change impacts to your community, an established climate change preparedness team, and sufficient organizational and political support to conduct your climate resiliency study. You and your team should also have a list of planning areas relevant to climate change impacts on the major sectors in your community.

Chapter 8 and Chapter 9 next offer recommendations on how to identify your ***priority planning areas*** for action, including how to:

- conduct a ***vulnerability assessment*** based on climate change projections for your region, the sensitivity of your planning areas to climate change impacts, and the ability of your community to adapt to climate change impacts (Chapter 8);
- conduct a ***risk assessment*** based on the consequences, magnitude, and probability of climate change impacts, as well as on an evaluation of risk tolerance and community values (Chapter 9).

At the completion of these chapters, your team should have a list of its priority planning areas to focus on for the next stage of preparedness planning.

Chapter 10 guides development of your climate change plan for your identified priority planning areas, including how to:

- establish a vision and guiding principles for a ***climate resilient community***
- set ***preparedness goals*** in each of your priority planning areas based on these guiding principles
- develop, select, and prioritize possible ***preparedness actions***.

At the completion of these chapters, your team should be able to publish a cohesive climate change preparedness plan based on the series of preparedness goals and actions developed in your selected priority planning areas. Chapter 11 then guides you on implementing your climate change preparedness plan, including how to:

- identify a list of important ***implementation tools***
- develop an understanding of how to manage risk and uncertainty in your planning effort.

Chapter 12 guides you on measuring your progress and updating your plans, including how to:

- develop ***measures of resilience***, and use these to track the results of your actions over time
- review your assumptions and other essential information to ensure that your work remains relevant to your community's most salient climate change impacts
- update your plans regularly.

At the close of the chapter, you should have a list of measures of resilience for your team's work and an understanding of how and when to update your plan. Chapter 13 provides final thoughts on how to prepare for climate change effectively and establish a lasting positive influence.

Finally, the appendices provide valuable supporting information, including: summaries of observed changes in the United States; a science primer of climate change impacts; summaries from the U.S. National Assessment Synthesis Team's reports on climate change impacts in regions and native homelands of the United States; and a current list of additional resources on climate change science, impacts, and preparedness.

For governments intending to mark their progress in use of this guidebook, a checklist that captures the major milestones of the process can be found at the front of this guidebook. In general, the steps and milestones of this checklist are consistent with the guidebook's chapter headings, as well as the Five Milestones process of ICLEI - Local Governments for Sustainability's Climate Resilient Communities Program.

It is important to note that the guidebook's preparedness process can be tailored for implementation across communities, within a single community, or even within an individual agency or department in the United States or elsewhere. You may also choose to tailor the process based on your resource availability or other factors; strategies for working with limited resources are offered at various points in the guidebook. Finally, although the guidebook is written for local, regional, and state governments in the United States, the fundamental principles of the guidebook can also be applied in tribal governments, non-governmental organizations, and private sector businesses sensitive to climate variability and change.

key terms

The following key terms are used throughout this guidebook.

Adaptive capacity: describes the ability of built, natural, and human systems to accommodate changes in climate (including climate variability and climate extremes) with minimal potential damage or cost. As a general rule, systems that have high adaptive capacity are better able to deal with climate change impacts. For instance, agriculture in a given region will have greater adaptive capacity if the farms of that region have a choice of water sources for irrigation (i.e., in the face of water shortage) and the financial ability and training to switch crop types (i.e., if another crop were proven to grow better based on new climate characteristics).

Climate resilient community: one that takes proactive steps to prepare for (i.e., reduce the vulnerabilities and risks associated with) climate change impacts.

Implementation tools: the authorities and/or avenues over which your government has control or influence in policy, planning and infrastructure, in order to take your preparedness actions successfully.

Measure of resilience: a quantitative or qualitative judgment that you make and track over time to determine how well your actions meet the preparedness goals you have set.

Planning areas: describe the areas in which a government or community manages, plans, or makes policy affecting the services and activities associated with built, natural, and human systems. Planning areas can be as broad or as specific as you deem necessary. Examples of planning areas include water supply, wastewater treatment, public health, road operations and maintenance, forestry, and parks. Planning areas are a subset of sectors.

Preparedness action: the activity or activities that your government undertakes to achieve its preparedness goals.

Preparedness goal: what you want to accomplish in your priority planning areas through preparedness action.

Priority planning areas: the planning areas which your community or government determines to be most important for focusing your preparedness efforts, based on your community's vulnerabilities to climate change and associated risks.

Sector: a general term used to describe any resource, ecological system, species, management area, activity, or other area of interest that may be affected by climate change. General examples include forests (a resource), wetlands (an ecological system), salmon (a species), water supply (a management area), agriculture (an activity), or human health. The term may also be used to describe more specific aspects of these examples that are important to the community, such as water quality, coastal marshes, Oregon Coast Coho salmon (*Oncorhynchus kisutch*), dryland wheat farming, or elderly populations.

Sensitivity: the degree to which a built, natural, or human system is directly or indirectly affected by changes in climate conditions (e.g., temperature and precipitation) or specific climate change impacts (e.g., sea level rise, increased water temperature). If systems in a planning area are likely to be affected as a result of projected climate change, then that system should be considered sensitive to climate change. For instance, a community of coldwater fish at the southern edge of its range is highly sensitive to changes in climate, because even a slight

warming may make its habitat unsuitable. In turn, regional economies based on fisheries solely targeting those fish would also be highly sensitive to changes in climate.

Systems: refer to the built, natural, and human networks that provide important services or activities within a community or region. Built systems can refer to networks of facilities, buildings, and transportation infrastructure such as roads and bridges. Natural systems can refer to ecological networks of fish, wildlife, and natural resources like water. Human systems can refer to networks of public health clinics, courts, and government.

Vulnerability: the susceptibility of a system to harm from climate change. Vulnerability is a function of a system's sensitivity to climate and the capacity of that system to adapt to climate changes. In other words, systems that are sensitive to climate and less able to adapt to changes are generally considered to be vulnerable to climate change impacts. For example, coral reefs are vulnerable to damage from climate change, as they are sensitive to changes in climate and have limited capacity to adapt to those changes.

suggested checklist for governments on how to prepare for climate change

MILESTONE 1: Initiate your climate resiliency effort (Chapters 4-7)

☐ Scope the climate change impacts to your major sectors (Chapter 4)
☐ Pass a resolution or administrative order directing your government to prepare for climate change (Chapter 4)
☐ Build and maintain support to prepare for climate change (Chapter 5)
☐ Build your climate change preparedness team (Chapter 6)
☐ Identify your planning areas relevant to climate change impacts (Chapter 7)

MILESTONE 2: Conduct a climate resiliency study (Chapters 8-9)

☐ Conduct a climate change vulnerability assessment (Chapter 8)
☐ Conduct a climate change risk assessment (Chapter 9)
☐ Prioritize planning areas for action (Chapter 9)

MILESTONE 3: Set preparedness goals and develop your preparedness plan (Chapter 10)

☐ Establish a vision and guiding principles for a climate resilient community
☐ Set your preparedness goals
☐ Develop, select and prioritize your preparedness actions

MILESTONE 4: Implement your preparedness plan (Chapter 11)

☐ Ensure that you have the right implementation tools

MILESTONE 5: Measure your progress and update your plan (Chapter 12)

☐ Develop and track measures of resilience
☐ Update your plan

chapter 1 take action, take advantage: an introduction by King County Executive Ron Sims

King County Executive Ron Sims

In the spring of 2005 I asked my staff to put together a major conference on climate change. The purpose of the conference was not to consider the extent of greenhouse gas pollution or to explore new and alternative ways to generate clean, sustainable energy, although those endeavors have long been a focus of our work in King County. Rather, the purpose of the conference was to find ways to prepare our communities to adapt to a different world, a world of warmer temperatures and less predictable weather patterns; a world that has, in many ways, already arrived.

The idea of holding such a conference came to me after reading an editorial by Dr. Peter Ward, a professor of Geological Sciences at the University of Washington (*Seattle Times*, 2004). Dr. Ward discussed the important role that paleontologists play in our efforts to address climate change, arguing that we cannot ignore the lessons of our past. These lessons highlight how delicate our ecosystems are, especially in context of climate change and the catastrophic consequences that have resulted from seemingly small changes to the world's climate.

In King County, we have been attentive to this delicate balance for some time now. Because of the expected harmful effects of climate change on this region, we have chosen to develop expertise in preparing our community for these changes. Many of our region's problems and our proposed solutions are outlined in our 2007 King County Climate Plan. The experience of our team in developing the Climate Plan is the foundation for this guidebook.

The message of Dr. Ward's editorial and other similar commentaries on climate change is clear: ignore the effects of climate change at your own peril. So, as the leader of the fourteenth largest county government in the United States of America, I became determined to develop new ways to get the word out about preparing for this crisis. I decided that a national conference on the subject was long overdue.

"The Future Ain't What It Used To Be" Conference on Climate Change

In planning for the conference, "The Future Ain't What it Used to Be" (titled with respect to a famous Yogi Berra quote), we estimated that no more than 300 people would attend. We solicited leaders from public, private and not-for-profit organizations from across the nation. By the time the conference was ready to begin in October 2005, it was booked to capacity with over 700 people registered to participate. We had to stagger the attendance during the day to remain in compliance with the Seattle Fire Department's building capacity limitations. We had struck a chord of latent concern and people responded. That concern grows stronger every year.

Seven break-out sessions of the conference focused on a wide range of climate change effects, including impacts to hydropower, municipal water supplies, agriculture, and wastewater treatment. Because King County is an urban coastal region and an important port for the nation's fisheries and

maritime trade, we also convened experts on sea level rise, shoreline impacts, and consequences to fish and shellfish. Participants were hungry to receive both practical real life strategies as well broad based policy ideas, and we started those conversations.

The media was also very engaged. In the same month as the conference, a story broke that explained in some detail how the Pacific Northwest would be a region significantly impacted by the effects of climate change (*Seattle Times* October 9, 2005). The conference was then covered by Seattle's major daily papers as well as a national news wire (*Seattle Times* October 28, 2005; *Associated Press* October 28, 2005).

Our keynote speaker was former New Jersey Governor and U.S. Environmental Protection Agency Administrator Christine Todd Whitman, who expressed that meaningful federal limits on greenhouse gases were a necessary component of an overall emissions reduction program. She spoke eloquently of the role that local municipalities and states can and must play in the battle against climate change. I could not agree more.

The conference has had ripple effects that we keep seeing even now. At the close of the event we were flooded with requests to make the information discussed at the plenary and break-out sessions available on the King County website. The conference also served as the impetus for the State of Washington to commission a report on the economic impacts of climate change to water supplies, forestry, fisheries, agriculture and other sectors important to Washington's economy.

Perhaps most importantly, the idea for this guidebook was born from the great enthusiasm for additional knowledge, collaborative strategies, and shared resources that flowed from this conference. Soon after the conference ended, we gathered a climate team made up of county employees to start planning for climate change, and to record our experiences in this guidebook. Then, working with our conference partners from the Climate Impacts Group at the University of Washington, we quickly launched a writing collaboration.

Not surprisingly, ICLEI – Local Governments for Sustainability has joined with us and published the guidebook. No organization is doing more on the international scene than ICLEI in providing technical and policy assistance, peer networking opportunities, and general expertise to local governments on climate change emissions reductions. Now ICLEI has launched its new Climate Resilient Communities Program, which will provide assistance to local governments on preparing for climate change impacts.This guidebook will serve as a valuable resource for communities participating in the Climate Resilient Communities Program. Together with ICLEI and the Climate Impacts Group, King County is committed to making preparedness for climate change a critical part of how local, regional and state governments think about the future.

Mitigate and Adapt

But let me reaffirm that reducing or "mitigating" greenhouse gas pollution is a top priority for King County government. We have to address the cause of the problem so that we do not exacerbate its effects. In essence, mitigation is our number one preparedness strategy. If we do not stop the growth of and eventually reverse greenhouse gas emissions, then our opportunity to adapt will be limited by the rapid pace of climate change.

As a result of the critical importance of mitigation, there was a time, not long ago, when it was not acceptable to talk about adapting to – or preparing for – climate change. The reasoning was that time spent preparing for or adapting to the harmful effects of greenhouse gas pollution would divert resources from the essential need to reduce the emissions of those gases.

Even as I write these words, there are still many people who are reluctant to talk about specific adaptation or preparedness policies. But as responsible public leaders, we cannot afford the luxury of not preparing. We know now that some impacts are inevitable and we know that these impacts will affect many of the essential services and functions that our governments are expected to provide. We must prepare for the impacts underway while we work to avoid even worse future effects.

What about the perception that mitigation and adaptation activities compete against one another for resources and attention? While it may be true that preparing for climate change will call on resources that are useful for mitigation, it is just as likely that an open discussion about what is needed to prepare for the harmful effects of climate change will inspire action to reduce greenhouse gas pollution. Reality is a powerful motivator. This was, in fact, one of the findings of a 2006 Yale conference on climate change (Abbasi 2006). The reality of failing levees, melting snowpack, and rising coastlines is a powerful motivator. Proposing to make investments to shore up those levees, build reclaimed water systems to offset melting snowcaps, build higher seawalls, and protect shoreline communities will even more effectively bring the perils of climate change into the public eye.

"In essence, mitigation is our number one preparedness strategy. If we do not stop the growth of and eventually reverse greenhouse gas emissions, then our opportunity to adapt will be limited by the rapid pace of climate change."

That has been my experience. King County is making multi-million dollar investments to address these scenarios, including construction of a reclaimed water system and reconstruction of critical levees across the region. In each case, those adaptive infrastructure investments have helped – and not detracted from – our efforts to promote greenhouse gas mitigation policies, because they have raised the profile of the climate change problem. Our recent voter approved tax proposal to increase King County's transit system is proof of this. King County's transit initiative is a powerful mitigation strategy, given that automobiles in our region are the greatest contributor to greenhouse gas pollution.

Moreover, and perhaps even more importantly, as public leaders and public servants who have assumed the responsibility for the health, safety, and welfare of our citizens, we have a professional and moral obligation to prepare our communities for climate change. The climate is changing. There is much at risk. We must begin to prepare for these changes.

The Challenge of Our Generation and Opportunity of A Lifetime

Climate change is one of the greatest threats our society has ever faced. The atmospheric balance that sustains our lives is incredibly fragile, and the damage people are doing to it will have drastic consequences. These consequences cross racial, ethnic, religious, economic, and political boundaries. On a global scale under a "business as usual" scenario, the scientific prognosis is dire. The world and its people will experience:

- more poverty
- more hunger
- more disease
- more drought
- more flooding

No person, people, or nation will be spared. Only the degree by which we will have to adapt is in question.

And if ever there was an issue in the public domain that cried out for the involvement of our younger generation in this great country it is climate change. Every time I hear someone say "that new energy policy is just too expensive" or "we don't have the money to build a more robust levee system right now" I wonder how the next generation of Americans would calculate those costs.

However, climate change is also the greatest *opportunity* our society and world has ever faced. If we do what it takes to reduce greenhouse gas pollution to safe levels and prepare for the impacts that we see are underway, we will transform the economic foundation of modern civilization and can seize the opportunity to realize better health, social justice, and sustainable economic development throughout the world. We have the choice to act, and we must.

Solutions to this crisis vary from the simple to the complex – from changing light bulbs to comprehensive international "cap and trade" regulations. Likewise, preparedness solutions range from water conservation programs to regional flood control zoning districts. But at the heart of the crisis – driving our need for any of these solutions – is the world's reliance on fossil fuels for energy.

"No person, people, or nation will be spared. Only the degree by which we will have to adapt is in question."

Our addiction to fossil fuels promotes dependence on foreign oil, which compromises national security. Our addiction to fossil fuels also undermines our efforts to create new markets in clean, sustainable forms of energy.

The co-benefits of reducing dependency on fossil fuels are profound. New advances in renewable energy, architectural design, sustainable building materials, 21st century urban planning that strategically locates where we live, work and play in one geographic, pedestrian friendly community are just a few elements of this bright new future. Others include the new role agriculture is playing in the production of sustainable energy, and the critical importance of growing and purchasing local food as a strategy for building sustainable communities.

The potential benefits of growth in much-needed living wage jobs are no less significant. We have endless opportunities to create domestic jobs as we build and redesign our homes and buildings to be energy efficient and sustainable, and as we construct our physical infrastructure to be climate resilient. Similarly, the opportunities to develop jobs by stimulating markets in clean energy technologies such as wind, solar, geothermal and biofuels are limited only by our imagination and our collective determination to create real change.

These benefits are immediately relevant on a local level. For example here in Washington, roughly $30 million is spent each day on oil and gas. Most of that money leaves the state, contributing nothing to local economic development. By investing in biofuels made from crops grown in Washington, we can keep more of those energy dollars in the state, help local farmers, and create new jobs. Economic opportunities like those that we will realize in Washington can exist in every region of our country.

At the same time, taking the opportunity to adapt to climate change impacts will also bring benefits, if we act now. We can protect our valuable homes and families from flooding if we act now. In some regions of the world, we can also capture new agricultural opportunities, if we observe changes in crop patterns based on new average temperatures and precipitation patterns.

A Call to Action

Whether you view climate change as a crisis, an opportunity, or both, it is a reality. This guidebook is about how to take immediate action, to adapt effectively to that reality. The time to delay, defer, or deny is over. We must act.

I am eager to help build a more optimistic future – one of peace and prosperity. But I am also grounded by the fact that we must prepare our communities right now for the harmful impacts that we know are coming.

As Supreme Court Justice Oliver Wendell Homes once said, "A hundred years after we are gone and forgotten, those who never heard of us will be living with the results of our actions." Likewise, I will not be here in the Puget Sound region in 50 years, but 2.5 million people will be. The actions my community takes today will affect how climate change impacts those 2.5 million residents.

Foresight and preparedness are good government. They are the essence of what we do as leaders. The steps we take now to anticipate and get ready for climate change will have profound impacts on the world our children and grandchildren inherit.

Whether you are a public official like I am, an advisor to a regional government, or an agency staff member, this guidebook offers you a framework for starting to prepare for climate change. In the pages that follow you will discover a critical tool – in essence, a road map for actions – that your government organization can put in place today to help prepare your community to adapt to a changing climate. The actions you take now will have significant impacts for generations to come.

I hope this guidebook takes the mystery out of planning for climate change. I hope it inspires you.

And I hope your leadership is rewarded with a stronger, safer community that is prepared for the greatest threat and the greatest opportunity we will ever face.

Ron Sims
King County, Washington

chapter 2 a scientific overview of climate change and its impacts

Human activities have changed the Earth's atmosphere and climate in ways that will continue for centuries to come. This chapter briefly explains how and why these changes are happening.

2.1 A Brief Overview of Climate Change

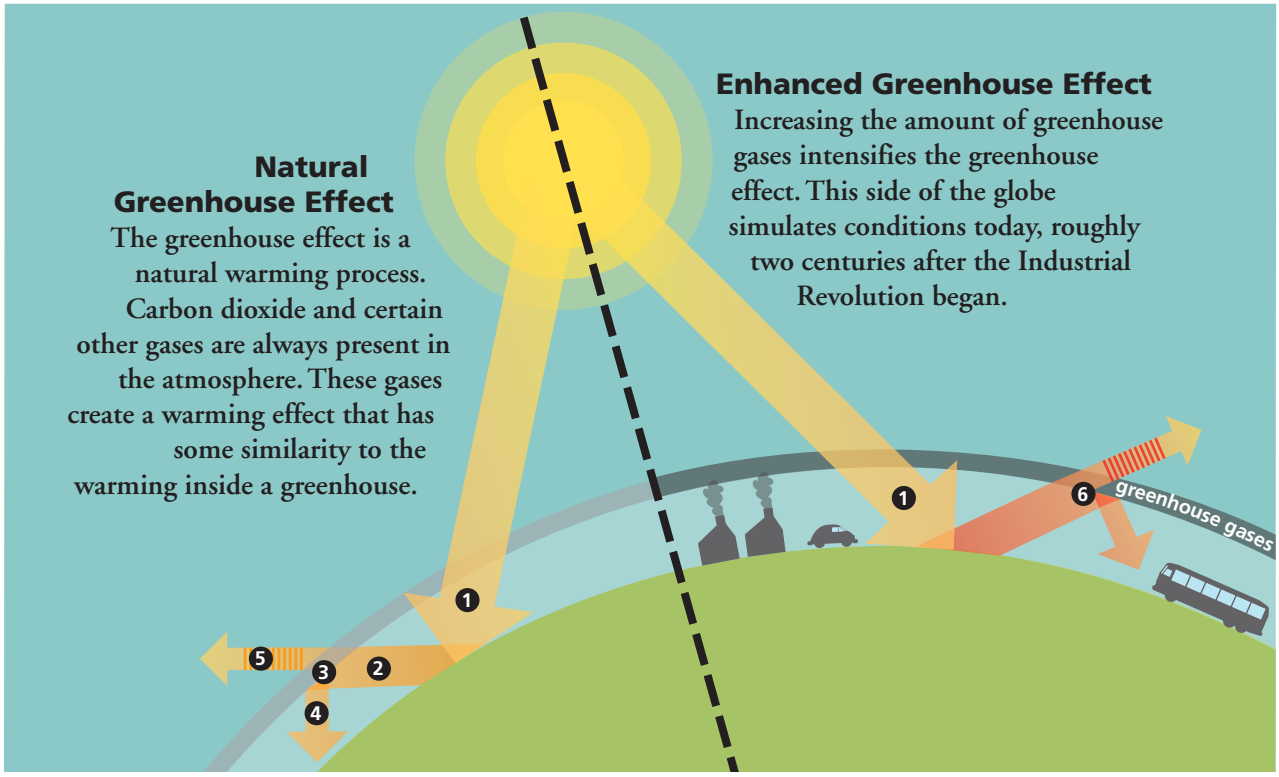
Life on Earth as we know it today is made possible by relatively warm temperatures. Without gases like water vapor, carbon dioxide (CO_2), and methane in the atmosphere, the Earth would be much colder than it is now – averaging 0°F instead of about 59°F – and most of the water on the planet would be frozen. At certain levels, these "greenhouse gases" make the planet livable for humans and many other kinds of plants and animals by trapping some of the heat radiating outward from the Earth (Figure 2.1), much like the walls of a greenhouse trap heated air. This process of limiting heat loss through the atmosphere is called the "greenhouse effect."

Through everyday activities such as burning fossil fuels (e.g., oil, coal, natural gas), agricultural practices, and clearing forests, humans have released large amounts of heat trapping greenhouse gases into the atmosphere in a short period of time (Table 2.1, Figure 2.2). Since about 1750 this rapid and large release of greenhouse gases has caused important changes in the composition of the Earth's atmosphere and, consequently, in our global climate.

Green-house gas	Percent change 1750-2005	2005 atmospheric concentration	Historical perspective on current concentration	Major sources, human and natural
Carbon dioxide	+35%	379 ppm	Higher than any in the past 650,000 years	Fossil fuel use, deforestation and land use changes, agriculture, cement production, decomposition of organic matter, oxidation of organic carbon in soils, oceans
Methane	+142%	1,774 ppb	Higher than any in at least 650,000 years	Agriculture, fossil fuel use, ruminants (e.g., cows) and manure management, landfills, wetlands, decomposition of organic matter
Nitrous oxide	+18%	319 ppb	Appears to be higher than any in the past 650,000 years	Agriculture, fossil fuel use, animal manure management, sewage treatment, nitric acid production, variety of biological sources in soil and water

Table 2.1 – Changes in greenhouse gas concentrations between 1750 (the start of the Industrial Age) and 2005. Concentrations of carbon dioxide are measured in parts per million (ppm), which refers to the total number of carbon dioxide molecules per one million molecules of dry air by volume. Methane and nitrous oxide are measured in parts per billion (ppb). Source(s): IPCC 2001a, USEPA 2006abc, IPCC 2007b

Figure 2.1 The Greenhouse Effect



Visible sunlight passes through the atmosphere without being absorbed. Some of the sunlight striking the earth ❶ is absorbed and converted to heat, which warms the surface. The surface ❷ emits heat to the atmosphere, where some of it ❸ is absorbed by greenhouse gases and ❹ re-emitted toward the surface; some of the heat is not trapped by greenhouse gases and ❺ escapes into space. Human activities that emit additional greenhouse gases to the atmosphere ❻ increase the amount of heat that gets absorbed before escaping to space, thus enhancing the greenhouse effect and amplifying the warmth of the earth. Figure adapted from illustration by the Marian Koshland Science Museum, National Academy of Sciences, USA. Figure used with permission.

Perhaps the most noticeable of these changes is that, on average, the Earth is getting warmer. Scientists have observed an increase in the world's average surface temperature over the last century, resulting in the popular term "global warming." Global average air temperature increased about 1.3°F during the 20th century (1906-2005) (IPCC 2007a). Most of this warming occurred in the second half of the 20th century and is likely to have been the largest increase in temperature of any century in at least the last 1,300 years *(ibid)*. The world's leading scientists on the Intergovernmental Panel on Climate Change (IPCC) now attribute most of the observed increase in temperature since the mid-20th century to human activities with more than 90 percent certainty. For more information on the IPCC, see Box 2.1.

> ***"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."***
>
> ***– Intergovernmental Panel on Climate Change (IPCC 2007)***

Evidence of our rapid warming trend is found throughout the world: glaciers are in widespread retreat (Figure 2.3); sea-ice is thinner and covers less area; snow cover has decreased; plants are blooming earlier; plant, insect, and animal species are shifting ranges; and sea level has risen, caused by both the expansion of warmer ocean water and the addition of water from melting ice sheets (IPCC 2001a, Parmesan and Galbraith 2004, IPCC 2007a)

Box 2.1 – Who is the Intergovernmental Panel on Climate Change (IPCC)?

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the World Meteorological Organization and the United Nations Environment Programme. The IPCC is comprised of hundreds of experts from around the world who are responsible for providing comprehensive, objective, transparent, and up-to-date evaluations of the current state of knowledge about climate change and its impacts on the world. The IPCC does not carry out direct scientific research on climate change. Instead, its reports are based mainly on other published, peer-reviewed scientific research, following strict procedures to ensure objectivity and transparency. IPCC report summaries, CD ROMs and Technical Papers are available free of charge. For more information on the IPCC, see *http://www.ipcc.ch/about/about.htm.*

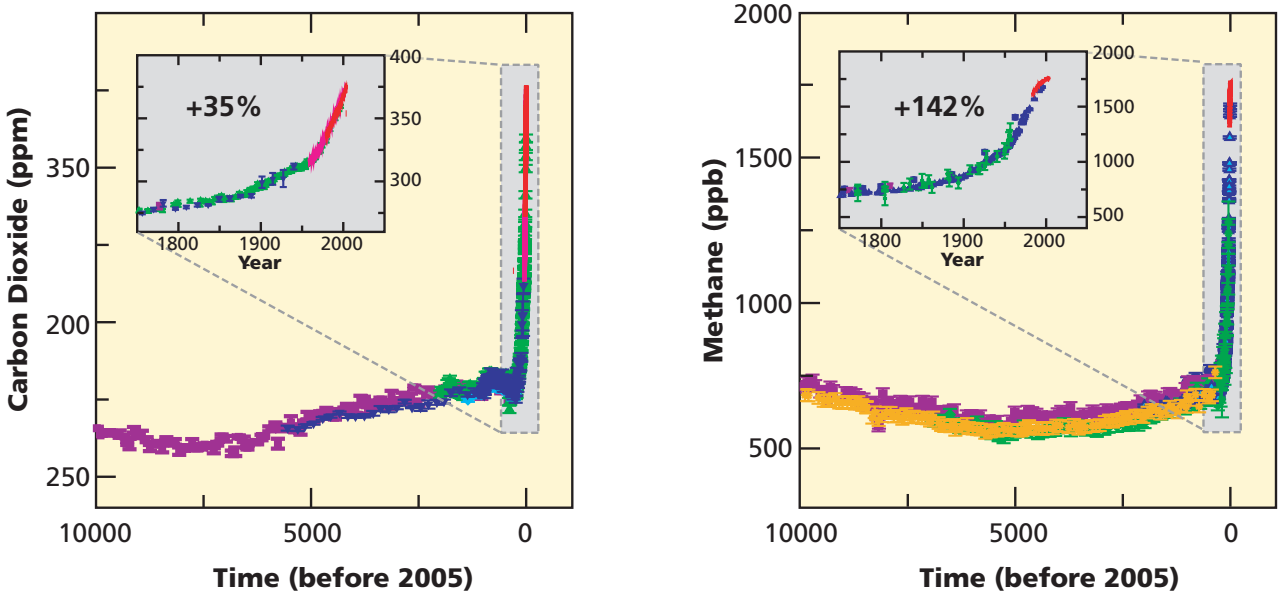
(Source: IPCC, *http://www.ipcc.ch/about/about.htm*)

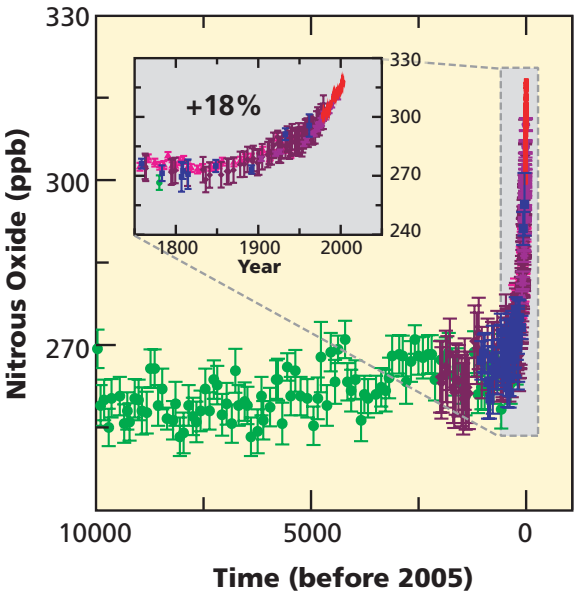
2.2 How Warm Will The World Get?

How warm the world will get, and how that warming will affect the world's human communities and ecosystems, is being studied intensively. The most comprehensive assessment of these questions, released in a report by the IPCC every five years, projects that global average temperature will increase by 3.2 to 7°F by 2100 (the "best estimate" range)[1] relative to the average temperature for 1980-1999 (Figure 2.4) (IPCC 2007a). It is important to note that these are *projections*, not predictions (see Box 2.2). For more on how scientists project future global climate change and its national, regional and local impacts, see Appendix B.

[1] The full range (5th to 95th percentile) of 21st century global climate change projections is 2.0°F to 11.5°F (IPCC 2007a).

Figure 2.2 Changes in the Atmospheric Concentration of Three Important Greenhouse Gases





The atmospheric concentration of three important greenhouse gases – carbon dioxide, methane, and nitrous oxide – has changed significantly over the last 10,000 years (large panels) and since 1750 (inset panels). The percent change in the concentration of each greenhouse gas from 1750 to 2005 is also shown in the inset panels. Concentrations of carbon dioxide are measured in parts per million (ppm), which refers to the total number of carbon dioxide molecules per one million molecules of dry air by volume. Methane and nitrous oxide are measured in parts per billion (ppb). Measurements shown include those taken from air trapped in Antarctic and Greenland ice cores (symbols with different colors for different studies) and direct atmospheric sampling (red lines). Figure adapted from: IPCC 2007a. Used with permission.

Figure 2.3 Rapid Changes in Glaciers Reveal the Impact of 20th Century Warming

A. Muir Glacier, 1941

C. Boulder Glacier, 1932

B. Muir Glacier, 2004

D. Boulder Glacier, 2005

Photos of Muir Glacier in Alaska's Glacier Bay National Park in (**A**) 1941 and (**B**) 2004. Warmer temperatures have contributed to melting of the 2,000 foot thick glacier and growth of vegetation in areas once covered by the glacier. Photo source: (**A**) U.S. Geological Survey, (**B**) U.S. Geological Survey by Bruce Molnia. Photos used with permission.

Photos of Boulder Glacier in Montana's Glacier National Park in (**C**) 1932 and (**D**) 2005. Only 26 of the 150 named glaciers in existence in 1850 remain. Model projections indicate that all of the park's glaciers will melt by 2030. Photo source: (**C**) T.J. Hileman, courtesy of Glacier National Park Archives, (**D**) Greg Pederson, courtesy of the USGS Repeat Photography Project. Photos used with permission.

Box 2.2 – What Is the Difference between Climate Projections and Climate Predictions?

Climate change *projections* are an estimate of the response of the climate system to possible future greenhouse gas and aerosol emissions over the next century and are typically based on climate model simulations. (See Appendix B for more information about how these projections are constructed.)

Climate *predictions*, or forecasts, can be thought of as declarations of future conditions based on the premise that we know how various components of a system are going to evolve given their current status and our ability to simulate their evolution in time.

The term "climate projections" is used in this guidebook in recognition that 21st century climate scenarios will vary depending on changes in global greenhouse gas emissions and the Earth's sensitivity to those changes. The greenhouse gas emission scenarios, in turn, are based on assumptions about the future evolution of society, including assumptions about demographic, socioeconomic, and technological developments that may or may not actually occur in the future. Each of these variables can follow different trajectories through the 21st century, leading to a range of potential temperature changes, for example, rather than a single estimate.

This projected warming has significant global implications (IPCC 2007a,b, Parry et al. 2007), including the following concerns:

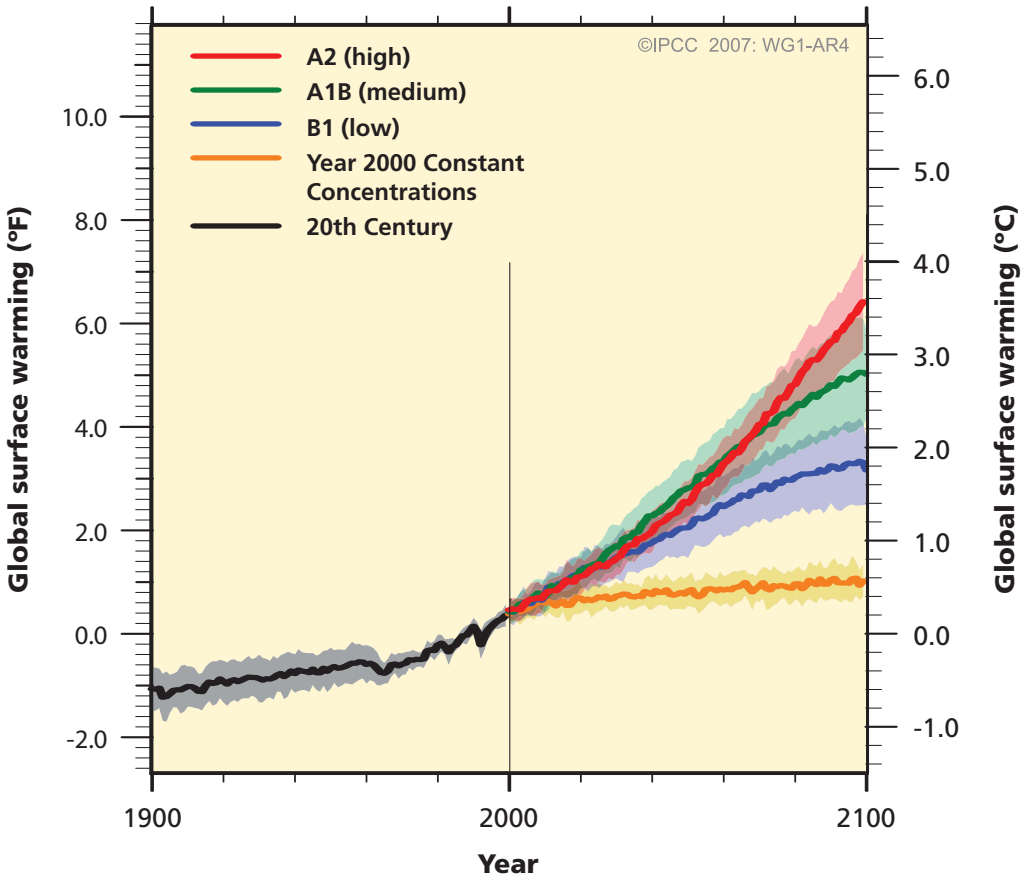
- sea ice and snow cover losses will continue, and declining snowpack will affect snow-dependent water supplies and streamflow levels around the world;
- sea level is projected to rise 7 to 23 inches during the 21st century due to melting snow and ice on land and thermal expansion of ocean waters;
- the risk of drought and the frequency, intensity, and duration of heat waves are expected to increase;
- more extreme precipitation is likely, increasing the risk of flooding;
- if the world's average temperature warms only an additional 2.7 to 4.5°F above pre-industrial levels, an estimated 20 to 30 percent of known plant and animal species would be at increasingly high risk of extinction.

Many of these changes are already underway. Furthermore, it is probable (at a likelihood greater than 66 percent) that many of the changes observed over the last 30 years can be linked at least partially to human-caused climate change (IPCC 2007b).

2.3 Projected National and Regional Consequences of Climate Change

Climate change impacts will be even more pronounced at the local and regional scales than at the national and global levels (NAST 2000). In 2000, the U.S. Global Change Research Program released the first national assessment of climate change impacts on the United States *(ibid)*. The report examined how 21st century climate may change in the U.S. and provided an initial

Figure 2.4 Global Temperature Projections For The 21st Century



This figure shows the range of global surface temperature projections for the 21st century relative to average global surface temperature for the period 1980-99. The projections are based on low (B1), medium (A1B), and high (A2) scenarios of greenhouse gas and other human-related emissions (e.g., aerosols such as sulfur dioxide). Solid lines show the multi-model average temperature change for each emission scenario. Shading denotes the + 1 standard deviation range of individual model annual averages. The orange line represents the change in average global surface temperature that would be expected if atmospheric greenhouse gas concentrations were held constant at year 2000 values. Note that the warming from all of these emissions scenarios would continue well beyond 2100. Figure adapted from IPCC 2007a. Used with permission.

assessment of major national and regional vulnerabilities to climate. A map of the U.S. National Assessment regions is shown in Figure 2.5.

The U.S. National Assessment found many common national concerns, including the following:

- average annual air temperature is projected to increase in all regions of the country, with the average national increase projected at the time of the assessment to be 5-9°F by the end of the 21st century;
- warmer temperatures, and in some regions lower snowpack, are expected to increase the risk of drought across the country;
- sea level rise and increased storm surges are expected to pose greater threats to coastal ecosystems and human communities;
- shifts in the types and distribution of forest species are likely;
- a near-term increase in forest growth is expected in most regions, because moderate increases in temperature and atmospheric concentrations of CO_2 have a temporary "fertilizing effect" (a phenomenon referred to as the "CO_2 fertilization effect"). On the other hand, overall forest growth could decrease over the long term, due to increased forest fires, insect outbreaks, and disease;
- natural ecosystems are particularly vulnerable to projected warming given that many natural ecosystems are not able to prepare for or adjust quickly to climate change impacts, and also given that non-native species may benefit from climate change more than native species;
- in all regions, the results of non-climate stresses (e.g., habitat fragmentation and patterns of human development) will be exacerbated by climate change impacts.

The U.S. National Assessment also found important differences in how climate change could affect different regions of the country. Decreases in snowpack, for example, will have greater implications for water supplies in the western U.S., where snowmelt runoff is the primary source of water supply, than in most other regions of the country. Changes in agricultural production vary depending on the region and crop; agriculture in northern regions (the Midwest, West, and Pacific Northwest) generally fared better under climate change scenarios than southern regions. Human health impacts, changes in extreme events, and impacts on coastal ecosystems also vary from region to region. An overview of impacts to U.S. regions is provided in Appendix C.

Figure 2.5 Mega Regions Analyzed in the U.S. National Assessment

Figure source: NAST 2000. Used with permission.

chapter 3 the case for governments to prepare for climate change

You may be a senior leader of government, a department staff member, or a member of the general public. At whatever level, you have many compelling reasons to begin preparing your government and community for climate change.

3.1 Why Governments Cannot Wait

Reducing greenhouse gas emissions today will play a critical role in determining how much climate change we experience in the future. However, for reasons provided below, governments cannot wait for global greenhouse gas emissions to be reduced before taking steps to prepare for climate change impacts.

- **Climate change is already in motion.** An increasing amount of physical evidence points to the fact that climate change is already in motion as a result of the greenhouse gases accumulated in the atmosphere to date, particularly since the 1950s (see Appendix A). In fact, many of the changes projected through at least the middle of the 21st century will be driven by present-day greenhouse gas concentrations. For instance, even if greenhouse gas emissions had been stabilized in 2000, we would see an additional 0.9ºF or more of warming globally in the 21st century, due to the concentration of greenhouse gases in the atmosphere in 2000 and the "lag time" of the Earth's oceans and atmosphere to warm (Hansen et al. 2005, Meehl et al. 2005, Wigley 2005, IPCC 2007a). Therefore, reducing greenhouse gas emissions will limit the severity of long term future impacts, but it will do little to alter the near-term changes already set in motion.

- **Significant reduction of greenhouse gas emissions is possible, but it is unlikely that greenhouse gas emissions will be stabilized or reversed in the near term.** Approximately 75 percent of CO2 emissions to the atmosphere over the past 20 years are due to fossil fuel burning (IPCC 2001a). If the world's nations move quickly and collectively towards a global clean energy economy, prospects for reducing global human greenhouse gas emissions are good. However, avoiding the worst climate change impacts will require reducing greenhouse gas emissions to the point where atmospheric concentrations stabilize and then decline. Given the dependence of global economic systems on fossil fuels and the time required for new technologies that reduce or replace fossil fuels to integrate into the global marketplace, any significant reduction in CO2 emissions is unlikely to occur soon enough to avoid many of the projected climate impacts.

- **Climate change is expected to continue long after greenhouse gases are stabilized.** Greenhouse gases remain in the atmosphere for tens to thousands of years before breaking down (Table 3.1). Until this happens, greenhouse gas molecules will continue to trap energy, causing continued warming. Additionally, even after atmospheric concentrations of greenhouse gases are stabilized, it will take hundreds of years for global

temperature and ocean levels to reach a new equilibrium due to the physical size and characteristics of the Earth's oceans and atmosphere (IPCC 2001c, IPCC 2007b). Together, these facts mean that atmospheric greenhouse gas concentrations and global temperature are expected to increase well into – and in all likelihood beyond – the 21st century.

Gas	Lifetime
Carbon Dioxide (CO_2)	5 to 200 years
Methane (CH_4)	12 years
Nitrous Oxide (N_2O)	114 years
Sulfur Hexafluoride (SF_6)	3,200 years
Carbon Tetrafluoride (CF_4)	50,000 years

Table 3.1 – Examples of greenhouse gas lifetimes. The table shows some of the important greenhouse gases along with two synthetic gases (SF_6 and CF_4) that have long atmospheric lifetimes. Lifetimes refer to the average amount of time an emitted gas with spend in the atmosphere before being chemically broken down, absorbed into the ocean, or otherwise removed from the atmosphere. For CO_2, a single value cannot be assigned since there are many removal processes that occur at a range of speeds. Table source: IPCC 2001a.

- **Climate change will likely lead to irreversible losses in some areas.** If no action is taken, climate change will likely lead to irreversible losses in nature, including extinction of species and permanent loss of habitat and special historical and cultural places. As noted previously, if the global average temperature increases only an additional 2.7 to 4.5°F over pre-industrial levels, an estimated 20 to 30 percent of the plant and animal species known in the world are likely to be at higher risk of extinction (Parry et al. 2007). Avoiding these losses, if possible, will require actively managing ecosystems systems and human choices.
- **Climate change will have largely negative economic consequences, but may also create economic opportunities.** Climate change will affect a wide array of economic sectors, including: agriculture, forestry, water supply, fisheries, health, energy, coastal development, transportation, and recreation and tourism. Non-economic resources such as biodiversity, air, and water quality will also be affected. Planning for climate change and its specific regional effects may help reduce the economic costs to these sectors while also creating opportunities to capitalize on its beneficial impacts.

Given these realities, managing climate change impacts is not simply a matter of "waiting it out." It is becoming increasingly necessary to take steps to prepare for the regional effects of climate change even as communities work together to stabilize global greenhouse gas emissions.

3.2 Reasons for Local, Regional and State Governments to be Proactive

There are several fundamental reasons for local, regional and state governments to be proactive in preparing for climate change impacts.

- **Planning for the future can benefit the present.** In assessing what the future climate holds, governments may find that many projected climate change impacts are in fact more extreme versions of what communities are already experiencing today as a result of present day climate variability and extreme climate events. Climate change, for example, will increase the risk of drought, which all communities experience periodically. Implementing a water conservation program in anticipation of this changing drought risk offers immediate benefits for managing current droughts as well as the more frequent and more intense droughts projected in the coming decades.

- **Preparing for climate change is "good government."** Governments across the United States and the world share a common goal of ensuring the safety, health and welfare of their communities now and into the future. Meeting this goal and maintaining the integrity of essential public services requires that governments anticipate trends and changes that could affect their environment, economy, and community well-being. Because climate change will affect a broad range of community assets and government services, operations and policy areas, preparing for climate change is thus a matter of "good government" and risk management.

- **Localities, regions and states are on the front lines of climate change impacts, and have a responsibility to respond.** Climate change is a global trend, but one which localities, regions and states will experience to different degrees and in different ways. Also, by nature, public programs and policy strategies designed at the federal or international level have a limited level of specificity, whereas local, regional and state governments are in a stronger position to tailor climate change preparedness strategies to their specific circumstances, and to the unique set of climate change impacts that they expect to face. Therefore, while higher levels of government can and must provide funding and support for climate change preparedness strategies on the ground, local, regional and state governments have an equal or even greater responsibility to plan proactively as well.

- **Proactive planning is more effective and less costly than responding reactively to climate change impacts as they happen.** Taking proactive steps to be flexible and to anticipate and address expected impacts can save money and protect the well being of communities. For instance, considering the impacts of climate change on water supply and demand in design criteria for a new reservoir can help ensure that the new reservoir meets future water needs and may be less costly than having to expand the reservoir in the future (if expansion is possible at all by that time).

- **Thinking strategically can reduce future risks.** Being proactive and strategic in planning for climate change impacts can create opportunities for modifying present-day policies and practices that can increase vulnerability to climate change. For example, zoning that concentrates development in an area at risk to future sea level rise and coastal flooding can be altered before that area is built out.
- **Thinking strategically can increase future benefits.** Being proactive can create opportunities for capitalizing on some of the benefits of climate change. A longer growing season, for example, could lead to greater agricultural production (provided that adequate water supplies are available). Similarly, warmer winter temperatures could lead to cost savings from reduced winter road maintenance requirements.
- **Anticipating future changes can add value to today's investments at low additional cost.** Preparing for climate change impacts may provide opportunities to add value to existing capital projects. "Piggybacking" a reclaimed water system onto a planned wastewater treatment system expansion, for example, reduces the marginal cost of adding the reclaimed water system while providing buffering capacity against projected water supply impacts.

Climate change is unlike most other public priorities in that it directly or indirectly affects a broad range of resources and activities in the public and private sector, including water resources, energy, public health, agriculture, forests, transportation, land use planning, stormwater management, and emergency management. Taking practical steps now with the best information available enables you to reduce your future risk and also realize possible near-term benefits.

3.3 Moving Beyond Common "Barriers"

You will face obstacles in planning for climate change. You may also encounter resistance from others in your organization or region. Often, however, the barriers (both perceived and real) to planning for climate change can be easily addressed. Some of the more common barriers to planning are addressed here.

The barrier: "I don't know how climate change will affect my community."
The local impacts of climate change may not be easily understood, especially if information on regional or local climate change impacts is limited.

A response: Climate change will affect communities and community government functions in a variety of ways. More obvious impacts could include an increased risk for extreme events such as drought, storms, flooding, and forest fires; more heat-related stress; the spread of existing or new vector-born disease into a community; and increased erosion and inundation of low-lying areas along coastlines. In many cases, communities are already facing these problems to some degree. Climate change raises the stakes in managing these problems by changing the frequency, intensity, extent, and/or magnitude of these problems.

Climate change impacts may also appear in unexpected ways. For example, some communities may have more difficulty meeting federally mandated summer air quality standards if increased

temperatures lead to higher concentrations of ground-level ozone (Shriner and Street 1997, IPCC 2001b). Lower summer streamflows could have effects not only on fish and wildlife, but also on industries discharging permitted industrial effluent to the streams. Other less obvious impacts may include increased costs for combating insect outbreaks on urban forests or agricultural crops or difficulty restoring populations of endangered species based on climate change impacts on habitat or the food web.

There are many sources of information on how climate change may affect the United States, its various sub-regions, and specific types of resources such as water supply, coasts, forests, and agriculture (see Chapter 4 and Appendix C). These sources can all be used to some degree to develop a better understanding of how climate change may affect your community even when information specific to your location is not available. Tips for reviewing these sources and organizing the information for planning are provided later in Chapter 4 and Chapter 8. Regional climate and/or resource management experts may also be good resources for finding out how climate change may affect your community.

The barrier: "Climate change action should happen at higher levels of government."
Media attention on policies for reducing greenhouse gas emissions (e.g., the Kyoto Protocol) may contribute to perceptions that climate change is an international-scale problem to be handled through federal policies and international agreements.

A response: While national and international policies have an important role in reducing greenhouse gas emissions, it may be a half-century or more before these policies lead to any substantive reduction in atmospheric concentrations of greenhouse gases and global average temperature. More importantly, the impacts of climate change will be felt most acutely at the local scale. Managing these impacts will require developing locally-based strategies.

The barrier: "I'll deal with climate change when I see that it is happening."
Acute climate change may not be evident in some sectors for several decades. This time lag may contribute to the perception that climate change is an issue to address when you see that "climate change is obviously occurring" or at some other point down the road.

A response: There is considerable evidence that climate change is already underway (see Chapter 2 and Appendix A). Deferring planning until climate change is "here" could cause costly delays and increase vulnerability to climate impacts given the time required to implement some preparedness strategies. For example, expanding a water supply system to accommodate the combined impacts of population growth and climate change may take 10 to 30 years before the additional capacity is online. This delay could leave a region vulnerable to drought, higher water rates, and broader economic costs.

Climate change ***mitigation*** refers to activities undertaken to reduce greenhouse gas emissions.

In some cases, waiting for more obvious signs of climate change may foreclose on lower cost preparedness options, leaving you with only expensive ways out. For example, a low cost strategy for managing the risk of more frequent or intense floods might be to leave a floodplain undeveloped. Hypothetically, if you wait to plan until you have perfect information about increased flood risk and allow development to continue in the floodplain, you may need to take a more costly approach later, such as installing dikes or other major infrastructure to protect property in the most vulnerable areas of the floodplain.

The barrier: "My community wants to focus only on reducing greenhouse gases."
Actual resource limitations – especially for projects considered to be in the category of "environmental policy" – could force you to choose between actions that reduce greenhouse gas emissions and your proposed preparedness efforts. On another note, you may also face a perception that if you focus on preparing for climate change, you are giving up the fight to reduce greenhouse gas emissions.

A response: Limiting the future damage of climate change to the world and your community requires both reducing greenhouse gas emissions and preparing for climate change impacts. If your community is already focused on greenhouse gas emissions reduction, seize the moment to start a community conversation about climate change impacts and the potential for climate change to exacerbate existing problems.

The barrier: "I'll deal with climate change when you can tell me exactly what I need to plan for."
Some fields (e.g., engineering and urban planning) traditionally demand precise information in order to make changes to physical structures, large-scale capital investments, or land use zoning.

A response: Climate change will require that you learn how to plan more effectively with evolving, imperfect information. Waiting for certainty can increase your vulnerability to climate change and potentially lead to high financial and social costs. You can incorporate existing information on climate change impacts into plans and designs and designs, if you write those documents to accommodate a reasonable range of projected extremes, and to be updated more frequently over time as your information improves. Where to obtain specific regional information about climate change impacts and how to deal with uncertainty are described in Chapter 4 and Chapter 11.

The barrier: "I'll wait until I see other communities planning for climate change."
The perception that no other "peer" communities (i.e., of your size and in your geographic area) are planning for climate change could make you, your public officials, or stakeholders in your community reluctant to invest in preparing for climate change.

A response: Many governments within the United States and elsewhere have begun to ask what climate change may mean for their communities. These efforts are being driven in part by public concern about climate change, increasing evidence that climate change is occurring, and increasing capabilities to provide information on climate impacts at the regional scale. A sample list of urban regions planning for climate change (in addition to King County, Washington) is provided in Box 3.2. It will also be useful for you to identify other "peer" communities who have invested in preparing for climate change, through networks such as ICLEI – Local Governments for Sustainability, the Center for Clean Air Policy's Urban Leaders Initiative, or the USEPA.

The barrier: "I don't have time or money to deal with climate change right now."
Governments must continually juggle multiple issues of immediate importance, often making it difficult to take on "new" issues such as climate change preparedness. Financial, technical, institutional, and/or human resource constraints can also limit an organization's ability to address climate change impacts.

A response: In many cases, climate change will exacerbate existing high priority management concerns rather than creating completely new challenges. Therefore, you may find that efforts to address existing management concerns affected by climate change may simultaneously reduce vulnerability to projected climate impacts, particularly if the projected impacts are included in the scope of today's decision making. You may also realize that the strategies used to manage both present-day concerns and projected climate impacts are similar (for a sample list of preparedness strategies, see Table 10.1). If this is true, it should be possible for you to accomplish some degree of planning for climate change by absorbing the work into your existing workplan – and using current financial, technical, institutional, or human resources. As your planning progresses, you can review your need for additional resources later, in the context of developing an overall long-term strategy.

The barrier: "I don't have the resources or political support to act."
Although the case for climate change action has gained public attention and political momentum in the last two years, support for climate change preparedness is not a given. You will need support from senior level management, whether an agency director, city or county manager, city or county council, or federal or state legislator, in order to create an institutional and political environment in which planning for climate change can occur. A lack of support from senior level management is a very real barrier to starting your effort – making it difficult for you to find the staff and financial resources to pursue preparedness strategies.

A response: You can make some progress in preparing for climate change with limited resources and/or political will. In some cases, you may identify the reasons why there is a lack of support, and you may be able to develop more support incrementally.

The barrier: "Our operations are based on historical statistics, not future modeling."
Many government services such as water supply management, wastewater treatment, stormwater operations, and flood zone management are guided by historical record. Using projections of future change can be hard to "sell" to plant or system managers, not to mention ratepayers and regulators.

A response: It is critical to recognize that the past is no longer a reliable guide to the future. When relevant and possible, move away from relying exclusively on historical climate conditions as the basis for decision making. This does not mean you should exclude the past altogether, however; much can be gained from looking at the impacts of past extreme events on communities, infrastructure, and natural systems. The key now is to avoid anchoring your decisions completely in historical records. Your government regularly makes decisions based on expectations and assumptions about the future, so this way of thinking should not be entirely new.

These common mindsets are just a few of the barriers that can hold you back from preparing for climate change impacts, and the responses here are meant to help you to overcome those barriers. As the next chapter outlines, perhaps no factors are more important than strong top-level leadership and a cohesive planning team to encourage you and your internal and external stakeholders to invest in climate change preparedness.

Box 3.1 – Examples of Early Preparedness Efforts

Boston Metropolitan Region, USA
Boston has developed a major academic report on climate change impacts to that region. The report, titled *Infrastructure Systems, Services and Climate Change: Integrated Impacts and Response Strategies for the Boston Metropolitan Area* (also known as Climate's Long-term Impacts on Metro Boston or CLIMB), was published in 2004 by researchers from local Boston universities. The five-year project was "designed to provide quantitative data on how infrastructure is affected by climate change." (Penney and Wieditz 2007)

London, UK
In 2001, the Greater London Authority set up the London Climate Change Partnership (LCCP), with representatives from a wide range of governments and agencies. The LCCP has prepared several guides and strategies for areas of expected impact including transportation, buildings, and the financial sector. Mayor Ken Livingstone has also revised the London Plan to incorporate climate change mitigation and adaptation policies and appointed a senior policy officer to develop a preparedness strategy using a process of extensive stakeholder engagement. According to the Clean Air Partnership, "In an 18-month period in 2005-2006 [Mayor Livingstone] made an estimated 100 presentations and organized 15 workshops with different stakeholder groups and agencies to build awareness of how climate change might affect their services." The partnership has also published *London's Warming*, a comprehensive report on climate change impacts to the London urban region. (Penney and Wieditz 2007)

Miami-Dade County, Florida
Miami-Dade County has been a leader on reducing greenhouse gas emissions for over ten years, and has recently formed a Climate Change Advisory Task Force (CCATF) to make recommendations regarding what actions are needed to make the community and its built environment, natural systems, health, and economy as climate resilient as possible. Miami-Dade has also agreed to be a pilot government for the ICLEI – Local Governments for Sustainability's Climate Resilient Communities Program. (ICLEI, personal communication)

New York City and the Metro East Coast Region, USA
The New York City Department of Environmental Protection established a Climate Change Task Force in 2003 for the purpose of evaluating climate change forecasts, impacts, indicators, and adaptation and mitigation strategies for water, sewage, and stormwater management in the region. The Task Force involves representatives from seven departments, including those responsible for water supply, water and sewer operations, and wastewater treatment. Task force responsibilities include: developing climate change scenarios, coordinating research, and outreach. (Penney and Wieditz 2007, CCSR 2007)

Washington State
Under Executive Order 07-02, the "Washington Climate Change Challenge," Washington State Governor Christine Gregoire has tasked the Washington Department of Community, Trade, and Economic Development (CTED) and Department of Ecology (ECY) to determine what steps Washington needs to take to prepare for the impacts of climate change. Preparation/ Adaptation Working Groups (PAWGs) have been created in five key economic sectors: fresh water, agriculture, public health, coasts and infrastructure, and forests. The PAWGs will review the projected climate impacts for each sector and identify key issues and vulnerabilities, specific adaptation measures, and critical research needs. (State of Washington, personal communication)

INITIATE YOUR CLIMATE RESILIENCY EFFORT **MILESTONE 1**

The following chapters recommend how to reach CRC Milestone One, "Initiate Your Climate Resiliency Effort":

Chapter 4: Scope the Climate Change Impacts to Your Major Sectors

Chapter 5: Build and Maintain Support to Prepare for Climate Change Impacts

Chapter 6: Build Your Climate Change Preparedness Team

Chapter 7: Identify Your Planning Areas Relevant to Climate Change

chapter 4 scope the climate change impacts to your major sectors

This chapter guides you to take the first step in initiating your climate resiliency effort: collecting and reviewing important climate information. The body of information you develop in this initial scoping step will provide a critical foundation on which all later stages of your preparedness effort will rest. As described later in this chapter, the sectors you address in your study may include: hydrology and water resources; agriculture; biodiversity; forests; recreation; energy; transportation; and health, among others.

4.1 Collect and Review Important Climate Information

Ask the question: "How could climate change affect my region, and do these impacts pose a risk for my community?" Answering this question requires collecting and evaluating basic information from published research on how climate is expected to change in your region – a fundamental and ongoing part of preparing for climate change impacts.

"Collecting essential information is an important and ongoing part of preparing for climate change."

Who does the work of collecting and analyzing information for you will depend on the resources you have available for this task (both in terms of staff and financial resources) and the amount of information available for your region. You may choose to do the work yourself, or delegate the task to other staff members, a consultant, a volunteer, or a university graduate student working under the supervision of a qualified researcher.

Determining how much information is enough will also depend on your resources and available information. Be aware that you will probably need additional information as your planning proceeds, and you should commit to monitoring the science over time for new information relevant to your community. The information provided in this chapter can help in these later stages as well.

4.1.1 Information Sources

You should be able to find some relevant information about regional climate changes, regardless of where your community is located, although you should be aware that the amount of detailed information available will vary widely from region to region. As a starting point, the 2000 U.S.

Box 4.1 – I'm Not an Expert. How Can I Evaluate the Credibility of a Source?

There are many sources of information on climate change, ranging from comprehensive synthesis reports to basic fact sheets. How can a non-expert evaluate the validity of climate change information?

The following questions will help guide an informal assessment of the credibility of individual climate change studies. Reliable research will have many – though not necessarily all – of the attributes listed below. In some cases, it may be difficult to determine if and how a study meets these criteria. When in doubt, consider consulting with experts from local universities, RISA teams, professional/technical organizations, federal agencies, and/or non-governmental organizations involved in climate change related activities. Also be aware that understanding the local impacts of climate change might require the expertise of more than one scientific discipline, and that you might want to consider consulting scientific experts from a variety of disciplines to ensure that your source is credible.

Questions to help you evaluate climate change studies:

- **Are the authors clearly identified as experts?** Are the authors considered credible and reliable sources of climate change information? Just as you would ask an expert witness to testify on the technical aspects of a case, you will want experts in climate science or climate impacts to guide your decisions. These experts may have advanced degrees in a related science (e.g., atmospheric sciences, chemistry, hydrology, fisheries, ecology, or forestry), be affiliated with respected climate change research groups, and/or have direct experience in climate science and impacts research.
- **Has the study been "peer-reviewed"?** To evaluate if a publication has been peer reviewed (or "refereed"), check the publisher's website, an individual issue of the journal in which the article appeared, or the preface of the report (if one exists). Some online databases and periodical directories now indicate peer-reviewed journals; reference librarians can also help track down information about individual sources. Unless explicitly stated otherwise, academic journals and major synthesis reports are generally peer reviewed, but conference proceedings, web-based contents, and other reports are generally not peer-reviewed (unless they are pulled directly from a peer-reviewed source).
- **Do the study results make sense?** Are the authors using data and peer-reviewed research to support their claims? Are the conclusions based on reasonable assumptions supported by other studies and consistent

National Assessment analyzed all regions of the U.S. (see Chapter 2); regional summaries from the U.S. National Assessment are provided in Appendix C.

Additional (and in some cases more current) information about projected changes in regional climate and climate change impacts can be found in regionally-focused climate change reports, fact sheets, and web sites such as those listed in Appendix D. Good potential places to find this information include: local universities, NOAA-funded Regional Integrated Sciences and Assessment (RISA) teams (see Appendix D.5), Regional Climate Centers, State Climatologists, state environmental agencies, and the U.S. Environmental Protection Agency. The utility of any one information source will depend on your specific information needs and the level of detail to which you want to explore a particular issue.

Above all, be an informed consumer of climate change science. Know that the usefulness of any of these given resources will depend on your specific information needs, as well as the level of detail to which you want to explore a particular issue. Evaluate the soundness of individual climate science reports and impacts studies. Box 4.1 provides questions for you to ask in order to gauge the credibility of the sources you find.

with the general theory associated with those assumptions? Are there obvious inconsistencies in the train of logic being applied or are the conclusions logically derived from the assumptions and supported by the data presented? Make sure that the claims are well documented, that they make sense to you, and that any information gaps or inconsistencies are adequately explained.

- **Are the results placed in the context of existing understanding?** Scientific research builds on the existing foundation of knowledge published in the peer-reviewed literature. Do the authors discuss the assumptions, data, analysis, and/or conclusions of their study in the context of the prevailing body of scientific knowledge? Do they support their conclusions with like examples from the published literature or point out differences and explain why they exist? Are the assumptions, analytical techniques, and conclusions well referenced with citations to relevant, credible literature, and other pertinent existing information?
- **Is there supporting evidence for the author's conclusions?** If multiple studies or individual researchers arrived at the same conclusion independently, the conclusion is more likely to have increased credibility.
- **Does the study address uncertainty?** Projecting climate change involves uncertainties in both how the natural world operates and how we alter it. Therefore, it is appropriate to report and discuss uncertainty. For example, projections of changes in climate or in regional impacts should be expressed as ranges of possibility (ideally with some estimate of the certainty associated with different numbers in the range) rather than as a single number.
- **What are the potential biases?** Who benefits from the study's conclusion? Who funded the study? Are the interests and values of the authors apparent? What are your personal biases – do you want to believe or ignore this author's conclusion? Awareness of potential biases helps you evaluate the validity of claims and your own decision making about the validity of scientific results.
- **How old is the study?** The science of climate change is rapidly evolving. As a specific example, the timing and amount of future warming is revised with every international assessment of climate change released by the IPCC. As a result, the timeliness of materials is often an important component of projected change and impacts. For older studies, the general findings may still be relevant even as the specific details change. What generation of climate change scenarios does this study rely on?

Based in part on Sagan 1997

4.1.2 How is Climate Expected to Change in Your Region?

You need to know something about the specific ways your region's climate may change in the future, in order to assess the potential impacts of climate change on your region. This section provides insights on the types of information you will want to collect and how to organize the information for use in the preparedness planning process.

Begin by collecting information on a few key climate variables, such as temperature and precipitation. Other important variables may include, but are not limited to, sea level, extreme weather (e.g., hurricanes and storms), and wind. As you collect your information, aim to respond to the question, "How is temperature (or precipitation, or sea level) projected to change during the 21st century?" with one of the following answers: "It is projected to increase/decrease/stay the same," or "The projected change is not yet known." Use specific numbers when available and always identify the specific future time horizon (e.g., 2020s, 2040s, 2080s).

Try to collect information about how climate changes will vary with season. Depending on availability, you might also be able to collect additional information about how the projected

changes will vary with season, or how other parameters (e.g., number of frost days, frequency of extreme rain events, etc.), or other conditions of concern (e.g., windstorms, heat waves) are projected to change. Another useful question to ask is, "Are the projected changes bigger or smaller than the variations between cold/warm or wet/dry years this region has experienced in the past?" This information will help you put the size of the projected changes into perspective.

Collect information about the range of climate change that your community could experience. When possible, avoid using only one projection of future climate (e.g., 12 inches of sea level rise). Remember that future changes in climate are really about a range of future possibilities ("projections"), *not* a single best-guess possibility (a "prediction") (Box 2.2). A common approach to planning for climate change is to develop three scenarios – "worst-case, "best-case," and "mid-range" – to limit the range of possible future outcomes. For now, collect what information you can about projected future change to make sure that your analysis adequately accounts for the amount of change your region could experience.

Understand and log the certainty of your information. Record the degree of confidence associated with the different aspects of the scenarios, regardless of the amount of detail available. In some cases, such as in the IPCC reports, this information will be clearly provided along with the climate change scenarios. In other cases, you may need to consult with climate science experts or use your best judgment based on the following **general** rules of thumb:

- temperature projections are much more certain than precipitation projections; and
- climate change projections less than five years old and/or based on multiple models are likely to be more robust and better reflect current understanding of climate change science.

You can also assess the certainty associated with climate projections by examining how much the available climate models agree about the direction of the projected change (more or less, up or down). In the U.S. Pacific Northwest, for example, ten climate models examined by the Climate Impacts Group universally agree that the region will warm during the 21st century, even though the specific amount of warming varies between models. There is less consensus in the models on whether precipitation will increase or decrease on an annual basis (although indications are that there will be a slight increase in annual precipitation with most of this increase coming during the winter months). Recognizing this uncertainty, King County chose to focus the vulnerability assessment informing its 2007 Climate Plan most heavily on impacts resulting from warmer temperatures, and less on those dependent on a specific change in the amount of winter precipitation.

Understand and track why projections of a change may vary from one study to another. You may find that the specific amount of projected change varies from study to study, often depending on the specific global climate model(s) and emission scenario(s) used in the study, or the method used to translate projected global change to the local level (see Appendix B). It is important to track this information to understand the reason for these differences. By keeping track of such information, you will be more able to resolve apparent contradictions as they occur, and you will be ready to update your scenario information as projections are revised. You may be able to work with the local scientific community to determine which scenario(s) best reflect current understanding.

Track other critical information about the studies and reports you collect. As you note how climate is projected to change in your region, be sure to record:

- the source of the information (including publication and year);
- the climate model(s) used to construct the climate projection (e.g., the National Center for Atmospheric Research's Community Climate System Model [CCSM]);
- the greenhouse gas emission scenario(s) used to guide the climate projection;
- both the timeframe for the future projection (e.g., the 2040s) and the timeframe for comparison (e.g., the 1970-1999 average historical climate);
- the geographical area over which the projection was made (e.g., the United States; the Pacific Northwest, which includes Washington, Oregon, Idaho; or the State of Washington).

As you review sources for information about projected changes in regional climate, you may come across reports on impacts to specific areas of interest, such as water supply, forests, and human health. These areas are referred to in this guidebook as sectors. Hold onto this information; you will want it for the next step.

Consider assembling the information you have collected in a table, such as that shown in Table 4.1 for the U.S. Pacific Northwest. When possible, work with knowledgeable climate change experts to review these scenarios for obvious errors, reasonable (or unreasonable) results, and appropriate confidence estimates.

Checkpoint: *Upon finishing this section, you should have a summary of how your region's climate is projected to change as a result of climate change. You should also have general understanding of how to identify what information is relevant to your community, so that you are able to communicate why and in what specific areas preparing for climate change will be important.*

SUMMARY OF PROJECTED CLIMATE CHANGES FOR THE U.S. PACIFIC NORTHWEST						
Climate Variable	**General Change Expected**	**Specific Change Expected and Reference Period**	**Size of Projected Change Compared to Recent Changes**	**Information About Seasonal Patterns of Change**	**Confidence**	**Source(s) & Context**
Temperature	Increase	+0.7 to 3.2°F (2020s) +1.4 to 4.6°F (2040s) compared to 1970-1999 average	- Projected warming much larger than the regional warming observed during the 20th century. - By the 2020s, average temperatures could be higher than most of those experienced during the 20th century.	Slightly more warming in summer than winter.	High confidence that the Pacific Northwest will warm (all models project warming).	- Publication: Mote et al. 2005b - Projections derived from ten climate models from IPCC 2007 simulating climate changes associated with high and low greenhouse gas emission scenarios. - Geographical region is the PNW, defined as Washington, Oregon, Idaho, and western Montana.
Precipitation	Very small increase	-4 to +7% (2020s) -4 to +9% (2040s) compared to 1970-1999 average	- Projected change is very small relative to the range of precipitation observed during the 20th century.	Slight decreases in summer and slight increases in winter.	- Changes in precipitation are less certain than changes in temperature. - Changes in summer precipitation are less certain than changes in winter precipitation. - Future years projected to continue to swing between relatively wet and dry conditions, making it likely that the change due to climate change will be hard to see	
Sea level	Increase	+7-23 inches globally at 2090-2099 (compared to 1980-1999 avg). Regional variation in land movement could affect sea level rise in specific locations	- Projected changes are in the ballpark of those observed recently (7”/century globally during 1961-2003 and 12”/century globally during 1993-2003).	n/a	- High confidence that sea level will increase globally, but much uncertainty in the specific amount of increase and how it will vary by location. - Some uncertainty about data indicating subsidence in South Puget Sound.	- Publication: IPCC 2007a, Snover et al. 2005 - Projections derived from multiple climate models simulating climate changes associated with high and low greenhouse gas emission scenarios.

SUMMARY OF PROJECTED CLIMATE CHANGES FOR THE U.S. PACIFIC NORTHWEST						
Climate Variable	**General Change Expected**	**Specific Change Expected and Reference Period**	**Size of Projected Change Compared to Recent Changes**	**Information About Seasonal Patterns of Change**	**Confidence**	**Source(s) & Context**
Heavy rainfall events	Unknown	Unknown	There has been an observed increase in the variability of average winter (October-March) season precipitation since 1973 for the Pacific Northwest, but no information on changes at smaller time scales (monthly, daily changes). Cause of this change is unknown at this time.	Unknown	Although heavy rainstorms are expected to increase globally, whether they do in the Pacific Northwest will be related to where and how the storm track moves in the future – could increase, decrease, or stay the same.	- Publication: Hamlet 2006
Wind storms	Unknown	Unknown	Unknown	Unknown	n/a	- Discussion with Climate Impacts Group

Table 4.1 – Sample summary table for projected regional climate change.

4.1.3 What are the Projected Impacts of Climate Change in Your Region?

Changes in temperature, precipitation, and sea level can affect communities in a variety of ways. It is often useful to group this information in relation to ***sectors*** – a general grouping used to describe any resource, ecological system, species, management area, activity or other area of interest that may be affected by climate change.

Table 4.2 lists potential impacts for common sectors. Impacts for your region would likely include some of the impacts listed there. The information sources identified in 4.1.1 are also good starting points for learning more about projected climate change impacts in your region. Additionally, sector-specific climate change reports (e.g., special reports on water resources, forest resources, etc.) may include information relevant to your region.

INITIAL SCOPING: A SAMPLE OF SECTORS AND POTENTIAL CLIMATE CHANGE IMPACTS	
Sector	**Impacts in some regions could include…**
Hydrology and water resources	• Shift in the timing of spring snowmelt to earlier in the spring • Lower summer streamflows, particularly in snowmelt-dependent water systems in the western U.S. • Increased risk of drought • Increased risk of flooding • Increased competition for water • Warmer water temperature in lakes and rivers • Changes in water quality (varies by water quality parameter)
Agriculture	• Changes in crop yields (varies by crop) • Potential ability to "double crop" • Increased risk of heat stress, particularly in the South • Increased demand for irrigation water due to longer and warmer growing season • Increased risk of pest outbreaks and weeds
Biodiversity	• Shift in the distribution and range of species • Loss of species not able to adapt to changes • Increased competition from invasive species • Loss of habitat
Forests (including parks and urban forests)	• Increase in growth and productivity in the near-term where soil moisture is adequate and fire risk is low • Shift in the distribution and range of species • Increased risk of insect outbreaks • Increased risk of forest fire • Increased competition from invasive species
Recreation	• Increased opportunities for warm season activities in milder regions of the U.S. • Decreased opportunities for warm season activities during the hottest part of the year, particularly in the southern U.S. (e.g., from heat, forest fires, low water levels, reduced urban air quality) • Reduced opportunities for cold season recreation due to decreased snowpack and/or reduced snow or ice quality • Increased reliance on snow-making at ski areas • Shifts in tourism dollars within a community from one recreation sector to another, or from communities losing recreational opportunities to communities gaining opportunities
Energy	• Reduced heating demand during winter months • Increased cooling demand during summer months • Increased or decreased hydroelectric generating capacity due to potential for higher or lower streamflows

INITIAL SCOPING: A SAMPLE OF SECTORS AND POTENTIAL CLIMATE CHANGE IMPACTS	
Sector	**Impacts in some regions could include…**
Transportation	• Fewer travel disruptions and lower maintenance and infrastructure costs associated with snow and ice • More travel disruptions associated with landslides, road washouts, and flooding • Increased road surface damage from higher temperatures • Potential reductions in water-based navigation due to lower summer streamflows • Increased maintenance requirements for roadside and median strip vegetation • Increased brush fires in roadside and median strip vegetation
Infrastructure	• Need for new or upgraded flood control and, erosion control structures • More frequent landslides, road washouts, and flooding • Increased demands on stormwater management systems with the potential for more combined stormwater and sewer overflows • Reduced effectiveness of sea walls with sea level rise
Coastal resources and ecosystems	• Increased erosion or damage to coastal infrastructure, dunes, beaches, and other natural features due to sea level rise and storm surge • Loss of coastal wetlands and other coastal habitats due to sea level rise, erosion • Increased costs for maintenance and expansion of coastal erosion control (natural or man-made) • Saltwater intrusion into coastal aquifers due to sea level rise • Increased risk of pollution from coastal hazardous waste sites due to sea level rise Loss of cultural and historical sites on coastline to sea level rise and related impacts
Aquatic ecosystems	• Shifts in species range and distribution • Increased competition from invasive species • Loss of near-shore habitat and coastal wetlands to sea level rise, where sufficient space for habitat migration is not available • Increased stress on coldwater species in lakes and rivers
Business	• Price volatility in energy and raw product markets due to more extreme weather events • Increased insurance premiums due to more extreme weather events • Fewer shipping disruptions associated with snow and ice • Impacts on business infrastructure located in floodplains or coastal areas • Shifts in business opportunities
Health	• More heat-related stress, particularly among the elderly, the poor, and other vulnerable populations • Fewer extreme cold-related health risks • Increase in vector-born illnesses (e.g., West Nile) • Reduced summer air quality in urban areas due to increased production of ground-level ozone
Emergency response	• Increased demands on emergency response services related to extreme weather events (e.g., heat, flooding, storms)

Sources: NAST 2000, IPCC 2001b, NAST 2001, Mote et al. 2003, UKCIP 2003

Table 4.2 – A sample of sectors and potential climate change impacts. Planning for climate change requires identifying which sectors of a community are likely to be affected by a changing climate. Most communities will be sensitive to climate change in one or more of the sectors listed above. The likelihood of any one impact occurring will vary by community. This list is not all-inclusive; other impacts not listed here may also occur.

Depending on your information needs, resources, and the amount of climate change information available for your region, a preliminary list of impacts like Table 4.2 (but tailored to your region) may be sufficient for launching for your preparedness planning effort. As you develop your list, identify the various departments and/or programs that may be affected by these projected impacts. This information will help you determine which departments need to be involved in developing your preparedness plan.

In some cases a more detailed assessment may be needed to gather necessary support from your internal and external stakeholders. In all cases, more detailed information will be needed for your vulnerability assessment and developing your preparedness plan. For each source you examine, evaluate and record:

- the sector(s) and/or types of species (where relevant) covered by the study
- the changes (impacts) projected by the study
- the time period in which those changes are expected (e.g., the 2020s, 2040s, 2100) and the reference period for comparison (e.g., 1950-2000 average conditions)
- how the size of the projected changes compare to recent conditions
- the models and greenhouse gas emissions scenarios used
- the amount of confidence in the projections (to the extent that this can be assessed)
- the geographic area covered by the study
- the departments and/or programs within your community government that will be affected by the projected impacts
- any other details that may be important for comparing and assessing the study results.

As with your research on changes in regional climate, record when projected impacts differ from study to study, and track the reasons that may have led those different conclusions. Remember that climate change impacts are estimated based on specific climate change scenarios; you will likely find a range of impact scenarios when there are a variety of climate change projections. Impact scenarios can also vary because of different methodologies and uncertainty associated with translating climate changes into sectoral changes, e.g., changes in water supply or fire risk.

Whether or not you need to consider a full range of impact scenarios depends partially on whether the climate change scenarios used to create them are up-to-date. For example, you might read a report that projects increased tree growth in your region's forests during the summer. Examining the context of that projection, you may realize that the report is based on a scenario of significant increases in summertime precipitation. Your research on projected regional climate change, however, may have clearly indicated that summertime precipitation is now projected to decrease slightly. Given that the projected impact was based on outdated climate change scenarios, you might choose to eliminate it from consideration. Alternately, you might recall that

simulation of future changes in summertime precipitation is considered to be extremely uncertain and decide to include the scenario of increased tree growth as a potential, but low-probability, future change caused by climate change.

Be sure to record this and other contextual information identified in Section 4.1.2. This information can help you evaluate the relevance or accuracy of the projected impact given the current understanding of how climate in your region is expected to change.

Checkpoint: *Upon finishing this section, you should have a summary of how climate change is likely to impact your region's natural and built resources, and which departments are likely to be affected by these projected impacts*

4.1.4 How to Work with Little Information

More is currently known about how climate change will affect some parts of the country and some resources than is known about others. Depending on where your community is located, you may have trouble finding impacts information that seems sufficiently detailed for planning, or you may have trouble finding impacts information at all.

One option for dealing with little information about projected climate change impacts is to look at how sensitive your community is to past and present-day climate (e.g., drought) and weather events (e.g., floods). A good place to begin is with the various department heads and staff in your community government. What does their experience tell them about sensitivity to 20th century climate and weather events? What analyses have been done within their respective departments on climate and weather impacts? Consider developing and distributing a questionnaire to gather the relevant information. King County, Washington, for example, added questions about sensitivity to climate variability into a larger survey on potential climate change vulnerabilities in the County (see Box 8.3). Other options include collecting information through staff meetings, special workshops, or lunch-time brown bag discussions. Interviews with long-time residents, examining government records, and reviewing media archives are also effective ways of gathering more information on the impacts of notable past climate and weather events.

In addition to examining past and present climate impacts, you can extrapolate information about local impacts from broader-scale studies or studies from other regions to develop a picture of how climate change might affect your region or specific sectors within your region (e.g., forests or water supply). This exercise can provide valuable qualitative information, but it is important to note that local impacts may vary from study results given the specific characteristics of the local system. If possible, consult with an expert familiar with the underlying causes of climate sensitivity to evaluate whether that information holds true from one region to another, and to find out any necessary caveats. The Appendix provides additional sources of information on climate change impacts and adaptation.

If you are not able to consult experts, we recommend that you do not rely on this information for developing detailed preparedness actions, except those that could be considered "no-regrets" (Chapter 11).

4.2 What Will Your Level of Commitment Be?

Once you have collected and reviewed a body of basic information about climate change impacts to your region, it is time to decide whether the information warrants moving forward with preparedness planning. Using the impacts listed in Table 4.2 or your own list of potential impacts for the region, ask the questions: Will climate change have an impact on my community and my government's responsibilities? Do these impacts appear significant enough to begin preparing for climate change?

"Yes, we will prepare for climate change." If the answer to these questions is "yes," it is time to begin preparing for climate change. If you are a public official, consider proposing a resolution that directs your government to form a team and take steps to prepare for climate change, including writing a preparedness plan with regular updates. This kind of legislation, like King County's Executive Orders on Global Warming Preparedness of March 2006 or the King County Council Ordinance on Global Warming of October 2006, can provide a useful foundation to which your government, your future preparedness team (Chapter 6) and your successors will be able to refer at a later date.

Your level of commitment to planning will differ from that of other governments. Several factors may influence the scale of your community's planning efforts, including:

- **The degree of interest and support for preparedness planning among your community's elected officials, your senior management, and your public.** Perceptions of how climate change may or may not affect the community will strongly influence this initial interest. Over time, you may find that the results of your vulnerability assessment will influence these perceptions, and persuade your stakeholders to commit more resources to a preparedness effort. Look for suggestions about building and maintaining support for preparedness in Chapter 5.
- **Logistical factors such as community size, resource availability, and types of authorities.** The size of your community will obviously determine the type and amount of technical, fiscal and staff resources available for preparedness planning. Lack of access to technical experts outside your government could also limit your efforts. Additionally, the range of authorities that your government has could influence how ambitious you want to be in developing your process and plan.

In some cases, your initial scoping exercise may show that climate change is a concern for your community, but that there is little your community can do on its own to plan for these impacts. For example, you may be part of a small community with limited public services. Or, climate change may have greater relevance to other levels of government (such as your county government) that provide many basic services to your community. In these cases, you may still want to move forward in the planning process with the objective of building support for planning within the other government organizations that do have a role in managing climate change impacts on your community. Your case may be strengthened by working with other similarly situated small communities in your region.

Consider proposing a resolution that directs your government to form a team and take steps to prepare for climate change, including writing a preparedness plan with regular updates.

If the answer is unclear, you may want to look for additional information and/or consult with local experts again (when available) to review your initial assessment. Box 6.2 provides information on identifying and selecting science advisors. Alternatively, the initial scoping exercise may show there are currently few impacts to the community that warrant preparedness actions. If so, stay tuned to developments in climate change science and your impacts assessment. New information may change your initial assessment.

The planning process provided in this guidebook can and should be scaled to the level that is appropriate for your community. At one end of the spectrum, you may need to work on this process in incremental steps, focusing initially on a simple literature review, reducing vulnerability to today's climate and weather events in one or two key sectors, and basic public education. At the other end of the spectrum, you may decide to launch an officially-recognized, multi-sector climate change preparedness program using a formally established preparedness team, a full-time preparedness coordinator, and new research (where appropriate) to examine climate change impacts and preparedness needs across multiple government departments.

Checkpoint: *Upon finishing this section, you should have passed a resolution that directs your government to form a team and take steps to prepare for climate change, including writing a preparedness plan with regular updates.*

The following chapters recommend how to reach CRC Milestone One, "Initiate Your Climate Resiliency Effort":

chapter 5 build and maintain support to prepare for climate change

Once you have scoped out the impacts of climate change to your community's sectors, you are ready to develop the support needed from your community and executive-level leaders to conduct a climate resiliency study. Outreach will play a major role in building and maintaining support to launch your planning effort. At later stages of planning, your work will also benefit from the investment in outreach by creating a common understanding among your various partners and stakeholders of how your region's climate may change in the coming decades. These partners and stakeholders may include public officials, local government staff, key businesses, non-governmental organizations, and the general public. To help build and maintain support for preparedness planning, this chapter provides guidance on how to:

- identify a climate change "champion"
- identify your target audience for your outreach activities
- develop a preparedness message
- spread the preparedness message.

As in other stages of the process, you should scale your activities related to building and maintaining support to fit your local, regional or state circumstances. Most importantly, you should also recognize that preparing for climate change requires an ongoing commitment to internal (i.e., within your government) and external (i.e., with the community-at-large) outreach at levels appropriate for your community.

5.1 Identify or Cultivate a "Champion" for Preparedness

Across local, regional and state governments already planning for climate change, at least one element is common: all have a leader or leaders at the high level of government who are committed to learning about climate change impacts and to making the hard decisions that will prepare that region most effectively for those impacts (Penney and Wieditz 2007). These hard decisions can be vulnerable to criticism when they challenge the *status quo*. Therefore, the champion who leads this change must be respected and trusted by the public and other leaders, conversant about climate change impacts, and willing to take risks by developing policy recommendations that will be different in some areas from the old ways of doing business.

In the best case scenario, you may already have a champion who can build support for preparedness planning. If you are a public official or an advisor to a public official, you may be that champion.

In other cases, clear leadership on this issue may be lacking, and you may have to cultivate a climate preparedness champion. You may also want to engage champions outside of your government to validate your internal efforts. You may be able to find a leader who is already committed to other environmental issues and who is willing to expand his or her focus to include climate change preparedness. Other potential champions include, but are not limited to, former elected officials or department heads (e.g., a former utilities director), key business leaders, long-range planners, and/or other respected members of the community-at-large. Depending on the values of your region, an "economic champion" on climate change could be even more powerful than an "environmental champion."

Checkpoint: *Upon finishing this section, you should have identified a climate change "champion," and should be involving that person in your preparedness effort (if he/she is not already leading it).*

5.2 Identify and Understand Your Audience for Outreach

Before beginning any outreach activities, identify your target audiences (e.g., other elected officials, senior management, other staff, general public) and understand their basic interests. For simplicity, you can consider your target audiences to be in four groups: the public sector; the private sector; non-profit organizations; and media. The general public is represented across all of these categories. You may also want to identify individuals who especially influence conventional opinion within each of these groups.

During the early stages of your outreach work you will likely need to focus on generating support internally through outreach to other elected officials, department heads, and/or staff members. As planning progresses, increase external outreach to community members and partners, and continue internal outreach to maintain support and interest within your organization for preparedness planning.

Know that different members of your audience will have different opinions and information needs, and that they may trust different sources of information. Be ready to listen and be flexible enough to tailor your message while keeping the core message consistent.

Outreach should be ongoing, especially as both internal and external audiences should later be tapped for input during the development of your climate change preparedness plan (Chapter 10) and/or support for specific preparedness actions. Various types of internal and external outreach activities are provided in 5.4.

Checkpoint: *Upon finishing this section, you should have a list of your target audiences for your climate change outreach activities. Who is your internal audience? Who is your external audience?*

5.3 Develop a Preparedness Message

Establishing a clear message on the importance of and need for climate change preparedness is vital to the success of your planning effort. The following are suggestions for developing a message to raise and maintain awareness and motivation for preparedness planning. Many of these message points also address the common barriers to preparing for climate change discussed in Chapter 3.

- **Describe changes that have already been observed.** There are many indications that the Earth's climate and various physical and ecological systems are changing in response to 20th century warming. Some of these may be changes that local residents have observed firsthand. Including this information can underscore that climate change is occurring and, in many respects, having a measurable impact on Earth's systems. Refer to Appendix A and more recent scientific studies to describe changes in climate, hydrology, and/or ecosystems that have already been observed in your region or similar areas. It is important to note that some of these changes may reflect changes in natural variability as well as long-term changes in average temperature. Be careful not to attribute observed changes to human-caused climate change entirely, unless there is scientific evidence to back up the claim.

- **Describe changes that are expected.** Using the information you collected in your initial scan (Chapter 4) and any additional information collected later in the planning process, provide information on how temperature, precipitation, snowpack, and other aspects of climate and the environment are expected to change in your region as a result of climate change.

- **Describe how climate change may impact the community.** Using the information you collected in Chapter 4, explain the potential regional and local consequences of climate change. Impacts may include sea level rise, changes in water supply, and increased risk of drought, forest fires, extreme events, flooding, and/or disease. Be careful not to overstate what you know about impacts to your region or you risk losing credibility with key audiences.

- **Convey the need for action but balance the challenges with optimism.** It is important to communicate why planning for climate change is needed; see Chapter 3 for more on this point. Be careful, however, that the message does not leave your audience with a sense of hopelessness. Discussions on climate change can quickly turn negative given the scale of the problem, the breadth of projected impacts, and the changes needed to deal meaningfully with these impacts. In engaging the public on the need for preparedness, communicate openly and practically with action-oriented language. Be careful to strike a balance between the realities of climate change, the need for action, and the proactive steps that can be taken to address the problem at all levels.

- **Identify other communities similar to yours that are planning for climate change.** In some cases, it may be helpful for people to see that other communities similar to yours are taking steps to address climate change impacts. ICLEI – Local Governments for Sustainability, its Climate Resilient Communities Program, USEPA, and the Center for Clean Air Policy's Urban Leaders Initiative are all good resources for identifying other communities working on climate change activities. Other such online clearinghouse sites may also be available (see Appendix D for more sources). With time, it will be possible to focus on those strategies that have worked for other community governments like yours. Identifying your peers and exchanging experiences can be empowering and helpful.

- **Develop a course of action.** Outline what you intend to achieve and the steps your local government intends to take to prepare for the projected changes. Update your message with details on your community's course of action as the planning process progresses and your plan is implemented.

- **Acknowledge that questions remain.** Do not be reluctant to admit that questions remain. Clearly communicating what you do know – while being honest about what questions still need to be answered – will be critical to gaining and maintaining credibility, interest, understanding, and support for your preparedness work. Be sure to emphasize, however, that enough information is available for (and warrants) moving forward with planning. Also note that your community will continue to follow developments in climate change science for new information that can help close key information gaps.

You will want to modify the content of your message according to your audience, the outreach tool you are using, and the status of your planning effort. Rather than trying to create all materials from scratch, consider drawing on existing sources of information, with permission and proper crediting of the source. A wide variety of materials that describe the causes and consequences of climate change – from fact sheets to posters and PowerPoint slides – may be available online and could be adapted for local outreach purposes. See Appendix 8.4.1 for suggested starting places.

Above all, keep your message simple. Work with local experts throughout your planning process, to distill information into a form that is both technically accurate and understandable. Also consider partnering with others, including other governments, university researchers and/or graduate students, and/or appropriate non-governmental organizations to do this public outreach.

Checkpoint: *Upon finishing this section, you should have the main points and supporting information of your outreach message assembled. What are the key points you want all audiences to hear? Remember that the details supporting the central message points will evolve over time and will vary with the outreach tool and audience.*

5.4 Spread the Message

To maximize the reach of a communications effort, use a variety of outreach tools and use them repeatedly. Be aware of which materials work for internal audiences (e.g. departments or city council, if you work in public office) and which are best for external audiences (e.g., general public and other partners or stakeholders). Following are a few suggestions.

For internal audiences:

- **Brown-bag seminars.** Brown bag seminars are typically lunchtime presentations where participants bring their own lunches and attendance is voluntary. Seminars can be structured around a theme, such as climate change impacts on water supplies. The substance of a conversation can build sequentially from one brown bag to the next (i.e., starting with the climate change fundamentals then moving into impacts and preparedness). Speakers may include: scientists or other experts; federal, state, or other local governmental agency staff who manage programs affected by climate change; elected officials or staff from community governments already preparing for climate change; and internal staff.

- **Department meetings.** Department meetings can be scheduled as needed to cover specific topics. Presentations from outside parties (e.g., climate or resource management experts) can be scheduled as part of the meeting. The meetings typically provide a good opportunity for discussion and coordination with other departments. Remember, however, that preparing for climate change will not necessarily fit neatly into the mission of a single department. It will probably be necessary to call an interdepartmental meeting that includes other agencies affected by the impacts you identify.

- **Scientific briefings to councils and executive staff.** Scientific briefings provide an opportunity for senior-level decision makers to ask questions of science experts directly. These briefings can be scheduled as part of a regular council meeting, during executive sessions, or as a separate meeting.

For both internal and external audiences:

- **Newsletters, fact sheets, utility inserts, and brochures.** Newsletters and other similar print material can incorporate information on climate change impacts and planning. Written materials can be distributed via the mail or at public meetings, libraries, or government offices.

- **Websites.** Websites are a particularly effective outreach tool, given how easily the Internet can be accessed across communities, income levels and professions (both within the government and by the general public). Information posted on the Internet can also be easily updated. A website can be designed to cater to a wide variety of audiences, using links to information of varying detail.

Box 5.1 – "The Future Ain't What It Used to Be: Planning for Climate Disruption" – The King County, Washington, Climate Change Conference

On October 25, 2005, King County, Washington, convened a major conference to discuss projected climate change impacts for Washington State, potential adaptation strategies, and broader goals for moving forward on planning for climate change. The conference, titled "The Future Ain't What It Used to Be: Planning for Climate Disruption", featured speakers from across disciplines and levels of government, including researchers, public officials, tribal representatives, private sector leaders, and citizens from across the region. The audience was equally diverse. Details on how the conference was organized are provided here.

Work in partnership. King County co-hosted the conference with 17 partners and 23 contributing organizations. Organizations represented a variety of different sectors, fields, and expertise, including insurance and financial services, environmental engineering, construction, architecture, and non-profit climate change advocacy organizations. Municipal government partners included the City and Port of Seattle. King County gained financial sponsorship, in-kind services and support from these entities and individuals by providing them with time at the speakers' podium, advertising space and opportunities to participate in shaping the discussion sessions. The conference also significantly strengthened the county's existing relationship with the Climate Impacts Group at the University of Washington.

Develop a common picture of climate change and its regional consequences. Organizers worked with the Climate Impacts Group to prepare 1) a scientific white paper about the effects of climate change, and 2) a series of primers containing compelling discussion questions about how to begin planning. These materials were distributed to participants at the conference and used to guide discussions during the conference working sessions. Organizers also structured the "bookend" plenary sessions 1) to provide an overview of climate change science, given by scientists, to establish a common understanding of the way regional climate has already changed and is projected to change, and 2) to elicit perspectives from elected officials to establish political direction and support for adaptation. More than a year after the conference, the background materials continue to be critical for developing a shared regional picture of climate change impacts to the Puget Sound region, and inspiring and guiding action across the region and within King County government.

For external audiences:

- **Public meetings.** Public meetings on climate change and its regional impacts can be scheduled as a means of reaching the general public. Meetings may be scheduled around particular events, such as launching a new program, decisions about major infrastructure investments that may be affected by climate change, or specific climate-related events such as drought. See Box 5.1 for an example.

- **Press releases/public statements.** Press releases and public statements, including legislative resolutions, can be distributed to draw the public's attention to specific activities that a community government is pursuing to manage the process of climate change preparedness.

Bring both scientific "expert" and stakeholder voices to the discussion. Conference organizers consciously brought together scientific experts, public officials, and stakeholders to begin to wrestle with the range of compelling questions about how to move forward. Speakers included former New Jersey Governor and former administrator of the U.S. Environmental Protection Agency Christine Todd Whitman, the mayor of Washington State's capitol (Olympia), and the business director of the Port of Seattle. From this diversity of people and disciplinary backgrounds emerged many compelling scientific, environmental, political, economic, and social questions. These discussions have been transcribed and can be found on the King County website.

Consider how climate change will affect different sectors. Breakout sessions of the conference were focused on impacts to specific sectors (e.g., agriculture, coastal areas, fish and shellfish, forestry, hydropower, water supply) with materials identifying probable "winners" and "losers" of climate change impacts. Sessions offered experts in those areas and concerned stakeholders an opportunity to come together to brainstorm solutions, raise questions and flesh out some initial opportunities or constraints for action. The papers and related discussion spotlighted memorable illustrations of how certain sectors, such as the Pacific Northwest ski industry, will be more vulnerable to climate change impacts. In the case of the ski industry, the winter preceding the conference had seen a record low snowfall, which had forced nine of 11 ski resorts to close in mid-January (ordinarily the height of the ski season). This lack of snow had forced some resorts cut staffing by 80 percent.

Planning for and holding the conference had many important benefits. First, the conference helped King County get organized on climate change adaptation. The conference prompted the county and region to assess climate change effects on our natural and built environments more systematically. The conference also began to involve a broad range of county staff, including capital improvement project managers, division directors and supervisors, and engineers and science staff, in thinking about the tradeoffs and decisions related to the new topic of climate change adaptation. Finally, the conference greatly enhanced the interactions and long term working relationships of County staff with their business, nonprofit, and academic counterparts for their specific sectors. All of these benefits fed into the knowledge, ideas, enthusiasm, and collaborative spirit that helped to launch the county's climate change action team and preparedness team in 2006, and later to develop the county's first comprehensive climate change action plan in February 2007. The conference also contributed to the State's subsequent funding of a statewide study of the economic impacts of climate change.

- **Media training events.** Media training events for reporters and editors can be used to increase media awareness of climate change, local impacts, and governmental action. Speakers may include climate scientists, other experts, and/or members of the community government. This can be an opportunity to showcase what you are doing about climate change, and for the media to talk directly with regional experts and local officials without the pressure of a deadline.

- **Events aimed at businesses and nongovernmental organizations.** Special events could include a large-scale leadership summit on climate change or, if resource constraints are an issue, one-on-one relationship building or smaller events such as workshops and seminars geared to the business community and nongovernmental organizations. These events can be used to solicit targeted feedback on preparedness options as well as for general outreach.

It is critical to view outreach as an ongoing activity rather than a one-time event. In general, timing is not a concern; outreach activities can be implemented at any point. Much can be gained, however, when outreach is tied to external events. For example, increased public or political concern about a drought or severe forest fires can create a more receptive audience for climate change preparedness messages if these events are likely to increase as a result of climate change. Be careful in these instances not to attribute a specific event to climate change. The cause-and-effect linkage of any single event to climate change is not scientifically possible at this time. Also, as your outreach continues, continue engaging and utilizing experts within your community government, in non-governmental organizations, at universities, and in professional associations to help to educate and engage.

Checkpoint: *Upon finishing this section, you should have a general idea of the different tools you can use for internal and external public education efforts and how you might want to employ these tools to build and maintain support for preparedness planning.*

The following chapters recommend how to reach CRC Milestone One, "Initiate Your Climate Resiliency Effort":

chapter 6 build your climate change preparedness team

To conduct your climate resiliency study, you will need to coordinate activities across departments, jurisdictions and levels of government. This coordination may be achieved through a climate change preparedness team (the focus of this section) and/or by designating a climate change "point person" within your government. This chapter will help you create your climate change preparedness team by answering a series of common questions related to:

- when, why, and how to form a preparedness team
- characteristics to look for in team leader(s) and members
- typical work efforts and products
- launching your preparedness effort.

A brief description of the creation, staffing, and responsibilities of King County's climate change preparedness teams is also included in Box 6.3 at the end of the Chapter.

6.1 Why Form a Team

For many governments, as in King County, climate change (and planning for its impacts) will affect many services, operations and infrastructure, including: water supply, flood control, wastewater treatment, public health, environmental protection, planning and zoning, parks and recreation, economic development, and emergency preparedness.

To the extent that you can, cast your net wide in recruiting your team. One or two people may not be sufficient to accomplish this workplan. How well your government and community respond to the consequences of climate change may not only depend on the preparedness of an individual department, but also on numerous, cumulative actions across departments, divisions, and programs. Forming a climate change preparedness team with a cross-section of representatives from relevant departments or programs is therefore useful for overseeing, coordinating, and advocating for preparedness efforts.

However, you may find that a full-scale cross-departmental preparedness team is not feasible in your circumstances. For example, your resources may be limited. Please note that you may still be able to develop your preparedness plan within your current framework by finding expertise outside

of your organization, as described in 6.5. You can assess your need for an expanded preparedness team as more information becomes available. Questions to consider when establishing a team are listed in Box 6.1.

Box 6.1 – Questions to Consider When Establishing a Climate Change Preparedness Team

- What are the major impacts and priority planning areas that your preparedness team will address? Are the departments responsible for managing these impacts and priority planning areas represented on the team?
- What is the specific charge of your preparedness team? (The range of the team's roles might include research about impacts, public education and policy development, and implementation of an adaptation plan. These roles will likely evolve over time based on conversation between members and the team leader.)
- Is your preparedness team being established as a permanent working group?
- How much time does the team have to accomplish this charge?
- What deliverables are expected and to whom? (Typical products include an agreed-upon summary of the impacts of climate change in the region, a description of how these impacts could affect different departments or programs, and a preparedness plan, based on how each department or program intends to prepare for impacts.)
- What resources are available for the team to accomplish its work? (This evaluation should include financial resources, staff support, and/or access to technical consultants in the public and private sectors.)
- What authorities does the team have to accomplish its task? (The team should be able to: draft proposed legislation from the county executive or mayor; review and revise operational plans, managerial priorities, and capital investments.)
- Will team decisions be made by consensus, through voting, or by decision of the team leader in conjunction with department heads?
- Who will lead the team?
- To whom is the team accountable?
- How will the team manage input from the public and other jurisdictions/ governmental entities potentially affected by adaptation strategies?

6.2 How to Select Members for Your Team

The number and background of team members will vary. The team makeup that is appropriate for your community will depend on the specific impacts likely to occur in your region; the governmental operations, infrastructure, and policies that will be affected; and how your community government intends to interact with other local governments, stakeholders, and the public to prepare for climate change. This understanding can and will evolve over time, and team members can be added over time as needed.

At a minimum, include one or more representatives from each department or division which is likely to be affected by climate change. Table 6.1 provides a quick reference list of departments and divisions that may need to be included in your preparedness team. Your team leader can work with department heads to have appropriate staff assigned to the preparedness team. Team members should have technical familiarity with the work areas being reviewed for adaptation planning. Technical briefings at the team meetings can help team members get familiar with climate change impacts and preparing for climate change.

POTENTIAL PARTICIPANTS IN A CLIMATE CHANGE PREPAREDNESS TEAM	
Planning Areas	
Agriculture	Planning and zoning
Economic development	Public health
Emergency management	Stormwater management
Fire	Transportation
Flood control	Wastewater treatment
Natural resources / environmental protection	Water supply
Parks and recreation	Coastal zone management and port and harbor management
Forestry and forest resources	

Other Potential Team Members	
Business community	Non-profit organizations
Consultants	Science advisor(s)
Native American Tribes	State and federal agencies
Neighboring governments	Metropolitan planning organizations

Table 6.1 – Potential participants in a climate change preparedness team. Potential participants in a climate change preparedness team. The actual make-up of your climate change preparedness team will depend on your organization's particular responsibilities, vulnerability to climate change, and relationships with the broader community.

You may also want to include external scientific advisors such as representatives from a nearby NOAA-RISA office and/or members of the broader community. External scientific advisors can direct team members to appropriate information sources and summarize climate change science and information about climate impacts into a less technical format (see Box 6.2). Members of the broader community may include non-governmental organizations, businesses, other jurisdictional governments and agencies (including those who may be affected by climate change impacts and/or adaptation strategies), and informal community leaders. Engaging these groups in a broader conversation will help ensure that workable strategies are developed and supported by the broader community.

Ideally, a majority of the team members should be authorized to make changes recommended by the collective team in the adaptation planning process. The best case scenario would be for the team to contain a large percentage of managers from the government, as well as advisory technical experts, so that the plans made by the team can be funded and confidently implemented once recommendations are made. If managers are not able to serve on the team, the team should contain credible staff members who have strong working relationships with department and division managers and can secure managerial support.

Box 6.2 – Tips for Selecting Science Advisors

Science advisors can help your climate change preparedness team understand the science of climate change, projected regional impacts, and the confidence with which projections of future change are made. They can "translate" scientific information into terms understandable by an educated layperson and help identify additional sources of information. In selecting a scientist to serve as a climate change science advisor, it is important to consider both their professional credentials and their communication skills.

To evaluate professional credentials, consider whether the individual has earned an advanced degree(s) in a pertinent scientific discipline from a recognized university, the number of years of relevant experience, ability to produce peer-reviewed publications, and/or familiarity with both the global and regional consequences of climate change.

To evaluate communications skills and appropriateness for involvement in a governmental planning process, make sure the person under consideration is:

- Interested in and willing to provide guidance on the use of scientific information in the planning process, including guidance on dealing with scientific uncertainty;
- A clear communicator. Consider inviting the advisor to give a talk to your team on an aspect of climate change or regional impact science (e.g., "Observed and projected global climate change," "Causes and consequences of climate change," or "Local impacts of climate change"). Note how well s/he communicates scientific information and how willing and able s/he is to answer questions and engage in discussion in an understandable and approachable manner.
- Understanding of, or at least willing to learn about, the timescales and constraints of governmental planning processes.

Good starting points for identifying potential scientific advisors are local universities, professional and/or technical societies, NOAA-RISA teams (see Appendix D.5), and non-governmental organizations involved in climate change related activities. It is important to recognize that time and funding constraints can limit a researcher's interest and ability to serve as a science advisor. This may be particularly true in areas where the demand for potential advisors exceeds supply.

External Advisory Boards

Preparedness planning and the specific strategies that come out of your planning process will need to reflect a sense of region-wide partnership and collaboration, and involvement from the general public will also be important. Depending on the scale of your planning effort, however, you may want to consider establishing an external advisory board instead of undertaking a major public process. Other reasons to expand the ownership of climate change preparedness to an external advisory board include the following:

- **Climate change crosses jurisdictions, sectors, and disciplines.** Climate change preparedness is not the exclusive task of government. On the contrary, government needs to urge businesses, non-governmental organizations, and residents to undertake their own preparedness activities, in concert with regional planning. It may also eventually be necessary to ask these groups to support changes in zoning, building codes, utility rates, or best management practices in the course of implementing a preparedness plan.

- **Preparedness strategies may benefit from fresh perspectives.** Building an outside team can bring fresh perspectives on how to adapt public

operations and services, from those not involved in those operations on a daily basis. A diversity of opinion and background can benefit the greater good, such that low income and vulnerable populations are represented as well as manufacturers, developers, engineers and scientists. If government feels "stuck" on a particular problem or solution, an external advisory board can provide outside perspectives on the issue.

- **Bold preparedness strategies may need political support.** Some governments may benefit from building an external advisory board of community leaders in the public and private sector to gain expert input, political capital, or other resources that the government might not have on its own. If board members are influential community leaders or well-connected professionals, they could prove to be very useful in spreading the word about the climate change preparedness effort, among the public and their broader networks of colleagues.

6.3 How to Select a Team Leader

Assign someone, or some combination of individuals, the responsibility of assembling the team and leading its efforts. This individual will also probably be different from your public "champion" who develops support for the cause but does not manage the efforts directly (see Section 5.1). Given that team members will come from various departments, the ideal team leader will be centrally located, have a good grasp of the organization's overall responsibilities and objectives, and be able to communicate well with colleagues from other departments or divisions.

Your preparedness team leader should have authority and technical familiarity to work with staff members across the broad scope of government agencies. S/he should have authority to require deliverables from the departments represented on the team, as well as a strong working relationship with the government's leadership, whom s/he will advise on the climate planning recommendations and progress over time. Without appropriate authority, the team leader may not be able to count on the willingness of departments to contribute.

It will be necessary for your team leader to have a general sense of which departments or divisions have authority over areas that are vulnerable to climate change. The leader should be able to identify the government functions likely to be affected by climate change based on the initial scoping of projected regional effects of climate change (Chapter 4). The team leader can then work with the relevant department heads to have appropriate staff assigned to the preparedness team. For this purpose, the team leader should have a strong relationship with department heads.

Basic understanding of climate change and climate change impacts is desirable but this knowledge can be improved through literature reviews, meetings with local experts, seminars, and other modes of public education. More critical are the leader's managerial skills, including their ability to facilitate large meetings on complex topics and keep the team focused. Preparing for climate change requires input from a number of diverse disciplinary experts and departmental representatives, and new ways of working together across public organizations. Your team leader will therefore need to be able to facilitate group interaction and develop a sense of commitment from team members to feel collectively vested in the same outcome. For this important but somewhat intangible aspect of team management, you will want to select a team leader who is respected personally without a personal or institutional agenda that could conflict with

productive teamwork. An ability to communicate clearly with the public and community leaders will also be essential.

6.4 What the Team Will Do

Your community's preparedness team can serve multiple purposes but its primary responsibility is to guide how the government entity adapts to climate change. Ideally, the team will (over time) review all programs and services provided by the government organization, identify those potentially affected by climate change, and propose strategies for adaptation. Large governments might consider instituting teams on two levels: a senior-level team that coordinates preparedness activities for the government as a whole, and technical-level teams that coordinate activities within individual departments. For smaller governments, a single interdepartmental team may be all that is needed.

Your team should engage in a five basic stages of work – effectively the five major process steps of this guidebook (or the Climate Resilient Communities program Five Milestones):

- conduct a climate resiliency study;
- identify priority planning areas for action, based on assessments of your vulnerability and risk in selected planning areas;
- set goals and develop your plan;
- implement your plan;
- measure your progress and update your plan.

Typical products include a consensus-based description of the regional impacts of climate change, how these impacts will affect the objectives, outcomes, and operations of different departments or programs, and how each department or program intends to prepare for these impacts.

Once the team is formed, the team as a whole should be briefed on what is currently known about climate change and major projected regional impacts. It is important for participants to know what the science can and cannot tell us at this point in time and how confident the scientific community is about various projected impacts. This step is valuable for establishing a common baseline of understanding among team members since it is unlikely that all team members will begin with the same degree of understanding or knowledge. The team will also need to address any remaining procedural issues noted in Box 5.1 and discuss how they would like to move forward in the planning process (using the remainder of this guidebook as a reference point for those discussions).

Establishing your team (or point person) and getting the necessary authorities and resources for the team will likely require action from your executive level leadership, which may be a mayor, city or county council, governor, or state legislature. This stage is therefore another good opportunity to launch your preparedness planning effort officially, with a resolution, press release, or another public event that would highlight the proactive steps your community is taking to address climate change impacts.

Be prepared for your team and its workplan to change. As you move through the vulnerability assessment detailed in Chapter 8, stop periodically to reflect on whether the team membership

appropriately reflects the impacts of climate change that matter to your region. It may be that climate change will affect more sectors or resource areas in your community than initially realized, meaning that additional team members from other departments or divisions or from different external organizations may be needed. Conversely, some members may not be needed if fewer or different vulnerabilities in certain sectors are found. Periodically evaluating the match between team members, identified regional consequences of climate change, and potential response strategies will ensure the right personnel are in place for preparedness planning.

6.5 How to Make Progress with Limited Resources: Assign a Point Person

When limited resources mean that forming a team is unrealistic, consider assigning a "climate change point person" to coordinate preparedness efforts and seek outside help. Your point person may be an existing staff member who takes on the additional responsibility of coordinating preparedness activities, or a new hire dedicated specifically to this task. Regardless, it will be important for that point person to have the following authorities, skills, and/or position in the government:

- authority to request meetings with government staff and to require informational updates and climate planning products from across work areas;
- technical familiarity with the roles, responsibilities, policies and practices across most or all areas of government, or an ability to learn quickly about those work areas;
- working relationship with the government's top leadership, for purposes of advising the leader(s) on plan and organizational recommendations;
- ability to research, write, and communicate about regional climate change impacts and community vulnerabilities in a policy context;
- personal initiative to champion a climate change planning process;
- resourcefulness in finding and using outside resources to produce a government adaptation plan.

Without these characteristics, especially appropriate authority, the success of a point person to lead an adaptation planning process may be limited. Note that the description of this point person mirrors that of the climate change preparedness team leader, and we strongly suggest that the role is important enough to be delegated to a high-level staff member of the government.

Checkpoint: *Upon finishing this section, you should have formed an interdepartmental climate change preparedness team representing the disciplines and departments appropriate for the climate change impacts you preliminarily scoped for your region. This team should have strong leadership and top-level support.*

Box 6.3 - Case Study: King County's Climate Change Preparedness Teams

In January 2006, the King County Executive established an interdepartmental "climate change action team," led by the Executive's Deputy Chief of Staff. This team was charged with developing planning, policy, and investment strategies to reduce climate change emissions and prepare for regional climate change effects.

The team is staffed by over 10 employees from the Executive Office, the Department of Development and Environmental Services, the Department of Executive Services, the Department of Natural Resources and Parks, the Department of Public Health, and the Department of Transportation. The core staff members of the team are:

- The Executive's Deputy Chief of Staff, who provides policy and political guidance for the team, convenes biweekly meetings, and directly advises the Executive;
- The Deputy Director of the Department of Natural Resources and Parks, who demonstrates strong departmental support for the team's work plan, and leads the development of climate change preparedness strategies from an interdepartmental advisory group, as explained below;
- A full-time climate change "coordinator" in the Executive Office, who writes, researches, and develops policy, planning and communications materials for the team;
- An almost full-time analyst in the Department of Natural Resources and Parks who advises the team on policy development and conducts the county's greenhouse gas emissions inventory; and
- An economist in the Department of Transportation, half of whose time is dedicated to the team.

The smooth functioning of the team is also dependent on strong involvement by high level department chiefs and managers who ensure that proposed actions can be funded and implemented. Staff from the Office of Management and Budget help to conduct cost benefit analyses of proposed actions and provide financial support for initiatives such as Chicago Climate Exchange membership and yearly 'carbon budgeting.'

King County has found that a mix of technical advisors and implementers is ideal, so that some team members can be "experts in the room" about climate science, while others can provide a "reality check" about funding and implementation. The key common denominator of all King County team members has been an ability to communicate about the need to adapt, and a problem-solving mindset to begin to develop long term strategies to do so. When returning to their respective workgroups from the preparedness team, these team members have also been expected to be the "champions" and "credible peers" on whom both their preparedness teammates and their colleagues can rely for communication about progress on the preparedness team's work plan.

In March 2006, based on the climate change action team's work, the Executive issued a series of Executive Orders on Climate change Preparedness, which directed departments to develop strategies in land use, public transportation, environmental management and renewable energy, to reduce emissions and prepare for climate change impacts. These Executive Orders also charged departments with developing a single climate change action plan to be submitted to the Executive in early 2007.

Over the course of the 2006 "launch" year, the team worked with the King County Council to develop an ordinance that built on and legislatively implemented the Executive Orders issued in March 2006, and similarly charged the departments with developing a comprehensive climate change action plan by February 2007. The team also worked with the King County Council to pass an ordinance approving entrance of the government into the Chicago Climate Exchange, in order to develop carbon market expertise, advocate for a federal cap on greenhouse gas emissions, and recommend carbon market rules that reward regional governments for actions that reduce greenhouse gas emissions.

The team has also worked extensively with other governments to advocate for broader reduction of greenhouse gas emissions, and to advise federal policy and funding of best practice regional climate change adaptation practices. These government-to-government exchanges include: a resolution by the National Association of Counties to stop climate change; an Urban Leaders Initiative, co-founded with the Center for Clean Air Policy, to develop recommendations for federal policy on how best to prepare regional governments for climate change effects; and a statement of shared action with the Republic of the Marshall Islands, to exchange experiences on how best to adapt to climate change impacts such as drought, flooding, and sea level rise.

In the end of 2006, the Executive Office also asked departments to form an advisory group on adaptation, with approximately 15 representatives from Department of Natural Resources and Parks, Department of Public Health, the Office of Emergency Management, the Department of Transportation's Roads Division, and the Department of Development and Environmental Services. This team is responsible for reviewing vulnerabilities of both government operations and the King County region to climate change impacts, and advising the Executive Office on how best to prepare for climate change impacts to public health, property, roads and transportation infrastructure, water supply, the county's wastewater system, shorelines, forests, agriculture and biodiversity. It has since evolved into a team that will implement both the mitigation and adaptation actions of the climate plan.

As mandated by the King County Executive and King County Council, the climate change action team drafted the county's first Climate Plan in early 2007, with the support of the adaptation advisory group. The plan, which focused on water supply, public health, emergency preparedness, flooding, salmon recovery, and forest health, was transmitted to the Executive and Council in February 2007. The development of this plan was guided by: greenhouse gas emissions inventory data; climate science research from the Climate Impacts Group at the University of Washington and the reported proceedings of the 2005 King County Climate Conference (Box 5.1); a vulnerability "scoping" questionnaire that was distributed in summer 2006 (Error! Reference source not found.); further discussions with technical experts in the county and the Climate Impacts Group at the University of Washington; and conventional public sector cost benefit analysis undertaken by the climate change action team and the Executive Office.

Through the climate change action team, Executive departments will be required to report annually on progress in implementing the plan. The teams are now engaged in implementation. The 2007 King County Climate Plan can be found at: *http://www.metrokc.gov/exec/news/2007/pdf/ClimatePlan.pdf*.

chapter 7 identify your planning areas relevant to climate change

This chapter helps you to develop an inventory of your ***planning areas*** – defined as the areas in which a government or community manages, plans, or makes policy affecting the services and activities associated with built, natural and human ***systems***. Your inventory of planning areas, and ultimately your prioritization of these planning areas (Chapters 8 and 9), will serve as a focus for your preparedness efforts and will allow you to apply the climate change information you accumulate strategically.

Planning areas could be as broad or as specific as you deem necessary. Examples of planning areas include water supply, wastewater treatment, public health, road and bridge operations and maintenance, forestry, and parks. We suggest that you group these planning areas by sector (using the list in Table 4.1 or some variation).

After listing your planning areas, identify current and expected stresses to systems in these planning areas. In articulating the stresses to your built, natural or human systems, be sure to consider the effects of both known climate conditions and non-climate stresses such as population growth, economic development and other major trends. Organize your results in a form like Table 7.1.

PLANNING AREAS are the areas in which a government or community manages, plans, or makes policy affecting the services and activities associated with built, natural and human ***systems***.

SYSTEMS refer to the built, natural and human networks that provide important services or activities within a community or region.

You should also consider listing the planning areas for which your government is not directly responsible but have relevance to the overall well-being of your community (e.g., public health services from a county or state agency, interstate transportation infrastructure, timber production, outdoor recreation).

Add these planning areas to your table. You might also consider adding information about the entity responsible for management of each planning area (although this information is not reflected in Table 7.1). You will need to work with these entities to coordinate efforts on climate change preparedness.

It is particularly important to review non-climate related stresses to your planning areas at this stage in the process. As you are no doubt aware, governments have limited resources. Although

1. Sectors	2. Planning Areas	3. Current and Expected Stresses to Systems in This Planning Area
Hydrology and water resources	Water supply management	Low water supply during hot, dry summers; managing drought *(current and expected)*
		Poor water quality during flood events *(current and expected)*
		Poor water quality during summer *(current and expected)*
		Aging infrastructure and lack of funding for system upgrades *(current and expected)*
		Meeting increased demand from population growth *(expected)*
Infrastructure	Stormwater management	Combined sewer overflows (CSOs) during heavy rainstorms *(current and expected)*
		Lack of funding for system upgrades *(current and expected)*
Transportation	Road operations and maintenance	Road buckling during heat waves *(current and expected)*
		Winter road maintenance (snow/ice removal) *(current and expected)*
		Managing brush fires along roadways *(current and expected)*
		Erosion around bridge footings *(current and expected)*

Table 7.1 – Current and expected stresses to systems in sample planning areas of water supply, stormwater management, and road operations and maintenance

at this stage of your climate preparedness efforts you are still essentially studying the scope of your climate change challenges, as you progress through the remaining chapters in the book you will begin the process of evaluating both the benefits and the costs of your proposed climate preparedness actions.

Ultimately your prioritization process will not only compare competing climate-related strategies, but will likely spill over into resource decisions regarding non-climate related planning areas as well. At this stage, the more explicit you are in articulating non-climate related stresses to planning areas, the better informed you will be as you select and prioritize your preparedness actions and implement your climate plan later on.

Checkpoint: *Upon finishing this section, you should have a list of planning areas relevant to climate change, as well as a description of current and expected stresses to built, natural and human systems in each of these planning areas. You may also identify other entities with whom you need to collaborate on preparedness efforts.*

CONDUCT A CLIMATE RESILIENCY STUDY **MILESTONE 2**

The following chapters recommend how to reach CRC Milestone Two, "Conduct a Climate Resiliency Study."

Chapter 8: Conduct a Climate Change Vulnerability Assessment

Chapter 9: Conduct a Climate Change Risk Assessment

chapter 8 conduct a climate change vulnerability assessment

Chapter 8 will take you through the three-step process necessary to complete a vulnerability assessment for your planning areas:

- a sensitivity analysis for the systems associated with the planning areas you identified in Chapter 7
- an evaluation of the adaptive capacity of the systems associated with each of these planning areas
- an assessment of how vulnerable the systems in your planning areas are to the effects of climate change.

A vulnerability assessment can be one of the more research-intensive phases of the planning process. As noted in Section 4.2, the scope and scale of your vulnerability assessment is up to you; aim for a level of detail that meets your resource and information needs. Suggestions for working with limited information and resources are offered in this chapter. See Box 8.1 on the next page for a general list of questions to consider when beginning a vulnerability assessment.

8.1 Review and Supplement Important Climate Information

It is important to have as much accurate information as possible about regional climate change and climate change impacts. Depending on the amount of information already collected and analyzed (see Section 4.1), you may want to supplement your existing base of information.

Follow the guidelines suggested in Section 4.1 for collecting and analyzing reports, web sites, fact sheets, and other information sources. You may choose to do the additional research yourself, or you may choose to delegate the task to other preparedness team members, staff members, a consultant, a volunteer, or a university graduate student working under the supervision of a qualified researcher. This work can happen simultaneously with the inventory process described in Chapter 4 and may need to be repeated at various points in the planning process depending on specific information needs.

Box 8.1 – Issues to Consider When Beginning a Vulnerability Assessment
Your vulnerability assessment can be conducted in-house, through the climate change preparedness team, or with the assistance of consulting agencies or university-based researchers. Before beginning your assessment, consider the following questions:

General Process and Scope:

- How much time is available for the assessment?
- On which planning areas do you want to focus the assessment?
- Who will perform the assessment? Do you have the technical capacity to perform it in-house?
- If outsourcing the assessment, what is the procedure that must be followed for hiring a contractor?
- What questions do you want the assessment to answer?
- Which specific decisions do you want the assessment to support?

Budget and Political Support:

- What is your budget for the assessment?
- Who will manage the assessment process and budget?
- Do you have political support for the assessment?

Technical:

- Will any model(s) be developed for the assessment? Will the local government be able to operate the model for future scenario analysis?
- What type of scenarios does the community want to model? (Best case? Worst case? Middle-of-the-road?)

8.2 Conduct Your Climate Sensitivity Analysis

In order to determine whether a system in a given planning area is sensitive to climate change, ask the question: "Will the systems associated with this planning area be significantly affected by projected changes in climate?" If the system is likely to be affected as a result of projected climate change, it should be considered ***sensitive*** to climate change.

SENSITIVITY is the degree to which a built, natural or human system is directly or indirectly affected by changes in climate conditions (e.g., temperature and precipitation) or specific climate change impacts (e.g., sea level rise, increased water temperature). If a system is likely to be affected as a result of projected climate change, it should be considered sensitive to climate change.

This section will walk you through a sample climate change ***sensitivity analysis*** for water supply, stormwater management, and road operations and maintenance, as illustrated in Table 8.1 at the end of this section.

Return to your list of planning areas created in Chapter 7 and your brief descriptions of the current and expected stresses on the systems associated with these planning areas (Table 7.1). Have your team use the information collected to this point to answer the following questions for the planning areas identified in Table 7.1. Your answers to these questions will complete your sensitivity analysis table:

- What are the known climate conditions affecting the stresses on your systems in this planning area? Be as specific as possible (e.g., list seasonal differences).
- How do these climate conditions affect the systems you have identified?
- What is the projected change in the climate conditions you have identified (and by what time period)?

- What is the projected climate change impact to the systems associated with this planning area (absent preparedness action)?
- To what degree is the system sensitive to changes in climate? You can assess this qualitatively (high, medium, low) by answering the questions provided in 8.2.1.
- What are the projected changes in stresses on a system as a result of the projected climate change impacts? Are they likely to get worse, stay the same, or improve as a result of climate change impacts? Or, do new system stresses emerge altogether (e.g., the appearance of an infectious disease in a region, or the decline of a species)?

As noted above, anywhere you have identified a system stress that will be significantly affected by a projected change in climate, you have identified a planning area that is sensitive to climate change.

8.2.1 Questions to Help You Analyze Degree of Sensitivity

You can determine the degree of sensitivity of a system by considering the following questions.

- **How exposed is the system to the impacts of climate change?** Exposure refers to the extent to which a system comes into contact with climate conditions or specific climate impacts. The greater the exposure, the higher the sensitivity to climate change. For example, coastal communities located along low-lying shorelines are more exposed and therefore more sensitive to sea level rise, increased storm surges, and flooding than coastal communities located on bluffs. Similarly, dryland farming is exposed to variability in precipitation amount and timing in a way that irrigation-based farming is not.
- **Is the system subject to existing stress?** Stressed systems are more likely to be sensitive to impacts of climate change. For instance, the sensitivity of the U.S. Pacific Northwest salmon population to climate change is likely to be much higher now than it would have been in the past due to the stresses of today's world: changes in natural streamflow patterns from the construction and operation of dams and reservoirs; the destruction of salmon habitat as a result of forest harvest practices (e.g., road building and clear cutting); the impacts of urbanization on river habitat; and increased frequency of flooding in unmanaged coastal rivers.
- **Will climate change cause the demand for a resource to exceed its supply?** Climate change will influence both the supply and demand for certain resources, such as water and electricity. If supply and demand for a resource are close enough that changes in climate can push them out of balance, that resource (and its associated system) can be considered to be sensitive to climate change. You may have already identified some situations like this if demand exceeds supply during specific known climate conditions (e.g., water supply shortages

during times of unusually low precipitation). It is also important to ask whether climate change might push some planning areas that have not yet experienced this type of problem into a situation where they will in the future.

- **Does the system have limiting factors that may be affected by climate change?** In many cases, there are specific factors that will limit a system's ability to adapt (or be adapted) to climate change. If these limiting factors can be identified, climate sensitivity and climate impacts can be better estimated. For example, tree growth is limited by summer water availability in many western U.S. low elevation dry forests. Tree growth would consequently be expected to decrease in these forests given that climate change is expected to decrease summer soil moisture. A decrease in summer soil moisture may also increase the risk of wildfires and insect outbreaks in western U.S. forests. As another example, some water supply systems are limited in their ability to provide summer drinking water by the amount of natural flow resulting from snowmelt in rivers during the summer. The reliability of the drinking water supply might decrease in locations where climate change is expected to decrease winter snowpack, and therefore decrease summer streamflows dependent on snowmelt.

- **For plant and animal species, is a species of concern in your system currently located near the edge or lowest elevation portion of its range?** Species located near the edge or at the lowest elevation portion of their range are likely to be most sensitive to warming. For example, tree species living in the Northern Hemisphere will be more sensitive to warming when located at the southern end of their range than when located in the middle or northern portion of the range (for a given elevation) since the southernmost species is already facing temperature and/or summer moisture limits.

- **What is the "impact threshold" associated with the system?** All systems have an associated ***impact threshold***, after which sensitivity to climate conditions increase. These thresholds may be created by design standards, operational capacity, or physical and biological factors, as described in the following paragraphs. This knowledge can be used with information about projected regional climate change to assess sensitivity and to evaluate the likelihood of significant impacts.

  In some cases, impact thresholds are related to infrastructure design. For example, sea walls or coastal defenses are typically built to handle surges in sea level that would occur during a certain size of storm hitting the coast at high tide, with some amount of additional buffer potentially factored in. Given this information, you can ask how much future sea level rise the coastal defense could accommodate before it would be overtopped during this type of storm. If the amount that the sea had to rise to reach this threshold were sufficiently large, the risk of overtopping would be very small over the lifetime of the infrastructure. Conversely, if the amount were small, the risk of overtopping will be large.

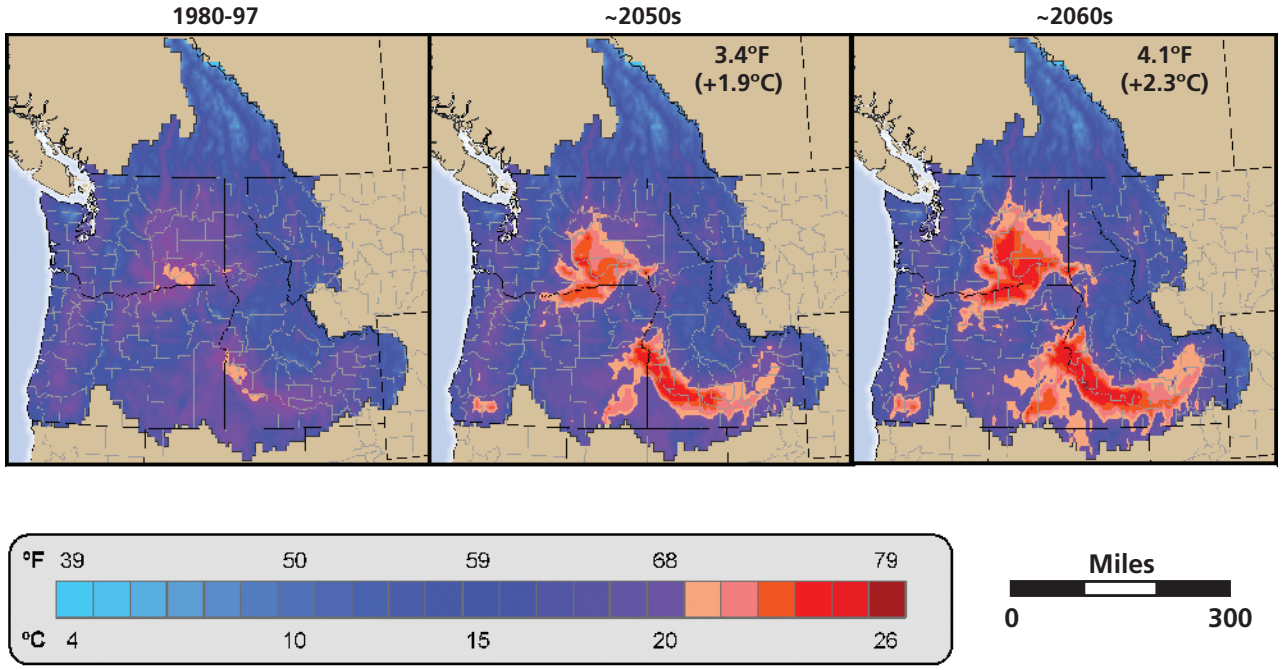
In other cases, natural systems have identified temperature thresholds. As climate change occurs, the frequency with which those temperature thresholds are exceeded will increase in many places. Many coldwater fish species, for example, have temperature "envelopes" that bound the ranges of comfort and tolerance. Pacific salmon rely on cool, ample summer streamflows for juvenile rearing and adult migration back to their spawning grounds. If average summer air temperature exceeds 68°F (20°C) for an extended period of time, salmon species using the rivers during these warm periods will be at greater risk of thermal stress from the warmer water temperatures, which can kill salmon by reducing dissolved oxygen, increasing metabolic rates, and increasing their vulnerability to pests and pathogens. In some areas of the U.S. Pacific Northwest, the warming projected over the first half of the 21st century is sufficient to turn large areas of the interior Columbia River basin into unpleasant or unsuitable habitat for some species of Pacific salmon (Figure 8.1).

8.2.2 Working with Limited Resources: Combining Resources

Many communities may be interested in a more quantitative sensitivity assessment of projected climate change impacts to their systems, but lack the financial resources to fund the needed research. One strategy for maximizing limited means is to pool resources with neighboring governments. This approach not only provides the benefit of cost-sharing, but also allows for developing and applying consistent information on projected climate change impacts in multi-governmental regional planning processes. Such an approach is being taken in Washington State's east central Puget Sound region (Box 8.2).

Checkpoint: *Upon finishing this section, you have completed your sensitivity analysis – the first of a three-step process in conducting your climate change vulnerability assessment.*

Figure 8.1 Recent and Projected Average August Surface Air Temperature in the Columbia River Basin, Compared to Temperature Thresholds for Local Salmon Populations



The left panel shows observed August surface air temperatures in the Columbia River Basin, which is located in the U.S. Pacific Northwest and southern British Columbia, Canada. Areas where the average August air temperature is greater than ~70°F (21°C), a temperature threshold which generally leads to conditions unsuitable for salmonids, are shown in red. Future temperature projections made with a relatively cool climate model (the National Center for Atmospheric Research Parallel Climate Model) are shown in the center and right panels. Future warming will likely increase stress on salmon populations that use these areas during summer, such as summer and fall chinook, summer steelhead, and sockeye salmon. Figure source: Climate Impacts Group, University of Washington.

Box 8.2 – Addressing Climate Change in a Regional Water Supply Planning Process in the Central Puget Sound Region of Washington State

In 2005, King County Executive Ron Sims invited a consortium of interested water suppliers, state agencies, tribes, and other groups in the King County region to participate in a voluntary water supply planning process with the goal of providing technical information for use in decision making. More than 20 entities are participating on a Coordinating Committee and on seven technical committees that have been established to provide information on a variety of technical issues. These committees are: Water Supply Assessment, Regional Water Demand Forecast, Climate Change, Reclaimed Water, Source Exchange Strategies, Tributary Streamflow, and Small Water Systems.

The Climate Change Technical Committee was formed to review the evaluation of climate change impacts on water demand, water supplies, and instream flows. Technical support to this Committee is provided by scientists at the Climate Impacts Group and graduate students from the University of Washington's Department of Civil and Environmental Engineering.

The first phase of the project was to understand and reach agreement on key aspects of climate change science and impacts as it related to the planning process. The result was a report containing 13 fully-referenced "building blocks" about the impacts of climate change on temperature, precipitation, water resources, and salmon habitat (Palmer et al. 2006). The exercise helped bring the committee members to a common level of understanding of peer-reviewed literature on what is known and widely accepted regarding climate change at both the global and regional scale.

The second phase involved modeling daily temperature and precipitation data for 2025, 2050, and 2075 at select locations in the region. The analysis used a combination of three different climate models and two different

Figure 8.2 – Watersheds Participating in Regional Water Supply Planning for the Central Puget Sound Region of Washington State. Figure source: University of Washington, Climate Impacts Group.

emissions scenarios. Phase 3 used the new climate scenarios and a hydrologic model to determine how climate change may affect daily streamflow at select locations in the study area, particularly inflows into reservoirs serving (or anticipated to serve) as major water supplies. All of the data developed in phases 1, 2, and 3 are available to the public on the internet (*http://www.climate.tag.washington.edu/*).

Phase 4 of the project requires developing a framework that other technical committees can use to estimate the impacts of climate change on municipal water demand and water supply. Phase 5 will look at available literature on particular questions raised by participants concerning possible impacts of climate change on cloud cover and on groundwater.

More information on the Climate Change Technical Committee and the Regional Water Supply Planning Process can be found at *http://www.tag.washington.edu/projects/kingcounty.html*.

1. Sector	2. Planning Area	SENSITIVITY ANALYSIS						
		3. Current and Expected Stresses to Systems in This Planning Area	**4. Known Climate Conditions Relevant to Systems in this Planning Area** *(direct and indirect)*	**5. How Known Climate Conditions Currently Affect Systems in this Planning Area**	**6. How Known Climate Conditions are Projected to Change**	**7. Projected Impact of Changes to Systems in This Planning Area** *(without preparedness action)*	**8. Projected Change in Stresses to Systems** *(without preparedness action)*	**9. Degree of System Sensitivity to Climate Change**
Hydrology and water resources	Water supply	Managing summer drought	Warm winter, spring temperatures *(indirect, via impacts on supply)*	Warm winter and spring temperatures lead to lower snowpack and earlier snowmelt, reducing summer supply.	Warmer temperatures expected across all seasons in all scenarios, especially during summer months. Slight increase in annual precipitation possible with most of the increase coming in winter. Drier summers expected.	More drought, summer water stress likely due to lower winter snowpack and warmer, drier summers. Population growth will compound this problem.	Likely to get worse.	High
			Warm summer temperature	Warmer summer temperatures increase water demand and evaporation rates.				
			Low winter and/or summer precipitation	Low winter precipitation leads to lower winter snowpack, reducing supply. Low summer precipitation increases water demand, especially when accompanied by warmer summer temperatures.				
		Warm stream temperatures during summer	Warm summer temperature	Warmer summer air temperatures can increase water temperature in some rivers and streams.	Summers projected to be hotter and drier in all scenarios examined. Summer streamflows likely to be lower due to lower winter snowpack, warmer summer temperatures, and less summer precipitation.	More problems with warm summer water temperature.	Likely to get worse.	High
			Low summer streamflow volume	Lower summer streamflows contribute to warmer water temperature in some areas.				

1. Sector	2. Planning Area	SENSITIVITY ANALYSIS						
		3. Current and Expected Stresses to Systems in This Planning Area	**4. Known Climate Conditions Relevant to Systems in this Planning Area** *(direct and indirect)*	**5. How Known Climate Conditions Currently Affect Systems in this Planning Area**	**6. How Known Climate Conditions are Projected to Change**	**7. Projected Impact of Changes to Systems in This Planning Area** *(without preparedness action)*	**8. Projected Change in Stresses to Systems** *(without preparedness action)*	**9. Degree of System Sensitivity to Climate Change**
Hydrology and water resources *continued*	**Water supply *continued***	Meeting increased demand from population growth	Warm winter, spring, and/or summer temperature *(indirect, via impacts on supply and demand)*	No current impact.	Warmer temperatures expected across all seasons in all scenarios, especially during summer months. Slight increase in annual precipitation possible with most of the increase coming in winter. Drier summers expected.	Climate change impacts on summer water supplies (see above) likely to be compounded by increasing summer demand due to population growth.	Likely to get worse.	High
			Low winter and/or summer precipitation *(indirect, via impacts on supply and demand)*	No current impact.				
Infrastructure	**Stormwater management**	Combined sewer overflows (CSOs) during heavy rainstorms	Precipitation intensity, frequency	Intense precipitation events increase risk of CSOs and nonpoint source pollution, and can also increase the risk of localized flooding.	Changes in intensity and frequency of precipitation not known at this time, but the intensity of winter precipitation has increased in the region since early 1970s.	More localized flooding, water quality problems possible if precipitation becomes more intense, frequent.	Could get worse but large uncertainties about changes in precipitation.	Uncertain
		Lack of funding for system upgrades	Precipitation frequency, intensity *(indirect)*	Intense precipitation events can strain current storm/sewer system collection system and contribute to combined sewer overflows.	Changes in intensity and frequency of precipitation not known at this time, but the intensity of winter precipitation has increased in the region since early 1970s.	More stress on the system likely if precipitation becomes more intense, frequent.	Could get worse but large. uncertainties about changes in precipitation.	Uncertain

1. Sector	2. Planning Area	SENSITIVITY ANALYSIS						
		3. Current and Expected Stresses to Systems in This Planning Area	**4. Known Climate Conditions Relevant to Systems in this Planning Area** *(direct and indirect)*	**5. How Known Climate Conditions Currently Affect Systems in this Planning Area**	**6. How Known Climate Conditions are Projected to Change**	**7. Projected Impact of Changes to Systems in This Planning Area** *(without preparedness action)*	**8. Projected Change in Stresses to Systems** *(without preparedness action)*	**9. Degree of System Sensitivity to Climate Change**
Transportation	Road operations and maintenance	Pavement buckling on asphalt roads during extreme heat events	Summer temperature	Extended periods of high summer temperatures can cause buckling on asphalt roads.	Summers projected to be hotter in all climate change scenarios examined.	More required asphalt maintenance likely.	Likely to get worse.	High
		Winter road maintenance (snow/ice removal)	Winter temperature Winter precipitation	Cold and snowy/icy winters require more snow and ice removal, road salt. Can also contribute to more road damage.	Warmer winters projected in all scenarios reviewed. Potential for slightly more winter precipitation in most scenarios. Changes in the frequency or intensity of freezing rain events unknown.	Need for snow removal likely to be reduced. Changes in potential for freezing rain uncertain.	Likely to improve, although benefit could be offset if freezing rain events increase.	High (but positive)
		Managing brush fires along roadways	Summer temperature Summer precipitation	Warm, dry summer conditions increase the risk of brush fires along roadways, which can spread into neighborhoods if not contained quickly. Fighting fires can affect traffic flow. Burnt areas can erode more quickly.	Summers projected to be hotter and drier in all scenarios examined.	Risk of brush fires likely to increase.	Likely to get worse.	

1. Sector	2. Planning Area	SENSITIVITY ANALYSIS						
		3. Current and Expected Stresses to Systems in This Planning Area	**4. Known Climate Conditions Relevant to Systems in this Planning Area** *(direct and indirect)*	**5. How Known Climate Conditions Currently Affect Systems in this Planning Area**	**6. How Known Climate Conditions are Projected to Change**	**7. Projected Impact of Changes to Systems in This Planning Area** *(without preparedness action)*	**8. Projected Change in Stresses to Systems** *(without preparedness action)*	**9. Degree of System Sensitivity to Climate Change**
Transportation ***continued***	Road operations and maintenance ***continued***	Erosion and landslides	Precipitation intensity, frequency	Intense and frequent precipitation events contribute to increased erosion around bridge footings, roads. Also contribute to landslides requiring road closures.	Changes in intensity and frequency of precipitation not known at this time, but the intensity of winter precipitation has increased in the region since early 1970s.	More frequent or intense events could increase problems with erosion and landsliding.	Likely to get worse.	Moderate

Table 8.1 – Climate change sensitivity analysis for systems in sample planning areas of water supply, stormwater management, and road operations and maintenance. Table 8.2 builds on Table 7.1 for the sample planning areas of water supply, stormwater management, and road operations and maintenance to include information about how climate change may affect current and expected stresses on systems for a hypothetical community in the U.S. Pacific Northwest. The contents of this table will vary from community to community, including within the Pacific Northwest.

8.3 Evaluate the Adaptive Capacity Associated with Systems in Your Planning Areas

Adaptive capacity describes the ability of built, natural and human systems associated with a given planning area to accommodate changes in climate with minimum disruption or minimum additional cost.

ADAPTIVE CAPACITY describes the ability of built, natural and human systems associated with a given planning area to accommodate changes in climate with minimum disruption or minimum additional cost.

Evaluating adaptive capacity is the second step in the vulnerability assessment of a planning area. As a general rule, systems that have high adaptive capacity are better able to deal with climate change impacts.

To develop your own adaptive capacity table, consider the projected climate change impacts that will affect systems in your established planning areas. In creating this table, you should be guided by the question: "To what extent are the systems associated with this planning area able to accommodate changes in climate at minimum disruption or cost?"

In conducting your adaptive capacity analysis, keep these considerations in mind:

- **Are the systems associated with this planning area already able to accommodate changes in climate?** Examples of systems that are flexible to change include: animal or plant communities that are able to move easily or modify their behavior in response to external changes; and infrastructure that is designed to accommodate a range of future climate conditions, such as a water supply system that has been expanded with reclaimed water.

- **Conversely, are there barriers to a system's ability to accommodate changes in climate?** Many factors can limit a system's ability to accommodate changes in climate. Examples include cases in which:

    - *A legal or regulatory system requires that plans, policies, regulations, and design standards be based on historic climate conditions, or sets other limits that constrain responses to climate change impacts.* For example, the U.S. Federal Emergency Management Agency (FEMA) is required to use historic streamflow data to determine the probability of a 100-year flood event when setting 100-year flood zone boundaries in flood plains. The implicit assumption in this type of planning is that historic streamflow provides a good benchmark for future flood risk, when in reality climate change is likely to increase the flood risk in the future.

    - *The number of competing uses for a system is high.* Flexibility in how a system is managed can often be limited by the needs of other competing uses for the system. The U.S. Pacific Northwest's Columbia River system, for example, is managed simultaneously for flood control, hydropower, irrigation supply, protection of endangered species, water quality, navigation, and recreation uses. Changing operations or regulations to compensate for the impacts of climate change to one use, hydropower production, may be limited by the needs of other uses, such as maintaining flows for protection of Snake River spring and summer run Chinook salmon.

- *The number of organizations involved in managing a system is high.* Flexibility in how a system is managed for climate change can be reduced when there are many organizations involved in the overall management of a system. As noted in the previous example, the Columbia River System is managed for a variety of uses. The responsibility for managing these uses rests with eight federal agencies, multiple state agencies in seven states, 13 Indian tribes, numerous public utility districts, and hundreds of other governmental subdivisions in the U.S. and Canada (NRC 2004). Increasing flexibility in the system is likely to be more challenging than if the management responsibilities rest within one or two organizations.

- *The system has biological, geographic or physical barriers that limit its flexibility.* One example of a biological constraint on adapting to climate change is the temperature threshold of salmon described in Section 8.2.1. Examples of geographic constraints include: the reality that an alpine meadow can only move so far up a mountain before it literally runs out of space to move; and the limitation that bluffs or a seawall place on inland migration of coastal wetlands in response to sea level rise.

- **Are the systems associated with this planning area already stressed in ways that will limit their ability to accommodate changes in climate?** Stresses unrelated to climate include development patterns, population growth, pollution levels, invasive species, disease, infrastructure decay, economic downturns, and damage from previous natural disasters.

    - An example of a natural system with a preexisting stress might be an ecosystem in which an invasive noxious weed out-competes an important local crop for natural resources, leaving the crop less able to accommodate changes in climate.

    - An example of a human system with a preexisting stress might be a community that has recently experienced economic downtown, and does not have the resources to purchase sufficient air conditioning for buildings.

    - An example of a built system with a preexisting stress might be a network of levees and flood control facilities that are already decaying and/or lack funding for repair, and would therefore not be able to accommodate more frequent 100-year floods.

- **Is the rate of projected climate change likely to be faster than the adaptability of the systems in this planning area?** Rates of change can have an important influence on adaptability. Natural systems have responded to past climate changes by migrating along with their preferred climate. By moving northward and upward in elevation, natural systems in the Northern Hemisphere could theoretically

continue to inhabit their preferred climate habitat despite climate change. For many regions of the country (and for the world as a whole), however, climate is expected to change faster this century than it has in recent history. Systems that take long periods of time to adjust (e.g., decades) may not be able to adapt quickly enough to avoid potentially significant impacts to ecosystems and communities.

- **Are there efforts already underway to address impacts of climate change related to systems in this planning area?** Your community may already be involved in activities aimed at reducing stresses on systems likely to be affected by climate change. Those efforts may increase the system's adaptability to climate change provided the current activities are appropriate given projected climate change impacts. Criteria for selecting and prioritizing preparedness activities in Section10.4 may be helpful for evaluating the effectiveness of ongoing planning activities for addressing climate change impacts.

Sectoral experts on your climate change preparedness team will be valuable sources for the information you need on existing policies, practices, infrastructure, and authorities in this stage of the assessment. You might also consider asking stakeholders and other colleagues how existing policies, practices, infrastructure, and authorities might provide both opportunities and barriers to preparing for climate change. This can be done face-to-face at public meetings, staff meetings, special workshops, lunch-time brown bag discussions, or via a questionnaire such as the one developed by King County, Washington, which integrated questions about existing regulatory barriers into a larger survey used to gather information on vulnerabilities in the County (see Box 8.3).

Add your evaluation of adaptive capacity for each planning area to a simplified version of the table you have been developing, as shown in Table 8.2 on the next page. Include observations that led you to your conclusion, so that you can refer to them later.

Again, at this stage your evaluation should remain qualitative. However, your understanding of the additional relative cost to a given system of accommodating projected climate change impacts will eventually help you to make prioritization decisions, as described later in this book.

2. Planning Area	3. Current and Expected Stresses to Systems in This Planning Area	7. Projected Impact of Changes to Systems in This Planning Area (without preparedness action)	ADAPTIVE CAPACITY ANALYSIS	
			10. Ability of the Systems in This Planning Area to Accommodate Projected Impacts with Minimum Disruption or Costs	11. Adaptive Capacity of this Planning Area
Water supply	Managing summer drought *(current and expected)*	More drought, summer water stress likely due to lower winter snowpack and warmer, drier summers. Population growth will compound this problem.	Cannot do anything to "adapt" snowpack to warmer temperatures. There are numerous regulatory constraints on reallocating water; there are limited options for expanding water supply; and summer demand is already greater than supply.	Low
Stormwater management	Combined sewer overflows (CSOs) during heavy rainstorms *(current and expected)*	More localized flooding and water quality problems may be possible if precipitation becomes more intense and frequent.	Can upgrade the system but this option is costly; some upgrades may already be underway.	Medium
Road operations and maintenance	Pavement buckling on asphalt roads during extreme heat events *(expected)*	More required asphalt maintenance likely.	Can replace asphalt more frequently but this is costly and dependent on industry-wide changes in asphalt for improved asphalt mixes.	Medium

Table 8.2 – Evaluation of adaptive capacity in systems associated with sample planning areas of water supply, stormwater management, and road operations and maintenance. This table builds on Table 7.1, a continued analysis of systems associated with the sample planning areas of water supply, stormwater management, and road operations and maintenance. As with the previous tables, the contents of this table will vary from community to community, including within the Pacific Northwest.

Checkpoint: *Upon finishing this section, you should have a qualitative summary of how adaptable the systems in your planning areas are to the projected regional impacts of climate change.*

Box 8.3 – King County Questionnaire for Preliminary Assessment of Climate Change Impacts and Adaptation Barriers

Experts on your climate change preparedness team will be valuable sources of the information needed in this stage of the assessment. You might also consider asking stakeholders and other colleagues how existing policies, practices, infrastructure and authorities might pose both barriers and opportunities to preparing for climate change. This can be done in many ways; one example is a questionnaire such as the one developed by King County below.

The King County climate team distributed this questionnaire in summer 2006 to its internal experts across the planning areas of regional water supply, road and bridge infrastructure, salmon recovery and biodiversity, stormwater and wastewater management, agriculture, forestry, public health, coastal management, and flood hazard management. It combines the two steps outlined in Chapter 8: a sensitivity analysis and an evaluation of adaptive capacity. The final question about cross-agency and cross-sector interactions is represented in the questions guiding your adaptive capacity evaluation in Section 8.3 (though it was not given a column in the sample table).

General Information

1. Name(s) of person(s), title(s) and division/ department completing this survey.
2. What is the natural or built resource that is the focus of this questionnaire response? Please use above sector name:

Assessing Sensitivity

3. How is your natural or built resource sensitive to present day climate variability?
4. How is climate change likely to affect your natural or built resource? Of these impacts, which present the greatest concern and why?
5. What additional information about climate impacts would help further your ability to manage climate change impacts?

6 Do you know of, or can you identify, potential economic impacts from climate change? Please state what the potential or expected impacts are and why they may occur.

Assessing the Capacity to Adapt to Climate Change

7. To what extent do current plans, policies, and regulations explicitly account for the impacts of climate variability or change, or inherently provide a buffer against climate impacts? Please provide examples.
8. How adequate are these existing plans, policies, or regulations for managing climate impacts? (very good, good, fair, poor) If answering for more than one plan, policy, or regulation, please answer for each.
9. What additional actions, authorities, policies, or regulations are needed for managing climate change impacts?
10. If specific recommendations are not identifiable, what process is necessary to identify adaptation strategies?
11. Do you have existing forums or committees to do this?
12. What recommendations can you make for near-term (less than 5 years) and longer-term actions or next steps?

Cross-agency and Cross-sector Interactions

13. To what extent do climate change impacts and adaptation activities in other sectors (listed above) affect your resource? Please specify.
14. To what extent do climate change impacts and adaptation activities in your resource affect other sectors (listed above)? Please specify.
15. What other county departments or governmental jurisdictions need to be involved in developing and implementing adaptation responses to climate change for your natural or built resource?
16. Is there currently a process or forum in place that facilitates this type of interaction? If so, please specify.
17. Please provide any additional information that you would like to share.

8.4 Completing the Assessment: How Vulnerable Are You to Climate Change?

The final step in the vulnerability assessment process is to combine your findings about sensitivity and adaptability to determine how and where your community is vulnerable to climate change. For each planning area listed in the preceding tables, consider sensitivity and adaptability of its associated systems to climate change. Planning areas with systems that are sensitive to climate and less able to adapt to changes are generally considered to be ***vulnerable*** to climate change impacts.

VULNERABILITY refers to the susceptibility of a system to harm from climate change impacts. Vulnerability is a function of a system's sensitivity to climate and the capacity of that system to adapt to climate changes. In other words, systems that are sensitive to climate and less able to adapt to changes are generally considered to be vulnerable to climate change impacts.

The vulnerability assessment can be a qualitative (high, medium, low) and/or quantitative exercise depending on the type of information available and the amount of resources available for a more quantitative investigation. Table 8.3 provides an illustration of qualitative assessment only. Box 8.4 provides an example of how the City of Olympia, Washington, conducted a study to investigate how and where the City is vulnerable to sea level rise.

Do not consider your vulnerability assessment to be static. Existing vulnerabilities that you identify in this assessment will change, and new vulnerabilities will emerge as a result of:

- climate change impacts on the frequency, intensity, duration, and/or extent of specific climate events;
- the emergence of new threats, such as the introduction of a new invasive species or disease into the community;
- new information on how climate change may affect specific systems in planning areas within your community;
- implementation of preparedness actions (as detailed in Chapter 11);
- changes in the community's size, economy, preferences, or other factors that can influence a community's vulnerability to climate change.

As described in Chapter 12, you should review your vulnerability assessment as you update your preparedness plan over time.

2. Planning Area	3. Current and Expected Stresses to Systems in This Planning Area	7. Projected Climate Change Impacts to Systems in This Planning Area	VULNERABILITY ASSESSMENT		
			8. Degree of Sensitivity of Systems in This Planning Area (see Table 8.1)	10&11. Adaptive Capacity of Systems in This Planning Area (see Table 8.2)	12. Vulnerability of Systems in this Planning Area
Water supply	Managing summer drought *(current and expected)*	More drought, summer water stress likely due to lower winter snowpack and warmer, drier summers. Population growth will compound this problem.	High – water supply is very sensitive to changes in snowpack.	Low – numerous regulatory constraints on reallocating water, options for expanding supply limited, summer demand already greater than supply.	High
Stormwater management	Combined sewer overflows (CSOs) during heavy rainstorms *(current and expected)*	More localized flooding, water quality problems possible if precipitation becomes more intense, frequent.	High – CSO events are sensitive to changes in the intensity and frequency of rain events.	Medium – can upgrade the system but costly; some upgrades already underway.	Medium
Road operations and maintenance	Pavement buckling on asphalt roads during extreme heat events	More required asphalt maintenance likely.	High – pavement buckling an existing problem on many roads.	Medium – can replace asphalt more frequently but costly; dependent on industry-wide changes in asphalt for improved asphalt mixes.	Medium

Table 8.3 – Vulnerability assessment for systems associated with sample planning areas of water supply, stormwater management, and road operations and maintenance. This table provides an example of a qualitative vulnerability assessment for systems in the sample planning areas of water supply, stormwater management, and road operations and maintenance.

Box 8.4 – Case study: Assessing Vulnerability to Sea Level Rise in the City of Olympia, Washington

The City of Olympia, Washington, has been concerned about climate change for over 17 years. Early in 1990, a representative of the local citizen Greenhouse Action Group approached the Olympia's City Council to ask what the City was doing to address the issue of climate change. In response, the City Council decided in May 1990 to make action on climate change one of its target issues for the next year. An interdepartmental Global Warming Task Force was launched and prepared a background report on the implications of climate change for Olympia, relying on a major report by Vancouver, BC and technical guidance from the Washington State Department of Ecology. The report also identified areas where the City had authority to act, steps the City had already taken, and possible future actions. Following publication of this background report, Council passed a resolution committing the City to a long-term strategy to reduce greenhouse gas emissions, increase tree cover and prepare for climate change.

Sea level rise is one of the primary issues Olympia must address. Sea level, already rising in Olympia about one foot per century due to post-ice age warming of the oceans and land subsidence, will be accelerated by climate change. Much of Olympia's downtown lies one to three feet above the current highest high tides, which occur once or twice a year (Figure 8.3). The report determined the downtown area, Port of Olympia, and the City's primary drinking water source would be particularly vulnerable to flooding and Budd Inlet's habitat and water quality would be at risk as well.

If no protection measures are taken, even one foot of sea level rise will result in ponding on some streets and flooding of low-lying structures. A two-foot rise will impact an even greater area. Pipes designed to convey stormwater away from downtown will be unable to discharge fast enough to prevent flooding during storms. At higher levels, flows will reverse and the sea will flow out of street drains and into the streets. A three-foot rise will overtop many places along the shoreline and flood a greater area. The wastewater system is combined with stormwater in much of Olympia's downtown. Higher sea levels will flow into the wastewater pipes through combined drains and infiltrate through pipe joints, challenging capacity at the regional wastewater treatment plant. Partly because the City's major supply source at McAllister Springs is subject to saltwater intrusion, the City is planning a new wellfield upgradient from the springs. Changes in precipitation may further impact the City groundwater drinking water supply.

Over the years, the City's climate change initiative was broadened into a commitment to sustainability. Since the early 1990s, the City has focused on climate change mitigation and other sustainability efforts, implementing policies to reduce greenhouse gas emissions and sustain natural resources. Internally, the City has reduced municipal vehicle emission, increased biodiesel usage, and moved towards utilizing 100% green power for all utility electricity needs. The City's water conservation and reclaimed water programs have mitigated the impact of increasing water demand; land use and transportation policies have promoted denser, less auto-dependent development; stormwater management, forest preservation and street tree planting have helped reduce the effects of urbanization; and the new waste management plan aims to move the City toward Zero Waste.

In response to growing concerns about impacts to Olympia's downtown, in late 2006 City staff began revisiting climate change and sea level rise issues. A work plan initiated by Public Works staff includes preparing a status report on climate change in Olympia with recommended next steps for further emission reductions and risk assessments, as well as a shift towards implementation of adaptation strategies. The City is engaging the community through public forums and other educational activities. The City is also forming partnerships among its Thurston County neighbors, drawing on resources from Ecology, the University of Washington's Climate Impacts Group and others, and currently serves on the statewide Coastal/ Infrastructure Preparation/Adaptation Working Group to recommend strategies to meet Governor Gregoire's Washington Climate Change Challenge.

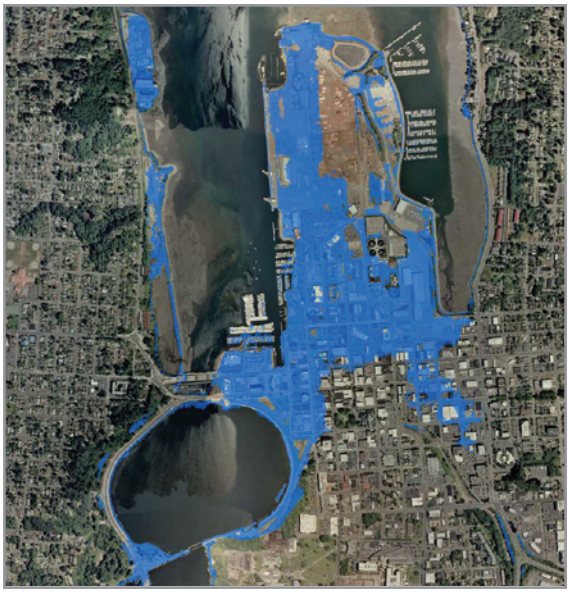
A copy of the City of Olympia's 1993 sea level rise assessment report, *A Preliminary Assessment of Sea Level Rise in Olympia, Washington: Technical and Policy Implications*, is available at http://www.ci.olympia.wa.us/cityutilities/stormwater/streams/.

Case study text courtesy of Rich Hoey (Director of Water Resources), Danielle Harrington, and Vince McGowan of the City of Olympia, and Dorothy Craig, consultant to the City of Olympia.

Figure 8.3 Inundation Levels in the City of Olympia, Washington, from Current and Projected Changes in High Tides

A. Tidal datum elevation 18 feet

B. Tidal datum elevation 19 feet



C. Tidal datum elevation 20 feet

D. Tidal datum elevation 22 feet

The City of Olympia is located at the south end of Puget Sound in a region that is considered vulnerable to sea level rise because of its low elevation, the intensity of development along its shoreline, and tectonic processes that appear to be causing land elevations in the south Puget Sound region to be sinking. The blue shading in figures (**A**) through (**D**) show areas that could be affected by progressively higher high tides resulting from the combined effects of global sea level rise, subsidence, and other events that affect sea level rise at a given location. For reference, the City currently experiences tide heights greater than 17 feet two to four times a year. If relative sea level rose 3 feet, the areas in blue on image (**C**) could be inundated 2-4 times a year, those on image (**B**) over 30 times a year, and those on image (**A**) nearly 200 times a year. Add the effects of a 100-year storm and the areas in blue on image (**D**) could be inundated in some areas with up to five feet of seawater. Image source: City of Olympia. Used with permission.

chapter 9 conduct a climate change risk assessment

Based on your knowledge about the vulnerabilities of systems in your planning areas, you are now ready to conduct a climate change ***risk assessment*** of those systems – the second step necessary to identify your ***priority planning areas*** (defined in Section 9.2).

9.1 Assess Your Climate Change Risks

As in other fields that require risk management, the process of priority setting for your climate change preparedness efforts will be based on your estimation of climate risk to systems in your planning areas. Risk is defined and described here as:

Risk = Consequence x Probability

- **Consequence of an impact.** What are the known or estimated consequences (economic, ecological, social, cultural and legal) of a particular climate change impact? For example, consider how costly failure of a flood wall can be or how coastal ecosystems and development will be affected by different projections of sea level rise. This estimation may be qualitative (high, medium, low) and/or quantitative (e.g., $18 million for the failure of a flood wall). Your assessment of consequence should also factor in the estimated scale of the impact, such as the size of the population or land area affected by a projected climate change impact. Consider also the cumulative costs associated with a higher frequency of minor events.

- **Probability or likelihood of an impact.** How likely is it that a projected impact will occur? Some climate change impacts, such as increasing average temperatures and sea level rise, are virtually certain. The degree to which these changes affect existing problems or lead to new problems was evaluated in your vulnerability assessment. Probability can be assessed qualitatively (high, med, low), particularly in cases where resources are limited, information is limited, or the consequences of the impacts are small. In cases where a quantitative estimate of probability is warranted, consider using more technical analytical techniques.

Use the information collected for your vulnerability assessment (Chapter 8) to estimate the consequence, probability, and resulting risk of specific climate change impacts to systems in your planning areas. Have each member of the preparedness team perform their own risk assessment for

systems in their respective planning areas. Team members may also want to survey staff within their home departments and/or technical experts (e.g., scientists, engineers, resource managers) to develop a more robust view of risk for systems in their planning areas.

Other considerations that can affect basic estimations of risk are your planning time frame, the geographic scale of the risk assessment, and attitudes towards risk. Planning for the impacts of sea level rise provides a good example of how each of these additional criteria factor into evaluating risk. The risk that low-lying coastal areas will be permanently inundated by higher sea levels is greater in 40 years than in 20 years (absent any adaptation) given that sea level is projected to be higher in 40 years than in 20 years. The risk of coastal erosion and flooding due to sea level rise in one estuary may be significantly different than the next depending on variations in coastal morphology, plate tectonics (e.g. uplift and subsidence), development patterns, and how much assets along the coast line are valued. Finally, attitudes towards risk can affect how individuals within your community and the planning process view and accept certain levels of risk, as described in Box 9.1. The degree to which any of these factors significantly alters the conclusions of the risk assessment should be considered.

Box 9.1 – Risk Perception and Risk Tolerance

How risk is viewed (risk perception) and accepted (risk tolerance) will play a significant role in your risk evaluation. Risk perception and tolerance can vary widely between individuals, over time, and/or with different thresholds. For example, one community may rank the potential for more extreme heat events higher than a neighboring community because of different perceptions of the risk associated with extreme heat events in each community. In another case, communities may have a high tolerance for a small increase in the risk of a 100 year flood event (from 1% annually to 5% annually, for example) but that tolerance may change if the risk of the event changes from a 1% to a 20% annual probability. Which risks will your community be willing to accept? Which are unacceptable? Your government leadership and/or community may be prepared to take large risks in some areas and none at all in others, especially if that planning area is already under threat. Community meetings and interviews with government leaders may provide insight into what risks are and are not acceptable, and at what thresholds these distinctions are made.

One approach for sorting your risk assessment is identified in Table 9.1. It is good practice to describe why a high, medium, or low rating was assigned to a given system. You can also convert each qualitative statement into a numeric score (high=5, medium-high=4, medium=3, medium-low=2, and low=1) to develop risk scores for each impact. This can be particularly useful for evaluating results from larger group surveys.

For cases where the consequence or probability of an impact is unknown, consider other factors that may help determine the appropriate level of risk:

- How important is the potential impact in context of other issues your government is currently managing?
- If the probability of the impact is unknown but you assume it increases, how problematic would that increase be for systems in your planning areas?

- If the projected impact exacerbates current or existing stresses to systems in your planning areas, how effectively is your government currently handling the stresses?
- What is the adaptive capacity associated with systems in that planning area?

These and other questions can help you make a preliminary estimate of risk when the consequence and/or probability of a projected climate change impact are unknown.

2. Planning Area	**3. Current and Expected Stresses to Systems in This Planning Area**	**7. Projected Climate Change Impacts to Systems in This Planning Area**	**RISK ANALYSIS**		
			13. Consequence of Impact (high, medium, low)	**14. Probability of Impact** (high, medium, low, unknown)	**15 . Estimated Risk to Systems in This Planning Area** (high, medium, low)
Water supply	More summer drought	More drought, summer water stress likely due to lower winter snowpack and warmer, drier summers. Population growth will compound this problem.	High – threat to public safety, loss in consumer confidence, lost revenue. Affects entire customer base.	High – already a concern and warmer, drier conditions expected.	High
Stormwater management	Combined sewer overflows (CSOs)	More localized flooding, water quality problems possible if precipitation becomes more intense, frequent.	Medium – contributes to water quality degradation, potential health, and ecosystem impacts. Affects combined sanitary/storm sewer piping in about 30% of the city.	Unknown at the regional level, but issue is already a major management concern and more intense precipitation observed since 1973.	Medium
Road operations and maintenance	Pavement buckling on asphalt roads during extreme heat events	More required asphalt maintenance likely.	Medium – potential implications for public safety, higher road maintenance costs, travel restrictions for heavy loads. Affects about 55% of the city's medium and high volume roadways.	High – warmer summer temperatures expected.	Medium-high

Table 9.1 – Qualitative risk assessment for systems associated with the sample planning areas of water supply, stormwater management, and road operations and maintenance. This table provides an example of a qualitative risk assessment for systems associated with the sample planning areas of water supply, stormwater management, and road operations and maintenance.

9.2 Establish Your List of Priority Planning Areas

After conducting your vulnerability and risk assessments for systems in your planning areas, you are now ready to identify your ***priority planning areas*** – or planning areas of particular importance to your community or government which are vulnerable to climate change impacts. From this point forward, your climate change preparedness efforts should focus on priority planning areas.

PRIORITY PLANNING AREAS are the planning areas which your community or government determine to be most important given your community's vulnerabilities to climate change and the associated risks.

As public decision-makers, you may already be generating ideas for how to reduce the climate change vulnerabilities and risks you have identified, and you may even be embedding cost-benefit evaluations in your thinking. However, at this stage of problem definition, we encourage you to refrain from formally proposing or prioritizing your possible actions yet, and simply focus on ranking the problems you face – in the form of a list of priority planning areas. In Chapter 10, we will provide more specific guidance on how to evaluate costs and benefits of individual preparedness actions in light of the other priorities of your government.

To identify your priority planning areas, group the results of your vulnerability assessment (Table 8.4) and your risk assessment into one of the following general categories of systems: high risk/high vulnerability, high risk/low vulnerability, low risk/high vulnerability, and low risk/low vulnerability. As illustrated in the vulnerability-risk matrix in Figure 9.1 you will want to make planning areas that have high-risk and high-vulnerability systems a priority.

How to prioritize planning areas that are *not* high-risk and high-vulnerability is up to your team. This decision will likely depend on a mix of criteria not explicitly captured in the vulnerability and risk assessment process, including considerations such as values, economic drivers, and other factors unique to a given community. Examples include:

- **Existing community government priorities.** For example, your administration may already be committed to reducing the risk of forest fires in adjoining forest lands. This effort may make preparedness planning in forest resources a higher priority over other planning areas.
- **Unique planning or funding opportunities.** Examples of unique opportunities include: one-time-only state grants for addressing coastal zoning planning, and plans to make significant upgrades to the community's stormwater collection system. These windows of opportunity may influence the decision to prioritize a planning area that would not otherwise have been chosen.

As illustrations, some of King County's climate change priority planning areas are: public health and emergency preparedness, water supply and streamflow management, coastal hazards management, and flood hazard management.

Figure 9.1 Sample Vulnerability-risk Matrix for Identifying Priority Planning Areas

PLANNING AREAS WITH SYSTEMS THAT ARE...

	Low Vulnerability	High Vulnerability
High Risk	***May be** priority planning areas*	***Should be** priority planning areas*
Low Risk	***Are unlikely to be** priority planning areas*	***May be** priority planning areas*

Remember that risk will change over time. New information on climate change and climate impacts will become available, allowing for better quantification of risks. Non-climatic factors like population growth will also place additional demands on government services and ecosystems, compounding the risk associated with climate change impacts. Climate change itself may shift the consequence, probability and magnitude (and therefore risk) of any particular event. Finally, preparedness planning itself may reduce risk associated with specific climate change impacts. For these reasons, periodically re-evaluate your risk assessment and selection of priority planning areas to make sure the priorities still reflect your community's needs.

***Checkpoint:** Upon completing this section, you should have a list of one or more priority planning areas identified. These priority planning areas will be the focus for your preparedness actions and long-term preparedness plan.*

---

chapter 10 set preparedness goals and develop your preparedness plan

Now that you have identified your priority planning areas, you are almost ready to set your preparedness goals and develop your preparedness actions to address the system stresses that climate change will impose in these areas. This chapter will guide you to take the following steps related to this goal- and action-setting stage:

- establish a vision for a ***climate resilient community***, as well as related guiding principles for resilience, which you will use to inform your process of setting ***preparedness goals*** in your priority planning areas;
- develop, select and prioritize ***preparedness actions*** and write a ***preparedness plan*** to meet the goals you have set.

10.1 Establish a Vision and Guiding Principles for a Climate Resilient Community

As you consider how to deal with the system stresses that climate change bring in your priority planning areas, keep this vision in mind: preparing for climate change is not about making your community "climate proof," but rather making it "climate resilient."

A ***climate resilient community*** is one that takes proactive steps to prepare for (i.e., reduce the vulnerabilities and risks associated with) projected climate change impacts. To achieve this vision, we recommend the following five guiding principles for resilience:

A 'CLIMATE RESILIENT COMMUNITY' is one that takes proactive steps to prepare for (i.e., reduce the vulnerabilities and risks associated with) projected climate change impacts.

- **Guiding Principle #1: Increase public awareness of climate change and its projected impacts on your community.** Outreach and education about climate change, how it affects your community, and what can be done to prepare for climate change can have multiple benefits. First, public education can foster public support for preparedness planning at the government level and influence changes in behaviors to decrease vulnerability and risk to climate change (e.g., water use efficiency at the household level). Secondly, public awareness about climate change impacts and preparedness planning may encourage your community to reduce individual and collective greenhouse gas emissions to prevent the worst impacts of climate change in the future. Different avenues for outreach are suggested in Chapter 5.

- **Guiding Principle #2: Increase your technical capacity to prepare for climate change impacts.** Building climate resilience requires developing a more complete understanding of how climate change affects your community at all levels of government, from public officials to managers and front-line employees. Employ your public outreach tactics inwardly ("inreach") to create more opportunities for learning about climate change, its impacts, and how preparing for climate change might affect individual job responsibilities. You can also improve technical capacity by creating staff positions for managing preparedness actions, expanding modeling capabilities to examine various "what if" scenarios, or permanently establishing the preparedness planning team to monitor preparedness actions across various government departments.

- **Guiding Principle #3: "Mainstream" information about climate change vulnerabilities, risks, and preparedness into planning, policy, and investment decisions.** As noted throughout the guidebook, climate change will affect many aspects of local, regional, and state government. In order to remain resilient to these impacts, look to "mainstream" climate change assumptions and preparedness actions into planning, policy-making, and investment decisions. This means developing more systematic ways of addressing climate change in government activities, making decisions more robust to a range of climate change scenarios, and increasing flexibility in how government services and programs are managed.

- **Guiding Principle #4: Increase the adaptive capacity of built, natural, and human systems in your community.** Built, natural, and human systems provide many essential functions that benefit a community, including mobility (e.g., via roads and bridges), erosion and flood control (e.g., via wetlands or forests) or habitat for a wide range of plant and animal species (e.g., via estuaries and grasslands), and public health services (e.g., via hospitals and medical clinics). Maintaining the adaptive capacity of built, natural, and human systems and the services they provide will benefit your community, its economy, and quality of life.

- **Guiding Principle #5: Strengthen community partnerships that reduce vulnerability and risk to climate change impacts.** Many climate change impacts will originate outside the jurisdictional boundaries of your community (e.g., the spread of new vector-borne disease into your region), or require the cooperation of other local and regional governments, federal and state agencies, tribes, non-profit organizations, and the private sector to address effectively. Working in partnership with these organizations will not only help your preparedness efforts, but will also help you to identify new roles that others can play to improve your community's resilience.

Once you have established your vision of a climate resilient community based on these or similar guiding principles, you are ready to set preparedness goals and develop, select, and prioritize actions relevant to your priority planning areas that will help you to meet this vision.

10.2 Set Preparedness Goals

The process of setting preparedness goals will provide essential structure to the next stages of your work, by identifying exactly what you want to accomplish in building resilience in your priority planning areas.

PREPAREDNESS GOAL: what you want to accomplish in your priority planning areas through preparedness action.

Preparedness goals will vary from one community to another based on a variety of factors, including the types and magnitude of projected climate change impacts and the scale of a community's planning effort. Therefore, we do not prescribe preparedness goals here. Instead, we suggest using the guiding principles outlined in Section 10.1 as well as the following considerations, to guide development of your specific preparedness goals.

- **Try to address all of the guiding principles (as relevant) in each of your priority planning areas.** Set at least one preparedness goal for each of your priority planning areas (e.g., goals for water supply, public health, transportation infrastructure). If possible, develop preparedness goals in each priority planning area to address each of the guiding principles above.
- **Engage others outside of your team.** Work with your team and government leadership to develop clearly written, attainable, and measurable preparedness goals. Public input on the goals can be obtained through public meetings, open comment periods, or other avenues. Most importantly, the team and government leadership should agree on the goals.
- **Be clear about your timeframe.** Goal-setting will also require identifying a time period for accomplishing these goals (e.g., 10 years, 20 years, or 50 years). This time period may be based on the type of information you have collected to date on climate change impacts (i.e., if you only have information on impacts projected through the 2050s), or you may choose a time period that is consistent with other long-range planning programs (e.g., your region's comprehensive land use plan). In general, be aware that the time period you choose can affect many aspects of your planning process, including how you assess your risk (see Section 9.2) and which preparedness actions you are able to pursue (see Section 10.4). You may also choose to set different time frames for specific actions as you get further into the planning process.

"ADAPTATION is not one activity or decision but rather a continuous set of activities, actions, decisions, and attitudes undertaken by individuals, groups, and governments." (Adger et al. 2005)

- **Remember – and remind your audience – that preparing for climate change is an on-going process.** You should be open to regular re-evaluation of policies and practices in light of known and projected

climate change impacts and other changes in the community so these policies and practices can be amended as needed.

See Box 10.1 for illustrations of specific preparedness goals associated with each of these guiding principles.

Checkpoint: *Upon finishing this section, you should have a list of preparedness goals, as well as an identified time period during which you expect to accomplish these goals.*

Box 10.1 – Illustrations of Climate Change Preparedness Goals

In 2006, the King County Executive and King County Council directed the county's climate team to work toward several broad preparedness goals. Through these policy statements, made in Executive Orders on Global Warming Preparedness and a Council ordinance, the Executive and Council also directed the team to develop a "Global Warming Mitigation and Preparedness Plan." This plan was later renamed the 2007 King County Climate Plan, a document which set further detailed goals for the county government in preparing for climate change.

In developing the 2007 Climate Plan, King County's climate team named the following six general priority planning areas (called "strategic focus areas" at that time):

- Climate Science
- Public Health, Safety, and Emergency Preparedness
- Surface Water Management, Freshwater Quality, and Water Supply
- Land Use, Buildings, and Transportation
- Economic Impacts
- Biodiversity and Ecosystems

King County developed further goals and actions in these areas related to: increasing public awareness, building technical capacity, integrating climate change assumptions into plans, policies and investments, improving the adaptability of natural ecosystems, and strengthening community partnerships.

Many of these goals and actions were written to reflect that preparedness activities already underway in King County departments as of the publication of the 2007 Climate Plan. Most goals were based on the answers to a questionnaire on climate change impacts that was circulated to a cross-section of department and division representatives in summer 2006 (see Box 8.3). These goals were then discussed with management teams of each department.

A sample of climate change preparedness goals from the King County Executive Orders, Council ordinance, and Climate Plan are provided here to illustrate the types of goals that governments can set in preparing for climate change, according to each of the guiding principles listed above.

Guiding Principle #1: Increase public awareness of climate change and its projected impacts on your community.
Example: "King County departments will raise awareness about climate change impacts, adaptation, and mitigation, and will collaborate interdepartmentally with climate science experts, other agencies, and other governments to adapt to climate change." (2007 King County Climate Plan)

10.3 Identify Potential Preparedness Actions

PREPAREDNESS ACTION: the activity or activities that your government will undertake to achieve its preparedness goals.

Now that you have developed preparedness goals in your priority planning areas, you are ready to develop a candidate list of preparedness actions. ***Preparedness actions*** are the activity or activities that your government will undertake to achieve its preparedness goals. For example, a goal for the public health planning area may include reducing mortality and morbidity rates associated with extreme heat events. Related preparedness actions would include opening additional cooling centers during extreme heat events, improving the use of early warning systems for extreme heat events, and working with the planning department to increase the use of shade trees to reduce temperatures in urban areas.

Example: "King County will help the region to understand and reduce risks of fall and winter flooding associated with climate change impacts." (2007 King County Climate Plan)

Guiding Principle #2: Increase your technical capacity to prepare for climate change impacts.
Example: "King County will be a primary leader in research, monitoring, and use of climate science in public policy decisions." (2007 King County Climate Plan)

Guiding Principle #3: "Mainstream" information about climate change vulnerabilities, risks and preparedness into planning, policy, and investment decisions.
Example: "[King County will] review and update [King County's] land use and environmental policies and regulations to protect natural resources from global warming threat."

Example: "King County will protect the integrity and safe operation of regional transportation infrastructure from climate change impacts." (2007 King County Climate Plan)

Example: "[King County will] use its existing waste and wastewater infrastructure for multiple uses and in innovative ways that… provide an additional natural resources hedge against impacts expected from global warming [such as declining water supply."

Guiding Principle #4: Increase the adaptive capacity of built, natural and human systems.
Example: "[King County will] use land use and transportation plans… to conserve natural resources and protect environmentally sensitive areas in ways that are coordinated, equitable, and supportive of global warming mitigation and adaptation."

Example: "King County will work to support the resilience of salmon, fish, wildlife, habitat conditions, and biodiversity to climate change impacts." (2007 King County Climate Plan)

Guiding Principle #5: Strengthen community partnerships that reduce vulnerability and risk to climate change impacts.
Example: "King County plans will guide the region to build preparedness for climate change impacts into all major investments in land and infrastructure." (2007 King County Climate Plan)

Example: "King County will implement the adopted 2006 King County Flood Hazard Management Plan, work to create a Flood Control Zone District by June 1, 2007, and work to establish a countywide fee for funding of necessary investments in the areas that are most vulnerable to increased fall and winter flooding." (2007 King County Climate Plan)

Think broadly when developing your list of candidate actions. This is your chance to brainstorm. There is no "one size fits all" prescription for determining which preparedness actions are best; you will need to evaluate the appropriateness of different actions for your community based on a number of factors, including your priority planning area vulnerabilities and the types of resources available to your community. At a general level, your actions will involve any combination of the following:

- **Modifying policies, practices, and procedures.** Existing regulations, policies, operating practices, development plans, and other modes of governing may need to be modified to increase resiliency. In particular, look for the following policy "red flags" – regulations, policies, practices and procedures that:

  - do not allow regular re-evaluation and adjustment in accordance with changing conditions;

  - require planning based strictly on the past, or pin certain decisions to certain periods or seasonal patterns;

  - reinforce trends that increase vulnerability or reduce adaptive capacity (e.g., development along flood plains).

  Specific modifications may include improving drought plans, retreating from or abandon vulnerable areas, changing building and zoning codes, adjusting utility prices, or developing contingency plans for low probability but high consequence events (UKCIP 2007). As you look at existing regulations, policies, etc., also consider whether the procedures and guidelines used to formulate new regulations need to be updated so that future regulations are more climate resilient.

- **Diversifying options.** You may increase your adaptive capacity and in turn reduce your vulnerability to climate change by providing a "buffer" against climate change impacts. Examples include developing new groundwater sources or wastewater reclamation capacity to diversify your water supply, or diversifying your community's economic base to move away from relying on sources of revenue that may be negatively affected by climate change (e.g., winter recreation).

- **Building new or upgrading existing infrastructure.** You may need to develop new infrastructure or upgrade existing infrastructure to accommodate climate change impacts. Illustrations of this include expanding stormwater collection systems, expanding wastewater treatment capacity, increasing bridge heights, or strengthening flood control levees.

- **Improving community awareness and preparedness.** Outreach and education will be needed to generate support for specific preparedness actions. Outreach and education can also be used to effect voluntary change at the individual household level, such as water conservation.

- **Partnership building with other communities and agencies.** Communities do not govern in isolation, and climate change impacts do not follow jurisdictional boundaries. Preparing for climate change will require building new collaborations or strengthening existing partnerships (e.g., with other local governments, tribes, federal and state agencies, non-profit organizations, and the private sector) to address the impacts that occur both within and outside of your community's jurisdiction.

A list of general climate change preparedness goals and actions for U.S. Pacific Northwest communities is provided in Table 10.1. This list builds on the sample tables used in previous chapters to illustrate how to identify priority planning areas by conducting vulnerability and risk assessments; it features the potential goals and actions in these identified priority planning areas, as well as goals and actions for a number of other additional planning areas.

Note that the preparedness actions listed in the table are traditional government activities, many of which may already be underway in your community. Preparedness can also involve more non-traditional government activities such as research, monitoring and data collection. The aim at this point is to cast a wide net, identifying as many potential preparedness actions as possible. Once your list is assembled, you will evaluate and narrow the list of your options for implementation.

Appendix D.4 identifies a variety of sources on preparing for climate change, many of which provide information on preparedness actions. Other jurisdictions and governmental entities facing similar climate change challenges may also be good sources of information on preparedness actions. This was the approach taken by London, England in their report, *Adapting to Climate Change: Lessons for London* (see Box 10.2).

POLICY "RED FLAGS" As you consider how you will prepare for climate change, watch for regulations, policies, practices, and procedures that:

- Do not allow regular re-evaluation and adjustment in accordance with changing conditions,
- Require planning based strictly on the past, or pin certain decisions/triggers to certain periods or seasonal patterns, and
- Reinforce trends that increase vulnerability or reduce adaptability (e.g., development along flood plains).

In some cases, a lack of detailed information can make it difficult to identify the most appropriate preparedness actions. For example, the fact that it is impossible to project exactly what climate change means for a certain species of shellfish or a certain pollinator means that it will be very difficult, if not impossible, to engineer resource management to specifically match anticipated climate conditions. In these cases, it may be more effective to maintain an ecosystem's overall resilience to climate change impacts rather than trying to focus on a specific segment of the ecosystem. This approach may provide other near-term benefits as well, potentially creating a "no regrets" or "win-win" result (see Section 10.4). Delaying action may also be an appropriate option if the additional time can be used to gather more information through research or monitoring (UKCIP 2007), although even in these cases there might be "no-regrets" actions that can be implemented.

Box 10.2 – Adapting to Climate Change: Lessons for London

In order to develop a list of potential preparedness actions for the major impacts of climate change projected for London, city planners and others commissioned a report reviewing "how other major international cities are managing climate risks." The report, *Adapting to Climate Change: Lessons for London*, describes innovative approaches used by other cities to protect their citizens and economies from extreme weather risks such as those expected to become more likely for London under climate change (London Climate Change Partnership 2006). The review examined eighteen cities' management of the climate-related risks of flooding, high temperatures, and limited water resources, the relevance of each city's approach to the specific climate change risks projected for London, and the applicability of each city's approach within London's planning and policy framework. The report will be used by the London Climate Change Partnership, a group of public and private sector organizations across London who have responsibilities that will be affected by the impacts of climate change, to inform the formation of climate adaptation planning policies for London. The report can be downloaded from *www.london.gov.uk/climatechangepartnership/*.

Checkpoint: *Upon finishing this section, you should have a list of potential preparedness actions for your priority planning areas.*

CLIMATE CHANGE PREPAREDNESS GOALS AND ACTIONS IN SAMPLE PRIORITY PLANNING AREAS (AND OTHER PLANNING AREAS FOR ILLUSTRATION)		
Priority Planning Area	**Preparedness Goal**	**Preparedness Action**
Water Supply	Expand and diversify water supply	• Connect regional water systems • Develop new groundwater sources • Construct new surface water reservoirs • Enhance existing groundwater supplies through aquifer storage and recovery • Implement new technologies such as reverse osmosis for desalination • Develop advanced wastewater treatment capacity for water reuse ("gray water")
	Increase usable storage in reservoirs	• Add capacity to reservoirs by raising dam height • Adjust reservoir operations to reflect changing conditions
	Reduce demand/ improve efficiency	• Increase billing rates for water • Change building codes to require low flow plumbing fixtures • Install high efficiency delivery systems for irrigated agriculture • Meter all water uses • Provide financial incentives (e.g., tax breaks, rebates) for switching to more efficient manufacturing processes, irrigation practices, and appliances
	Increase ability to transfer water between users	• Use water banks, water pools, and water markets to facilitate the reallocation of water resources • Renegotiate transboundary water agreements where applicable
	Increase drought preparedness	• Update drought management plans to recognize changing conditions • Increase authority to implement water restrictions and other emergency measures as needed
	Increase public awareness about climate change impacts on water supplies	• Include information on climate change impacts to water supplies and how residents can reduce water use in utility inserts, newsletters, web sites, and local newspapers
	Enhance the type of information used for managing water supply	• Expand the use of climate information (e.g. seasonal forecasts) in water resources planning and management • Actively monitor trends in snowpack, streamflow and other conditions affecting hydrology and water resources to anticipate problems • Conduct additional research on how climate change may impact you community's water supply

Stormwater and floodwater management	Increase capacity to manage stormwater	• Increase capacity of stormwater collection systems to accommodate projected changes in precipitation • Modify urban landscaping requirements to reduce stormwater runoff • Preserve ecological buffers (e.g. wetlands)
	Reduce property damage from stormwater and flooding	• Move or abandon infrastructure in hazardous areas • Change zoning to discourage development in flood hazard areas • Update building codes to require more flood resistant structures in floodplains
	Improve information used to manage stormwater and flood events	• Increase the use of climate and weather information in managing stormwater/flood risk and individual events • Update flood maps to reflect changing risk associated with climate change • Conduct additional research on how climate change may impact stormwater and flooding in your community
Road operations and maintenance	Reduce flooding and erosion impacts on infrastructure	• Increase capacity of stormwater collection systems to accommodate projected changes in precipitation • Modify urban landscaping requirements to reduce stormwater runoff • Preserve ecological buffers (e.g. wetlands)
	Reduce damage to asphalt from warmer summer temperatures	• Increase maintenance frequency of asphalt roads • Investigate potential of using other road surfaces on most heavily used roads
Additional Planning Areas for Illustration		
Salmon and marine ecosystems	Improve freshwater survival rates and carrying capacities	• Carefully limit harvests for selective fisheries • Protect and restore natural functions in watersheds (e.g., floodplains, woody debris) • Protect and restore instream flows • Minimize elevated summer water temperatures • Control water pollution
	Improve estuarine survival rates and carrying capacities	• Carefully limit harvests for selective fisheries • Improve hatchery practices • Reduce the spread of invasive species • Protect and restore nearshore habitat
	Improve marine survival and carrying capacities	• Carefully limit harvests for selective fisheries • Improve hatchery practices
	Improve information used in salmon ecosystem management	• Integrate climate change information into salmon restoration planning for freshwater and estuary environments

CLIMATE CHANGE PREPAREDNESS GOALS AND ACTIONS IN SAMPLE PRIORITY PLANNING AREAS (AND OTHER PLANNING AREAS FOR ILLUSTRATION)		
Priority Planning Area	**Preparedness Goal**	**Preparedness Action**
Forest ecosystems and parks	Maintain mixed landscape structure	• Expand or adjust protected areas to incorporate greater diversity of topographic and climatic conditions to allow for shifts in species distributions in response to climate change • Tailor timber harvest and/or prescribed burning to create a mosaic of patch sizes and age classes • Avoid creating monoculture forests and/or forests lacking a structural diversity (e.g., because of uniformly places or many large clearcuts)
	Maintain species diversity and within-species diversity	• Expand or adjust protected areas to incorporate greater diversity of topographic and climatic conditions to allow for shifts in species distributions in response to climate change • Plant local seeds and mixed species stands after harvest or disturbance • Reduce potential for invasive species
	Reduce the impact of climatic and non-climatic stressors	• Plant tree species or varieties known to have a broad range of environmental tolerances • Manage forest density to reduce susceptibility to severe fire, invasive or epidemic insects, and drought • Manage forests for changing fire risk and fire regime • Establish or enhance structural and lot development requirements in forested areas to reduce potential for fire damage
	Improve information used in forests and parks management	• Incorporate understanding of elevation-specific climate sensitivities into management strategies • Actively monitor trends in forest conditions, including drought stress, insects, and invasive species
	Increase public understanding of climate change impacts on forest and park ecosystems	• Add information on climate change impacts and what the community is doing to address impacts to forest and park ecosystems in community newsletters, web sites, and trailheads
Coastal ecosystems	Reduce shoreline erosion	• Preserve ecological buffers to allow for inland beach migration • Enhance shoreline protection where retreat and accommodation are not possible
	Reduce property damage from erosion, flooding events, sea level rise	• Reduce development in coastal hazard areas • Incorporate climate change impacts into design requirements for coastal structures • Move or abandon shoreline infrastructure • Restore wetlands for run-off storage and flood control

Coastal ecosystems *continued*	Maintain or enhance coastal habitat	• Preserve ecological buffers to allow for inland migration of wetlands, salt marshes, and other habitat systems • Reduce spread of invasive species
	Improve information used in managing coastal systems	• Increase monitoring and control of invasive species • Incorporate information on sea level rise into coastal planning and ecosystem restoration
Agriculture	Adjust production to reflect changing conditions	• Change planting dates • Consider double cropping where longer growing seasons allow • Change planting varieties • Promote greater use of heat-resistant, insect-resistant and disease-resistant crops
	Improve agricultural water supply and use	• Promote new irrigation technologies to improve water use efficiency • Promote water conservation • Use market forces to distribute water • Diversify and expand water infrastructure
	Improve information used in managing agriculture	• Be aware of how climate change affects global agriculture • Work with county extension agents to distribute information to farmers on projected climate change impacts to agriculture
Public health	Reduce impacts of extreme heat events	• Open additional cooling centers during extreme heat events • Extend hours for public wading pools during extreme heat events • Improve use of early warning systems for extreme heat events • Increase use of shade trees to reduce temperatures in urban areas
	Improve disease surveillance and protection	• Increase monitoring of known diseases and potential diseases moving into the area • Increase public education on disease prevention for West Nile and other vector-borne illnesses that could to increase as a result of climate change • Increase emergency planning for disease outbreaks
	Improve information used in managing public health	• Monitor global trends in the spread of disease

Table 10.1 – Climate Change Preparedness Goals and Actions in Sample Priority Planning Areas (and Other Planning Areas for Illustration). This table represents possible preparedness goals and actions for the sample planning areas of water supply, stormwater management, and road operations and maintenance (for the purposes of this table, labeled as priority planning areas). It also includes possible goals and actions for other planning areas, as illustration. This list is not all-inclusive, and the appropriateness of these actions will vary on a case-by-case basis. (Sources: Mote et al. 1999; NAST 2001; Hamlet 2003; Mote et al. 2003; Kay et al. 2005a)

10.4 Select and Prioritize Preparedness Actions

As Table 10.1 indicates, there are a number of possible preparedness actions to take for managing climate change impacts. Given a constant reality of competition for financial and human resources, how do you know which actions to choose for your preparedness plan, and in what sequence to implement them?

The general criteria described here can help guide your selection and prioritization of the specific preparedness actions you will use (adapted from Willows and Connell 2003, Adger et al. 2005, Smith 1997). Note that actions will not – and do not need to – meet all of the listed criteria. The more criteria that are met, however, the more likely the action will help reduce your vulnerability to climate change.

As you evaluate the initial list of actions for selection, sort your choices into groups as follows:

- Tier 1 actions are those that can and will be implemented in this planning process;
- Tier 2 actions are those that could be implemented now or in the future but require additional information, resources, or authorities before implementing. Note that you may want to begin exploring these additional information, resource, and authority needs as part of your current planning effort;
- Tier 3 actions are those that are not suitable candidates at this time.

Document why certain preparedness actions were or were not selected for the current planning effort. Reasons for ranking Tier 2 and 3 actions may change over time, making some of the Tier 2 and 3 actions more relevant in the next update of the preparedness plan.

Key Criteria

- **Will the actions meet your preparedness goals?** A key consideration when selecting and prioritizing actions for preparedness planning is whether the action will meet the overall preparedness goals chosen for your planning effort, and in turn your guiding principles for a climate resilient community.
- **Do the benefits of the action exceed the costs?** In general, the benefits gained from an action should exceed the costs of implementing the action. This includes economic as well as non-economic costs and benefits, which can be difficult to quantify. The benefit-cost calculation will be affected by many criteria, including your planning time horizon, the lifespan of the decision, and the frequency of specific climate change impacts (e.g., how often a particular flood threshold may be crossed). Consider using your benefit-cost analysis to help identify the "no regrets," "low regrets," or "win-win" scenarios as described in Section 11.2, especially in cases where there is greater uncertainty. Note also that the benefit-cost criteria will also influence specific choices associated with certain actions (e.g., the cost of enlarging your stormwater collection system by 5% versus 15%).

- **Is the action robust under a range of climate change scenarios?** Actions should meet their intended purpose under a range of plausible future climate change scenarios. This is particularly true for decisions with a long life span or long-term implications, such as those related to infrastructure and land use changes, since these types of decisions will be affected by a greater range of climate change impacts than projects lasting only a few years. For example, a setback requirement for coastal development based on an estimate of 12 inches of sea level rise is less robust than a requirement that can accommodate a broader range of sea level rise (e.g., 6 inches to 3 feet).

  Actions must also be robust to changes in the frequency or severity of specific climate impacts. Some mechanisms used to reduce climate and weather stresses in planning areas in the past could be less suitable for the long-term change that climate change represents because of a change in the frequency, intensity, duration, or extent of some climate impacts. Temporary pumps, for example, may be appropriate for managing flooding that occurs two or three times a year but would not be appropriate if the frequency increased to 100 times a year. Similarly, beach nourishment is a common response to erosion events that may not be economically feasible over the long term in some locations given the potential for climate change to increase erosion in coastal areas. This is not to say that these short-term preparedness actions do not have a role in preparedness planning. It does mean, however, that additional actions for addressing the "big picture" issue may be needed to reduce the need for short-term, crisis-oriented solutions.

- **Is the action flexible and does it increase flexibility in how a planning area is managed or functions?** Policies, practices, and procedures need to be flexible so they can be adjusted in response to changing conditions (both climate and non-climate). Can the action be easily adjusted as conditions change? Does the action make it easier to modify or reverse decisions once implemented if new information warrants a change?

- **Can the action be implemented, and in what time frame?** Ease of implementation will depend on your time frame and the availability of relevant legal and administrative authorities, staff resources, technical resources, and fiscal resources. Can a preparedness action be implemented within the existing operational framework of your community, or are additional authorities and/or resources required? In the later case, who must grant these additional authorities and resources?

  Typically, actions that can be implemented under the current operational framework will be preferred in the near term compared to actions requiring significant resources or state or federal action. This may include preparedness actions such as disease monitoring or water conservation that may already be part of your community's current operations but will need to be expanded because of climate change. In

these cases, you may choose to implement the "low hanging fruit" first while deferring action on other, more ambitious actions.

Note, however, that choosing preparedness actions is not always about choosing the actions that are easy to implement right away. In some cases, the very fact that an action requires more time or resources to complete will require implementing the action in the near-term. A good example is developing the capacity to treat and distribute "gray" (or reused) water. Because it will take time to secure the additional authorities and resources needed to develop this capacity, you may choose to begin working on this action sooner rather than later.

Additional Factors

- **Are there unique "windows of opportunity" for implementing a particular action?** In some cases, the timing of key decisions being made in other planning arenas can influence the selection and implementation order of preparedness actions. For example, your community may already be planning a major upgrade of its water main system, creating a timely opportunity to install reclaimed water lines along with the new water mains. In another example, a rare opportunity to purchase development rights in an area vulnerable to sea level rise may lead to choosing this action in the near term for protecting coastal areas over other actions. Other timely windows of opportunity may include periodic license renewals (e.g., Federal Energy Regulatory Commission dam relicensing procedures) and state legislative sessions.

- **Is the action equitable?** Actions should be equitable, meaning that they should not make impacts worse in other areas or limit the adaptive capacity of other communities, vulnerable populations, or future generations. Projected losses in hydropower generating capacity due to declining snowpack should not be replaced with power produced by coal-burning power plants, which would increase greenhouse gas emissions and accelerate climate change.

- **Will the action decrease the risk of losing unique environmental or cultural resources?** Some preparedness actions may be preferred because of their potential role in protecting unique environmental or cultural resources. For example, these may include important ecosystems, Native American reservation land and burial sites, or historic districts.

- **Will the action address a risk for which there is greater scientific confidence?** The confidence the scientific community assigns to specific climate change projections will vary by climate change variable (e.g., temperature, precipitation, wind direction and speed) and by region. In the U.S. Pacific Northwest, there is greater confidence in the range of projected temperature changes than for changes in precipitation. All things being equal, actions addressing temperature-driven climate change impacts (e.g., changes in streamflow volume and timing in U.S.

Pacific Northwest rivers) may be ranked higher than actions addressing precipitation-driven impacts given the uncertainties associated with changes in precipitation amount, intensity, and frequency.

Now that you have prioritized your preparedness actions to meet the goals set for your priority planning areas, you are ready to write your preparedness plan. An illustration of how this can come together is King County's 2007 Climate Plan, which is available online.

Checkpoint: *Upon completing this section, you should have a final list of preparedness actions and a plan that will be implemented in your current round of preparedness planning.*

chapter 11 implement your preparedness plan

Now that you have selected and prioritized preparedness actions in your priority planning areas and written your preparedness plan, this chapter will provide guidance on how to:

- ensure that you have the right ***implementation tools***
- manage uncertainty and risk over time.

11.1 Ensure that You Have the Right Implementation Tools

IMPLEMENTATION TOOLS are the authorities and/or avenues over which your government has control or influence in policy, planning and infrastructure.

Implementing your selected preparedness actions will draw on a variety of (existing and in some cases new) implementation tools, which are the authorities and/or avenues over which your government has control or influence in policy, planning, and infrastructure.

The tools you have to implement preparedness actions will depend on the size of your government and the authorities it holds. Common tools are listed in Box 11.1. Notice that preparing for climate change does not require starting from scratch. Many of the tools used to implement preparedness actions are legislative, regulatory and/or fiscal authorities that your government uses in its day-to-day operations. Also note that preparing for climate change does not happen in a void. Your community already administers a wide array of programs and regulations that can be used as avenues for implementing your preparedness actions. Look for opportunities to merge specific preparedness actions into existing planning efforts, such as updates to your community water supply plan or development master plans.

Box 11.1 – Common Implementation Tools for Climate Change Preparedness Actions

Here are a few conventional tools that you may need when implementing your climate change preparedness actions:

- Zoning rules and regulations
- Taxation (including tax incentives)
- Building codes/design standards
- Utility rates/fee setting
- Public safety rules and regulations
- Issuance of bonds

The following can also be considered implementation tools:

- Infrastructure development
- Permitting and enforcement
- Management practices
- Outreach and education
- Emergency management powers
- Partnership building with other communities

As you begin to look at how you might use specific tools to implement your preparedness actions, consider how the tools are currently being used and whether the tools can be used "as is" or with slight modification for climate change preparedness. For example, you may find that local permitting procedures do not include flexibility needed to adjust to changing conditions. One option for addressing this problem is modifying general permitting procedures to include re-opener clauses that require a permit to be re-examined under certain circumstances. You may have identified this need already in your strategy selection process, or it may become evident as you start getting into the "nuts and bolts" of implementation. In either case, continue working on ways to increase flexibility whenever you run into the institutional barriers that can limit the success of your preparedness planning effort.

Like other aspect of preparedness planning, implementing the preparedness plan is not a one-time event. Many actions will need to be implemented in phases; some may take years or decades to implement. You will need to reevaluate all of your actions and your plan periodically to gauge their effectiveness as the community changes and new information on climate change impacts emerges.

Finally, securing continued support over time will be a critical element of implementation. Continue building and maintaining support for your community's planning efforts through education and outreach activities (many of which may now be folded into specific preparedness actions).

11.2 Manage Uncertainty and Risk

Preparing for climate change is a challenge in part because of the uncertainties that exist around local impacts. Ideally, you would choose preparedness actions knowing exactly how, when, and where climate change will affect your community. As you know from having to manage other challenges facing your community (e.g., population growth, rising health insurance costs, natural disasters), this level of certainty is not possible. Consequently, when it comes to planning for climate change, you must do as you always do – make decisions in the face of uncertainty.

Risk is another component of climate change preparedness planning that must be managed. All decisions from the personal to the community level involve some informal assessment of risk. When should a homeowner, for example, purchase earthquake insurance for a home? When should a community concerned about bioterrorism purchase smallpox vaccines? The outcome of these decisions will be shaped by personal experience, thresholds for tolerating risk, and new information about risks and probabilities, all of which can change over time and space.

So how can governments manage uncertainty and risk, given that they will always be factors in preparing for climate change? One approach is to implement "no regrets," "low regrets," or "win-win" actions[2]. A "no regrets" action provides benefits in current and future climate conditions even if no climate change occurs. A water conservation program, for example, provides benefits today by potentially reducing the need for water restrictions during drought and delaying the need to develop new water supplies as population grows, potentially saving the utility and its rate payers millions of dollars in expansion costs. These benefits will accrue regardless of how climate changes in the 21st century but would be even greater with climate change given the potential for climate change to increase the frequency and intensity of drought in many regions of the country.

[2] See Willows and Connell 2003, Luers and Moser, de Loë et al. 2001

"Low regrets" preparedness actions provide important benefits at relatively little additional cost or risk. For example, a utility planning stormwater system upgrades may expand the capacity of its stormwater collection system by 10 percent, for example, in anticipation of more extreme precipitation events if the benefits of the added capacity exceed the marginal cost increase. Similarly, a community concerned about the impacts of sea level rise may increase setback requirements for coastal development by an additional 200 feet as part of a Master Plan development provided the benefits of the additional setback exceed the marginal cost.

"Win-win" actions reduce the impacts of climate change while providing other environmental, social, or economic benefits. For example, preserving riparian wetlands not only provides critical habitat for climate-sensitive species but also provides water quality and flood protection benefits now and under plausible climate change scenarios.

Another approach is quantitative modeling. Modeling integrates different climate change scenarios with our current understanding of how systems respond to changes in temperature and precipitation or other climate-related variables to put boundaries on a range of future conditions. Modeling can also help identify which uncertainties are significant and how specific preparedness actions may help manage those uncertainties.

Recent advances in downscaling techniques have improved the overall accuracy of smaller-scale climate change impacts assessments used to guide local policies and infrastructure choices. The City of Seattle, for example, sponsored research examining the impacts of climate change on the city's water supply (Wiley 2004). The study found that snowpack in the watersheds contributing to Seattle's water supply could decline by as much as 50 percent by 2040, reducing the system's current gross yield by 14 percent. The study also found that while uncertainty was present at each level of the analysis, the uncertainties were no greater than those found in traditional water supply studies that rely on evaluation of historic records and were not "necessarily significant enough to mask the underlying trends or scale of impacts" (*ibid*, p. 149).

While modeling can be an effective tool for quantifying future impacts, modeling is not required for climate change preparedness nor will it eliminate all of the uncertainties in planning for climate change. Modeling should be viewed as one tool of many that your government can utilize for preparedness.

Chapter 12 measure progress and update your plan

How do you demonstrate to your internal team, community and stakeholders that your climate change preparedness plan and actions are truly working to make your community more resilient to climate change? How do you know if your plan or action is not working, and how it might need to be modified? This chapter provides insights on how to answer these questions by suggesting four recurring steps for your team to take:

1. Measure your progress in implementing the preparedness actions you have developed, and identify whether they are helping you to meet your vision of a climate resilient community, which you established in Chapter 10.

2. Periodically review your basic assumptions, including those related to: the vulnerability and risk assessments that guided your identification of priority planning areas, your vision and guiding principles for a climate resilient community, the preparedness goals you set to meet this vision in your priority planning areas, and the information you collect from measuring the results of your actions. Some or all of the important assumptions guiding your preparedness efforts will change over time.

3. Update your climate change preparedness plans and actions regularly, based on the information you collect from measuring your progress and reviewing your assumptions.

4. Share your learning. Look beyond your plans for opportunities to share your climate change information.

These four steps should not mark the end to your climate change preparedness efforts. We recommend these as recurring steps for your team to pursue at regular intervals for the foreseeable future.

12.1 Measure Your Progress

Measuring progress on climate change preparedness should happen at multiple levels and for multiple audiences, from your community to your internal team. For each level and audience, you may want to focus on different priority planning area or provide different degrees of detail. One tool we offer at the start of this guidebook – a suggested preparedness checklist for governments – can address both audiences and can help you tell your story about preparing for climate change in a clear, easily understood way.

The checklist presented at the beginning of the guidebook outlines a number of steps, based on the material of this guidebook, which can help you to mark your progress in preparing for climate change. The Five Milestones of the ICLEI – Local Governments for Sustainability Climate Resilient Communities Program are also reflected in this checklist. Whether for your community and other stakeholders, for your internal team, or for recognition in the Climate Resilient Communities Program, completing the checklist will provide you with useful information about progress in your preparedness workplan.

Developing Measures of Resilience

Remember that a climate resilient community as defined in Chapter 10 is one that takes proactive preparedness actions which effectively reduce the vulnerabilities and risks associated with climate change impacts. Suggested guiding principles for achieving this vision of a climate resilient community were provided in Chapter 10; they informed your development of preparedness goals

A MEASURE OF RESILIENCE is a quantitative or qualitative judgment that you develop and track over time to determine how well a preparedness action meets the preparedness goals you have set in a given priority planning area.

You may already have access to information that indicates how well you are meeting your goals and in turn your vision of climate resilience, based on relevant data being collected now by your government. However, you may also want to develop new ***measures of resilience*** to incorporate into your performance measurement system, your budget process, or another community indicator report.

To develop measures of resilience, first consider the guiding principles you used to set your preparedness goals. Reframe these guiding principles in the form of questions to ask yourself whether your preparedness actions are meeting the vision that they set. As an illustration, here are five sample guiding questions based on the guiding principles previously proposed:

1. **Has awareness about climate change and its projected impacts on your priority planning areas increased? Is there support among your government, your community and your stakeholders to prepare for climate change impacts?** (Guiding Principle #1: Increase public awareness of climate change and its projected impacts on your community.)

   Potential ways to measure public awareness about climate change impacts:

   - community surveys tracking participation in public meetings on climate change impacts;
   - surveys tracking "hits" to community-sponsored climate change webpages;
   - surveys tracking requests for climate change-related publications (e.g., fact sheets, brochures, reports);
   - surveys evaluating trends in the number and types of questions or comments received by government agencies about climate change in your priority planning areas;

- surveys of the number of media stories about climate change impacts in your region;
- qualitatively, whether public officials understand 1) how climate change impacts relate to major decisions in your priority planning areas and 2) how those decisions could reduce or increase climate change vulnerabilities or risks.

2. **Have you increased technical capacity in your government and community to prepare for climate change impacts in your priority planning areas? Is this technical capacity being used effectively to evaluate vulnerability and risk in your priority planning areas?** (Guiding Principle #2: Increase your technical capacity to prepare for climate change impacts.)

   Potential ways to measure technical capacity to prepare for climate change impacts in your priority planning areas:

   - number of technical experts you have on staff who can advise you on the latest research about climate change impacts in your priority planning areas, and/or the existence of an ongoing relationship with outside climate science advisors;
   - the existence and regular use of ongoing forums for sharing the latest information on climate change in your priority planning areas with internal and external stakeholders, including government employees, the business community, and the general public.

3. **Is climate information being considered in decisions in your priority planning areas? Is there a formal mechanism in place that "mainstreams" or otherwise facilitates climate change preparedness in your priority planning areas?** (Guiding Principle #3: "Mainstream" information about climate change vulnerabilities, risks, and preparedness into planning, policy, and investment.)

   Potential ways to measure the "mainstreaming" of climate change information and preparedness in your priority planning areas (adapted from Ligeti et al. 2007):

   - the number of plans or other governing documents in your priority planning areas in which climate change is addressed qualitatively or quantitatively;
   - existence and thoroughness of guidelines on how to integrate new or updated information on climate change vulnerability, risk and preparedness into decision making;
   - existence and number of dedicated staff to help facilitate preparedness actions across departments and external stakeholders (or the amount

of additional staff time used for implementation of climate change preparedness actions);

- existence and amount of funds for vulnerability and risk assessments, preparedness actions, and measurement of resilience;
- existence of forums which have been established for information sharing about vulnerabilities, risks and preparedness; information about who attends these forums, what information is shared and used, and how information is shared and used.

4. **Are your actions increasing or maintaining the adaptive capacity of built, natural, and human systems in your priority planning areas?** (Guiding Principle #4: Increase the adaptive capacity of built, natural, and human systems in your community.)

   Potential ways to measure the adaptive capacity of built, natural, and human systems in your priority planning areas:

   - survey or accepted media coverage of how well your community handles an extreme heat event, a drought, or 100-year rain event before and after certain preparedness actions have been implemented (with the understanding that each event is unique, such that a direct comparison is not always possible);
   - amount of money you have saved (or not) based on an implemented preparedness action, such as an improved flood hazard management plan, improved regional levee system, or other infrastructure investments made to improve adaptive capacity;
   - indication of the health of regional fish and wildlife, based on observations by leading ecologists and/or monitoring.

5. **Are community partnerships in place to enable the most robust decision-making possible for climate change preparedness in priority planning areas? Have you engaged community stakeholders in development and implementation of your preparedness actions in your priority planning areas?** (Guiding Principle #5: Strengthen community partnerships that reduce vulnerability and risk to climate change impacts.)

   Potential ways to measure community partnership and stakeholder engagement in decreasing vulnerability and risk in your priority planning areas:

   - the existence and regular use of ongoing forums for sharing the latest information on climate change with internal and external stakeholders, including government employees, the business community, and the general public (also noted above as a measure of technical capacity);

- the existence of "consensus" reports on vulnerabilities and risks in your priority planning areas, developed collaboratively by a full range of stakeholders;
- the existence of a community task force or citizens' advisory panel on climate change preparedness in your priority planning areas, representing a range of different community perspectives and other specific interests.

Ideally, your government will be able to develop a measure or measures that respond to each of these questions. If your government has been working on climate change preparedness for a few years, or if your government already collects information in priority planning areas related to some of these considerations, you may already be able to measure your resilience and track your improvements over time. On the other hand, if you face resource constraints that prevent you from developing measures now, you can also use these guiding questions informally, simply by answering "yes" or "no."

How often you measure your progress in climate change preparedness will depend on: the nature of the vulnerabilities and risks that you are addressing in your priority planning areas; the planning horizon, investment rules and/or other factors related to a given capital project or system in your priority planning area; and your government's budget cycle. Please refer to accepted public sector resources for details on how to develop a robust performance measurement system for a public policy environment.

12.2 Review Your Assumptions

Remember that climate change preparedness is an ongoing process. As natural, social, economic and political conditions change, your original assumptions may also need to change. In conjunction with your measurement, you can use the following questions to review the basic assumptions guiding your work:

- **Have new peer-reviewed scientific findings improved or changed your understanding of your community's vulnerabilities?** Science is based on almost-constant inquiry, discovery, and findings. You will probably receive new (and sometimes seemingly conflicting) scientific reports. Work with your science advisors to determine whether new findings are truly relevant to your work – and whether they should influence you to change your course. New reports should be held to the same high standards of your initial scoping stage and vulnerability assessment (Chapters 4 and 8). Reports that conflict with your initial scoping results or vulnerability assessment should not necessarily lead you to change your course, unless you have strong scientific advice or evidence to do so.
- **Have your priority planning areas changed?** A change in public officials or development of new stakeholder relationships can quickly change your priorities and related funding for climate change preparedness. You may also receive new information, based on new scientific findings, that leads you to change the focus of your preparedness effort. For instance, you may have initially identified

preparedness goals for several priority planning areas only to find that another planning area that you had not addressed at all (e.g., coastal erosion control, flood hazard management, or extreme heat response planning) has become an even more urgent concern to address. In this case, you will want to reprioritize your planning areas and set new preparedness goals at the next appropriate window of opportunity.

- **Are your vision and guiding principles still relevant to the results your team wants to achieve?** Ideally, your team will have established a vision and guiding principles that are flexible to different conditions, so that you do not have to change them drastically over time. However, with new information and some experience in implementing your preparedness actions, you may want to broaden or narrow the language of your vision and guiding principles to make them most relevant to your current efforts.
- **Have you collected significant new information about the success (or failure) of your preparedness action in building climate change resilience?** After tracking and measuring your progress over a significant amount of time, you may find that the preparedness action you have implemented is not actually improving the resilience of sea walls, ecosystems, or vulnerable communities in your region and may even be making a problem such as coastal erosion, species decline, or heat stress worse. Alternatively, you may find that your action is so successful and critical that you need funding to do more of the same. The information collected in your measurement step, if used to review the course you have charted, can thus become critically useful for updates to your priority statements, public reports, budget requests, and investment decisions.

While this list does not include all of the questions you may want to ask as you proceed in your climate change preparedness efforts, it can begin to help you ensure that your assumptions, your work, and your measures of resilience remain appropriate to current natural, economic, social and political conditions in your region.

12.3 Update Your Plans

Once you have collected new information useful for reviewing and modifying your basic assumptions, you are ready to update your climate change preparedness actions and plan. At this point, you should also remain aware of the opportunities that plan updates offer to share your information and influence climate change preparedness planning beyond your team. Consider the following when you update your preparedness actions and plans:

- **Incorporate the most urgent and/or specific information in budget proposals and other short-term decisions.** Sometimes, new information about the risks of climate change to your region will demand more urgent and detailed action than a broadly written plan updated on a four- or five-year cycle can provide. For example, as King County has found with flooding, you may recognize that a

natural hazard in your region is becoming more frequent and more intense, with immediate damage and costs in terms of public health, safety and property. This kind of new information will demand quicker decisions, on a shorter time scale and with more detail than most comprehensive plans can offer. In these cases, annual or even quarterly budget negotiations or other short-term decision arenas may therefore become your most appropriate windows of opportunity to raise specific climate change issues that you are facing. (King County has responded to its recent flooding events and new information about expected future flooding by proposing an improved flood hazard management plan, as well as a new countywide flood control zoning district, with taxing authority to cover the costs of regional levee improvements.)

- **Incorporate new climate change information into your regular planning updates.** Comprehensive land use plans, shoreline management plans, and other planning documents tend to be updated once every four or five years. If the climate change impact that you intend to address does not pose an obviously urgent concern to your community, and can be effectively addressed in broad language, these planning update years can be useful windows of opportunity to address climate change. King County has employed this approach in both the 2004 Comprehensive Plan update (incorporating climate change emissions reduction goals) and the upcoming 2008 Comprehensive Plan update (now on track to include goals related to climate change preparedness).

12.4 Share Your Learning

As you improve upon your preparedness actions, share the results of your plan. Transparency and accountability in your climate change preparedness effort can help the public and your team see that your actions achieve desired results. In some cases, such a proposed tax package that requires broad public support, it could be incredibly useful for your team and government to share detailed findings about your progress with your broader community.

Sharing your results publicly will also help improve your community partnerships. Outside partner institutions can benefit from information about how well your actions are working, especially if you are measuring the results of collective work in a priority planning area such as efforts to protect an endangered species, ecosystem, or shared water or forest resource. Additionally, when you can tell the story of your successes and lessons learned (backed up by sound quantitative and qualitative data) with city, state, regional, and federal governments, you are providing evidence that your actions deserve funding and political support from other levels of government.

Above all, learn through open and honest inquiry. If you do not have a culture of open inquiry, you may find it difficult to ask direct, tough questions about the success of your preparedness actions. However, it will become increasingly important to know what is actually unfolding, and how well you are responding. Have your actions delivered the benefits you expected? How can they be changed based on what you have learned? Have your priority planning areas changed? Do you need to assess climate change impacts on new planning areas or add new members to your preparedness team?

You must teach yourself and your team about what it will take to make your communities more resilient to climate change. You are the expert(s) about what public policies, organizational approaches and infrastructure investments work for your communities. You must make educated decisions now about what your next five, ten, fifteen and more years will bring, and set up a process of learning for the future that will help you and your successors to modify your preparedness actions and plans as you begin to see their effectiveness.

chapter 13 taking the long view: final thoughts on preparing for climate change

What are the basic actions that you can take as a public decision-maker today to ensure a positive lasting influence on your government and community, so that future generations do not bear the worst effects of climate change? In summary, here are a few final thoughts on how to prepare for climate change effectively:

> *It is my job as an elected leader to put in place the infrastructure so people in the future don't feel the impacts of climate change. Things will change, but we must do the work so people are not living in an age of crisis, that they have a good quality of life. We do things now to adapt to help preserve the quality of life without people really knowing it. It is my job to prepare.*
>
> *– King County Executive Ron Sims*

In order to prepare your community for climate change impacts, focus on reducing your vulnerabilities and risks.

In order to reduce your vulnerabilities, you must either reduce the sensitivity of systems in your priority planning areas, or build your adaptive capacity (e.g., by constructing a new or improved sea wall). In order to reduce your risk, you can seek either to lower the probability of an impact occurring or to reduce its consequences, by avoiding high-risk choices (e.g., preventing new development in a floodplain).

Have foresight – establish institutions to deal with climate change impacts on an ongoing basis.

Even if you build a team of talented individuals who can motivate and guide others across your government and community to take action on climate change, you will still need to leave strong systems in place that last well beyond your term. Ask your team, your government and your community to have foresight. Incorporate climate change considerations into long-range planning documents, "mainstream" climate change preparedness into infrastructure investments and basic budget decisions, and try to establish a culture of climate change preparedness.

Remain flexible and expect surprises.

As a public decision-maker, you probably already know how to plan under conditions of uncertainty very skillfully. In the future, climate change preparedness will demand that you make even more decisions with incomplete and evolving information. Continue to seek the best new information about climate change in your region; you may find answers to some questions that you have about climate change impacts to your community, but you may also find that some major scientific uncertainties remain. Try to build your preparedness process to be flexible to a range of climate change scenarios. Expect surprises.

Take action.

We are all forced to prepare for climate change effects now because we have not reduced our contribution to the problem of climate change – global greenhouse gas emissions. Work with other governments to reduce your greenhouse gas emissions now, so that the chain of climate change cause and effect will be broken. At the same time, prepare for the climate change impacts you know are already underway. Seize the moment – to slow climate change and protect quality of life for future generations.

Abbasi, D.R. 2006. Americans and climate change: Closing the gap between science and action. In *A Synthesis of Insights and Recommendations from the 2005 Yale F&ES Conference on Climate Change.* New Haven, Connecticut: Yale University Press.

(ACIA) Arctic Climate Impact Assessment. 2004. *Impacts of a Warming Arctic: Arctic Climate Impact Assessment, Overview Report.* Cambridge University Press. Available for download at http://www.amap.no/acia/

Adger, W.N., N.W. Arnell, E.L. Tompkins. 2005. Successful adaptation to climate change across scales. *Global Environmental Change* 15: 77-86.

Alexander, L. V., et al.. 2006. Global observed changes in daily climate extremes of temperature and precipitation. *Journal of Geophysical Research* 111, D05109, doi:10.1029/2005JD006290.

Andersen, P. 2005. Former EPA chief urges action on global warming. *Associated Press* 28 October 2005.

Andreadis, K.M. and D.L. Lettenmaier. 2006. *Geophysical Research Letters* 33, L10403, doi:10.1029/2006GL025711, 2006.

Arendt, A.A., K.A. Echelmeyer, W.D. Harrison, C.S. Lingle, and V.B. Valentine. 2002. Rapid wastage of Alaska glaciers and their contribution to rising sea level. *Science* 297: 382-386.

Burkett, V.R., Zilkoski, D.B., and Hart, D.A.. 2003. Sea-level rise and subsidence: implications for flooding in New Orleans, Louisiana, in Prince, K.R., and Galloway, D.L., eds., *U.S. Geological Survey Subsidence Interest Group Conference, Proceeding of the Technical Meeting*, Galveston, Texas, November 27-29, 2001, p. 63-70. Available for download at http://www.nwrc.usgs.gov/hurricane/Sea-Level-Rise.pdf

Carter, L.M. 2003a. *U.S. National Assessment of the Potential Consequences of Climate Variability and Change – Educational Resources Regional Paper: The Northeast.* U.S. Climate Change Research Program, Washington, D.C. Available only in HTML format at http://www.usgcrp.gov/usgcrp/nacc/education/northeast/default.htm

Carter, L.M. 2003b. *U.S. National Assessment of the Potential Consequences of Climate Variability and Change – Educational Resources Regional Paper: The Southeast.* U.S. Climate Change Research Program, Washington, D.C. Available only in HTML format at http://www.usgcrp.gov/usgcrp/nacc/education/southeast/default.htm

Carter, L.M. 2003c. *U.S. National Assessment of the Potential Consequences of Climate Variability and Change – Educational Resources Regional Paper: Great Plains*. U.S. Climate Change Research Program, Washington, D.C. Available only in HTML format at http://www.usgcrp.gov/usgcrp/nacc/education/greatplains/default.htm

Cayan, D., S.A. Kammerdiener, M.D. Dettinger, J.M. Caprio, and D.H. Peterson. 2001. Changes in the onset of Spring in the western United States. *Bulletin of the American Meteorological Society* 82(3): 399-415.

(CCSR) Center for Climate Systems Research, Climate Impacts Group. 2007. *New York City Department of Environmental Protection Climate Change Task Force*. Web page available at http://www.ccsr.columbia.edu/cig/taskforce/ (accessed 7.27.07)

Center for Democracy and Technology. 2007. *Open CRS: Congressional Research Reports for the People, Frequency Asked Questions.* Web page available at http://www.opencrs.com/faq.php (accessed 5.6.07).

de Loë, R.C., R.D. Kreutzwiser, and L. Moraru. 2001. Adaptation options for the near term: climate change and the Canadian water sector. *Global Environmental Change* 11(3): 231-245.

DeGaetano, A.T. and R.J. Allen. 2002. Trends in twentieth-century temperature extremes across the United States. *Journal of Climate* 15: 3188-3205.

Doughton, S. 2005. The truth about global warming. Seattle Times 9 October 2005.

Easterling, D.R., G.A. Meehl, C. Parmesan, S.A. Changnon, T.R. Karl, and L.O. Mearns. 2000. Climate extremes: Observations, modeling, and impacts. Science 289:2068-2074.

Feng, S. and Q. Hu. 2004. Changes in agro-meteorological indicators in the contiguous United States: 1951-2000. *Theoretical and Applied Climatology* 78:247-264.

Hall, M.H.P. and D.B. Fagre. 2003. Modeled climate-induced glacier change in Glacier National Park, 1850–2100. *BioScience* 53(2): 131-140.

Hamlet, A. F. 2003. The role of transboundary agreements in the Columbia River Basin: An integrated assessment in the context of historic development, climate, and evolving water policy. pp. 263-289. In H. Diaz and B. Morehouse (eds), *Climate, Water, and Transboundary Challenges in the Americas*. Dordrecht/Boston/London: Kluwer Press.

Hamlet, A.F. 2006. Hydrologic implications of 20th century warming and climate variability in the western U.S. Ph.D. dissertation, University of Washington, Seattle.

Hansen, J., L. Nazarenko, R. Ruedy, Mki. Sato, J. Willis, A. Del Genio, D. Koch, A. Lacis, K. Lo, S. Menon, T. Novakov, Ju. Perlwitz, G. Russell, G.A. Schmidt, and N. Tausnev. 2005. Earth's energy imbalance: Confirmation and implications. *Science* 308(5727): 1431-1435, doi:10.1126/science.1110252.

(IPCC) Intergovernmental Panel on Climate Change. 2001a. *Climate Change 2001: The Scientific Basis, Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC),*[J. T. Houghton, Y. Ding, D.J. Griggs, M. Noguer, P. J. van der Linden and D. Xiaosu (Eds.)], Cambridge University Press, Cambridge, England. Available for download at http://www.grida.no/climate/ipcc_tar/.

(IPCC) Intergovernmental Panel on Climate Change. 2001b. *Climate Change 2001: Impacts, Adaptation, and Vulnerability, Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC),* [J. J. McCarthy, O.F. Canziani, N.A. Leary, D.J. Dokken, and Kasey S. White (Eds.)], Cambridge University Press, Cambridge. Available for download at http://www.grida.no/climate/ipcc_tar/.

(IPCC) Intergovernmental Panel on Climate Change. 2004. "The Preparation of the IPCC Reports", Geneva, Switzerland. Fact sheet prepared December 2004. Available for download at http://www.ipcc.ch/about/faq/IPCC%20Procedures.pdf (accessed 5/6/07)

(IPCC) Intergovernmental Panel on Climate Change. 2007a. *Climate Change 2007: The Physical Basis: Summary for Policy Makers, Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, United Kingdom, and New York, NY. Available for download at http://www.ipcc.ch/WG1_SPM_17Apr07.pdf.

(IPCC) Intergovernmental Panel on Climate Change. 2007b. *Climate Change 2007: The Physical Basis, Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, United Kingdom, and New York, NY. Available for download at: http://ipcc-wg1.ucar.edu/wg1/wg1-report.html

Jones, G.V., M.A. White, O.R. Cooper, and K. Storchmann. 2005. Climate change and global wine quality. *Climatic Change* 73: 319-343.

Kay, J.E., J.H. Casola, A.K. Snover, and Climate Impacts Group. 2005a. "King County Sector Breakout Fact Sheets". Fact sheets prepared for King County (Washington)'s October 27, 2005 climate change conference "The Future Ain't What It Used to Be: Preparing for Climate Disruption". Climate Impacts Group, Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Seattle. Available for download at: http://www.cses.washington.edu/db/pdf/kc05sectorssumall475.pdf

Kay, J.E., J.H. Casola, and A.K. Snover. 2005b. "Climate Impacts Science Primer". Fact sheet prepared for King County (Washington)'s October 27, 2005 climate change conference "The Future Ain't What It Used to Be: Preparing for Climate Disruption". Climate Impacts Group, Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Seattle. Available for download at: http://www.cses.washington.edu/db/pdf/kc05regccscience466.pdf

Kunkel, K.E., D.R. Easterling, K. Hubbard, and K. Redmond. 2004. Temporal variations in frost-free season in the United States: 1895-2000. *Geophysical Research Letters* 31, L03201, doi:10.1029/2003GL018624, 2004.

Levitus, S., J. Antonov, and T. Boyer. 2005. Warming of the world ocean, 1955–2003. *Geophysical Research Letters* 32, L02604, doi:10.1029/2004GL021592.

Ligeti, E., J. Penney, and I. Wieditz. 2007. *Cities Preparing for Climate Change: A Study of Six Urban Regions*. Clean Air Partnership, Toronto, Canada.

Logan, J. A., and J. A. Powell. 2005. Ecological consequences of climate change altered forest insect disturbance regimes. In F. H. Wagner (ed.), *Climate Change in Western North America: Evidence and Environmental Effects*. Allen Press (In review).

London Climate Change Partnership. 2006. *Adapting to Climate Change: Lessons for London.* Greater London Authority, London, England. Available for download at http://www.london.gov.uk/climatechangepartnership/

Lu, Q., R. Lund, and L. Seymour. 2005. An update of U.S. temperature trends. *Journal of Climate* 18(22): 4906-4914.

Meehl, G.A., W.M. Washington, W.D. Collins, J.M. Arblaster, A. Hu, L.E. Buja, W.G. Strand, H. Teng. 2005. How much more global warming and sea level rise?, *Science* 207(5716): 1769-1772, DOI: 10.1126/science.1106663

Molnia, B. F. 2001. Assessing the response of Alaska's glaciers to Post-Little Ice Age climate change. *American Geophysical Union, Fall Meeting 2001*, abstract #IP41A-03.

Mote, P.W. 2005. Declining mountain snowpack in western North America. *Bulletin of the American Meteorological Society* 86: 39-49.

Mote, P. W. 2006. Climate-driven variability and trends in mountain snowpack in western North America. *Journal of Climate* 19(23): 6209-6220.

Mote, P. W., D. J. Canning, D. L. Fluharty, R. C. Francis, J. F. Franklin, A. F. Hamlet, M. Hershman, M. Holmberg, K. N. Ideker, W. S. Keeton, D. P. Lettenmaier, L. R. Leung, N. J. Mantua, E. L. Miles, B. Noble, H. Parandvash, D. W. Peterson, A. K. Snover, and S. R. Willard. 1999. *Impacts of Climate Variability and Change, Pacific Northwest*. National Atmospheric and Oceanic Administration, Office of Global Programs, and JISAO/SMA Climate Impacts Group, Seattle, WA. 110 pp.

Mote, P. W., E. A. Parson, A. F. Hamlet, K. N. Ideker, W. S. Keeton, D. P. Lettenmaier, N. J. Mantua, E. L. Miles, D. W. Peterson, D. L. Peterson, R. Slaughter, and A. K. Snover. 2003. Preparing for climatic change: The water, salmon, and forests of the Pacific Northwest. *Climatic Change* 61:45-88.

Mote, P.W., A.F. Hamlet, M.P. Clark, and D.P. Lettenmaier. 2005a. Declining mountain snowpack in western North America. *Bulletin of the American Meteorological Society* 86(1): 39-49.

Mote, P. W., E. P. Salathé, and C. Peacock. 2005b. *Scenarios of Future Climate for the Pacific Northwest*. A report prepared for King County (Washington)'s October 27, 2005 climate change conference "The Future Ain't What It Used to Be: Preparing for Climate Disruption". Climate Impacts Group, Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Seattle.

National Academy of Sciences (undated), "The National Academies Study Process: Ensuring Independent, Objective Advice", Washington, D.C. Brochure available for download from *http://www.nationalacademies.org/onpi/brochures/studyprocess.pdf* (accessed 5/6/07)

(NAST) National Assessment Synthesis Team. 2000. *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change*. U.S. Global Change Research Program, Washington D.C.

(NAST) National Assessment Synthesis Team. 2001. *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change, Foundation Report*. U.S. Global Change Research Program, Washington D.C.

(NPS) National Park Service Glacier Monitoring Program for North Cascades National Park (*http://www.nps.gov/noca/naturescience/glacial-mass-balance1.htm*, accessed 11/6/06)

(NRC) National Research Council Water Science and Technology Board. 2004. Managing the Columbia River: Instream Flows, Water Withdrawals, and Salmon Survival. Washington, D.C.: The National Academies Press. *http://books.nap.edu/catalog.php?record_id=10962#toc*

National Snow and Ice Data Center Press Release, April 5, 2006, "Winter Sea Ice Fails to Recover, Down to Record Low" *http://nsidc.org/news/press/20060404_winterrecovery.html* (accessed 2/14/07)

Orr, J.C., V.J. Fabry, O. Aumont, L. Bopp, S.C. Doney, R.A. Feely, A. Gnanadesikan, N. Gruber, A. Ishida, F. Joos, R.M Key, K. Lindsay, E. Maier-Reimer, R. Matear, P. Monfray, A. Mouchet, R.G. Najjar, G.K. Plattner, K.B. Rodgers, C.L. Sabine, J.L. Sarmiento, R. Schlitzer, R.D. Slater, I.J. Totterdell, M.F. Weirig, Y. Yamanaka, and A. Yool. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. *Nature* 437(7059): 681-686.

Palmer, R., M.Wiley, A. Polebitski, B. Enfield, K. King, C. O'Neill, and L. Traynham. 2006. Climate Change Building Blocks. Report to the Climate Change Technical Subcommittee of the Regional Water Supply Planning Process. University of Washington, Seattle.

Parmesan, C. and H. Galbraith. 2004. *Observed Impacts of Climate Change in the U.S.* Pew Center on Global Climate Change, Arlington, VA.

Parry M.L., O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (Eds.). 2007. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, United Kingdom.

Perry, N. 2005. Climate change hits home. *Seattle Times* 28 October 2005.

Robert E. Kennedy Library, 2002. "Peer Reviewed or Redereed Journals", California Polytechnic State University, San Luis Obispo, California. Fact sheet last updated January 2002. Available for download at *http://www.lib.calpoly.edu/research/guides/pdfs/peer_review.pdf* (accessed 5.6.07)

Rothrock, D.A.,Y.Yu and G.A. Maykut. 1999. Thinning of the Arctic sea-ice cover. *Geophysical Research Letters* 26:3469–3472.

Sagan, Carl. 1996. *The Demon-Haunted World: Science As a Candle in the Dark*. Ballantine Books, March 1997 ISBN 0-345-40946-9, 480 pgs. 1996 hardback edition: Random House, ISBN 0-394-53512-X, xv+457 pages plus addenda insert (some printings).

Shea, E. and the Pacific Islands Regional Assessment Group. 2001. *Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change, Pacific Islands Report.* East-West Center, Honolulu, Hawai'i.

Shriner, D.S., and R.B. Street. 1997. Chapter 8: North America. In R.T. Watson, M.C. Zinyowera, and R.H. Moss (eds), *IPCC Special Report on The Regional Impacts of Climate Change, An Assessment of Vulnerability, A Special Report of IPCC Working Group II*. Cambridge University Press, Cambridge, England.

Smith, J.B. 1997. Setting priorities for adapting to climate change. *Global Environmental Change* 7(3): 251-264.

Snover, A.K., P.W. Mote, L.C. Whitely Binder, A.F. Hamlet, and N.J. Mantua. 2005. *Uncertain Future: Climate Change and Its Effects on Puget Sound.* Climate Impacts Group, Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington. Available for download from: *http://www.cses.washington.edu/db/pdf/snoveretalpsat461.pdf*

Stewart, I. T., D. R. Cayan, and M. D. Dettinger. 2004. Changes in snowmelt runoff timing in western North America under a 'business as usual climate change scenario', *Climatic Change* 62:217-232.

Stirling, J. 2004. "Evaluating Scientific Information on the World-Wide-Web". Flinders Medical Centre, Bedford Park SA, Australia. Fact sheet available for download at: *http://www.lib.flinders.edu.au/info/branch/medical/evaluation.pdf* (accessed 5.6.07)

(UCS) Union of Concerned Scientists. 2006. *Climate Change in the U.S. Northeast: A Report of the Northeast Climate Impacts Assessment*. Union of Concerned Scientists, Cambridge, MA.

(UKCIP) UK Climate Impacts Programme. 2003. "Climate change and local communities – How prepared are you?", UK Climate Impacts Programme, Oxford, England.

(UKCIP) UK Climate Impacts Programme. 2007. "UKCIP Tools: Adaptation Wizard (prototype version 1.1)." UK Climate Impacts Programme, Oxford, England. *http://www.ukcip.org.uk/resources/tools/adapt.asp* (accessed 5/07/07)

(USEPA) United States Environmental Protection Agency. 2002. "Saving Florida's Vanishing Shores" (brochure). EPA publication number EPA-430-F-02-007. *http://www.epa.gov/climatechange/effects/coastal/saving_FL.pdf*

(USEPA) United States Environmental Protection Agency. 2006a. "Climate Change – Greenhouse Gas Emissions", *http://epa.gov/climatechange/emissions/co2.html*, accessed 2.15.07

(USEPA) United States Environmental Protection Agency. 2006c. "Methane", *http://www.epa.gov/methane/sources.html*, accessed 2.15.07

(USEPA) United States Environmental Protection Agency. 2006c. "Nitrous Oxide", *http://www.epa.gov/nitrousoxide/sources.html*, accessed 2.15.07

Ward, P. 2005. It's Written In Stone: Global Warming Is Real**.** *Seattle Post – Intelligencer* 6 February 2005: sec. G:1.

Wigley, T. M. L. 2005. The climate change commitment. *Science* 307(5716): 1766–1769.

Wiley, M.W. 2004. Analysis techniques to incorporate climate change information into Seattle's long range water supply planning. M.S.C.E. thesis, Department of Civil and Environmental Engineering, University of Washington, Seattle.

Willows, R. and R. Connell (editors). 2003. *Climate Adaptation: Risk, Uncertainty, and Decision-making*. UK Climate Impacts Programme, Oxford, England.

appendix a summary of observed changes in the United States

SUMMARY OF OBSERVED CHANGES IN THE UNITED STATES	
Indicator	*Change*
Surface air temperature	*Increased air temperatures.* Average U.S. air temperatures warmed by 1.4°F (0.8°C) during the 20th century (1898-2000). Warming trends were greatest in the winter (3°F or 1.7°C) and smallest in the fall (0.9°F or 0.5°C). Although the magnitude of change varies within regions, warming was generally found throughout the Western U.S., the Northeast, and the upper Midwest. Some cooling trends were evident in parts of the Southeast and Ohio River Basin (Lu et al. 2005).
Temperature extremes	*Longer frost-free season.* The length of the frost-free season has increased nationally by about 2 weeks on average between 1895-2000. Most of this change is due to an earlier spring rather than a later fall. The length of the frost-free season has increased much more in the western U.S. (+19 days/century) than the eastern U.S. (+3 days/century) during this period. *Fewer extreme cold and more extreme warm nights.* A global-scale analysis of changes in daily climate extremes finds that extreme nighttime cold events (temperatures in the lowest 10% of the historic record) have decreased in the U.S. by as much as 30 days (6 days/decade) during 1951-2003, particularly in the western U.S. Extreme nighttime warm events (temperatures in the highest 10% of the historic record) have increased by as much as 20 days (4 days/decade) during 1951-2003. *Changes in warm and cold spells.* There is notable regional variation in trends for cold spells. Significant increases in warm spells (up to 18 days/decade) were found throughout the U.S. except for parts of the Southeast, which show a slight decrease in warm spells. Results on trends in cold spells are mixed with many areas of the U.S. (particularly the central U.S.) showing an increase in cold spells despite an overall decrease in the number of extreme cold nights. (Alexander, L. V. et al. 2006, DeGaetano and R.J. Allen 2002, Easterling et al. 2000, Feng and Hu 2004, Kunkel et al. 2004)
Average precipitation	*Small increases in average precipitation.* Nationally, average annual U.S. precipitation has increased by 5-10% over the last 100 years, mostly during summer. However, increasing precipitation has been interrupted by multi-year anomalies such as the drought years of the 1930s and early 1950s (Feng and Hu 2004, IPCC 2001a [updated with *http://cdiac.esd.ornl.gov/trends/trends.htm*]).
Precipitation extremes	*Increase in more extreme precipitation.* Trends in 1-day and multi-day heavy precipitation events in the U.S. have increased over the course of the 20th century. Increases in extreme precipitation events are responsible for much of the observed 5-10% increase in average annual precipitation in the U.S. during the 20th century. Droughts in general have become shorter, less frequent, and smaller in terms of area affected between 1925 and 2003 with the exception of the Southwest and parts of the interior West, where drought duration and severity has increased (Andreadis, K.M. and D.L. Lettenmaier 2006, Easterling et al. 2000).

Mountain snowpack	*Overall decline in mountain snowpack.* Widespread declines in spring snowpack have been observed in much of the western U.S. between 1950 and 1997. Snowpack losses exceed 50% in many areas and 75% in some areas. Losses are greatest in western Washington, western Oregon, and northern California. Increases have been observed in the southern portion of California's Sierra Nevada range and several other locations in the southwest primarily due to the combined effects of increased precipitation and/or higher elevations. While some of this change is due to natural variation in temperature and precipitation, the widespread nature of the trends is consistent with global patterns of temperature increases (Mote 2005a, Mote 2006)
CHANGES IN HYDROLOGY AND OCEANOGRAPHY	
Indicator	*Change*
Snowmelt and stream-flow timing	*Snowmelt and peak streamflow are occurring earlier.* The timing of snowmelt and peak streamflow has moved earlier into the spring in western U.S. snow-fed river basins since mid-20th century (Cayan et al. 2001, Stewart et al. 2004).
Duration of ice cover of rivers and lakes	*Duration of ice cover has decreased.* Ice cover duration on rivers and lakes has decreased by about two weeks over the 20th century in mid- and high latitudes of the Northern Hemisphere (IPCC 2001a).
Glaciers	*Glaciers are thinning and retreating.* Glaciers are thinning and retreating throughout the U.S. due primarily to increasing temperatures. Approximately 40% of the ice cover in North Cascades National Park has been lost in the past 150 years. In addition, 73% of the 38 square mile area of Glacier National Park covered by glaciers in 1850 had disappeared by 1993. Glaciers in Alaska are experiencing widespread retreat, thinning, and/or stagnation, especially at lower elevations. Of the nearly 700 named Alaskan glaciers, less than a dozen are currently advancing (Molina 2001, Arendt et al. 2002, Hall and Fagre 2003, NPS 2006).
Arctic sea ice extent and thickness	*Arctic sea ice extent and thickness has decreased.* March 2006 had the lowest Arctic winter sea ice extent since the beginning of the satellite record in 1979. Arctic sea ice thickness decreased by 40% from 1958-1976 to 1993-1997 (Rothrock et al. 1999, IPCC 2001a, National Snow and Ice Data Center 2006).
Sea level	*Sea level has risen.* Estimated average global sea-level rise for the 20th century is 6.7 inches (0.17m), primarily due to thermal expansion of the oceans. There is high confidence that the overall rate of sea level rise increased from the 19th century to the 20th century. Sea level rise rates in some regions have been affected by ocean circulation and by vertical land movements resulting from plate tectonics and glacial rebound of land surfaces (IPCC 2001a , IPCC 2007a,b).
Sea surface temperatures	*Sea surface temperatures have increased over the 20th century.* The trend for the upper 9,800 feet (3000 meters) was 0.07°F (0.037°C) for 1955-1998 with a large part of the change in ocean heat content occurring in the upper 2,300 feet (700 meters) (IPCC 2001a, Levitus et al. 2005).
Ocean pH	Ocean waters are becoming more acidic (with ocean pH decreasing by 0.1 pH units) as a direct result of increasing carbon dioxide in the atmosphere and uptake by the oceans. Ocean acidification is corrosive to the shells and skeletons of many marine organisms such as coral reefs and certain phytoplankton at the base of the food web (Orr et al. 2005).

Timing (phenology) of ecological events.	Earlier Spring flowering of plants, changes in breeding times for animals, and elongated growing seasons have all been documented. For example, in the western U.S., an earlier onset of spring has resulted in earlier first bloom of lilac (~7.5 days) (1968-1994) and honeysuckle (~10 days) (1957-1994). The average laying date for tree swallows has advanced nine days (1959-1991); the breeding season for Mexican jays has advanced 10 days (1971-1998). When timing shifts for separate but mutually dependent species occur at different rates, species interactions are disrupted and population declines have been noticed (Cayan et al. 2001, Parmesan and Galbraith 2004).
The geographic range of plants and animals	The range of many plant and animal species has shifted in latitude and/or in elevation. Mountain pine beetle, a pest that attacks and kills a variety of Western North America pines, is moving further north and into higher elevations. The well-studied Edith's checkerspot butterfly has shifted northward and upward. The red fox has shifted its range northward; on Baffin Island, the red fox range expanded northward by 600 miles in only 30 years. The tree line at high latitudes in the Northern Hemisphere has moved upward during the 20th century. Sea level rise and resulting salt water intrusion has largely eliminated low-lying pine forest barrens in the Florida Keys, reducing habitat availability for species dependent on the pine barrens (Logan and Powell 2005, Parmesan and Galbraith 2004).
Composition of ecological communities	The mixture of species in ecological communities is changing. Cold-adapted species are declining and warm-adapted species are increasing. For example, in the inter-tidal communities of Monterey, California, warm water fish species are increasing and cold water fish species are decreasing (Parmesan and Galbraith 2004).

Table A.1 – Summary of Observed Changes in the United States

Figure B.1 Climate Change Impacts Science Primer: How Do Scientists Project Future Climate and its Impact on Local Resources?

Fort Thompson Big Bend Dam, USACE Digital Visual Library

CO_2 emissions

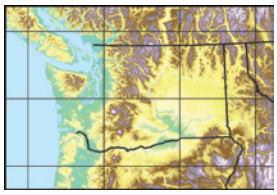
*See **Climate Impacts Science Questions** for answers to Q1-Q8*

1. Estimate future atmospheric greenhouse gas concentrations and other climate drivers

Q1 - *What do scientists have to know before they can project future climate?*

2. Use climate models to project future climate at a global scale

Q2 - *How does a climate model work?*
Q3 - *Why do climate change projections have such a large range?*
Q4 - *Why can I believe climate change projections if weather predictions are often wrong?*
Q5 - *Which aspects of climate model projections of climate change are most certain? Which are less certain?*



Credit: Climate Impacts Group, University of Washington

Washington State topography with typical CM grid (~150 miles on a side)

3. Downscale climate model results to project future climate at a regional scale

Q6 - *How do scientists "translate," or downscale, global temperature, precipitation, and sea level rise projections to a regional scale?*

4. Use regional models and observed relationships to project impacts on natural resources (e.g., water)

Q7 - *How do scientists project the impact of climate change on natural resources?*

Credit: USDA Agricultural Research Service Image Gallery

Soybean Field

5. Use resource management models or empirical relationships to understand implications for resource decisions

Q8 - *How do resource managers modify management decisions to account for projected climate change impacts?*

Adapted from Kay et al. 2005

Q1: What do scientists have to know before they can project future climate?

Before scientists can project future climate, they need to estimate how factors that influence climate ("climate drivers") are likely to change in the future. Two important climate drivers are atmospheric concentrations of greenhouse gases and small particles known as aerosols, which are released through fossil fuel combustion and biomass burning and can affect the amount of solar radiation reaching the earth's surface. These drivers are affected by human choices about energy use, implementation of new technologies, family size, land use change, and other factors. Scientists develop scenarios for future greenhouse gas and aerosol emissions by making a range of assumptions about trends in future development, global population, and per capita energy consumption. These emission scenarios are then put into climate models to project future climate changes (see Q2).

Q2: How does a climate model work?

A climate model is a computer program that solves a series of scientifically established equations to "model" the interactions between major components of the climate system, including the atmosphere, ocean, land surface, ice sheets, and the biosphere[3]. The relatively coarse resolution of climate models (approximately 150 mile [241 km] horizontal resolution, 0.6 mile [.07 km] vertical resolution, and one-half hour temporal resolution) means some physical processes must be simplified. Because the regionally important influence of local topography and water bodies on climate is not included in climate models, "downscaled" climate model results should used to project future changes in climate at a regional (sub-national) scale (see Q6).

Q3: Why do climate change projections have such a large range?

Roughly speaking, the range of future climate change projections results from two sources of uncertainty: uncertainty in future climate drivers (see Q1) and uncertainty in modeling how the climate system works (see Q2). With improved understanding of the climate system, some of the uncertainty in future model projections could be reduced. However, even if scientists had perfect models of the climate system, future socio-economic and political decisions and their influence on human climate drivers make it impossible to exactly project future climate conditions. The uncertainty in human climate drivers is smaller in the near future (e.g., 2020s), but much larger in the distant future (e.g., 2090s).

Q4: Why can I believe climate change projections if weather predictions are often wrong?

Although frequently viewed as the same, weather and climate forecasting are actually quite different. Much of this difference is attributable to the difference between weather and climate and how this distinction affects the sensitivity of forecasting models. Weather refers to the state of the atmosphere at a specific place, day, and time while climate describes the long-term statistics (averages, ranges) of weather conditions associated with a location. A successful weather forecast describes the state of the atmosphere at an exact time, e.g., Monday afternoon or Wednesday morning. Skillful weather forecasts are only possible to about seven days because weather forecasts depend heavily on the exact state of the atmosphere at the beginning of a weather model forecast

[3] The term "biosphere" refers to those portions of earth's land, ocean, and atmospheric systems inhabited by living organisms as well as dead organic matter such as soil organic matter and oceanic remains (Source: IPCC 2001a)

("initial conditions"), which are very difficult to determine precisely. Small changes in initial conditions can have important effects on the overall forecast.

Climate prediction, on the other hand, is not as sensitive to initial conditions. Climate prediction depends on well-understood interactions between the atmosphere, land surface, oceans, and ice sheets, as well as slowly varying climate drivers like greenhouse gases, solar radiation, and volcanic aerosols. Consequently, to the extent that the physical interactions are understood and climate drivers are reasonably predicted, the climate can be well simulated over extended periods of time (typically 30 years).

Q5: Which aspects of climate model projections of climate change are most certain? Which are less certain?

Climate scientists have the most confidence in climate model temperature projections for several reasons. First, the warming trends and variability observed over the 20th century are well represented in climate model simulations for that period, which helps to directly relate simulated warming patterns with rising greenhouse gasses. Second, the simulated warming trends are substantial compared to year-to-year and decade-to-decade variability in temperature, which implies the trends are a robust result. Third, there is close agreement among all climate models on the magnitude of warming resulting from increased greenhouse gasses.

Confidence in sea level rise projections is also high, although recent evidence that the Greenland ice sheet is melting faster than expected could lead to higher estimates of sea level rise if the recent increase continues and is not a short-term phenomenon (IPCC 2007a,b).

Scientists are less certain about precipitation changes in the climate simulations. First, processes controlling precipitation vary considerably around the globe and do not respond in the same way to climate change. Thus, the precipitation response to climate change will be regionally specific. Second, many of the processes that control precipitation in the atmosphere (e.g., spatial resolution, topography) are not well represented in current models due to the limitations of current computers and the long simulations needed for climate research. Third, unlike temperature projections, there is a lack of agreement in both the direction (wetter/drier) and magnitude (how much wetter/drier) in the response of precipitation to climate change in global climate models. Finally, the year-to-year and decade-to-decade variability in precipitation is large compared to any trend due to climate change, so simulated trends are difficult to distinguish from natural variability.

Climate models also have trouble representing important patterns of climate variability such as the El Niño-Southern Oscillation (ENSO), which can influence temperature and precipitation patterns in many parts of the world. It is unknown at this time how ENSO or other natural patterns of climate variability could change as a result of climate change.

Q6: How do scientists "translate" (or "downscale") global temperature, precipitation, and sea level rise projections to a regional scale?

Raw global climate model output has very coarse spatial resolution (see Q2) that cannot resolve all of the processes important for future climate projections at the regional scale. Projecting regional climate change, therefore, requires downscaling global climate model results. Downscaling is important because it allows climate scientists to incorporate the influence of finer

scale influences of topography and water bodies on regional climate into future climate projections.

Two methods of downscaling are commonly used: statistical methods and regional climate modeling (RCM). Statistical methods relate climate model projections to historical regional climate variations. Statistical methods assume that climate change will only affect the mean climate, not the variability in climate. RCM uses global climate model output and models finer-scale climate features resulting from local topography and water bodies. In principle, RCM should be more realistic than statistical downscaling because no assumptions about future variability in climate are made when using RCM.

In addition to temperature and precipitation projections, global sea level rise projections must be downscaled. Sea level projections depend not only on changes in global sea level but also on changes in local land elevation (e.g. subsidence and uplift due to regional plate tectonics or glacial rebound) and ocean circulation. Once global sea level rise and regional factors affecting sea level are taken into account, regional sea level rise projections can be determined and used to assess the impacts on coastal resources.

Q7: How do scientists project the impact of climate change on natural resources?

Once regional-scale climate projections are obtained (see Q2 and Q6), these projections – combined with resource models and observations of how climate affects resources – can be used to project climate change impacts on natural resources. For example, regional hydrology models can be used to assess climate change impacts on stream flow timing and volume. Observed impacts can also be used to formulate equations for projecting climate change impacts. For example, if scientists can develop an equation that describes the dependence of winter wheat production on temperature in the current climate, this equation can be used with projected future temperatures to estimate winter wheat production in future climates.

Q8: How do resource managers modify management decisions to account for projected climate change impacts?

After identifying projected changes in regional climate (Q6) and natural resources (Q7), resource management models and observations can be used to assess the impact of climate change on management decisions. For example, resource managers could use altered streamflow scenarios to drive a water management model and estimate the impacts of climate change on hydropower operations or municipal water supply. For resources such as forestry and fisheries where quantitative management models do not exist or are being developed, resource managers can use observations of how historic climate fluctuations have affected the resource to get a baseline understanding of potential climate change impacts.

appendix c U.S. national assessment regional summaries

The following "mega region" summaries provide an overview of findings from the U.S. Global Change Research Program's 2000 U.S. National Assessment (NAST 2000). For a map of the regions, see Figure 2.5. Additional studies on regional impacts have subsequently been published in some U.S. regions and support the National Assessment's findings, further reinforcing the importance of understanding how climate change may affect the range of issues that regional and local governments manage on a day-to-day basis. When possible, the newer regional studies are used to supplement the NAST 2000 regional summaries. For a list of the National Assessment regional studies and other studies, see Appendix D.

1. Northeast United States[4]

Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Delaware, Pennsylvania, Maryland, West Virginia, and the District of Columbia

A recent assessment (UCS 2006) of climate change impacts to the Northeast projected increases in average temperatures by 2100 on the order of 5-11°F for summer and 6-10°F for winter depending on which of two greenhouse gas emissions scenarios used in the assessment (a low versus high carbon dioxide emissions scenario) is realized over the 21st century. Annual precipitation is projected to increase 10% by the end of the century. Winter precipitation, which was sensitive to the choice of emissions scenarios in the UCS 2006 study, is projected to increase 20-30% by 2100 under the higher emissions scenario. Little change is expected in summer precipitation in either scenario but both scenarios lead to more intense more frequent heavy precipitation events.

The projected changes in temperature and precipitation are expected to affect many aspects of the Northeast's environment. Streamflows and water supply could be impacted as warmer winter temperatures lead to more winter precipitation falling as rain rather than snow, lower snowpack, and earlier spring snowmelt. Winter flood risk and winter streamflows are likely to be greater with the shift to more winter rain and projections for an overall increase in winter precipitation. The risk for late summer and fall drought increases despite the projected increase in winter precipitation, however, due to higher summer temperatures, increased evaporation, a longer growing season, and lower summer streamflows.

Changes in extreme heat are a concern in the Northeast. For the low emissions scenario, the Northeast may see at least 30 more days per year when average temperatures exceed 90°F and three to nine more days where temperatures exceed 100°F. For the high emissions scenario, the number of days exceeding 90°F increases to more than 60 days per year and the number of days above 100°F increases between 20 and 30 days. When the effects of humidity are taken into account along with the projected increases in temperature, the typical New England summer day is expected to feel 12-16°F warmer than the typical summer day for the period 1961 to 1990.

[4] The UCS 2006 assessment defines the Northeast as including the states of Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, and Pennsylvania. The NAST 2000 assessment also included Maryland, Delaware, West Virginia, and the District of Columbia in definition of this region

Many aspects of the Northeast economy are vulnerable to climate change impacts (NAST 2000)[5]. Coastal development is at increased risk of coastal flooding and damage from storm surges due to sea level rise. Increased water temperatures in the region's estuaries, bays, and coastal wetlands may force lobsters to migrate to cooler waters. The length of the winter snow season could be cut 25-50%, impacting the region's ski and snowboarding industry. The potential for more snow-free days could, however, increase warm-season recreation activities such as hiking. The region's fall foliage, a major tourist attraction currently dominated by maple, beech, and birch trees, could be affected by the northward migration of species in response to increasing regional temperature. Forest diebacks and a delay or mis-timing of peak colors could also negatively affect fall foliage-related tourist activities (NAST 2000, Carter 2003a).

2. Southeast United States

Virginia, North Carolina, South Carolina, Kentucky, Tennessee, Georgia, Alabama, Louisiana, Mississippi, Arkansas, eastern Texas, and Florida

Average annual temperature in the Southeast is projected to increase 4-10°F over the 21st century while changes in precipitation vary from near zero to a 25% increased depending on the model analyzed (Carter 2003b). Increases in high temperatures, the regional heat index, and ground-level ozone are also anticipated. This raises concerns for human health in the Southeast, particularly for lower income households which have fewer financial resources for air conditioning and other adaptive measures. Existing problems with regional water quantity and quality are likely to worsen due to the increased risk for drought, salt water intrusion, warmer water temperatures, and extreme precipitation events. The incidence of red tides, fishkills, and bacterial contamination in shellfish is expected to increase with warmer summer temperatures *(ibid)*. Additionally, more flooding in low-lying coastal communities is expected (NAST 2000).

Climate change impacts on agricultural production in the Southeast vary by crop, area, and climate change scenario. Some crops, including rice, soybeans, cotton, and peanuts, may benefit from the CO_2 fertilization effect (see Section 2.3) (Carter 2003b). The benefit is lost, however, if temperatures are too high or precipitation losses are too great (-20% or more) *(ibid)*. Citrus yields may benefit from fewer freeze events or decline as a result of a shortened (but necessary) period of dormancy. An increase in the frequency of extreme hot summer days may lead to more heat stress in crops and increase the need for irrigation, which many agricultural operations in the Southeast do not have. Overall, agricultural impacts are expected to be negative in the lower Mississippi Valley and Gulf Coast and positive in the Atlantic Coastal Plain (NAST 2000).

Estimates of changes in forest growth are uncertain. Forest process models run with wetter, less warm scenarios (relative to other warming scenarios) project increased pine and hardwood forest growth in the Southeast by the end of the 21st century, particularly in the northern half of the region. Models run with warmer and drier climate scenarios, however, show decreased forest growth in some areas and shifts from pine-dominated forests to savannas and grasslands as a result of increased fire and decreased soil moisture.

---

[5] Like the UCS 2006 study, the National Assessment (NAST 2000, 2001) projects that Northeast temperatures will increase as a result of global warming. The projections in the National Assessment are slightly different from those found in UCS 2006, however, due to differences in the area covered and the climate models and emissions scenarios used for each assessment. NAST 2000 projects that minimum winter temperature will increase from about 4-5°F to as high as 9°F by the end of the 21st century. Summer maximum temperatures are expected to increase on the order of 2-3°F or 7-11°F depending on the model chosen (NAST 2001).

Sea level rise and storm surge are a major concern for the Southeast. In Florida, approximately 8% (4,500 square miles) of the state's total land area lies within 4.5 feet of sea level (USEPA 2002). Most of this is located in southern Florida. Saltwater intrusion into the Everglades – a freshwater ecosystem – from higher sea level and tidal flooding would negatively affect how the ecosystem functions and the diversity of life within it. Additionally, high sea levels could affect the Biscayne Aquifer, which is recharged by freshwater from the Everglades. The Biscayne Aquifer provides almost all of the freshwater for the Florida Keys, the City of Miami, and the lower East Coast of Florida *(ibid)*.

Human development and natural subsidence of coastal land areas can compound the impacts of sea level rise. The greater New Orleans metropolitan area currently sits 5-10 feet below sea level and is continuing to sink as much as 0.4 inches annually due to groundwater pumping, natural compaction of soils, and tectonic activity (Burkett 2003). The combined effects of sea level rise and subsidence could leave the New Orleans region 8 to 12 feet below mean sea level by 2100, increasing the risk of flooding even as the region struggles to improve flood control systems in the wake of 2005's Hurricane Katrina *(ibid)*.

3. Midwest United States

Ohio, Indiana, Michigan, Illinois, Wisconsin, Minnesota, Iowa, and Missouri

Average annual temperature in the Midwest is projected to increase 5-10°F over the 21st century and precipitation is likely to increase 10 to 30% on average in much of the region (NAST 2000). Changes in average winter temperature are potentially more significant, particularly in the most northern areas of the region. One climate model used in the NAST 2000 projected an increase in average winter temperatures on the order of 15°F in northern Minnesota and Michigan's Upper Peninsula. This is in addition to the average 4°F warming already observed in these northern areas during the 20th century.

Climate change is projected to have important impacts on Midwest water resources. Water levels in the Great Lakes are expected to decline significantly due to increasing temperatures and evaporation. These declines are likely to lead to more competition for water within the region and between the U.S. and Canada, decreased hydropower generation, fewer wetlands, and increased water-based transportation costs, some of which may be offset by decreased ice cover and a longer navigation season. Projected increases in heavy precipitation events are likely to lead to more flooding and non-point source pollution.

With respect to human health impacts, the Midwest is likely to benefit from fewer extreme cold outbreaks while the potential for more heat-related illnesses increases during the summer. Heat-related stress is particularly a concern for urban areas where the concentration of paved surfaces elevates nighttime temperatures. Urban areas are also likely to see more problems with summer air quality as a result of warmer temperatures. Finally, the projected increase in extreme precipitation events may lead to an increase in insect or tick-borne disease.

Agricultural production is generally expected to increase due to lengthening of the growing season and the carbon dioxide fertilization effect (see Section 2.3), but not in all areas. Warmer air temperatures and reduced soil moisture are expected to increase forest fire risk and forest susceptibility to disease and insects, contributing to declines in both coniferous and deciduous trees. Impacts on the forest industry could be significant particularly when combined with the pressure to convert forest land to other land uses.

Major changes in freshwater ecosystems are expected. Warmer water temperatures favor warm water fish species over cold water fish species and increase the risk of invasive species. The potential for more nutrient pollution (from the projected increase in heavy precipitation events) and warmer water temperatures increases the risk for algae growth in freshwater lakes. As noted previously, declining lake levels throughout the region could reduce wetlands habitat. This has implications for the migrating birds and other wildlife dependent on wetland systems for all or part of their life stages.

4. Great Plains

Montana, Wyoming, North and South Dakota, Nebraska, Kansas, Oklahoma, Texas

Average annual temperature in the Great Plains is projected to increase 5-12°F over the 21st century, although the distribution of this warming will vary spatially and by season (NAST 2000). Temperature increases are likely to be greatest along the eastern edge of the Rocky Mountains and more warming is expected in winter and spring than summer and fall (Carter 2003c). Precipitation changes also vary by location. Overall, annual precipitation is expected to increase by 13% or more with the largest increases in the eastern and northern parts of the Great Plains. More intense rainfall events are expected, especially in the Southern Great Plains. Both models used in NAST 2000 show a decreasing precipitation trend along the eastern flanks of the Rocky Mountains during the 21st century, however.

Climate change is projected to increase competition for water among agricultural, urban, industrial, recreational, and natural ecosystem water uses through increased temperature, increased evaporation, reduced soil moisture, and changes in the timing of snowmelt runoff from the Rocky Mountains (NAST 2000). An increased risk of drought will also heighten competition for water.

The carbon dioxide fertilization effect (see Section 2.3) will likely increase productivity of crops and grasses in the region provided there is sufficient water supply and soil nitrogen. Specific changes in agricultural production and irrigation water needs water will vary by crop type and location, however. The potential for invasive species such as leafy spurge, field bindweed, and jointed goatgrass to out-compete native species on agricultural land and range lands is already a major concern in the region; climate change may contribute to the spread of invasive species where native species are unable to adapt quickly enough to changes in temperature and soil moisture.

The potential for more extreme heat is expected to increase. Extreme heat events can have a major impact on livestock as well as people in the region. Urban and rural flooding is more likely given projected increases in storm intensity. More intense rainfall events will also lead to more soil erosion and degraded surface and ground water quality from stormwater runoff containing fertilizers, herbicides, pesticides, livestock wastes, salts, and sediments. The stress of managing climate impacts is expected to disproportionately affect rural family farmers and ranchers and the urban poor.

5. West

California, Nevada, Utah, Arizona, New Mexico, and Colorado

Average annual temperature in the West is projected to increase 3-4°F by the 2030s and 8-11°F by the 2090s (NAST 2000). Both wetter and drier conditions are expected. A major concern in the West is climate change impacts on water resources. Western states are reliant on winter snowpack for most of their summer water supply. Warmer temperatures are expected to significantly reduce mountain snowpack, altering the timing of peak snowmelt runoff and reducing the amount of water available during spring and summer. These changes have implications for municipal and industrial water supply, irrigation, hydropower generation, and provision of instream flows for threatened and endangered freshwater species. Snowpack losses could be offset to some degree by increased winter precipitation if climate change brings a wetter winter climate and water supply systems are able to capture the additional precipitation. A wetter climate would also bring concern for increased soil saturation, landslides, and flooding in some areas.

Forest growth could increase as a result of the carbon dioxide fertilization effect (see Section 2.3). This could lead to less desert area and a shift towards more woodlands and forests in parts of the West. Productivity may eventually decline, however, if climate is drier, temperature increases are too great, and/or the carbon dioxide fertilization effect levels off. The potential for more forest fires is also a potential limiting factor. Forest fires are expected to increase regardless of changes in average precipitation; as long as year-to-year variability remains high, wet years will encourage more plant growth and the accumulation of fuel loads which are then available to burn in dry years.

Potential impacts on agricultural production in the West vary. Crop yields in Western states could increase given the potential for a carbon dioxide fertilization effect and increased precipitation. Warmer temperatures could lengthen the growing season and, where adequate irrigation water is available, shift growing regions northwards. Warmer temperatures could also contribute to more heat stress, pests, weeds, and disease in agricultural crops. Temperature and the length of the growing season are particularly important to wine production. Changes in the types of wine grapes and location of growing areas in California may be required as a result of increasing temperatures. Warmer temperatures are also likely to affect the timing of key physical processes in grape production and development, affecting the ability of grapes to reach optimal levels of sugar, acid, and flavor (Jones et al. 2005). Adaptation capabilities of fruit and nut trees, which take decades to get established and form an integral part of the West's agricultural economy, are a concern. In all cases, the availability of adequate irrigation water supplies is a potentially limiting factor.

Recreation and tourism in the West are also likely to be affected by climate change. Winter sporting activities are expected to have a shorter season, particularly in low elevation areas and areas where snowmaking is not an option. The summer recreation season is likely to be lengthened due to warmer temperatures but may be limited by heat during the peak of the season.

6. Pacific Northwest

Washington, Oregon, and Idaho

Average regional temperature in the Pacific Northwest (PNW) is expected to increase 2°F by the 2020s and 3°F by the 2040s compared to 1970-1999 (Mote et al. 2005b). Temperatures are projected to increase across all seasons with the greatest increase occurring during the summer months. Changes in annual precipitation are less certain but most models project a slight increase in winter precipitation. Changes in extreme precipitation events are uncertain. The effect of warmer temperatures on winter snowpack and summer water supplies is a major concern in the PNW. Warmer winter temperatures are expected to lead to more winter precipitation falling as rain rather than snow, particularly in mid-elevation basins where average winter temperatures are currently near freezing. This will result in to less winter snow accumulation, higher winter streamflows, earlier spring snowmelt, earlier peak spring streamflow, and lower summer streamflows in rivers that depend on snowmelt (i.e., most rivers in the PNW). These changes, combined with population growth, are likely to increase existing conflicts among competing water uses, including urban water supplies, instream flows for salmon, irrigated agriculture, hydropower, navigation, and recreation.

Climate change is expected to affect salmon – a culturally and economically significant PNW resource – across all freshwater life stages as a result of changes in the timing and volume of streamflow. Projected increases in winter flooding, decreased summer and fall streamflows, and warmer summer water temperatures will further degrade freshwater and estuary salmon habitat in the PNW. These changes will likely cause severe problems for already stressed salmon stocks, including federally protected stocks listed under the Endangered Species Act. The projected impacts of climate change on PNW forests will vary by forest type and sensitivity to changes in soil moisture and snowpack. Forests located in areas where soil moisture is the dominant limiting factor (like lower elevations in eastern Washington), for example, are likely to be negatively affected given projected decreases in soil moisture. Increased drought stress increases the risk of forest fire and vulnerability to insects such as the mountain pine beetle, particularly in areas east of the Cascades Mountains. Sea level rise is expected to require substantial infrastructure investments, increase the risk of coastal erosion, and threaten coastal habitat. Impacts on agriculture will vary with crop type and availability of irrigation water, particularly in the semi-arid interior PNW. The carbon dioxide fertilization effect (see Section 2.3) may increase agricultural production where water supplies are sufficient but may also increase competition with weeds and vulnerability to pests.

7. Alaska and the Arctic Region

Average annual temperature for the Arctic region, which includes Alaska, northern Canada, Greenland, Norway, Sweden, Finland, and northern Russia, is projected to increase 5.4 to 9°F over land for the 21st century (ACIA 2004). Projected winter temperature increases are even larger; models show an increase in average winter (December, January, and February) temperature on the order of 7.2 to 12.6°F over land by the 2090s. Total annual precipitation is likely to increase about 20% with most of the increase concentrated in the coastal regions and in winter and autumn. Although substantial, the expected increase in precipitation is not likely to be enough in many areas to compensate for increased evaporation from warmer temperatures.

The warming projected for the Arctic region will exacerbate many changes already occurring as a result of the dramatic warming seen in much of the region since the mid-20th century (up to

7.2°F during winter months). Sea ice extent is expected to decline 10 to 50% by the 2090s with most of the loss coming in the summer months. Animals dependent on sea ice, including polar bears and ringed seals, could become extinct before the end of the century as a result of this decline. Snow cover is likely to be reduced by 10-20%. Boreal (northern) forests are projected to expand northward into tundra regions while tundra expands into the polar desert regions, limiting habitat availability for some species and disrupting closely integrated ecosystems. White and black spruce, key tree species in Alaska's boreal forests, are likely to see decreased growth in drier interior regions as warmer temperatures increase drought stress. Increased drought stress and warmer temperatures also contribute to projected increases in the frequency, intensity, and duration of forest fires and losses from insects such as the spruce bark beetle and spruce budworm.

The social, cultural, and economic implications of climate change for the Arctic region are significant. Indigenous communities dependent on hunting, trapping, gathering, and fishing for sustenance as well as social and cultural traditions are likely to face greater challenges as the range of key species like salmon, herring, walrus, whales, caribou, and moose shift in response to warming temperatures. Thinning ice and thawing permafrost also increase the risk associated with hunting and gathering.

Damage to coastal infrastructure is likely to increase as sea level rise, increased winter storm surge reach (from loss of sea ice), and thawing permafrost contribute to increased coastal erosion. In the interior, thawing permafrost can damage water and sanitation pipes, oil and gas pipelines, roads, airstrips, buildings, and other critical infrastructure. Longer periods of thawing permafrost are also likely to limit access to logging and land-based oil and gas production activities. Alaska has already seen a 50% decline in the number of days where the tundra is sufficiently frozen to allow for transport of oil and gas exploration and extraction equipment. On the positive side, reduced sea ice may open more summer shipping routes and increase opportunities for off-shore oil exploration and extraction.

8. Islands of the Caribbean and the Pacific

Commonwealth of Puerto Rico and U.S. Virgin Islands in the Caribbean; Hawaiian Islands, American Samoa, Commonwealth of the Northern Mariana Islands, Guam, the Federated States of Micronesia, the Republic of the Marshall Islands, and the Republic of Palau in the Pacific.

The Hadley Center global climate model projects an increase in average annual temperature in the tropical Pacific Basin of 1.8°F for the 2025-2034 period (Shea et al. 2001). Much of this warming is concentrated in a horseshoe-shaped pattern extending southwest from the U.S./Mexico border and due west along the equator from the coasts of Central American and northern South America towards the international dateline. Additional analysis of late 21st century temperature projections (2071-2100) for the Pacific using nine global climate models projects an increase in average annual temperature of 3.6°F to 4.7°F depending on the greenhouse gas emissions scenario *(ibid)*. The pattern of concentrated warming is similar to that projected by the Hadley Center model. No specific temperature projections were provided in the National Assessment for the Caribbean, although average air and water temperatures are also projected to increase in the Caribbean (NAST 2000).

Precipitation projections for the Caribbean and the Pacific are variable depending on location, season, and model period. Winters are projected to get slightly wetter and summers slightly drier

in the Caribbean in the 21st century *(ibid)*. For the Pacific region, more precipitation is expected in some areas while other areas may experience drier conditions.

Climate change impacts to the Caribbean and Pacific Island regions are expected to be driven by increasing air and water temperatures; changes in natural variability (particularly the El Niño/La Niña oscillation); changes in the frequency, intensity, and pathways of tropical hurricanes and typhoons (collectively referred to as "cyclones"); changes in ocean circulation patterns; and sea level rise *(ibid)*. The small size and relative isolation of the islands make these areas particularly vulnerable to climate change impacts. Additionally, key components of many island economies – subsistence agriculture and fishing, tourism, commercial fishing, and commercial agricultural production – are highly sensitive to climate.

The availability of freshwater is a major concern. Many islands already face problems with freshwater supply as a result of increasing population, tourism, and urban centers (NAST 2000). These shortages are compounded by a lack of adequate storage and/or a mismatch between where the rain falls and where it is needed most. Climate change may reduce the amount and quality of freshwater by increasing the risk of drought and salt water intrusion into groundwater supplies, particularly on smaller islands. In the Caribbean, an increased risk of flooding and landslides due to more intense precipitation events is also a major concern *(ibid)*.

Sea level rise and storm surge are expected to have significant impacts on islands in the Caribbean and the Pacific. Many economic activities and population centers are concentrated on the coasts (Shea et al. 2001). Sea level in the Pacific region is projected to increase 3.9-4.7 inches in the 2020-2040 period and 11.8-15.0 inches by the 2080-2099 period *(ibid)*. Sea level rise increases the risk for erosion, inundation of low-lying areas, damage from storm surges, and salt water intrusion into groundwater supplies (NAST 2000).

Biodiversity of island ecosystems – both terrestrial and aquatic – is likely to be further stressed by climate change. Extinction rates in the island regions are already the highest relative to other regions of the U.S. due to habitat destruction and competition from invasive species. Species have limited ability to migrate in response to these and future changes given their small populations and physical isolation. Climate change may negatively affect forest ecosystems by increasing the risk for flooding, drought, fires, or disease (NAST 2000). Coastal mangrove swamps may also be squeezed out of existence where there is inadequate space to move inland in response to sea level rise. Warmer ocean temperatures may negatively impact coral reef communities by causing coral bleaching, in turn affecting the cultures, economies, and ecology of many island communities.

Changes in cyclone intensity, frequency, and paths could also have significant impacts on islands in the Caribbean and the Pacific. There is great uncertainty as to how climate change may affect these characteristics, however (NAST 2000). Increasing sea surface temperature in the Pacific is likely to expand areas in the Pacific where tropical cyclones form and migrate through, potentially increasing the risk of cyclones to many Pacific island communities (Shea et al. 2001).

9. Native Peoples and Homelands

Projected climate changes affecting native peoples and homelands in the United States in the coming century differ based on geographic location. At present, more than half of the two million native individuals currently registered with a tribe in the United States live on or near reservations, many acres of which are located in the western United States, southwestern United States, Great Plains and Alaska (NAST 2000). Projected climate change information for these

regions, provided in other summaries, can be potentially useful information for native peoples who live there. Other native people live in Hawaii and the Pacific and Caribbean Islands; the projected climate change impacts to these regions are also covered in separate summaries. However, specific information about climate change impacts does not exist uniformly for many native communities.

Native communities often rely more heavily on natural resources for subsistence and economic livelihood, have already been stressed by past relocations, and have fewer financial resources for disruptions to daily life *(ibid)*. Climate change impacts thus pose unique social, economic and cultural threats to these communities beyond what numerical information about temperature, precipitation and other climate trends can convey.

One example is that areas of the Arctic (including Alaska), where many native peoples rely on the land and the sea for food and livelihood, are projected to experience significant climate change impacts. According to models, rapid Arctic warming will continue to affect Alaska, with temperatures projected to increase between 1.5 and 5°F by 2030, and either 5 - 12°F or 7 - 18°F by 2100, depending on the model used (Hadley and Canadian, respectively) *(ibid)*. Northern regions and the winter season are expected to see the strongest warming trend. In the results of both commonly used models (Hadley and Canadian), precipitation is projected to increase across most of Alaska, with upwards of 20-25 percent projected increase in precipitation in the north and northwest, and a 10 percent projected decrease in the coastal south *(ibid)*. However, models also project that warming will be associated with increased evaporation, offsetting the precipitation increases and leading to drier soils throughout Alaska.

Anecdotally, Eskimo communities such as the Yupik have observed that winter seasons are warming, and that temperature shifts are disrupting key species in the regional food web on which their people rely. Satellite photos and related ecological analysis of sea ice retreat are consistent with these community observations that populations of fish, seals, walruses and other food sources are being weakened as a result of climate change *(ibid)*.

It is clear that a number of emerging issues expected to result from climate change will be common across native communities, such as:

- impacts to land-based and coastal economic livelihoods and subsistence, such as described in the Yupik community example, and exacerbating already poor economic conditions;
- human health impacts, such as extreme heat, expected to worsen already poor living conditions in rural areas which may not have electricity for cooling systems;
- impacts to status of water rights due to potentially reduced snowpack and changes in previously accepted seasonal streamflow patterns; and
- damage to or loss of historical and special heritage sites, such as ceremonial landscapes with culturally important traditions involving fish and wildlife *(ibid)*.

appendix d sources of information on climate change science, impacts, and adaptation

There are many sources of climate change information. These fall into several general categories, which are described below in Appendix D.1. Appendices D.2 through D.4 list a variety of organizations, reports, fact sheets, and web sites that may be helpful. This Appendix also includes information on the National Oceanic and Atmospheric Administration's Regional Integrated Sciences and Assessment (RISA) program, whose regional teams may provide a good starting point for understanding how climate change may affect your region (Appendix D.5).

D.1 Types of Climate Change Information

Before publication, most scientific results are examined and critiqued by independent scientific scholars in a process called "peer review." The peer review process helps prevent the publication of bad science. The process of critiquing a document is also called "refereeing."

Peer-reviewed assessment reports. Assessment reports, such as those developed by the Intergovernmental Panel on Climate Change or the United States' National Academy of Sciences, are invaluable. Scientific assessments collect the disparate and sometimes conflicting pieces, reviewing hundreds of scientific papers published in peer-reviewed journals. They reconcile different points of view where possible and note them where not, and summarize the state of knowledge in an (often lengthy) document.

Most peer-reviewed climate change assessment reports to-date provide climate change (temperature, precipitation, sea level rise) scenarios for various large regions of the world. These reports are also useful for developing a general sense of how different sectors are sensitive to climate. Regionally focused assessment reports can provide more in-depth and spatially relevant information on climate impacts.

- *Pros:* highly credible, often all or partially "translated" for understanding by an educated layperson, comprehensive evaluation of current state of understanding.
- *Cons:* typically focused on large geographic areas (continents, globe), may not provide sufficiently detailed information for regional planning efforts, scientific findings may be dense and difficult to understand despite translation.

Peer-reviewed journal articles and books. Single peer-reviewed journal articles and/or books can be useful for science advice, but are sometimes too limited in scope to provide policymakers with a robust perspective. These documents should be used in context of other findings, ideally under the guidance of a trained professional.

- *Pros:* highly credible, can provide more detailed information relevant to specific geographic areas and/or ecosystems/sectors.
- *Cons:* highly technical, narrow focus, difficult for layperson to ascertain the consistency of a single article or study with the broader scientific consensus.

The "gray literature" (papers and reports from research groups and governmental agencies; conference proceedings). Governmental agencies (like the Environmental Protection Agency and the Department of Energy), academic research groups, professional societies, and non-governmental organizations may produce papers or reports describing the results of research or assessment. This is referred to as gray literature. Conference proceedings are the collected papers presented at a conference or workshop. They often present preliminary research results, are not usually peer-reviewed, and may not be the final thoughts of the author. Some of these papers, reports, and conference papers are rewritten for later publication in a scientific or scholarly journal that is peer-reviewed.

- *Pros:* provide quick access to research results, may provide more in-depth and spatially relevant information on climate impacts
- *Cons:* may not be peer-reviewed, often hard to find (If you know that an agency or group has studied the problem you're interested in, you might need to contact them directly to find out whether they have a relevant research report.)

Fact sheets and brochures. Many institutions and organizations, such as the Environmental Protection Agency, Union of Concerned Scientists, produce fact sheets and/or brochures on climate change geared for the non-expert.

- *Pros:* typically presented in a form easily understood by the educated layperson
- *Cons:* summary format, lacks details and nuances necessary for confident use of the information in planning and analysis, often prepared by advocacy groups with possible biases, sources often not referenced (making it difficult to verify information and/or find more details on specific points).

Media Stories. National and local media outlets are increasingly reporting on the projected impacts of climate change. However, it is difficult for news stories to adequately convey the nuances and caveats associated with scientific information. Before using any of the information cited in a media story it is essential to verify it with the quoted source. Obtaining the more detailed information underlying that presented in the story helps ensure that the results are relevant for the application you have in mind.

- *Pros:* local media often focus on impacts projected for your specific community or region, presented in an easily understandable form.
- *Cons:* information must be verified with original source before using.

Sources: Robert E. Kennedy Library 2002, IPCC 2004, Stirling 2004, Center for Democracy and Technology 2007, National Academy of Sciences 2007.

D.2 Institutional Sources of Information on Climate Change Science, Impacts, and Adaptation

The following is a sampling of institutional information sources on climate change science, impacts, and adaptation.

MAJOR INSTITUTIONAL SOURCES	
International	
Organization	*Description*
ICLEI – Local Governments for Sustainability	ICLEI – Local Governments for Sustainability is an international association of almost 1,000 local governments worldwide and more than 250 in the United States that have made commitments to sustainable development and climate protection. ICLEI, founded in 1990 as the International Council on Local Environmental Initiatives and now known officially as ICLEI – Local Governments for Sustainability, strives to advance solutions to global climate change through cumulative local action. ICLEI provides technical and policy assistance, software training, climate expertise, information services and peer networking to help members build capacity, share knowledge, and implement sustainable development and climate protection at the local level. Website: *http://www.iclei.org/*
Intergovern-mental Panel on Climate Change (IPCC)	The IPCC was jointly established by the World Meteorological Society (WMO) and the United Nations Environment Programm (UNEP) in 1988 to assess scientific understanding of all aspects of climate change. The IPCC consists of three working groups: Working Group I assesses the scientific basis for climate change, Working Group II focuses on the impacts of and potential adaptations to climate change, and Working Group III addresses the mitigation (prevention or slowing) of climate change. Every five years, each working group publishes a peer-reviewed consensus report. The latest series of IPCC reports was published in spring 2007. While the IPCC charter is highly relevant to public policy, the IPCC does not establish or advocate specific actions. Website: *http://www.ipcc.ch/*
United Nations Environment Program (UNEP) – Climate Change	UNEP, established in 1972, is the voice for the environment within the United Nations system. UNEP acts as a catalyst, advocate, educator and facilitator to promote the wise use and sustainable development of the global environment. To accomplish this, UNEP works with a wide range of partners, including United Nations entities, international organizations, national governments, non-governmental organizations, the private sector and civil society. UNEP's climate change work covers a broad range of activities related to understanding, mitigating, and adapting to climate change. Website: *http://www.unep.org/themes/climatechange/*
World Meteorological Organization	WMO is a Specialized Agency of the United Nations (UN) with a membership of 187 Member States and Territories. It is the UN system's authoritative voice on the state and behavior of the Earth's atmosphere, its interaction with the oceans, the climate it produces, and the resulting distribution of water resources. Website: *http://www.wmo.ch/*

National (U.S.)	
Organization	*Description*
National Academy of Sciences (NAS)	The NAS brings together committees of experts in all areas of scientific and technological endeavor to provide pro bono assessments of critical national issues in the sciences and the arts for the U.S. government and the public. The NAS consists of four academies collectively known as the National Academies: the National Academy of Sciences, the National Academy of Engineering, the Institute of Medicine, and the National Research Council. The National Academies carry out a wide range of activities on issues related to global-scale changes in climate, land use and land cover, oceans and freshwater resources, atmospheric chemistry, and ecological systems resulting from natural variability or human influences, and the potential impacts of these changes on human systems and ecosystems. Website: *http://dels.nas.edu/globalchange/*
National Center for Atmospheric Research (NCAR)	NCAR is a federally funded center that conducts scientific research and provides facilities and services for the atmospheric and Earth sciences community. NCAR's climate change research covers a range of topics including past climate change, the greenhouse effect and global warming, projecting future climate, drought, and wildfires. NCAR is managed by a nonprofit consortium of North American universities called the University Corporation for Atmospheric Research (UCAR). Website: *http://www.ncar.ucar.edu/*
National Oceanic and Atmospheric Administration (NOAA)	NOAA is a federal agency within the U.S. Department of Commerce focused on the ocean and the atmosphere. NOAA's Climate Program Office (CPO) focuses on developing a broader user community for climate products and services, provides a focal point for climate activities within NOAA, leads NOAA climate education and outreach activities, and coordinates international climate activities. The CPO supports development and application of climate information at the regional scale through its Regional Integrated Sciences and Assessments (RISA) program (see below for more information on the RISA program). Website: *http://www.noaa.gov/climate.html*
United States Environmental Protection Agency (US EPA)	The EPA's mission is to protect human health and the environment. In practice, the EPA develops and enforces environmental regulations, offers financial assistance to state environmental programs and educational institutions research efforts, performs environmental research, sponsors voluntary partnerships and programs, and promotes environmental education. Much of EPA's work to date in the area of climate change has focused on programs for reducing greenhouse gas emissions. Website: *http://www.epa.gov/climatechange/*
U.S. Global Change Research Information Office (USGCRIO)	Provides access to data and information on climate change research, adaptation/mitigation strategies and technologies, and global change-related educational resources on behalf of the various U.S. Federal Agencies involved in the U.S. Global Change Research Program (USGCRP). Website: *http://www.gcrio.org/index.php*

State and Regional	
Organization	*Description*
Alaska Center for Climate Assessment and Policy (ACCAP)	The Alaska Center for Climate Assessment and Policy (ACCAP) was created to assess the socio-economic and biophysical impacts of climate variability in Alaska and make this information available to local and regional decision-makers. The Center also strives to improve the ability of Alaskans to adapt to a changing climate. Research efforts currently focus on climate impacts on Alaska's transportation sector and water resource management. ACCAP is a NOAA-funded Regional Integrated Sciences and Assessment (RISA) team. For more on the RISA program and teams, see Appendix D.5. Website: *http://www.uaf.edu/accap/*
California Applications Program (CAP)	The California Applications Program (CAP) and the California Climate Change Center (CCCC) aim to develop and provide better climate information and forecasts for decision makers in California and the surrounding region. By working directly with users, CAP and CCCC are working to evaluate climate information needs and utility from the user perspective. Research areas include hydrology and water resource management, forest fire, snowpack, and human health. CAP is a NOAA-funded Regional Integrated Sciences and Assessment (RISA) team. For more on the RISA program and teams, see Appendix D.5. Website: *http://meteora.ucsd.edu/cap/*
Carolinas Integrated Sciences and Assessments (CISA)	The Carolinas Integrated Sciences and Assessments (CISA) team is committed to improving the range, quality, relevance, and accessibility of climate information for decision-making and management of water resources in North and South Carolina. Major research areas include water resources management and coastal impacts. CISA is a NOAA-funded Regional Integrated Sciences and Assessment (RISA) team. For more on the RISA program and teams, see Appendix D.5. Website: *http://www.zebra-baker.com/CISA*
Climate Assessment for the Southwest (CLIMAS)	The Climate Assessment for the Southwest (CLIMAS) program was established to assess the impacts of climate variability and longer-term climate change on human and natural systems in the Southwest. The CLIMAS mission is to improve the ability of the region to respond sufficiently and appropriately to climatic events and climate changes. Major research areas include water resource management, snowpack, forestry and forest fires, agriculture, and human health. CLIMAS is a NOAA-funded Regional Integrated Sciences and Assessment (RISA) team. For more on the RISA program and teams, see Appendix D.5. Website: *http://www.ispe.arizona.edu/climas*
Climate Impacts Group (CIG)	The Climate Impacts Group (CIG) is an interdisciplinary research group studying the impacts of natural climate variability and global climate change ("global warming") on the U.S. Pacific Northwest. Through research and interaction with regional stakeholders, the CIG works to increase the resilience of the Pacific Northwest to fluctuations in climate. The CIG's research focuses on four key sectors of the Pacific Northwest environment: water resources, aquatic ecosystems, forests, and coasts. The CIG is a NOAA-funded Regional Integrated Sciences and Assessment (RISA) team. For more on the RISA program and teams, see Appendix D.5. Website: *http://www.cses.washington.edu/cig/*

State and Regional *continued*	
Organization	*Description*
New England Integrated Sciences and Assessment (NEISA)	The New England Integrated Sciences and Assessments (NEISA) is an engaged research program devoted to the development of decision relevant information concerning climate and air quality for the citizens of New England. NEISA is a University of New Hampshire coordinated, multi-institutional and multi-disciplinary integrated assessment focusing on the relationship between climate, air quality, and human health in New England. The NEISA climate change web page includes an interactive map of 150 stations in New England with links to climate indicator data. Data for all 150 stations also available for download from the site. Website: *http://neisa.unh.edu/*
NOAA Regional Climate Centers	A nationwide network of six regional centers that can assist in interpreting present past and present day climate conditions, quantifying climate variability, and assessing the likelihood of extreme weather events. The Regional Climate Centers are supported by the National Climate Data Center at the National Oceanic and Atmospheric Administration. Website: *http://www.ncdc.noaa.gov/oa/climate/regionalclimatecenters.html*
Northeast Climate Impacts Assessment (NECIA)	The Northeast Climate Impacts Assessment (NECIA) is a collaboration between the Union of Concerned Scientists (UCS) and a team of independent experts to develop and communicate a new assessment of climate change and associated impacts on key climate-sensitive sectors in the northeastern United States. Website: *http://www.northeastclimateimpacts.org/*
Pacific Regional Integrated Sciences and Assessment (Pacific RISA)	The Pacific Islands Regional Integrated Science and Assessment (Pacific RISA) program is focused on reducing Pacific Island vulnerability to climate-related extreme events such as drought, floods, and tropical cyclones. The program emphasizes the effective engagement of Pacific Island communities, governments and businesses in developing effective policies to build resilience in key sectors such as water resource management, coastal resources, agriculture, tourism, disaster management and public health. Pacific RISA is a NOAA-funded Regional Integrated Sciences and Assessment (RISA) team. For more on the RISA program and teams, see Appendix D.5. Website: *http://research.eastwestcenter.org/climate/risa/*
Southeast Climate Consortium (SECC)	The Southeast Climate Consortium (SECC) uses advances in climate sciences, including improved capabilities to forecast seasonal climate, to provide scientifically sound information and decision support tools for agriculture, forestry, and water resources management in the Southeastern U.S. The SECC conducts research and outreach to a broad community of potential users and forms partnerships with extension and education organizations to ensure that SECC products are relevant and reliable. The SECC is a NOAA-funded Regional Integrated Sciences and Assessment (RISA) team. For more on the RISA program and teams, see Appendix D.5. Website: *http://secc.coaps.fsu.edu/*

State Climatologists	State Climatologists are individuals who have been identified by a state entity as the state's climatologist and who are also recognized by the Director of the National Climatic Data Center (NCDC) of the National Oceanic and Atmospheric Administration as the state climatologist of a particular state. State Climatologists currently exist in 47 states and Puerto Rico. They are typically either employees of state agencies or are staff members of state-supported universities. While the specific services provided by any single State Climatologist office will vary, the overall function of the State Climatologist is to collect, disseminate, and interpret climate data. Website: *http://www.stateclimate.org/*
Western Water Assessment (WWA)	The Western Water Assessment (WWA) works to identify and characterize regional vulnerabilities to climate variability and change, and to develop information, products, and processes to assist water-resource decision makers throughout the Intermountain West. Research areas include water and climate, tree-ring reconstructions of streamflow, an Intermountain West climate summary, the Colorado River, water demand and conservation, and western water law and policy. The WWA is a NOAA-funded Regional Integrated Sciences and Assessment (RISA) team. For more on the RISA program and teams, see Appendix D.5. Website: *http://wwa.colorado.edu/*
Non-profit	
Organization	*Description*
Colleges and universities	Researchers at state and local universities can be a source of technical expertise. Relevant departments/ programs may include atmospheric sciences, environmental sciences, civil and environmental engineering, biology, chemistry, forestry, marine sciences, and public policy. State and local university libraries are also good places to find peer-reviewed journals and other published information on climate change. *Website: (varies with each organization)*
Heinz Center	The Heinz Center is a nonprofit institution dedicated to improving the scientific and economic foundation for environmental policy through multisectoral collaboration among industry, government, academia, and environmental organizations. The broad goal of the Global Change program at the Heinz Center is to continue analysis of policy responses to global environmental changes, both in terms of mitigating change and in terms of preparing for change. Some Heinz Center publications may be of particular interest to impacts and adaptation work. *Website: http://www.heinzctr.org/Programs/Global_Change/index.shtml*
National Council for Science and the Environment	The National Council for Science and the Environment is a not-for-profit organization dedicated to improving the scientific basis for environmental decision-making. The Council works closely with the many communities creating and using environmental knowledge, including research, education, environmental, and business organizations, as well as governmental bodies at all levels. *Website: http://ncseonline.org/*

Non-profit *continued*	
Pew Center for Climate Change	A non-profit and non-partisan organization bringing together business leaders, policy makers, scientists, and other experts for analysis of key climate issues and outreach to policy makers and other key stakeholders. *Website: http://www.pewclimate.org/*
Union of Concerned Scientists	UCS is an independent nonprofit alliance of more than 100,000 concerned citizens and scientists. UCS was founded in 1969 by faculty members and students at the Massachusetts Institute of Technology who were concerned about the misuse of science and technology in society. UCS activities include conducting technical studies; working with policymakers, the news media, and the public; and issue advocacy. *Website: http://www.ucsusa.org/*

Table D.2 – Institutional Sources of Information on Climate Change Science, Impacts, and Adaptation

D.3 Sources of Information on Climate Change Science

The following is a sample list of information sources on climate change science. Information is listed within general categories first by scope (general, global, national, regional, state, city) then by title; the specific order should not be seen as an endorsement of any one source over another. Please note that the "last modified" dates provided for web sites in this table may not apply to all pages on the site and do not guarantee that the information presented on the site is the most up-to-date assessment of climate change science. Readers are encouraged to check with first authors (for papers and reports), sponsoring organization (for web sites), or other institutional sources (e.g., local universities). See Appendix D.2 for information on the institutions identified in this table.

GLOBAL WARMING SCIENCE		
Scope	*Title*	*Description*
General	Ask Dr. Global Change	Web site created by the U.S. Global Change Research Information Office (GCRIO) using a question and answer format that covers a variety of topics related to climate and climate change. Updated on an as-needed basis. Website: *http://www.gcrio.org/doctorgc/index.php*
General	Climate Change 101: The Science and Impacts	An 8-page brochure written by The Pew Center providing an overview of the scientific evidence of climate change and explaining the causes and projected impacts of climate change. Published in 2006. Website: *http://www.pewclimate.org/docUploads/101_Science_Impacts.pdf*
General	Climate Change	Web site created by the U.S. Environmental Protection Agency (US EPA) providing a general overview of the climate change science and policy, greenhouse gas emissions, health and environmental effects, and strategies for reducing individual greenhouse gas contributions. Also includes a comprehensive database of 250 climate change-related web sites and a climate change web site for kids. Last modified in 2007. Website: *http://epa.gov/climatechange/index.html*
General	Climate Change Science	Web site created by the United Nations Framework Convention on Climate Change (UNFCCC) providing basic information on the greenhouse effect and the carbon cycle, current evidence of climate change, future climate change impacts, and the Intergovernmental Panel on Climate Change. Information also available in Spanish. Website: *http://unfccc.int/essential_background/feeling_the_heat/items/2902.php*
General	The Discovery of Global Warming	Web site and book with the same title providing a history of how scientists came to understand the influence of humans on climate. Both the book and the website are authored by Dr. Spencer Weart, a physicist and science historian at the University of Maryland. Book published in 2003. Web page last modified in 2005. Website: *http://www.aip.org/history/climate/*

GLOBAL WARMING SCIENCE *continued*		
Scope	*Title*	*Description*
General	Encyclopedia of the Earth	Web site created by the National Council for Science and the Environment featuring a fully searchable collection of articles written in non-technical language by scholars, professionals, educators, and experts who collaborate and review each other's work. The scope of the Encyclopedia is the environment broadly defined, with particular emphasis on the interaction between society and the natural spheres of the Earth. The site is a specially adapted "wiki" where access is restricted to approved experts and all content is reviewed and approved by Topic Editors prior to being published from the wiki to public Encyclopedia. Released 2006 and continuously updated Website: *http://www.eoearth.org/*
General	Global Warming	Web site created by the National Aeronautics and Space Administration's (NASA) Earth Observatory with information on global warming and what it is, evidence for global warming, building a climate model, predicting future warming, and potential effects of global warming. Last modified May 2007. Website: *http://earthobservatory.nasa.gov/Library/GlobalWarmingUpdate*
General	Global Warming Frequently Asked Questions	Web site created by the National Oceanic and Atmospheric Administration (NOAA) providing brief answers to questions like "What is the greenhouse effect?", "Is climate becoming more variable?", and "Is sea level rising?". Last modified in 2006. Website: *http://www.ncdc.noaa.gov/oa/climate/globalwarming.html*
General	Global Warming Science	Web site for the Union of Concerned Scientists (UCS) providing a variety of "Global Warming 101" summaries on global warming science and impacts. Also includes links to several regional and state-specific impacts assessments. Pages updated in 2005 and 2006. Website: *http://www.ucsusa.org/global_warming/science/*
General	The Paleo Perspective on Climate Change	Web site created by the National Oceanic and Atmospheric Administration (NOAA) providing information on climate change, how scientists study climate change, and how tree rings, ice cores, and other natural recorders of historic climate are used to gain better understanding of Earth's climate. Last modified in 2006. Site also available in Spanish. No "last updated" information provided. Website: *http://www.ncdc.noaa.gov/paleo/globalwarming/paleostory.html*
General	Weather and Climate Basics	Web site created by the National Center for Atmospheric Research (NCAR) providing basic overviews of weather and climate change. Includes link to web site for children. Last modified in 2003. Website: *http://eo.ucar.edu/basics/index.html*

MORE DETAILED MATERIALS		
Scope	*Title*	*Description*
General	Climate Change Science: An Analysis of Some Key Questions	National Academy of Sciences (NAS) publication written at the request of the White House to help inform the Administration's ongoing review of U.S. climate change policy. The report answers specific questions about climate change, such as: "Is climate change occurring? If so, how much?" and "Is human activity the cause of increased concentrations of greenhouse gases and other emissions that contribute to climate change?". Published in 2001. Website: *http://newton.nap.edu/html/climatechange/index.html*
General	CGD Research: Climate FAQs	Web site created by the Climate and Global Dynamics Division of the National Center for Atmospheric Research (NCAR) Earth & Sun Systems Laboratory addressing frequently asked questions (FAQs) about climate change. No "last updated" information provided. Website: *http://www.cgd.ucar.edu/research/faqs/*
Global	Climate Change 2007: The Physical Science Basis, Summary for Policy Makers	An 18-page report by the Intergovernmental Panel on Climate Change (IPCC) Working Group I summarizing its latest comprehensive assessment of observed and projected global climate change. The Fourth Assessment Report builds upon past IPCC assessments and incorporates new knowledge gained since the Third Assessment in 2001. Final language in the Summary for Policy Makers was approved, line-by-line, by consensus with scientists and government representatives from 113 countries. Published in 2007. See related entries for the Technical Summary and Foundation Report for more information. Website: *http://ipcc-wg1.ucar.edu/wg1/wg1-report.html*
Global	Climate Change 2007: The Physical Science Basis, Technical Summary	More detailed summary of the Intergovernmental Panel on Climate Change (IPCC) Working Group I report assessing current scientific knowledge of climate change drivers, observed changes in climate, and future climate change projections. The Fourth Assessment Report builds upon past IPCC assessments and incorporates new knowledge gained since the Third Assessment in 2001. Published in 2007. See related entries for the Summary for Policy Makers and Foundation Report for more information. Website: *http://ipcc-wg1.ucar.edu/wg1/wg1-report.html*
Global	Intergovernmental Panel on Climate Change Fourth Assessment Report Frequently Asked Questions	A 34-page report prepared by the Intergovernmental Panel on Climate Change (IPCC) Working Group I answering a variety of "Frequently Asked Questions" (FAQs) about global climate change, including what factors determine earth's climate?, what is the relationship between climate change and weather?, what is the greenhouse effect?, how are temperatures on earth changing?, how is precipitation changing?, and what caused the ice ages and other important climate changes before the industrial era?. Answers to the FAQs are based on the IPCC's most recent Fourth Assessment Working Group I report, *Climate Change 2007: The Physical Science Basis*. Website: *http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Pub_FAQs.pdf*

TECHNICAL-LEVEL MATERIALS		
Scope	*Title*	*Description*
General	Real Climate	Web blog for discussion by prominent climate scientists of recent peer-reviewed journal articles, general media articles on climate, and other "hot topics". Updated daily. Website: *http://www.realclimate.org*
Global	Climate Change 2007: The Physical Science Basis, Foundation Report	Detailed report by the Intergovernmental Panel on Climate Change (IPCC) Working Group I assessing current scientific knowledge of climate change drivers, observed changes in climate, and future climate change projections. The Fourth Assessment Report builds upon past IPCC assessments and incorporates new knowledge gained since the Third Assessment in 2001. The Foundation Report was produced by more than 600 authors from 40 countries. More than 620 expert reviewers and a large number of government reviewers also participated. Published in 2007. See related entries for the Summary for Policy Makers and Technical Summary for more information. Website: *http://ipcc-wg1.ucar.edu/wg1/wg1-report.html*
INFORMATION CLEARINGHOUSE WEBSITES		
Scope	*Title*	*Description*
General	Climate Change Related Links Directory	Comprehensive on-line database of 250 climate change-related web sites compiled by the U.S. Environmental Protection Agency. Last modified in 2007. Website: *http://epa.gov/climatechange/index.html*
General	Earth Portal	Web site created by the National Council for Science and the Environment to provide access to a comprehensive source of understandable science-based information on the Internet. The first components of the Earth Portal, The Encyclopedia of the Earth, was released in 2006 (see entry above). Other components of the Earth Portal will be available after April 22, 2007. Website: http://www.ncseonline.org/05earthportal/cms.cfm?id=1250
General	Global Warming and Climate Change Policy Websites	NASA Goddard Space Flight Center web page with an extensive list of climate change science and policy web sites. Website: *http://gcmd.gsfc.nasa.gov/Resources/pointers/glob_warm.html*

Table D.3 – Sources of Information on Climate Change Science

D.4 Sources of Information on Climate Change Impacts and Adaptation

This table highlights some of the information available on climate change impacts and adaptation. This list is not all-inclusive and does not include individual peer-reviewed publications found in scientific journals. See Appendix D.2 for information on the institutions identified in this table.

GLOBAL WARMING IMPACTS AND ADAPTATION		
International, Multi-national, or Other		
Scope	*Title*	*Description*
Global	*Climate Change 2007: Impacts, Adaptation and Vulnerability, Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report*	Comprehensive peer-reviewed assessment by the Intergovernmental Panel on Climate Change (IPCC) of observed and projected climate change impacts on water resource management, ecosystems, coastal systems, food production, forests, human health, and industry and societies. The report also includes an assessment of adaptation practices, options, constraints, and capacity. Major regional summaries (e.g., North America, Europe, Asia, etc.) are also included. The Fourth Assessment Report builds upon past IPCC assessments and incorporates new knowledge gained since the Third Assessment in 2001. The report includes a Summary for Policy Makers (SPM), a Technical Summary, and the full-length detailed chapters. The report was authored by more than 600 scientists with extensive peer review by the scientific and policy community. Final language in the SPM was negotiated line-by-line by appointed IPCC and national government representatives. Published in 2007. Website: *www.ipcc-wg2.org/*
Global	The Urban Climate Change Research Network	The Urban Climate Change Research Network (UCCRN) is a consortium of individuals and institutions dedicated to the analysis of climate change mitigation and adaptation and energy issues from an urban perspective. It is designed to enhance cutting-edge scientific, economic and planning-related research and to promote knowledge sharing among researchers and urban decision-makers and stakeholders about all aspects of climate change and cities. The network will be a valuable researchers, individual cities, coalitions of Mayors, and organizations focused on providing technical assistance to cities. Website: *www.uccrn.org/Site/Home.html*
North America	Chapter 14 – *North America, in Climate Change 2007: Impacts, Adaptation and Vulnerability, Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report*	Chapter 14 in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report on impacts, adaptation, and vulnerability (see above description). Chapter summarizes observed and projected climate change impacts on North America. Published in 2007. Website: *www.ipcc-wg2.org/*

National		
Scope	*Title*	*Description*
United States	*Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change*	Commonly referred to as the "National Assessment", this peer-reviewed report provides an overview of the consequences of climate change for the U.S. as a whole and for specific geographic regions (e.g., Northeast, Southeast, Great Plains) and resource sectors (e.g., agriculture, water, human health). The results of the National Assessment are provided in a 154-page overview report and a 612-page foundation report, which provides more detailed information on each region and sector. More than 300 scientific and technical experts provided detailed comments on part or all of the report in two separate technical reviews. Published in 2000. Website: *www.usgcrp.gov/usgcrp/nacc/default.htm*
United States	*Observed Impacts of Global Climate Change in the U.S.*	A 67-page report published by the Pew Center on Global Climate Change reviewing the broad range of ecological changes that have occurred in response to observed changes in global and U.S. climate. Published in 2004. Website: *www.pewclimate.org/global-warming-in-depth/all_reports/observedimpacts/index.cfm*
United States	*A Synthesis of Potential Climate Change Impacts on the United States*	A 56-page report published by the Pew Center on Global Climate Change concluding a series of Pew Center reports that examine the impacts of climate change on several economic sectors and natural resources in the U.S. Published in 2004. Website: *http://www.pewclimate.org/docUploads/Pew-Synthesis.pdf*
Regional (all for the U.S. unless noted otherwise)		
Scope	*Title*	*Description*
Great Lakes region	*Confronting Climate Change in the Great Lakes Region: Impacts on Our Communities and Ecosystems*	A 92-page report released by the Union of Concerned Scientists (UCS) and the Ecological Society of America, and written by leading university and government scientists in the Great Lakes region. This report examines the potential impacts of climate change upon the various ecosystems of the Great Lakes region. Web site includes links to individual state summaries, fact sheets, and Power Point slides. Published April 2003. Website: *www.ucsusa.org/greatlakes/glchallengereport.html*
Great Lakes region	*Preparing for Climate Change: The Potential Consequences of Climate Variability and Change: Great Lakes Overview*	A 106-page regional report produced as part of the 2000 U.S. National Assessment (see description in "National" section). Provides details on observed changes in 20th century climate and projected climate change impacts on the Great Lakes region. Includes information on water resources, water ecology, land ecology, agriculture, human health, and recreation and tourism. Although some of the specific details of the assessment may be out of date, the report can be used to develop a basic understanding of where climate sensitivities may exist. Published October 2000. Website: *www.gcrio.org/NationalAssessment/greatlakes/greatlakes.pdf*

Great Plains states	*Potential Consequences of Climate Variability and Change for the Great Plains*	A 27-page regional report produced as part of the 2000 U.S. National Assessment (see description in "National" section). Provides details on observed changes in 20th century climate and projected climate change impacts on the Great Plains states. Although some of the specific details of the assessment may be out of date, the report can be used to develop a basic understanding of where climate sensitivities may exist, particularly in states with little recent information. Published 2000. Website: *www.usgcrp.gov/usgcrp/nacc/greatplains.htm*
Great Plains states (central)	*Preparing for Climate Change: The Potential Consequences of Climate Variability and Change: Central Great Plains*	A 104-page report produced as part of the 2000 U.S. National Assessment (see description in "National" section). Provides details on projected climate change impacts on the central Great Plains states. Includes information on water resources, cropping systems, ranching and livestock, conservation/natural areas, and wildlife. Although some of the specific details of the assessment may be out of date, the report can be used to develop a basic understanding of where climate sensitivities may exist. Published July 2002. Website: *www.nrel.colostate.edu/projects/gpa/*
Gulf Coast region	*Confronting Climate Change in the Gulf Coast Region: Prospects for Sustaining Our Ecological Heritage*	An 82-page report released by the Union of Concerned Scientists (UCS) and the Ecological Society of America and written by leading university and government scientists in the Gulf states. This report examines the potential impacts of climate change upon the various ecosystems of the Gulf Coast region. Web site includes links to individual state summaries, fact sheets, and Power Point slides. Published October 2001. Website: *www.ucsusa.org/gulf/gcchallengereport.html*
Gulf Coast region	*Preparing for Climate Change: The Potential Consequences of Climate Variability and Change: Gulf Coast Region*	An 85-page regional report produced as part of the 2000 U.S. National Assessment (see description in "National" section). Summarizes key findings from stakeholder workshops in 1998 and provides detailed analysis of climate impacts to coastal ecosystems and maritime forests. Although some of the specific details of the assessment may be out of date, the report can be used to develop a basic understanding of where climate sensitivities may exist. Published June 2003. Website: *www.usgcrp.gov/usgcrp/Library/nationalassessment/gulfcoast/gulfcoast-brief.pdf*
Mid-Atlantic States	*Preparing for a Changing Climate: Mid-Atlantic Overview*	A 68-page report produced as part of the 2000 U.S. National Assessment (see description in "National" section). The report identified potential positive and negative impacts of climate change and variability across the Mid-Atlantic Region, focusing on agriculture, forests, fresh water quantity and quality, coastal zones, ecosystems, and human health. Published March 2000. Website: *www.usgcrp.gov/usgcrp/Library/nationalassessment/newsletter/2000.06/midatl.html*

Regional (all for the U.S. unless noted otherwise) ***continued***		
Scope	*Title*	*Description*
Midwest	*Potential Consequences of Climate Variability and Change for the Mid-western United States*	A 22-page regional report produced as part of the 2000 U.S. National Assessment (see description in "National" section). Provides details on observed changes in 20th century climate and projected climate change impacts on the U.S. Midwest. Although some of the specific details of the assessment may be out of date, the report can be used to develop a basic understanding of where climate sensitivities may exist, particularly in states with little recent information. Published 2000. Website: *www.usgcrp.gov/usgcrp/nacc/midwest.htm*
Native peoples and homelands	*Potential Consequences of Climate Variability and Change for Native Peoples and Homelands*	A 27-page regional report produced as part of the 2000 U.S. National Assessment (see description in "National" section). Provides details on observed changes in 20th century climate and projected climate change impacts on Native peoples and homelands in the U.S. Although some of the specific details of the assessment may be out of date, the report can be used to develop a basic understanding of where climate sensitivities may exist, particularly in states with little recent information. Published 2000. Website: *www.usgcrp.gov/usgcrp/Library/nationalassessment/12Native.pdf*
Northeast states	*Climate Change in the U.S. Northeast*	A 52-page report providing information on climate change impacts to regional temperature, extreme events, streamflows and water supply, winter snow, and sea level rise. The web site also includes a 8-page summary fact sheet. A major synthesis report on the impacts of climate change to forests, agriculture, coastal marine resources, human health, and urban centers is expected in 2007. Published October 2006. Website: *www.climatechoices.org/ne/resources_ne/nereport.html*
Northeast states	*Confronting Climate Change in the U.S. Northeast: Climate, Impacts, and Solutions,*	A 160-page report produced by the Northeast Climate Impacts Assessment (NECIA), which represents a collaboration between the Union of Concerned Scientists (UCS) and a team of more than fifty independent experts to develop and communicate a new assessment of climate change, impacts on climate-sensitive sectors, and solutions in the northeastern United States. Report topics include impacts to coasts, marine environments, forests, water, agriculture, winter recreation, and human health. Most of the research is also presented in more technical detail in the formal scientific literature, including a special issue of the journal *Mitigation and Adaptation Strategies to Global Change* (in press, 2008). These thirteen papers, as well as several additional peer-reviewed NECIA technical papers and technical appendices, are available for download on the Northeast Climate Impacts web page. Published July 2007. Website: *www.northeastclimateimpacts.org/*

Northeast states	*Indicators of Climate Change in the Northeast*	A 40-page report summarizing how key indicators of New England climate and ecosystems have been changing over the past 100 years. Indicators examined include temperature, growing season, bloom dates, ice break-up, precipitation, sea level rise, sea surface temperature, and snowpack. Report produced by Clean Air – Cool Planet (*www.cleanair-coolplanet.org*) and the University of New Hampshire – Climate Education Initiative (*www.sustainableunh.unh.edu/climate_ed/*). Published October 2005. Host website includes an interactive map of 150 stations in New England with links to climate indicator data. Data for all 150 stations also available for download from the site. Website: *neisa.unh.edu/Climate/index.html*
Northeast states	*Potential Consequences of Climate Variability and Change for the Northeastern United States*	A 26-page regional report produced as part of the 2000 U.S. National Assessment (see description in "National" section). Provides details on observed changes in 20th century climate and projected climate change impacts on the Northeast. Although some of the specific details of the assessment may be out of date, the report can be used to develop a basic understanding of where climate sensitivities may exist, particularly in states with little recent information. Published 2000. Website: *www.usgcrp.gov/usgcrp/nacc/northeast.htm*
Pacific Northwest	*Impacts of Climate Variability and Change: Pacific Northwest*	A 116-page regional report produced by the University of Washington's Climate Impacts Group as part of the 2000 U.S. National Assessment (see description in "National" section). Provides details on observed changes in 20th century climate and projected climate change impacts on the U.S. Pacific Northwest. Although some of the specific details of the assessment are out of date (e.g., 21st century temperature projections), the report can be used to develop a basic understanding of where climate sensitivities exist in the Pacific Northwest. Published 1999. Website: *www.cses.washington.edu/db/pdf/moteetalgreenbook96.pdf*
Pacific Northwest	*Sea-level Rise and Coastal Habitats in the Pacific Northwest: An Analysis for Puget Sound, Southwestern Washington, and Northwestern Oregon*	A 106-page report produced by the National Wildlife Federation examining the implications on climate change and sea level rise on coastal habitat in the U.S. Pacific Northwest. Published July 2007. Website: *http://www.nwf.org/sealevelrise/*
Rocky Mountain/Great Basin states	*Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change, Rocky Mountain/Great Basin*	A 240-page regional report produced as part of the 2000 U.S. National Assessment (see description in "National" section). Provides details on observed changes in 20th century climate and projected climate change impacts on the Rock Mountain/Great Basin region in the following sectors: water, agriculture and ranching, outdoor recreation and tourism, and natural ecosystems (Rocky Mountain, Aquatic, and Great Basin ecosystems). Although some of the specific details of the assessment may be out of date, the report can be used to develop a basic understanding of where climate sensitivities may exist, particularly in states with little recent information. Published February 2003. No online copy available.

Regional (all for the U.S. unless noted otherwise) ***continued***		
Scope	*Title*	*Description*
Southeast	*Potential Consequences of Climate Variability and Change for the Southeastern United States*	A 28-page regional report produced as part of the 2000 U.S. National Assessment (see description in "National" section). Provides details on observed changes in 20th century climate and projected climate change impacts on the Southeast. Although some of the specific details of the assessment may be out of date, the report can be used to develop a basic understanding of where climate sensitivities may exist, particularly in states with little recent information. Published 2000. Website: *www.usgcrp.gov/usgcrp/nacc/se-mega-region.htm*
Southeast	*Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change, Southeast Report*	A 111-page regional report produced as part of the 2000 U.S. National Assessment (see description in "National" section). Provides details on observed changes in 20th century climate and projected climate change impacts on the Southeast in the following sectors: agriculture, forests, water quality, air quality, and extreme weather. Although some of the specific details of the assessment may be out of date, the report can be used to develop a basic understanding of where climate sensitivities may exist, particularly in states with little recent information. Published December 2002. No online copy available.
Southwest	*Preparing for a Changing Climate: Southwest*	A 66-page report produced as part of the 2000 U.S. National Assessment (see description in "National" section). Provides an assessment of the impacts of climate variability and climate change on important social and economic sectors, including ranching, water resources, mining, urban areas, natural ecosystems, energy, and human health. Published September 2000. Website: *www.ispe.arizona.edu/research/swassess/index.html*
U.S.-affiliated Pacific Islands	*Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change, Pacific Islands Report*	A 97-page report published in October 2001 summarizing the key findings and recommendations of the Pacific Islands Regional Assessment of the Consequences of Climate Variability and Change (the Pacific Assessment). The Pacific Assessment was conducted as a regional contribution to the 2000 U.S. National Assessment (see description in "National" section). Provides information on projected climate change in the tropical Pacific, impacts to Pacific islands, and considerations for adapting to climate change. Website: *www2.eastwestcenter.org/climate/assessment/report.htm*
U.S.-affiliated Pacific and Caribbean islands	*Potential Consequences of Climate Variability and Change for the U.S.-Affiliated Islands in the Pacific and Caribbean*	A 35-page regional report produced as part of the 2000 U.S. National Assessment (see description in "National" section). Provides details on observed changes in 20th century climate and projected climate change impacts on the U.S.-affiliated islands in the Pacific and Caribbean. Although some of the specific details of the assessment may be out of date, the report can be used to develop a basic understanding of where climate sensitivities may exist, particularly in states with little recent information. Published 2000. Website: *www.usgcrp.gov/usgcrp/nacc/islands.htm*

Western states	*Potential Consequences of Climate Variability and Change for the Western United States*	A 27-page regional report produced as part of the 2000 U.S. National Assessment. Provides details on observed changes in 20th century climate and projected climate change impacts on the western U.S. Although some of the specific details of the assessment may be out of date, the report can be used to develop a basic understanding of where climate sensitivities may exist, particularly in states with little recent information. Published 2000. Website: *www.usgcrp.gov/usgcrp/nacc/west.htm*
State		
Scope	*Title*	*Description*
All states	USEPA state climate change impacts information sheets	This series of fact sheets, produced by the USEPA in 1998, provides an overview of projected climate change impacts on a state-by-state basis. Although the specific details (e.g., temperature projections) may be out of date, the fact sheets can be used to get a basic understanding of where climate sensitivities may exist, particularly in states with little recent information. Website: *yosemite.epa.gov/oar/globalwarming.nsf/content/ImpactsStateImpacts.html*
Alaska	*Potential Consequences of Climate Variability and Change for Alaska*	A 30-page regional report produced as part of the 2000 U.S. National Assessment (see description in "National" section). Provides details on observed changes in 20th century climate and projected climate change impacts on Alaska. Although some of the specific details of the assessment may be out of date, the report can be used to develop a basic understanding of where climate sensitivities may exist. A more comprehensive assessment for the entire Arctic region was completed in 2004 (see following description). Published 2000. Website: *www.usgcrp.gov/usgcrp/nacc/alaska-mega-region.htm*
Alaska	*Impacts of a Warming Arctic: Arctic Climate Impact Assessment*	The first comprehensive, peer-reviewed evaluation of Arctic climate change and impacts for the region and the world. The Scientific Report (1,042 pages) includes chapters on past and present day Arctic climate, climate change modeling and scenarios, and climate change impacts on Arctic ecosystems, indigenous culture, and infrastructure. The Overview Report (140 pages) provides a summary of the more detailed Scientific Report. Prepared by an international team of more than 300 scientists, other experts, and members of the Arctic's indigenous communities. Published in 2004. Website: *www.acia.uaf.edu/*
California	California Climate Change Portal	Comprehensive web site created by the State of California to support the state's efforts to reduce greenhouse gas emissions and adapt to climate change impacts. Website: *www.climatechange.ca.gov/*

State *continued*		
Scope	*Title*	*Description*
California	*Our Changing Climate: Assessing the Risks to California*	The first of a series of biennial science reports produced by the State of California on the potential impact of global warming on certain sectors of the California economy. The report includes information on future global warming scenarios for the state and associated impacts to public health, water resources, agriculture, forests and landscapes, and coasts (via sea level rise). Numerous appendices provide more detail on each of these areas. Also available in Spanish. Published 2006. Website: *www.climatechange.ca.gov/biennial_reports/2006report/index.html*
California	*Preparing for the Impacts of Climate Change in California: Opportunities and Constraints for Adaptation*	This white paper examines California's opportunities and constraints for managing the impacts of climate change. It reviews the extant literature on adaptation and provides examples from selected sectors in California to illuminate the constraints and, in some cases, limits to the ability to adapt to climate change. Based on these insights, recommendations are made for how government, research, and civil society can help California most effectively prepare for climate change impacts. Published March 22, 2006. Website: *www.energy.ca.gov/2005publications/CEC-500-2005-198/CEC-500-2005-198-SF.PDF*
Iowa	Climate Change in the Hawkeye State	Web page by the Union of Concerned Scientists (UCS) summarizing climate change impacts to Iowa. Includes links to 1) a fully referenced 16-page report on climate impacts on Iowa (published January 2004), 2) a 4-page fact sheet of the report, and 3) a 14-page technical summary of climate change projections for Iowa. Page last updated August 10, 2005. Website: *www.ucsusa.org/global_warming/science/climate-change-in-the-hawkeye-state.html*
Minnesota	Global Climate Change and its Impact on Minnesota	Web page by the Minnesota Pollution Control Agency providing an overview of climate change, why it is a concern to Minnesotans, and greenhouse gas emissions trends. Includes link to a 2-page fact sheet on climate change impacts to Minnesota (created December 2002). Page last updated January 24, 2007. Website: *www.pca.state.mn.us/hot/globalwarming.html*
New Hampshire	Global Warming in New Hampshire	Web page by Union of Concerned Scientists (UCS) summarizing climate change impacts on New Hampshire. Page includes a link to a 5-page fact sheet on global warming impacts to New Hampshire's climate, economy, and health. Page last updated March 20, 2006. Website: *www.ucsusa.org/global_warming/science/global-warming-in-new-hampshire.html*

New Mexico	*Potential Effects of Climate Change on New Mexico*	A 51-page report prepared by state agency personnel in accordance with Governor Bill Richardson's Climate Change and Greenhouse Gas Reduction Executive Order 05-033, issued June 9, 2005. The report provides an overview of climate change impacts on water resources, infrastructure, agriculture natural systems, outdoor recreation and tourism, environmental quality and health, and environmental justice and native peoples in New Mexico. Published December 30, 2005. Website: *www.nmenv.state.nm.us/aqb/cc/Potential_Effects_Climate_Change_NM.pdf*
North Carolina	*Measuring the Impacts of Climate Change on North Carolina Coastal Resources*	A 101-page report assessing the impacts of climate change on North Carolina's coastal real estate market, the impacts of sea-level rise on coastal recreation and tourism, and the impacts of stronger tropical storms and hurricanes on business activity. The report's website includes a summary brochure and PowerPoint presentation. Published March 15, 2007. Website: *econ.appstate.edu/climate/*
Oregon	*The Economic Impacts of Climate Change in Oregon: A Preliminary Assessment*	A 25-page report published by Resource Innovations, a research and technical assistance program at the University of Oregon, providing a preliminary assessment of the economic impacts of climate change on eight key sectors of Oregon's $121 billion economy: municipal water supplies, agriculture, forestry, snow-based recreation, coastal tourism and infrastructure, power generation, salmon recovery, and public health. Published October 2005. Website: *climlead.uoregon.edu/publicationspress/Consensus_report.pdf*
Washington	Climate Change	Web site created by the Washington State Department of Ecology providing a variety of information about climate change, its impacts to Washington State, reducing greenhouse gas emissions, and adapting to climate change impacts. Includes links to a variety of reports and fact sheets. Website: *www.ecy.wa.gov/climatechange/*
Washington	*Climate Impacts on Washington's Hydropower, Water Supply, Forests, Fish, and Agriculture*	A 43-page report prepared by the University of Washington's Climate Impacts Group (CIG) providing an overview of projected climate change impacts on Washington State's hydropower, water supply, forests, fish, and agriculture. The report was prepared for King County, Washington for the October 2005 "The Future Ain't What It Used to Be: Planning for Climate Disruption" conference. A variety of fact sheets, primers, and Power Point presentations related to Pacific Northwest climate impacts and the October 2005 conference are also available on the CIG's conference web site: *http://www.cses.washington.edu/cig/outreach/workshops/kc2005.shtml* Website: *http://www.cses.washington.edu/db/pdf/kc05whitepaper459.pdf*
Washington	*Impacts of Climate Change on Washington's Economy: A Preliminary Assessment of Risks and Opportunities*	A 122-page report published by the Washington State Department of Ecology and Department of Community, Trade, and Economic Development examining the potential impacts of climate change on seven key sectors, industries, and regions of Washington State, including water resources, forest ecosystems, and agriculture. Published November 2006. Website: *www.ecy.wa.gov/climatechange/economic_impacts.htm*

Local		
Scope	*Title*	*Description*
Multiple cities	*Cities Preparing for Climate Change: A Study of Six Urban Regions*	A 74-page report produced by the Clean Air Partnership examining the activities of six cities and urban regions that have recently assessed their vulnerability to climate change, identified adaptation strategies for reducing this vulnerability, and begun to put these strategies in place. Communities examined included London, England; New York City (USA); Boston, Massachusetts (USA); Halifax, Nova Scotia (Canada); Vancouver, British Columbia (Canada); the City of Seattle, Washington (USA); and King County, Washington (USA). From this research, the report also derives a broad framework to guide local governments on adapting to climate change. Published May 2007. Website: *www.cleanairpartnership.org/ pdf/ cities_climate_change.pdf*
Boston, MA	*Infrastructure Systems, Services and Climate Change: Integrated Impacts and Response Strategies for the Boston Metropolitan Area*	A 165-page report describing how global warming could impact the Boston metropolitan area, what those impacts are likely to cost, and what adaptive measures can be taken to protect the region from the worst of these effects. The media summary prepared for the report provides a shorter and less technical overview of the report's findings. Published August 13, 2004. Website: *www.net.org/proactive/newsroom/release.vtml?id=28962*
London, England	*Adapting to Climate Change: Lessons for London*	A 161-page report commissioned by the London Climate Change Partnership to review how other major international cities are managing climate risks. Published July 2006. Website: *www.london.gov.uk/climatechangepartnership/docs/adapting-climate-change-london.pdf*
London, England	*London's Warming*	This 311-page study, commissioned by the London Climate Change Partnership, examines the potential impacts on London of climate change over the next 80 years. Both the full Technical Report and the Summary are available online. Website: *www.london.gov.uk/gla/publications/environment.jsp*
New York, NY metropoli-tan region	*Climate Change and a Global City: An Assessment of the Metropolitan East Coast Region*	The Metropolitan East Coast (MEC) Regional Assessment is one of eighteen regional components of the 2000 U.S. National Assessment (see description in "National" section). The MEC assessment focuses on the impacts of climate variability and change to the 31 counties of the New York City metropolitan region. The assessment focuses on seven sector studies: coasts, infrastructure, wetlands, water supply, public health, energy demand, and institutional decision making. Related web links include link to individual sector summaries, regional demographics (as of 2000), GIS information, climate change scenarios, and information on the global climate models used in the analysis. Published in 2000. Website: *metroeast_climate.ciesin.columbia.edu/sectors.html*

New York, NY metropolitan region	Climate Change Information Resources – New York Metropolitan Region	Web site created by the Center for International Earth Science Information Network at Columbia University with the goal of advancing scientific research and public policy by improving the communication of climate change data and information to urban policy- and decision-makers and residents and, by doing so, improving their capacity to respond to the impacts of climate change. Website: *ccir.ciesin.columbia.edu/nyc/*
Puget Sound region, Washington	*Uncertain Future: Climate Change and its Effects on Puget Sound*	A 33-page report written by the University of Washington's Climate Impacts Group combining an examination of current scientific literature and new research to provide an overview of projected climate change impacts on Puget Sound. The report focuses on the consequences of a warmer climate on the larger Puget Sound ecosystem, including impacts on regional temperature and precipitation, snowpack, streamflow, water quality, and marine ecosystem structure and function. Implications for ecosystem management are also highlighted. A more detailed foundation report is also available for additional background information. Published in 2005. Website: *www.cses.washington.edu/db/pubs/abstract461.shtml*

Table D.4 – Publications on Climate Change Impacts and Adaptation

D.5 Regional Resources on Climate: NOAA's Regional Integrated Sciences and Assessment Teams

The Regional Integrated Sciences and Assessments (RISA) program, funded by the National Oceanic and Atmospheric Administration's Climate Program Office, was established in the mid-1990s to improve the link between climate sciences and society. The RISA program supports research and stakeholder interaction aimed at improving our understanding of how climate affects various regions of the United States, and facilitating the use of climate information in decision making at the regional and local level.

RISA research team members are primarily based at universities though some of the team members are based at government research facilities, non-profit organizations, or private sector entities. Currently funded RISA teams are shown in Figure D.5.1. These teams are responsible for monitoring and analyzing climate data and applying, providing, and interpreting climate information for resource managers and policymakers in the U.S. RISAs can be a good resource for regionally-specific information about climate change and regional climate change impacts. Depending on the region, the research focuses on the fisheries, water, wildfire, agriculture, public health, and coastal restoration sectors. Current RISA team locations and the regions and sectors they currently study are listed in Table D.5.1.

The RISA program may expand in the future into regions not currently covered as funding and opportunities become available. Please check with the Federal Registry to see current funding opportunities under the RISA program. RISA expansion would require the support of NOAA leadership and Congress. More information about RISA can be found on the web: *http://www.climate.noaa.gov/cpo_pa/risa/*.

Figure D.5.1 Currently Funded Regional Integrated Sciences and Assessment (RISA) Teams

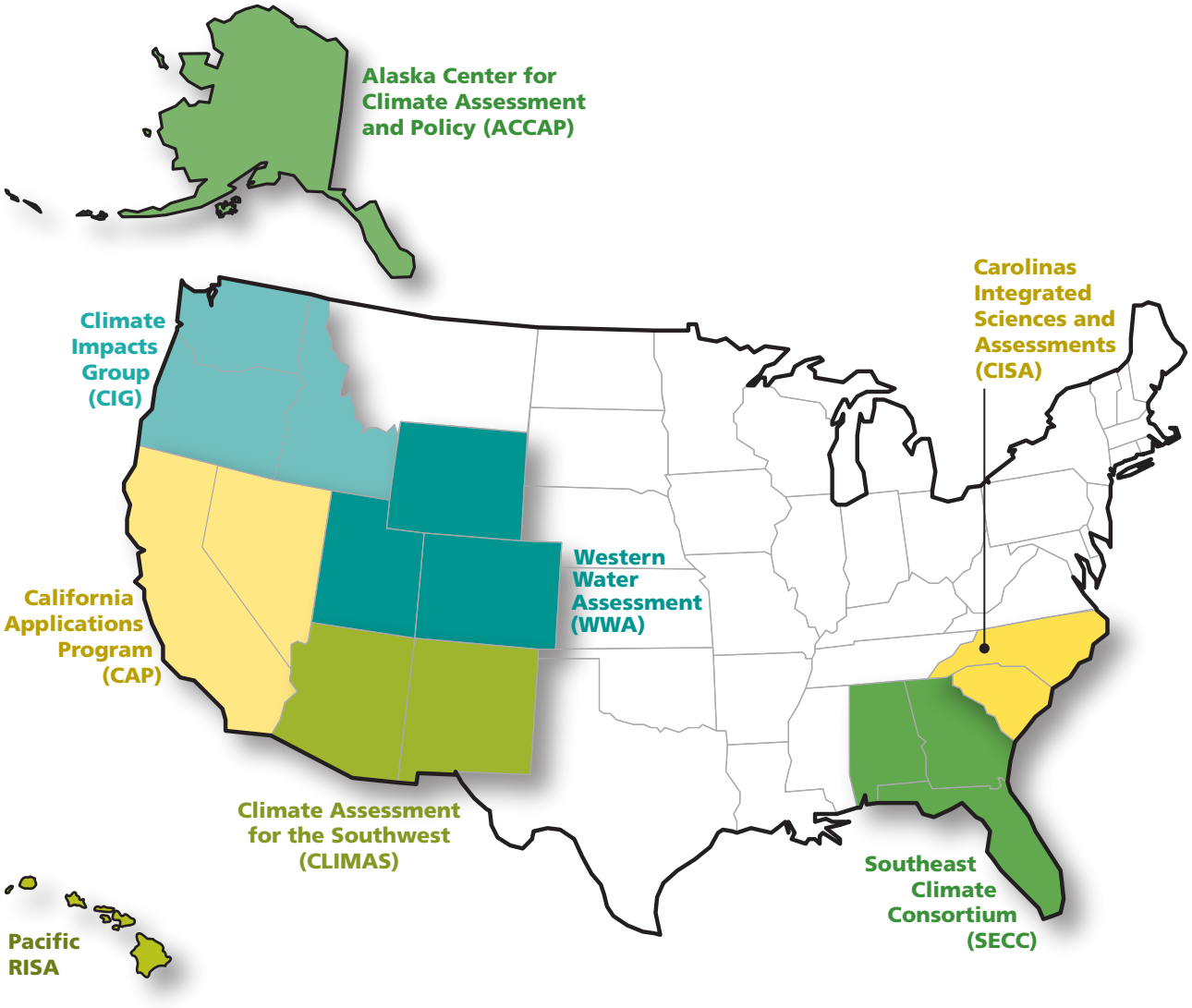


Figure adapted from illustration by the Climate Program Office, National Oceanic and Atmospheric Administration. Used with permission.

RISA	States Covered	URL	Areas of Research
Alaska Center for Climate Assessment and Policy	Alaska	*http://www.uaf.edu/accap/*	Water resource management, transportation
California Applications Program	California	*http://meteora.ucsd.edu/cap/*	Water resource management, forest fires, snowpack, human health
Carolinas Integrated Sciences and Assessments	North and South Carolina	*http://www.zebra-baker.com/CISA*	Water resource management, forestry, coastal impacts
Climate Assessment for the Southwest	Arizona, New Mexico	*http://www.ispe.arizona.edu/climas/*	Water resource management, forestry, forest fires, snowpack, human health, agriculture
Climate Impacts Group	Washington, Oregon, Idaho	*http://www.cses.washington.edu/cig/*	Water resource management, forestry, snowpack, fish, coastal impacts
Pacific RISA	Hawaii, Marshall Islands, Northern Mariana Islands, Guam, Federated States of Micronesia, American Samoa	*http://research.eastwestcenter.org/climate/risa/*	Water resources management, coastal impacts
Southeast Climate Consortium	Florida, Georgia, Alabama	*http://secc.coaps.fsu.edu/members/coaps.htm*	Agriculture, forestry, water resource management
Western Water Assessment	Colorado, Utah, Wyoming	*http://wwa.colorado.edu*	Water resource management, agriculture, snowpack

Table D.5.1 – Regional Integrated Sciences and Assessments (RISA) Program Teams

If you are a local, regional, or state decision-maker, this guidebook will answer your questions about preparing for climate change:

- How do you scope out the problems of climate change across ***sectors*** of your community?
- How do you raise and maintain support to prepare for climate change?
- Whom should you include on a climate change ***preparedness team***?
- Which of your ***planning areas*** are relevant to climate change impacts?
- How do you evaluate your climate ***sensitivity*** and ***adaptive capacity*** (i.e., conduct a climate change ***vulnerability assessment***)? How do you conduct a climate change risk assessment?
- How do identify your climate change ***priority planning areas***?
- How do you establish a vision and guiding principles for a ***climate resilient community***?
- How do you begin to develop climate change ***preparedness goals and actions*** in these ***priority planning areas***?
- How do you develop a climate change ***preparedness plan***?
- How do you ensure that you have the right ***implementation tools*** to take your preparedness actions?
- How do you develop ***measures of resilience*** to track your progress and update your plans over time, to ensure that your efforts are really making your community more resilient to climate change?

King County

CLIMATE IMPACTS GROUP

ICLEI Local Governments for Sustainability