





# Planning for the U.S. National Assessment of the Consequences of Climate Change

A Report of the Aspen Global Change Institute
Elements of Change Series
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Editors

ASPEN GLOBAL CHANGE INSTITUTE


# Planning for the U.S. National Assessment of the Consequences of Climate Change

A report on the Aspen Global Change Workshop
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# Acronyms

**AGCI** Aspen Global Change Institute
**ARM** Atmospheric Radiation Measurement
**AVHRR** Advanced Very High Resolution Radiometer
**BATS** Biosphere-Atmosphere Transfer Scheme
**BESIS** Bering Sea Impacts Study
**CCM** Community Climate Model
**CENR** Committee on Environment and Natural Resources
**DOE** Department of Energy
**DOI** Department of Interior
**EPA** Environmental Protection Agency
**ENSO** El Niño/Southern Oscillation
**ET** Evapotranspiration
**FAST** Fourier Amplitude Sensitivity Test
**FEMA** Federal Emergency Management Administration
**FERC** Federal Energy Regulatory Commission
**FFES** Fossil Free Energy Scenario
**FIFE** First ISLCP Field Experiment
**GCM** General Circulation Model
**GDP** Gross Domestic Product
**GHG** Greenhouse Gas
**GIS** Geographic Information System
**GCLP** Global Change in Local Places
**GLOBE** Global Learning and Observations to Benefit the Environment
**IBIS** Integrated Biosphere Simulator
**IPCC** Intergovernmental Panel on Climate Change
**ISLCP** International Satellite Land-surface Climatology Project
**LAI** Leaf Area Index
**LAID** Land-Atmosphere Interactions Dynamics
**LES** Large-Eddy Simulations
**LESS** Low-Emissions Supply System
**LIDAR** Light Detection and Ranging Instrument
**LSP** Land Surface Processes
**LSX** Land Surface Exchange
**LWC** Liquid Water Content
**NACO** National Assessment Coordination Office
**NAFTA** North American Free Trade Agreement
**NALT** National Assessment Leadership Team
**NASA** National Aeronautics and Space Administration
**NAST** National Assessment Synthesis Team
**NAWG** National Assessment Working Group
**NCAR** National Center for Atmospheric Research
**NGO** Non-governmental Organization
**NOAA** National Oceanic and Atmospheric Administration
**NPP** Net Primary Productivity
**NSF** National Science Foundation
**NSTC** National Science and Technology Council
**NWP** Numerical Weather Prediction
**OSTP** Office of Science and Technology Policy
**PAR** Photosynthetically Active Radiation
**PFT** Plant Functional Type
**PILPS** Project for Intercomparison of Land Surface Parameterization Schemes
**PLAID** Patchy Land-Atmosphere Interactions Dynamics
**RAMS** Regional Atmospheric Modeling System
**SCM** Single Column Model
**SGCR** Subcommittee on Global Change Research
**SiB** Simple Biosphere Model
**SVATS** Soil Vegetation Atmosphere Transfer Schemes
**TOGA-COARE** Tropical Ocean Global Atmosphere Combined Ocean Atmosphere Response Experiment
**TNC** Total Non-Structural Carbon
**TREGRO** Tree Growth Model
**USDA** U. S. Department of Agriculture
**USGCRP** United States Global Change Research Program
**VEMAP** Vegetation/Ecosystem Modeling and Analysis Project
**WG** Working Group (of IPCC)
**WGNE** Working Group on Numerical Experimentation

# A Summary and Reflections on the Meeting

Tom Wilbanks

*Oak Ridge National Laboratory*
*Oak Ridge, Tennessee*

During the period July 29 through August 7, 1997, more than 60 people convened at the Aspen Global Change Institute (AGCI) in Aspen, Colorado, for a process entitled "Planning for a U. S. National Assessment," devoted to the forthcoming National Assessment of Consequences of Climate Change. Attendees included representatives of the Office of Science and Technology Policy (OSTP) and federal agencies, regional workshop teams, the expert community, and a few people from local government and the private sector.

Lasting eight working days plus a weekend, the session began with reviews of the early workshops on regional consequences of climate variability and change and with breakout groups to discuss issues for major sectors across the U. S., along with a discussion of the Intergovernmental Panel on Climate Change (IPCC) regional assessment experience. With this background, it then turned to the U. S. national assessment, starting with a review of discussion documents produced by the National Assessment Working Group (NAWG) and the U. S. Global Change Research Program (USGCRP). Directions, emphases, processes, and organizational structures were discussed at length in both plenary and breakout sessions, and a strong consensus was reached by the participants. Finally, the participants discussed the Forum planned for November 1997 and provided a starting point for organizing the forum.

The context for this active, intensely participative meeting was the vision of a national assessment of consequences of climate change and variability articulated by Jerry Melillo at the regional workshops and at the Aspen conference itself. His vision was of a strikingly new approach to environmental policy assessment in the United States, grounded in dialogues at the regional/local level between regional experts and regional stakeholders: farmers, ranchers, local business people, local government leaders, local interest groups, and citizens at large. Activated by the regional workshops, this consultation would raise the level of awareness of local citizens of climate change issues, invite them to consider vulnerabilities to possible impacts, and then identify the major issues at the regional scale from the point of view of citizens and voters. Out of this democratic process of information exchange would come a picture of vulnerabilities of our country to impacts of climate change and variability not as a function of scenarios or local climate change forecasts that could result simply in arguments about assumptions, but as a strong, robust set of views from the grassroots across the country.

Out of this democratic process of information exchange would come a picture of vulnerabilities of our country to impacts of climate change and variability.

Moreover, this would not be a one-time process. The regional workshops and subsequent regional assessments would catalyze the development of stakeholder networks that would support a continuing process of information exchange, education, and outreach related to climate change issues. In fact, this approach might well serve as a model for addressing other thorny environmental policy issues in the United States in the future.

Most of the attendees in Aspen came because they were attracted by this vision, articulated by a leader who so compellingly represented the White House; and the group commitment was

to develop an assessment design that would convert it into a workable plan for producing the national assessment document and also a workable plan for establishing the longer-term process. At a preliminary level, at least, the participants went away thinking that they had done so, that the leadership of the effort (Jerry Melillo, Robert Corell, Paul Dresler, Michael MacCracken, et al.) were in agreement with the consensus (or had at least accepted it), and that the National Forum in November would serve to publicize and refine the plan.

In a very real sense, by the end of the Aspen meeting the attendees had come to share an "Aspen spirit" that was forged through their participation in an intensive joint experience among a highly diverse group of people, gathered because of their commitment to the national assessment and (in most cases) their belief in the basic vision for that assessment. This vision included several dimensions:

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(1) that the regional assessments, with stakeholders involved at every stage, would be the foundation of the national assessment; the national synthesis would be constructed largely from these building-blocks:

(2) these assessments could be done at a high level of professional quality, according to a template that would make aggregation and synthesis possible, although quantitative modeling would probably not be undertaken by every region;

(3) that, in fact, by drawing on the knowledge bases of stakeholders and local /regional experts the assessment would be stronger than if it were based only on the knowledge base of national experts and modelers; and

(4) moreover, that such a participative approach would increase the usefulness and credibility of the assessment for national policy making, mirroring the geographical and topical diversity of the report's principal audience, the U. S. Congress.

But the "Aspen spirit" was more than a philosophy about how best to produce an assessment product. It was partly the discovery of profound value in the interaction of people from diverse professional backgrounds in considering climate change issues. It was partly a sense that the participants were helping to break new ground in processes for environmental policy making in the U. S., pioneering a new kind of three-way engagement among scientists, policymakers, and stakeholders. And it was partly a drive to convert this one-time assessment (and that one-time meeting) into a continuing structure for analysis, assessment, stakeholder interaction, and out reach that will enable our country to do its very best in exploring the challenges and opportunities associated with global change.

# Session Synthesis Essay

# AGCI Workshop Discussions on Planning for the U. S. National Assessment of the Consequences of Climate Change

Michael C. MacCracken
William Easterling
Co Chairs

**Overview**

The U. S. Global Change Research Program (USGCRP) has initiated a national assessment of the consequences of climate change and climate variability for the United States and the significance of these consequences for its people, its environment, and its economy. With the increasing certainty about human-induced effects on climate and with the recent evidence for increasing climate variability, it is particularly important that society be made more aware of what is happening, what the significance of the changes could be, and how to be better prepared to cope and adapt to the changes and variations.

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The purpose of the meeting held at the Aspen Global Change Institute (AGCI) in August 1997 was to explore how to design a national assessment process that would examine the vulnerabilities of the U. S. - its ecological systems, its major economic sectors, and its social infrastructure - to climate variability and climate change. The AGCI meeting also provided an opportunity for participants, particularly for those who had participated in and were planning regional workshops, to present and synthesize information gained from past assessments and workshop findings and inter actions.

**Background and Expectations**

As background for the workshop, the USGCRP's National Assessment Working Group (NAWG) had developed draft plans and objectives for the proposed national assessment. In addition, the USGCRP agencies together with the Office of Science and Technology Policy (OSTP) had sponsored four regional workshops in the preceding three months and four more were planned for late 1997 and a dozen more for 1998. All of this provided a rich background for discussion at the AGCI meeting.

The AGCI participants were asked to contribute to the development of the national assessment by identifying several key criteria, by concluding that the process must: involve a broadly defined research and stakeholder community; consider the nation's vulnerabilities to climate variability and climate change in the context of other important environmental stresses and current concerns; and account for region to region differences as well as common themes reaching across regions. The set of questions used to initiate the Aspen discussions is included as an Appendix to this essay.

**Approach and Goal**

Extensive discussions took place at the workshop about all aspects of the planned assessment. The AGCI participants made clear their support for the proposition that the assessment being organized by the Subcommittee on Global Change Research (SGCR) needs to be carried out as a public-private partnership and as an iterative and continuing process to provide a scientifically based evaluation and summary of current understanding. They also suggested that the assessment process needs to be designed to be comprehensive and integrative, to couple research by scientists with specific policy-relevant needs of stakeholders, to ensure scientific excellence and credibility, to be open and transparent, and to provide planners, managers, organizations, and the public with information needed to cope with and increase their resilience to natural climate fluctuations and projected climatic changes resulting from human activities.

The assessment needs to be an iterative and continuing process to provide a scientifically based evaluation and summary of current understanding.

Based on plans developed by the NAWG, a goal statement for a National Assessment had been developed. As proposed, the goal of the national assessment is to determine the local, regional, national, and international implications of climate change and climate variability within the U. S. in the context of other existing and potential environmental, economic, and social stresses. Of particular importance is understanding the regional mosaic of impacts that have been and will be occurring as a result of the global-scale changes that are underway and will continue over the coming decades.

Throughout the Aspen meeting there was considerable discussion about this goal statement and about the various components that it implied. As an outcome of these deliberations, an expanded conception of the goal statement was suggested, with two equally important aspects:

* to develop a more complete understanding by the scientific community, government, private industry, and the public of the local, regional, national, and international implications of global change in the context of other existing and potential environmental, economic and social stresses and opportunities;
* to establish and maintain a continuing, interactive dialogue among interested groups and individuals engaged in exploring the challenges and opportunities associated with global scale changes that are underway and will continue over the coming decades, thereby underpinning a sustainable future.

The most important aspect of this formulation was the recognition that the assessment must be a process through which the conduct of a traditional “scientific assessment” is coupled with a commitment to two-way communication between the providers and the users of scientific information/research/assessment results in a dialogue designed to facilitate the use of new scientific insights by decision makers at all levels in addressing practical problems.

The discussions clearly indicated that the national assessment process should be designed to establish and maintain a continuing, interactive dialogue among government officials, business and industry, planners and managers, non-profit organizations , the scientific research and education communities, and the public. A multi-pronged approach should be used to generate the needed information about the implications of climate change and variability for the U. S.:

Regional assessment activities should focus on the issues of most importance at the regional level across the U. S. Based on the distinctive regional characteristics and potential consequences of climate change, a rich array of regional workshops should take place,

encompassing every state and territory (see Table 2.2 for listing as of April, 1998). In carrying out the regional assessments that are planned to be follow-ons to the regional workshops, it was recognized that some combining of workshop regions may be appropriate for strengthening analysis capabilities and that this could be done while retaining the richness and diversity created by the more detailed regional texture.

Sectoral assessment activities should focus on issues that are national in scope and of importance to the services and goods on which people, society and the economy depend. Ten high priority sectors relating closely to human needs were tentatively identified by the AGCI participants for consideration: food availability; water availability; human health; energy availability; forest products and services; ecosystem goods and services; housing and urban services; national and international economies; environmental quality; and natural disasters and extreme events. The first National Assessment will focus on five sectors: agriculture, water resources, coastal zone, and health.

National assessment activities should identify common themes and core issues concerning the implications of long-term climate change and variability for the U. S. These findings should be integrated and consolidated into a synthesis report that will serve as a national summary for decision makers.

In addition, to promote consistency and coherence across the regions and sectors, it was suggested that a series of baseline scenarios should be prepared that provide the best estimates of how the nation is expected to develop economically, demographically, and technologically over the next 50 years. A series of scenarios should also be developed that define the ranges of expected changes in climate, resource use, and ecosystem distribution for use in evaluating the potential consequences of long-term climate change for the U. S.

Discussions about the coupling of research and assessments concluded that a strengthened assessment-oriented research program, dedicated to supporting the development of useful information for decision makers, should be a high priority. The research efforts should be broadly based and aimed at improving fundamental understanding of the Earth system as well as the basis for achieving improved predictive understanding. These research and predictive efforts must be essential partners in order to ensure an effective national assessment process.

The assessment process must include a commitment to two-way communication between the providers and the users of scientific information to facilitate the use of new scientific insights by decision makers.

**Organization and Responsibilities**

There were extensive discussions about how the assessment process should be organized. The U. S. Global Change Research Program has a statutory mandate to undertake scientific assessments of the implications of climate change. Responsibility for conducting the assessments is legally given to the National Science and Technology Council (NSTC) within the Executive Branch of the Federal Government. Within the NSTC structure, the Subcommittee on Global Change Research (SGCR) of the NSTC's Committee on Environment and Natural Resources (CENR), which oversees the USGCRP, has been assigned responsibility. To carry through the assessment process, it is being proposed that responsibility for the analysis and for the preparation of the periodic assessment reports be vested in both the scientific community and in those who will be affected and can and must cope with the consequences of long-term environmental change.

Based on discussions at the AGCI workshop about implementing the concept of a public-private partnership, it was suggested that responsibility for the national as assessment process should be distributed among several entities, as illustrated in Figure 2.1.

* **A National Assessments of Global Change Oversight Committee** should be established to provide oversight for the national assessment process, to ensure its overall credibility and integrity, and to encourage timely progress. Members should be drawn from the regional, sectoral, and national communities and include representatives from public interest groups, business and industry, state and local governments, Congress, and the federal agencies. A National Assessment Technical Advisory Committee should also be established that includes leading scientists and technical experts in order to provide expert advice and review of the assessment process. (Note: In the official organization plan that was adopted March 12, 1998 and that established the National Assessment Synthesis Team (NAST), the NAST assumes the role of intellectual leadership for the assessment as well as preparation of the synthesis report. To ensure full stakeholder input, the synthesis report will draw heavily from the results of both regional and sectoral assessments and an open technical and public comment and review process is planned. The report will also be reviewed by agencies and agency-identified experts and groups.)

Responsibility for the assessment will be vested in both the scientific community and in those who will be affected and can and must cope with the consequences of long-term environmental change.

* **A National Assessment Synthesis Team** that includes leading scientists and experts should be established to provide intellectual leadership and integration for the national assessment process, serve as a strong bridge between regions and sectoral aspects of the national assessment, and prepare the integrating synthesis report.

* **Regional, Sectoral, and Scenario Teams** should be established to have direct responsibility for designing and developing baseline scenarios, and for assembling, analyzing, and considering the scientific findings and their implications for the regions and sectors. The assessment teams should be organized in a way that is open, inclusive and multidisciplinary.

* **A National Assessment Coordination Office** should be established by the SGCR, with staff coming from outside and within government. This office should have responsibility for coordination among the elements of the national assessment process. This office should be co-located and work in cooperation with the USGCRP's interagency coordination office and with the Working Group II Technical Support Unit of the Intergovernmental Panel on Climate Change (IPCC), for which the U. S. will be continuing to serve as the developed country co-chair.

* **The Working Group on National Assessments**, organized under the SGCR, should coordinate overall Federal Government participation in the national assessment, should assist in the initiation and oversight of regional and sectoral teams, and should help ensure a linking to emerging scientific information. In addition, this working group should coordinate plans for enhancing USGCRP and related research activities in areas underpinning the national assessment process.

**Products of the National Assessment**

In conducting the assessment, and in particular in starting the process with the regional workshops, four fundamental questions are being posed. In slightly expanded forms, these are:

(1) What are the current environmental stresses in the region or sectoral area and how would these be expected to play out in the future in the absence of climate change?

(2) How will projected changes in climate and climate variability exacerbate or ameliorate the effects of the existing regional or sectoral stresses, or introduce new stresses?

(3) What information is needed to provide better and more certain estimates of the consequences of climate change and variability?

(4) What strategies may help the region to cope with the anticipated consequences, especially in ways that also will help in coping with other stresses?

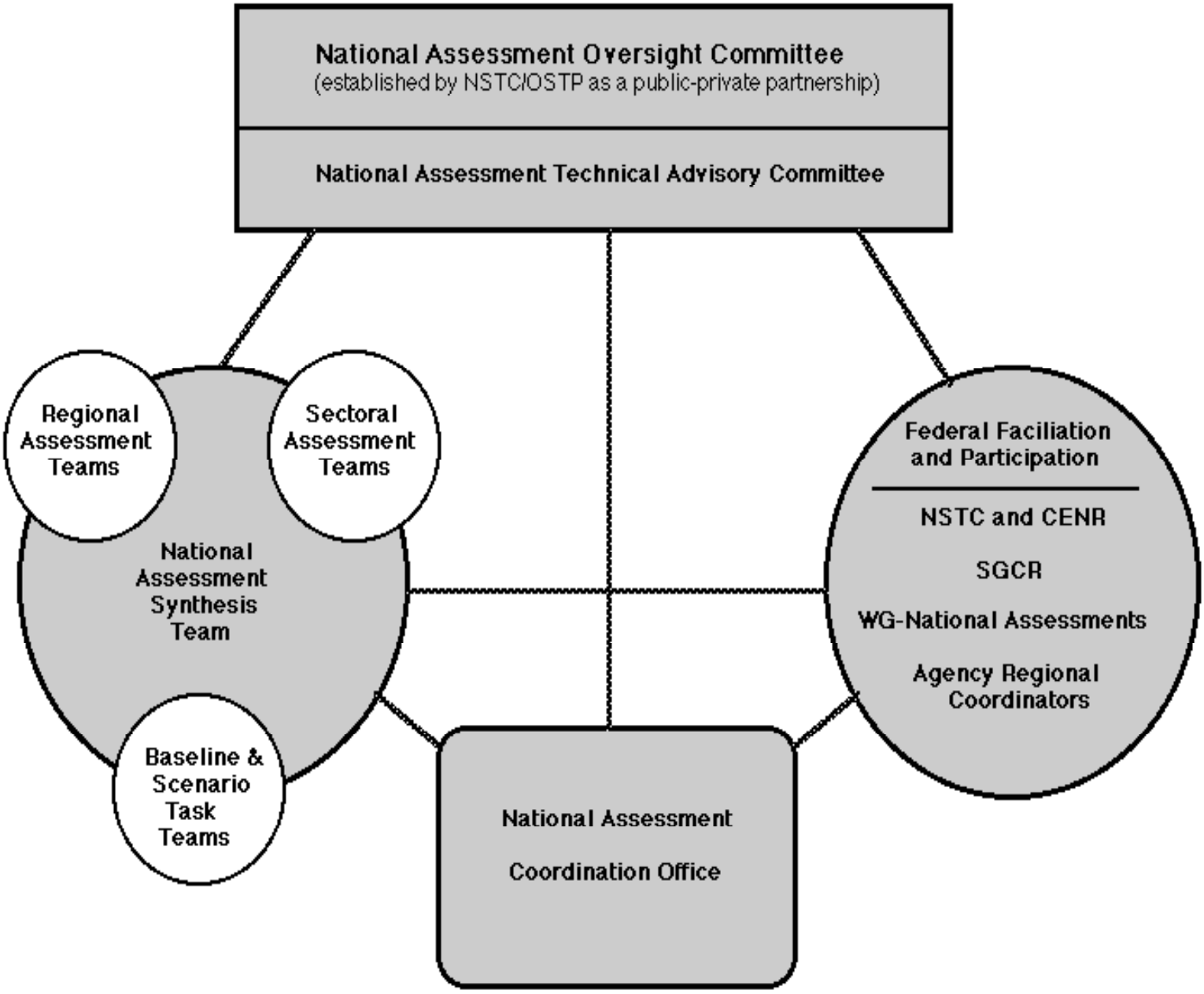


**Figure 2.1**
**National Assessment Organizational Structure**

Addressing these questions was seen as vital if individuals and organizations are to better cope with the influences of climate change and variability over the next several decades.

The workshop participants urged the USGCRP to ensure that assessment results be provided through a continuing broad-scale, multi-sectoral assessment process. They suggested that a series of national-level summary reports should be prepared for each region and each sector; these should be based on more-detailed findings and documentation generated for and published by each regional or sectoral assessment team. The set of national-level summary reports for each region and sector should be accompanied by a synthesis report that provides an overview and integration that draws upon and generalizes from the information developed in the regional and sectoral reports.

## 1997 Workshops

| Region | Organizing Institution(s) | Site | Dates | Coordinating Agency(s) |
|---|---|---|---|---|
| Central Great Plains | Colorado State University and University of Nebraska/NIGEC | Fort Collins, CO | May 27-29 | DOE |
| Alaska | University of Alaska | Fairbanks, AK | June 3-6 | DOI |
| Southeast | University of Alabama, Huntsville and Florida State University | Nashville, TN | June 25-27 | NASA, NOAA |
| Pacific Northwest | University of Washington | Seattle, WA | July 14-16 | NOAA, NASA |
| Southwest - Colorado River Basin | University of Arizona | Tucson, AZ | September 3-5 | DOI, NOAA |
| New England | University of New Hampshire | Durham, NH | September 3-5 | NSF |
| Middle-Atlantic | Pennsylvania State University | State College, PA | September 9-11 | EPA |
| Northern Great Plains | University of North Dakota | Grand Forks, ND | November 5-7 | NASA |

## 1998 Workshops

| Region | Organizing Institution(s) | Site | Tentative Dates | Coordinating Agency(s) |
|---|---|---|---|---|
| Rocky Mountains and Great Basin | Utah State University | Salt Lake City, UT | February 16-18 | DOI |
| Gulf Coast | Southern University and A&M College | Baton Rouge, LA | February 25-27 | EPA |
| Southwest - Rio Grande River Basin | University of Texas - El Paso | El Paso, TX | March 2-4 | NASA |
| Hawaii and Pacific Islands | Center for Application of Research on the Environment | Honolulu, HI | March 3-6 | FEMA, DOI, NOAA, NSF, NASA |
| California | University of California, Santa Barbara | Santa Barbara, CA | March 9-11 | NSF |
| Metropolitan East Coast | Columbia University | New York City, NY | March 23-24 | NSF |
| Great Lakes | University of Michigan | Ann Arbor, MI | May 5-7 | EPA |
| Appalachians | West Virginia University | Morgantown, WV | May 27-29 | USFS |
| Caribbean/Southern Atlantic Coast | Florida International University | Miami, FL | July 21-23 | NOAA |
| Eastern Midwest | Indiana University | Indianapolis, IN | June 29-30 | USDA |
| Southern Great Plains | Texas A&M University | Fort Worth, TX | September | USDA |
| Tribal Lands | TBD | TBD | September | NASA |

**Table 2.2**

**Regional Workshop Schedule**

**Schedule for the National Assessment**

Regional workshops have already begun (see Table 2.2). The workshop discussions indicated that sectoral activities should be organized as soon as possible to provide a complimentary contribution to the assessment process. In continuing the series of regional workshops and initiating sectoral activities, lessons learned from the preceding workshops should be used to build an even more effective process for future activities.

In addition, the participants agreed with the NAWG proposal that broad input should be sought in the development of the assessment plan. It was recommended that the U. S. Climate Forum, to be held on November 12-13, 1997 at the Department of Commerce and National Academy of Sciences in Washington D. C., be used to bring together several hundred participants to expand and refine the set of questions that must be addressed in the national assessment for it to be most useful for stakeholders.

Building upon the U. S. Climate Forum, and assuming rapid implementation of the assessment plans by the USGCRP agencies, regional prioritization of issues and the initial results of regional and sectoral analyses and assessments should be available in draft form in 1998, with revision and review completed by later in 1999. The first national synthesis report should then be able to be completed by the end of 1999 as called for by OSTP. Legislation establishing the USGCRP calls for scientific assessments of global change to be conducted periodically, and it was agreed that future updates should appear periodically. It was suggested that the schedule in each region and sector would depend primarily on the development of new information and understanding.

Relevance to the needs of policymakers should be ensured by the continuing and close involvement of stakeholders and decision makers.

**Ensuring Scientific Credibility and Relevance**

Discussions make clear that the credibility of national assessment reports needs to be ensured by requiring an open and inclusive process that encourages the participation of the most qualified scientific, technical, and socioeconomic experts in their preparation. Assessment reports should fairly represent the range of expert opinion about particular issues, with careful recognition of risks and uncertainties. Draft and final assessment reports should be subject to an open and wide-reaching review process, and accommodation should be made for well-documented and reviewed alternative interpretations. Relevance to the needs of policymakers should be ensured by the continuing and close involvement of stakeholders and decision makers. Internal and external evaluation processes should be developed in order that the continuing series of assessment activities and reports presents a clear and fair presentation of scientific understanding and stakeholder interests and needs.

**Outreach and Communication**

Based on experience from past assessments, the value of the assessment process will depend on the broad communication of the findings and lessons emerging from the dialogue among the many and diverse stakeholder and the scientific communities. The regional workshops, which participants recommended should provide the core of the assessment activity along with similar sectoral workshops over the next year, were seen as the primary pathways for involvement and communication in the first phases of the assessment. It was suggested that national meetings such as the U. S. Climate Forum in November 1997 should also be used to encourage participation in the assessment process.

Participants indicated that assessment activities, workshop reports, and analytic findings should be broadly communicated through the media, the Web, and other channels and that reports should be made widely and inexpensively available. Outreach should also be strongly encouraged through programs that target both formal ( i. e., school-based) and informal (i. e. , museum, park and community-based) educational communities.

**The "Spirit of Aspen"**

The most important outcome from the AGCI meeting was a new spirit, an " esprit d'Aspen," a realization that the discussions had led to a vision for a new way of interacting, thinking about, working on, and communicating the importance and complexity of global change. This new vision is based on participation in the process of those at all levels and of all types of interests in a partnership that strongly embraces a bottoms-up, issue-driven approach to relating science and society. This will require new partnerships between the Federal and local-regional levels of government; between the public and private sectors; between the scientific community and policy makers; and among all of these important players.

The value of the assessment process will depend on the broad communication of the findings and lessons emerging from the dialogue among the many and diverse stakeholder and the scientific communities.

This new vision also involves focusing on the global change issue in a way that is designed to help address the consequences of climate variability and change for real people in real places at the local and regional (as well as at the national and international ) levels. The vision calls for a mechanism that organizes and prioritizes the research effort based not only on scientific uncertainties, but also on needs identified (by stakeholders) in the context of a grassroots effort to engage stakeholders in both identifying the most important issues and developing appropriate response options. The active, continuing involvement of stakeholders in this new paradigm of collaboration/engagement with the scientific community at all stages was viewed as essential.

Developing this partnership among all of the participants would create an integrated framework that would collectively pursue three primary objectives:

(1) the provision of information to support decision making (including but not limited to the production of periodic assessment reports);

(2) research/analyses to support the generation of new and useful information; and

(3) education/communication/outreach activities designed to: communicate the results of research from the scientific community (the providers of scientific information) to decision makers; communicate the concerns and information needs of decision makers (the users of scientific information) to the scientific community; and enhance public understanding of the implications of global change at the local, regional and national (and international) levels. "Communication " in the context of the national global change assessment must therefore be interactive (i. e., two-way) and continuing.

**Epilogue**

This new vision for bridging the recognized gap between science and society generated an enthusiasm among the AGCI participants that has carried on since Aspen, and energized a wide number of planning and outreach activities. Many commented following the workshop that they had been so actively engaged that they barely had time to start to explore the Aspen area - they had caught the "Aspen spirit" and they were grateful.

**Acknowledgments**

As organizers of the assessment component of the 1997 Aspen Global Change Institute summer session, we want to first acknowledge the enthusiastic participation of the many attendees, particularly the many contributions of those who have been leading the regional workshop efforts. We want to acknowledge the efforts of the USGCRP agencies and Executive Offices in assisting in the preparation for and sponsorship of the meeting, with particular recognition to Dr. Jerry Melillo, at the time Associate Director for Environment at the Office of Science and Technology Policy, Dr. Robert Corell, Chair of the Subcommittee on Global Change Research, and Mr. Paul Dresler, Chair of the National Assessment Working Group.

We also express special thanks to the staff of the Aspen Global Change Institute, including Director John Katzenberger and Office Manager Jenifer Blomquist who together provided such gracious arrangements, and writer/editor Susan Hassol, who has transformed the sometimes disjointed discussions at the workshop into a coherent and important proceedings.

We are especially grateful for the efforts of Melissa Taylor of the National Assessment Coordination Office, who provided extensive support in organizing for and then in assembling summary materials from the workshop. We also very much appreciated the efforts of the various participants who helped to lead and summarize the discussions of the many breakout groups.

We also very much enjoyed and are grateful for the hospitality of the citizens of Aspen and the friends of AGCI who hosted special evening dinners.

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This new vision is based on participation in the process of those at all levels and of all types of interests in a partnership that strongly embraces a bottoms-up, issue-driven approach to relating science and society.

# Appendix A to Chair's Essay

# Questions Used to Initiate the AGCI Discussions

Would it be better to have a broad focus involving all aspects of global change or to concentrate on climate change in the context of multiple stressors?

To start off discussions of the Aspen workshop, a number of questions were posed to the participants upon their arrival. These were intended to be provocative and stimulating rather than impose a rigid structure on the workshop. Thus while included here the final deliberations that resulted were a consequence of a continuing reworking of the questions through debate and interaction. For these reasons, these questions were not, and are not, used as a way in which to encapsulate the results of the meeting.

The initial questions were grouped into three areas:

**A. Questions about Regional Activities**

(1) In undertaking a national assessment of the consequences of climate change and natural variability, would it be better to have a broad focus involving all aspects of global change or to concentrate on climate change in the context of multiple stressors? What type of assessment is possible given the information that is available?

(2) Are the regions identified too big or too small, too few or too many? Are the regions reasonably defined and able to address issues that arise in a satisfactory manner?

(3) What information do the regions need from other regions, or from areas outside of the U. S.? How can we treat the international couplings that may affect how regions are affected or may respond?

(4) What are the steps that must be taken in order to retain interest at the regional level during the assessment process?

**B. Questions about Sectoral Activities**

The charter for this USGCRP activity is to prepare a national assessment. We have been assuming that this will require both regional and sectoral focuses. The experiences so far with regional workshops and past experiences with national assessments would be expected to provide insights about a number of key questions, including:

(1) If we have one component of the national assessment that has a regional focus, how do we deal with issues outside the regions that will have feedbacks to the regions? Along the same lines, if we have another component of the assessment that has a sectoral focus, how do we deal with issues or actions that feed back to the regions?

(2) What is the best way to organize the sectoral cross-cuts? Do we require each region to be organized to address each sector or do we undertake separate nationwide assessment efforts?

(3) What are the sectoral cross-cuts that are suggested by the regional studies that have taken place? How should national cross-cuts be different or similar to what is done in the regions (e. g., do regions focus on farming and disease vectors while the national cross-cuts focus on food production/availability and public health)?

(4) Will information from the present set of regions provide adequate information for the sectoral studies, and how should it be integrated?

(5) What are the steps that must be taken in order to undertake a set of activities that would lead to national sectoral assessments?

**C. Questions About Integration and Synthesis**

In addition to issues and questions of scope and organization, there are questions of structure and conduct of the national assessment. These would seem to include:

(1) What overall coordination and guidance is needed to integrate and synthesize the regional and sectoral efforts?

(2) What types of information must be provided from the national level (so thereby encompassing all regions and sectors) in order that the results from regional and sectoral efforts can be synthesized into a national assessment useful to decision makers and policymakers?

(3) What must we do to ensure that the assessment process is seen as open and flexible? That it is seen as scientifically-based and credible?

(4) What must we do in order to ensure that the findings of the national assessment reach stakeholders of all types and levels? What sort of communication process is needed?

What must we do in order to ensure that the findings of the national assessment reach stakeholders of all types and levels? What sort of communication process is needed?

These are just a few of the issues and questions that have been arising as we have discussed how to develop and structure a plan for the national assessment. We have some ideas and options for approaching these questions. However, we have been learning that the best ideas usually trickle up and we look forward to hearing your ideas as we work toward a full first draft of a plan for how best to conduct a credible, open, and informative national assessment of the impacts of climate change.

# A "Brainstormed" List of Ideas Gleaned from Regional Workshops for Creating More Effective Interactions

## 1

* engage key stakeholders
* make personal contacts
* hold informal "exploration" meetings
* link to existing groups
* have broad membership on steering committee
* provide leadership opportunities
* look at existing commissions to see what works regarding stakeholder input
* use university extension units
* encourage participants to engage their peers
* involve the press
* involve school groups
* engage local business leaders
* find local political champions

## 2

* draw out and address the public's questions
* listen to stakeholders
* use breakout groups more than plenary sessions
* utilize trained facilitators
* get well-known keynote speakers at workshops
* discourage scientists from arguing fine points at the meetings
* use good, simple graphics to bring scientific work to the public
* identify and showcase opportunities as well as negative impacts
* get scientists to listen to people's needs
* create a straw document at the meeting

## 3

* use people's needs and questions to drive new research
* link science to the needs of the nation
* send photographs and videos from the meeting to participants afterward
* use pre and post workshop surveys to assess relevance to stakeholders
* remember that this is an iterative process
* build upon and share successes

# Some Observations on the Regional Workshop Process: Where Do We Go From Here?

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**Introduction**

In the period May-July 1997, four regional workshops were held. These were pioneering efforts to bring global change scientists and regional stakeholders together to communicate what was known and not known with respect to climate change, to identify key regional issues, and to discuss how to improve understanding of how best to cope with existing and future stresses. Experience with these workshops to date suggests certain approaches for ensuring continuity and a high level of effectiveness. Regardless of the approach, effective communication appears to be an underlying, critical element that will likely govern the success of this on-going effort .

Intensive efforts need to be devoted to contacting stakeholders and bringing them to the table.

**I. Articulating the Objectives**

It has seemed to prove useful to start each of the regional workshops by clearly stating the goals of the workshop and by placing the workshop activities into the broader framework of leading to a national assessment that is science based. Subsequently, the goals and objectives of the workshop, and their relation to the broader set of activities, need to be restated at key junctures within each workshop so as to keep everyone clearly focused on the goals, especially within breakout sessions. It is ideally useful to restate the goals and purpose of each workshop as the break-out groups are being charged with a task.

**Suggestion:** A one or two-page handout could be provided to participants as part of their workshop package.

**The lack of input and representation by a broad community of stakeholders is a serious drawback to capturing the key stakeholder issues and concerns within a region.** Intensive efforts need to be devoted to contacting stakeholders and bringing them to the table. This normally requires that this be started very early in the workshop planning process.

**Suggestion:** Each workshop's planning board could be composed of a broad mix of members ranging from academicians to business people to state and local government representatives to Native Americans, as specific circumstances and regions dictate. At least half of the panel could be comprised of members from the private sector, state and local government, and Native American communities, as these individuals may also provide additional links to other stakeholders.

**Suggestion:** Various White House and federal agency offices ( e. g., press offices and public relations offices) could provide assistance in identifying and reaching out to stakeholders, and work closely with the regional workshop planning/steering committees. Inclusion and involvement should ideally occur as early as possible. Bringing stakeholders to the table after the process has begun is likely to be a considerably more formidable task.

Regional organizers should be wary of inadvertently subsuming the USGCRP/OSTP regional workshop activities into an existing regional assessment project or activity. Such a circumstance can lead to an identity crisis of sorts, resulting in confusion that may subsequently compromise the purpose and goals of the USGCRP/OSTP activity as well as the original activity.

It is useful to post a workshop outline with a general invitation to comment, on a Web site well prior to the meeting. Writing one or two paragraphs on the plenary and breakout sessions, describing what they are, why they are important, what the impacts are likely to be, who is involved, and who will be impacted has proven helpful.

Expertise is needed for effectively communicating science to a non-science audience.

**II. Outreach and Planning Media/Communications Strategies:**

Individuals versed in public affairs and media outreach should also be members of each workshop's planning board. This will provide:

* A longer lead time to organize media coverage;
* A better understanding of the goals and purpose of the workshop which, in turn, makes for more effective outreach; and
* Expertise for effectively communicating science to a non-science audience, at the appropriate level.

Getting the press and media involved and interested has to begin very early on, well before the actual workshop. Federal agency press and public relations offices should also be called upon for assistance in the outreach process.

**Suggestion:** Consider targeting natural trends or events in conjunction with workshop topics (e. g., El Niño).

**Suggestion:** Consider inviting science educators that participate in the GLOBE program, or physicians conducting research on a host of environmental issues.

**Suggestion:** Consider choosing a "catchier" workshop title with a "real world" approach to help make a connection between predicting weather and climate and assessing its impact in areas not conventionally considered.

**Suggestion:** Design a logo specifically for the workshop rather than using a grouping of the logos of all of the sponsors.

**III. Selecting Speakers**

**Excellent communication skills appear to be essential criteria for selecting speakers, chairs of break-out groups, and rapporteurs.** Communicating at the appropriate level is crucial to engaging people and in keeping workshops running smoothly, staying focused, and achieving a useful product.

**IV. Structuring the Agenda**

**A baseline educational component is needed in each workshop that will serve to identify what is known, what is not known, and what is meant by uncertainties with respect to climate change and climate impacts. Providing a regional flavor to these results has proven quite useful.**

Background reading materials such as the IPCC WG I and II Summaries for Policymakers, Tom Karl's observational records of temperature and precipitation for regions of the U. S., and a smattering of key figures such as the ice core records of CO2 and temperature projected into the future can be quite useful. Tom Karl's figures and the ice core figure showing the extreme covariance of CO2 and temperature often prove to be clear and effective. Many people, including many scientists, are not familiar with the IPCC results and have never seen any of the above-mentioned figures.

Identify what is known, what is not known, and what is meant by uncertainties with respect to climate change and climate impacts.

It would be quite beneficial to have the IPCC conclusions presented by someone intimately familiar with the IPCC reports (especially Working Groups I and II). Describing the IPCC process itself should also be considered. Our experience to date suggests that all too often people selected regionally to present a summary of the IPCC results end up expressing the results ambiguously, or equivocate, or take issue with some of the conclusions, or have their personal take on certain conclusions, or identify criticisms around the margins but fail to effectively deal with them at their core. The net effect is to garble the summary points contained within the IPCC report or to render the IPCC essentially inconclusive.

Applying a statistical confidence level of 95 percent in order to ascribe certainty, or the lack thereof, as is standard procedure in science circles, often renders many robust conclusions in the IPCC inconclusive or significantly lacking in confidence or certainty, before a non-science audience. One should bear in mind that outside of science circles, many policy and business-related decisions are routinely made with far less statistical certainty, and often with no reference whatsoever, to requiring any degree of statistical certainty. In short, this rigorous statistical standard has little or no meaning for most people outside of scientific circles. Consequently, a great deal of the IPCC's strength is often lost or muddled in this process.

It would also be beneficial if the person selected to present the IPCC conclusions had some measure of political sensitivity and some feeling for expressing confidence levels and/or certainty, as they are understood and/or interpreted in non-scientific circles. This person should also be an excellent and effective communicator who is well versed in expressing science to non-science audiences.

**Breakout session discussions have often proven relatively successful compared to more plenary presentations**. More time needs to be scheduled for discussions and synthesis or integration of information, either in the breakout groups or in the plenary session or both.

**With few exceptions, presentations of science have often been overly technical and employed charts and figures that are too detailed and difficult to read**. More effort should be directed at selecting effective speakers and at presenting science clearly and articulately at the appropriate level for a non-scientific audience.

**Having a keynote address by some well known regional, local, or national political figure, such as Vice President Gore in the case of the SE workshop, or the President's Science Advisor, Jack Gibbons, in the case of the NW workshop, is important in that it draws publicity and interest from all quarters while highlighting the seriousness of the issue.** In any event, whomever is chosen to deliver the keynote address should also be well briefed in terms of the goals and purposes of the workshop, and its relationship to a larger and longer effort.

Besides arranging for breakout sessions as such, assure places in the agenda for brief summary reports from the breakout session groups to the group as a whole in order to identify overlaps, opportunities for cross-fertilization, and issues that have been overlooked.

The breakout groups work best when they are focused on key constraints and/or issues for the region that cut across conventional sectoral boundaries. For example, land, ecological systems, and society are cross-cutting categories. Industry and agriculture are sectoral categories.

Breakout groups work best when they are focused on key constraints and/or issues for the region that cut across conventional sectoral boundaries.

**V. Engaging Stakeholders in the Process**

Some have suggested that a workshop should begin with views from stakeholders within the region about current realities, economic and environmental status, environment-related stresses, and (as appropriate) views about climate variability and change issues. The experts should listen first, not stifle local expression by talking first.

**Suggestion:** One approach might be to arrange a panel of stakeholders representing a balance of climate-sensitive activities in the region and invite them to offer their views at the outset without a specific focus on climate change issues, then listen to the expert overviews of climate change vulnerabilities, and then revisit regional interests/concerns in light of the climate change issues raised.

In preparation for the workshop, work closely with the non-research participants to provide them with background information, help them understand what will be going on, increase their confidence that they have something to contribute, and enable them both to appear and be well-informed as members of working groups.

**Where Do We Go From Here?**

To help in planning future activities, a number of questions need to be discussed at the workshops.

(1) How does each workshop or each workshop steering committee continue to engage and involve all of the relevant regional stakeholders and scientists in an on-going dialogue?

(2) How does each steering committee continue to build stakeholder involvement, especially in those regions where stakeholder participation was sparse?

(3) What is required to foster an on-going dialogue on regional climate vulnerabilities and multiple stresses?

(4) Are topics such as mitigation and adaptation options and strategies the logical progression to the first round of regional workshops? What about the issues of energy efficiency, energy

efficient technologies, and new technologies as themes for future discussions within each region?

(5) What are the issues and themes that will help foster an on-going dialogue among the relevant regional stakeholders and scientists?

(6) How can an electronic list (fax and email) for each region be facilitated that will foster continued dialogue among stakeholders and scientists? Can these lists interact with other lists from other regions? What are the best ways to facilitate or enhance the ability of stakeholders to keep in touch (including use of regional web sites)?

(7) What about the issue of funding and funding responsibilities? What funding arrangements can be made to continue hosting periodic meetings with stakeholders?

(8) How can new and emerging science information be made available to each regional steering committee for distribution and discussion?

(9) Is there a need to set up a specific funding mechanism for the continuation of regional workshop activities and stakeholder outreach?

(10) What are the short-term, medium-term, and long-term information needs and requirements of each region?

(11) What role can and should the USGCRP, OSTP, and the various federal agencies play to help facilitate all of the above?

Work closely with the non-research participants to provide them with background information, help them understand what will be going on, and increase their confidence that they have something to contribute.

# Perspectives and Principles from Other Assessments

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Policy-relevant assessment is a more organic process involving researchers and stakeholders in an interactive exercise that builds understanding rather than trying to define "truth."

Many assessments of complex environmental issues have failed to meet the needs of the decision makers they were intended to serve. This is due to:

* lack of focus on decision makers' specific information needs
* inadequate stakeholder involvement and communication at all phases
* insufficient integration of quantitative and qualitative factors relevant to decision makers
* processes driven by scientists who are often amateurs at outreach and facilitation and may not understand stakeholders needs

When researchers apply assessment models as mechanistic predictive tools, they risk producing results that are not sufficiently relevant and are prone to misuse in decision making (Bernabo, 1998). Policy-relevant assessment is a more organic process involving researchers and stakeholders in an interactive exercise that builds understanding rather than trying to define "truth." The emphasis must be on providing practical information in an easily usable form.

**The Problem of Contrasting Cultures**

The underlying difficulty in conducting scientific assessments to assist decision making is rooted in the divergent purposes and different professional cultures of researchers and managers (Bernabo, 1995). Scientists ultimately seek to understand an issue while the decision makers' job is to decide. Decisions usually have deadlines and must be based on whatever level of scientific understanding exists, taking account of all the other societal factors that apply to the decision. The technical aspects are generally given less weight than social and political factors, much to the dismay of researchers pursuing scientific "truth." In short, science is a culture based on objective facts, proof, rationality, measurements, and incremental progress. Policy, on the other hand, is a culture based on subjective human values, beliefs, emotions, perceptions, deadlines, and crises.

Effective and useful assessments must bridge these two cultures, and so must not only be technically sound but also policy credible. Researchers are well-versed on what is required to ensure scientific credibility, such as using well-documented and peer-reviewed information. But they often find that the needs of decision makers require stretching assumptions beyond what they believe "good science" allows, forcing them to make expert judgments and informed guesses or else forfeit contributing effectively to the process. Making the assessment policy-credible depends on how transparent, inclusive and unbiased the whole process is perceived to be by stakeholders. By applying multi-stakeholder approaches, assessment processes inform decision makers in a manner that facilitates sustainable outcomes that are technically and politically viable for society.

A key problem observed in previous assessments is how relevance is defined. Assessments are often designed based on researchers understanding of the scientific issues and their educated guesses of what decision makers would like to know rather than eliciting the decision makers' needs at the outset. With an approach that fails to fully engage the assessment's target audience in the initial design, it is unlikely that even the assessment's questions will be focused on those matters most relevant to decision making. What usually results is a state-of-the-science assessment with minimal usefulness to decision making. In practice, such results unintentionally provide fodder for opposing advocates on the issue to use selectively for supporting their predetermined positions in the policy debate.

**The Role of Uncertainty**

Another recurring theme is the issue of scientific uncertainty in the policy context. It has been observed that science is more effective at converting ignorance into uncertainty than it is at converting uncertainty into certainty. The level of certainty required for action is a function of the societal perception of the issue. The greater the societal consensus on an issue, the less scientific certainty required for action. The higher the societal costs of a policy, the greater the degree of certainty required for action. The inverse of these principles is also true and imply that enough certainty in the science is always defined relative to the political certainty in the issue. Therefore, enough scientific certainty in the policy process is a dynamic factor, not a static end point from research. These are political issues, not scientific ones. (For a treatment of some of the scientific issues in "Characterizing and Communicating Scientific Uncertainty," see AGCI's Elements of Change 1996 , Session Two.)

Science alone cannot provide answers to policymakers' ultimate questions because science necessarily is silent on the human values that underlie the decisions societies make.

Science alone cannot provide answers to policymakers' ultimate questions because science necessarily is silent on the human values that underlie the decisions societies make. The scientific method itself is designed to screen out the value preferences and biases of the subjective humans beings who conduct research. Technical information is useful in identifying issues, developing options, providing understanding, and evaluating consequences for policy actions. But in the end, human values must be applied to determine what is "good" policy for a given society on a specific issue.

**Lessons Learned from Past Assessments**

Based on dozens of past environmental assessments on a range of issues in several countries, some significant lessons emerge that provide insights for improving the usefulness of assessments for decision makers. The Social Learning Project at Harvard University (Clark and Dickson, 1998) has documented how decision makers have responded to various assessments. Five general lessons about assessments that have been judged most effective by decision makers are as follows:

(1) The assessment process is inclusive and well-designed. Communication can be more important than model integration in determining success. Complex model wiring diagrams suggesting all the pathways to be studied are of limited value unless there is a carefully planned process of interactive flow of information among researchers, synthesizers, stakeholders, reviewers and end users.

(2) The assessment results in expanding options for decision makers. The assessment process can provide a vehicle for finding win-win solutions. Merely providing detailed analysis of specific policies rarely advances the decisions as usefully as when new options are generated in

an interactive process between producers and users of the information.

(3) The assessment focuses on real uses at the regional level. Broad generalizations on the national or global scale have limited value at the more local scales where most impacts of a decision are experienced. Averages integrating over large areas can obscure the more localized texture that political representation is based on in national and global fora.

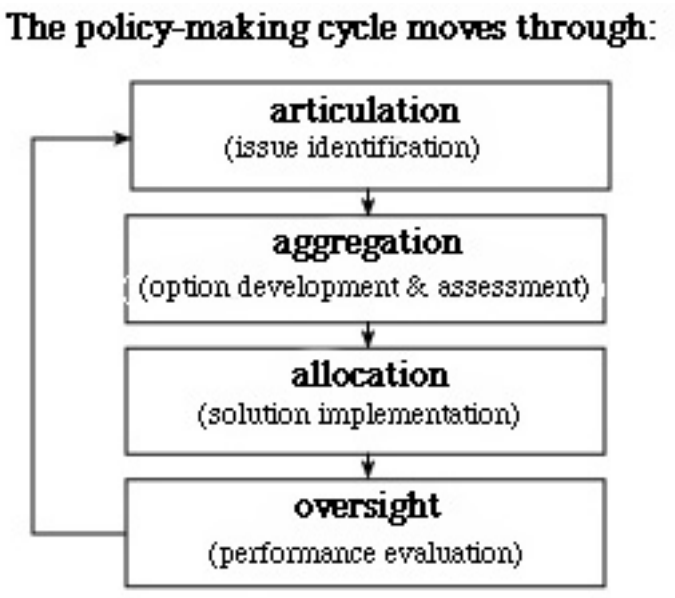
(4) Multiple partial assessments are performed on key components. The end results of large integrations of many factors tend to suffer from the limitations of their weakest links. These limitations and their complexity make them harder to use and interpret by decision makers than sets of comparable, separate analyses.

(5) Assessments are conducted repeatedly by a core group. Single-time grand integration efforts are less likely to benefit from the learning required to be most useful for decision makers. Assessments ultimately need iteration to yield successively better results with a stable core group of assessors who incorporate the learning as they proceed.

The assessment process can expand options for decision makers and provide a vehicle for finding win-win solutions.

These lessons indicate the primary importance of the process, not just the report or other tangible outputs of an assessment effort. In fact, the value of a report is often outweighed by the interactive learning process involving researchers, assessors, decision makers, stakeholders, and the public.

As policy-making moves through this cycle (Figure 2.3), there is a shift in what decision makers want to know.




**The Policy-Making Life Cycle**

**What is a Policy-Relevant Assessment?**

A policy-relevant assessment is an iterative multi-stakeholder process for systematically analyzing data and synthesizing information into a form that facilitates use in decision making (see Figure 2.4).

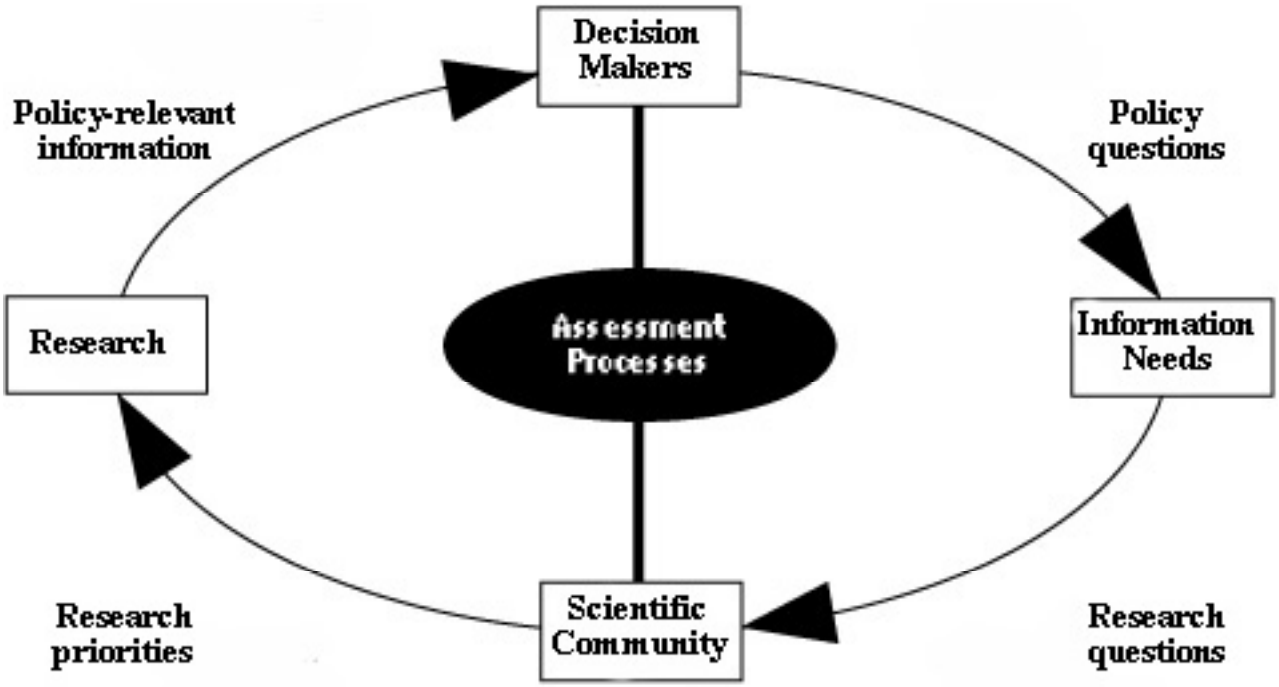



**Figure 2.4**
**A policy-relevant assessment is an iterative process linking science and decision making.**

Based on the lessons of past efforts, there are a number of factors that enhance the effectiveness of policy-relevant assessments. These attributes include:

* responding to clearly defined needs relevant to decision making
* involving decision makers in framing the questions and designing the process
* maintaining interaction with end users during planning and implementation
* developing and implementing a multi-stakeholder communication strategy
* establishing credibility with periodic open reviews of the science by research peers and the assessment's process and assumptions by stakeholders
* using the full spectrum of research approaches and tools to address the issues of importance to decision makers that can be quantitatively modeled and those that can only be qualitatively described, explicitly estimating uncertainties
* managing the process for successful assessment outputs rather than as research
* using assessment specialists to integrate the outputs of expert teams

**Evolution of Assessments**

When taken together, the attributes outlined above suggest a new model for conducting assessments that is less mechanistic and more organic than previous efforts. Assessment can be practiced as a learning-centered dialogue, rather than the traditional exercise in defining "truth" or predicting probable future outcomes. The previous style was mechanistic, Newtonian, and reductionist, based on "truth," predictions , science, outcomes and answers. The evolving style requires a more organic and holistic approach based on learning, options, the context of decision making, establishing processes and framing questions.

**Lessons Learned from the Joint Climate Project**

In 1990, a project was designed and conducted by Science & Policy Associates, Inc., called the "Joint Climate Project to Address Decision Makers' Uncertainties." This private-federal partnership, sponsored by the Electric Power Research Institute, the U. S. Environmental Protection Agency, the U. S. Forest Service, and the U. S. Departments of Energy, Agriculture and Interior, established a multi-stakeholder dialogue to help identify some major questions U. S. decision makers had about climate change and then had scientists determine what research and time frames would be required to address those questions. The project yielded several key findings with implications for enhancing communication and increasing the value of research results.

**From the decision makers' perspective**

* International perspectives drive policy.
* Climate change impacts and human responses are key to decision making.
* Implications of uncertainties need clarification.
* Certainty is not a prerequisite for action.

Assessment can be practiced as a learning-centered dialogue, rather than the traditional exercise in defining "truth" or predicting probable future outcomes.

**From the researchers' perspective**

* Timely and useful results are available before reliable predictions.
* Greater emphasis is needed on impacts and human response strategies.
* Integrated assessments and case studies are useful.
* Expect the unexpected.
* An international perspective for research is essential.

**Lessons in Communication**

Discussion during the Joint Climate Project provided ample evidence that both researchers and decision makers are uncomfortable with the current situation and are anxious to develop and sustain a productive dialogue. Doing this successfully will require:

* balancing research and response strategies (it's not a choice of whether we act OR do research; both are needed)
* approaching climate change in a "relative risk" context
* focusing on educating decision makers on the facts and uncertainties of the issue
* recognizing that research does not always provide the answer and may even increase uncertainty in some areas
* developing an ongoing facilitated process between decision makers and researchers to direct research

**Negotiations Versus Dialogue**

There is a distinction between negotiations, which are necessary but not sufficient, and dialogue, which facilitates more productive negotiations.

**In negotiations:**

* all societal perspectives are reduced to one official position
* motivations and options are not explicit
* each party seeks to maximize its advantage
* there is convergence toward a single least-objectionable outcome

**Dialogue:**

* expands the diversity of positions addressed
* examines motivations to enhance level of understanding
* reaches consensus on a range of options
* provides the basis for win/win solutions

**Conclusions**

Better solutions require:

In facilitated dialogues, decision makers and researchers:

* establish consensus on significance of science
* increase mutual understanding
* develop new options and analyses for better solutions

Targeted assessments are science for decision making which:

* focus on stakeholder needs, not global common denominators
* examine specific risks and benefits for stakeholders
* develop research to fill policy-relevant gaps

There is a distinction between negotiations, which are necessary but not sufficient, and dialogue, which facilitates more productive negotiations

Improving assessments to meet the needs of decision makers requires new approaches that involve stakeholders in interactive learning processes. Facilitated dialogues between the producers and users of assessments build understanding, enhance relevancy, and increase the credibility of the results. The value of moving beyond traditional approaches is demonstrated by recent examples of successful assessments applying structured dialogues, interactive design phases, and multi-stakeholder implementation. Policy-relevant assessments are interactive learning processes rather than truth-defining end-points. To be of greatest value, they must include both the quantitative and qualitative factors for analyzing decision making options.

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# Alaska and the Bering Sea Regional Workshop on Climate Change Impacts

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Future climate change is predicted to be largest in the Arctic region and the presently observed change in climate is already quite large.

The Bering Sea Impacts Study (BESIS) area is perhaps the largest of all the U. S. regional impacts assessment regions, covering the Western Arctic from the Mackenzie River to the Lena River. It includes the Bering Sea fisheries, a very important component of the Alaskan economy, and of economic interest to the Japanese and Russians who also fish these waters. Additional important elements of the study region include other renewable and non-renewable resources, Native populations in numerous small villages practicing subsistence lifestyles, and transboundary issues with Russia and Canada, involving, for example, climate effects on the migration of polar bears and caribou herds.

A workshop was convened in June of 1997 by the Center for Global Change and Arctic System Research, University of Alaska, Fairbanks, and sponsored by the U. S. Global Change Research Program, the National Science Foundation, the Department of the Interior, and the International Arctic Science Committee. Its goals were to tell stakeholders about the importance of climate change on issues of particular concern to them; to hear stakeholders concerns; to refine the coarse impact assessments already compiled from previous workshops; to define a research agenda to further improve the impact assessments; and to develop support, with the help of the stakeholders, for mitigation and adaptation options.

This region is important to the nation for several reasons. First, future climate change is predicted to be largest in the Arctic region and the presently observed change in climate is already quite large, exceeding the changes predicted by global climate models. Second, the economic and social impacts of climate change could be widespread since the region produces 20 percent of U. S. domestic petroleum consumption, has the two largest fishing ports in the U. S. (Dutch Harbor and Kodiak), and has the largest parks, wildlife refuges and preserves in the U. S. It also has other major wildlife resources and has sometimes been considered the "Serengeti of the North."

Quoting from the International Geosphere/Biosphere Program's 1991 Belagio report, the workshop stressed the regional emphasis in global change prediction. "...Global change predictions will be of greatest value to decision makers on a regional basis, and if scientists from throughout the region are involved from the start in the processes through which change is generated."

Although the resolution of current general circulation models (GCMs) represents Alaska poorly, it is nonetheless clear that there is a great amplification of climate change in high latitudes and that the climate signal will be strongest there. Figure 2.5, comparing images of the region at 400 kilometer resolution and 40 km resolution illustrates the need for finer resolution regional assessments.

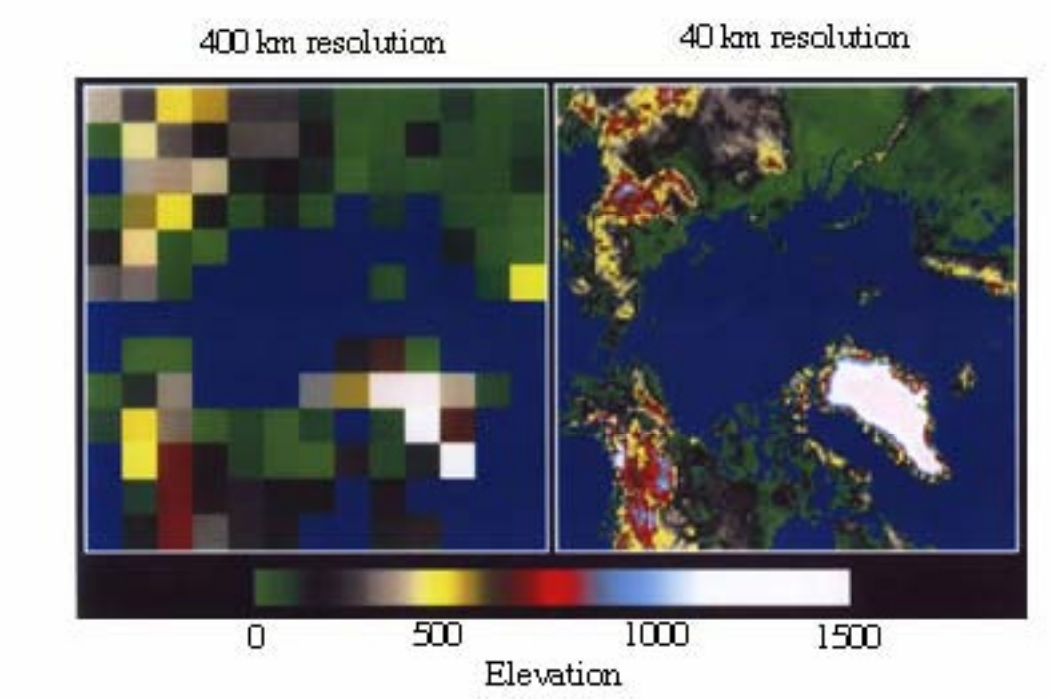



**Figure 2.5**
The region at 400 km and 40 km resolution

Global change predictions will be of greatest value to decision makers on a regional basis, and if scientists from throughout the region are involved.

The Intergovernmental Panel on Climate Change (IPCC) in 1995 reported that expected changes in the region with a doubling of carbon dioxide would include:

* Pronounced reductions in seasonal snow, permafrost, glaciers, and periglacial features, with a corresponding shift in landscape processes (High Confidence);
* Increases in the thickness of the active layer of permafrost and disappearance of extensive areas of discontinuous permafrost (High Confidence);
* Disappearance of up to a quarter of the present mountain glacier mass (Medium Confidence);
* Less ice on rivers and lakes; later freeze-up and earlier break-up (Medium Confidence);
* Substantially less sea ice in the Bering Sea and Arctic Ocean (30 to 50 percent for the latter) and reduction in ice thickness (Medium Confidence).

The IPCC 1995 Assessment further reported that:

* Many components of the cryosphere are sensitive to changes in atmospheric temperature because of their thermal proximity to melting. The extent of glaciers has often been used as an indicator of past global temperatures (High Confidence).
* Projected warming of the climate will reduce the area and column of the cryosphere. This reduction will have significant impacts on related ecosystems, associated people, and their livelihoods (High Confidence).
* There will be striking changes in the landscapes of many high mountain ranges and lands at high northern latitudes (High Confidence). These changes may be exacerbated where they

are accompanied by growing numbers of people and increased economic activities (Medium Confidence).

Modeling studies project a dramatic northward shift of hundreds of kilometers of the permafrost boundaries as well as a shift in treeline with associated severe impacts to ecosystems. The IPCC predicts poleward migration of treeline and establishment of new ecosystems as entire forest types disappear (High Confidence); changes in the migration patterns of polar bears and caribou (High Confidence); and fisheries and marine mammals displacement due to ocean temperature and sea ice changes with many species shifting poleward about 150 km for every 1° C temperature increase (High Confidence).

**Observational evidence**

Air temperatures over most of Alaska have increased by 3 to 4°C in winter/ spring from 1961-1990. This trend of 1°C per decade exceeds model predictions, is highly significant and has caused substantial impacts.

Observed changes in this region have been dramatic over the past three to four decades:

* Air temperatures over most of Alaska have increased by 3 to 4°C in winter /spring from 1961-1990, and about 1°C in summer. This winter/spring trend of 1°C per decade exceeds model predictions, is highly significant and has caused substantial impacts.

* Annual snowfall has increased from 1950-1990 by about 20 percent in Canada (N of 55°) and about 11 percent over Alaska.

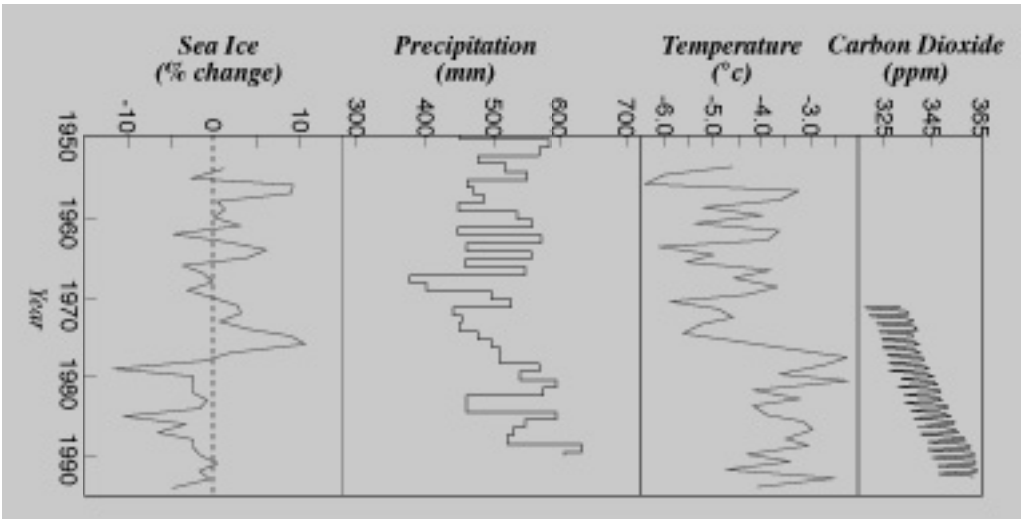



**Figure 2.6**
Climate-Related Observations

* Cyclone and anticyclone frequency has increased over the Arctic between 1952 and 1989.

* Sea ice extent in the Bering Sea has been reduced by about 5 percent over the last 40 years, with the steepest decrease occurring in the late 1970s.

* Glaciers have generally receded, with typical ice thickness decreases of 10 meters over the last 40 years.

* Borehole measurements in permafrost have shown warming of up to 2 to 3°C over the last 100 years in some areas, as well as thawing at both top and bottom in the discontinuous permafrost areas.

Figure 2.6 shows four graphs of climate-related observations in this region. In addition , the mass balance of most glaciers in Alaska has been substantially reduced, as shown, for example, by the dramatic recession of the Muir Glacier (not solely due to climate change). Also, discontinuous (patchy and relatively shallow) permafrost terrain which underlies much of Alaska, is very close to the melting point (much of it is at -1°C), and given that melting is now occurring from both top and bottom, it will not take much more for it to disappear completely. Whole forest ecosystems could be transformed into wetlands, bringing drastic changes.

A sudden climate shift was observed in the region in 1976, involving a jump in temperature which affected numerous environmental parameters, including the number of Canada Goose nests on the Columbia River, the salinity of Puget Sound, wind speeds in the subtropical North Pacific, the amount of chlorophyll in the Central North Pacific, salmon catches in Alaska, sea surface temperature in the NE Pacific, and sea ice extent in the Bering Sea. A total of 33 environmental variables were studied by Ebbesmeyer et al., 1991 , combining these variables into a single statistical measure which demonstrates how a relatively small step jump in climate effects the environment in a major way (Figure 2.7).

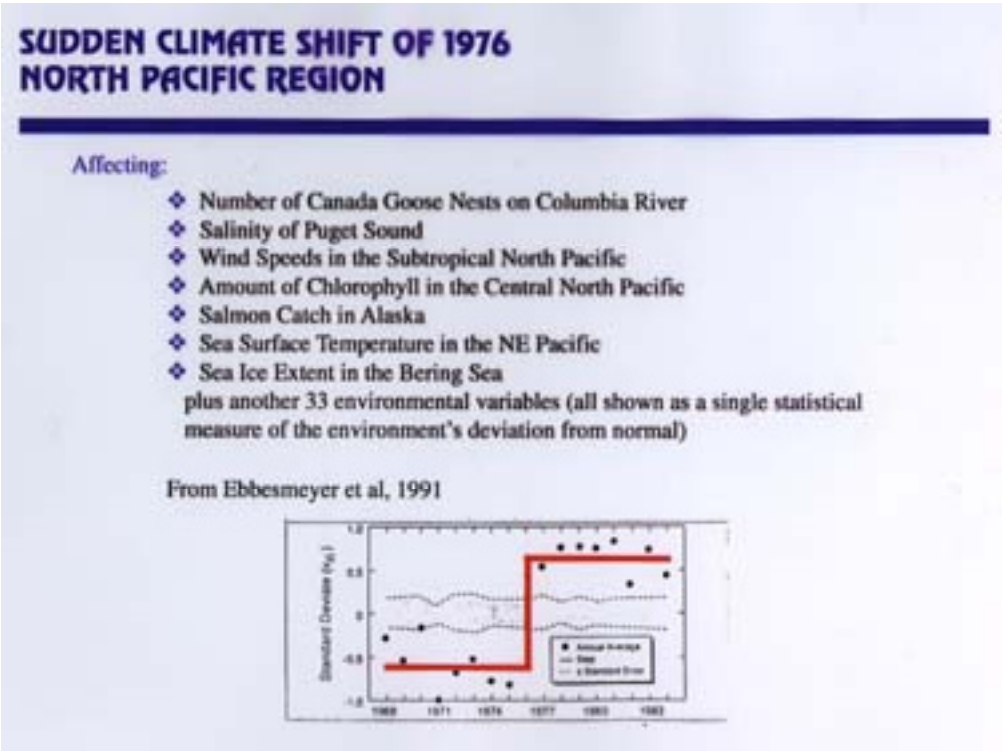



**Figure 2.6**
Climate-Related Observations

Discontinuous permafrost terrain, which underlies much of Alaska, is very close to the melting point, and given that melting is now occurring from both top and bottom, it will not take much more for it to disappear completely.

**Social and Economic Impacts**

In the end, it is the importance of addressing societal responses to regional climatic change that underlies our fundamental concern about global change. There are four time scales to consider:

(1) Seasonal to interannual (1-5 years), covering the El Niño-Southern Oscillation (ENSO) time frame where some forecasting ability exists.

(2) Decadal (20 years), the time scale of immediate practical concern to stakeholders for whom longer time scales are of little practical value. Predictions over this time scale are considerably more difficult than over the 1-5 year time scale.

(3) Century (100 years), the greenhouse effect time scale of interest to scientists and climate modelers and the time scale for significant human impacts of such processes as sea-level change and soil fertility change.

(4) Longer-term, including global change effects such as the bioaccumulation of contaminants which must be considered in impact assessments.

**Working Groups**

It is the importance of addressing societal responses to regional climatic change that underlies our fundamental concern about global change.

The major impact areas addressed by working groups at the workshop were:

* Fisheries: climate effects on commercial, recreational and subsistence fisheries
* Coastal Zone: sea level rise, storm surges, erosion, effects on communities
* Land ecosystems: overgrazing, forest fires, insect outbreaks, permafrost thawing
* Resources: non-renewable resource development and transportation, energy systems
* Infrastructure: maintenance of roads, airports, sea ports, etc.
* Social/cultural issues: important parts of five impacts areas above

The position papers of these working groups include discussion of why the impacts area is of interest, what previous impacts have occurred, what were their causes, and how people coped with them. The papers also include discussion of current pressures and additional stresses expected due to climate change, uncertainties, additional research needed, and mitigation and adaptation measures or policy decisions that can help to reduce impacts.

Likely impacts on fisheries include changes in ocean productivity (location, volume and species), changes in anadromous fish (those that go up rivers from the sea to spawn) productivity and markets, seafood and fish industry (harvesters and processors) financial stresses, stresses on industry lenders and equipment manufacturers, and loss of fishing industry jobs and support services.

The impacts on land, including forestry, agriculture, parks and wildlife are likely to include insect outbreaks (such as the higher incidence of spruce bark beetles already observed), and more fire damage due to a warmer and drier climate in some areas.

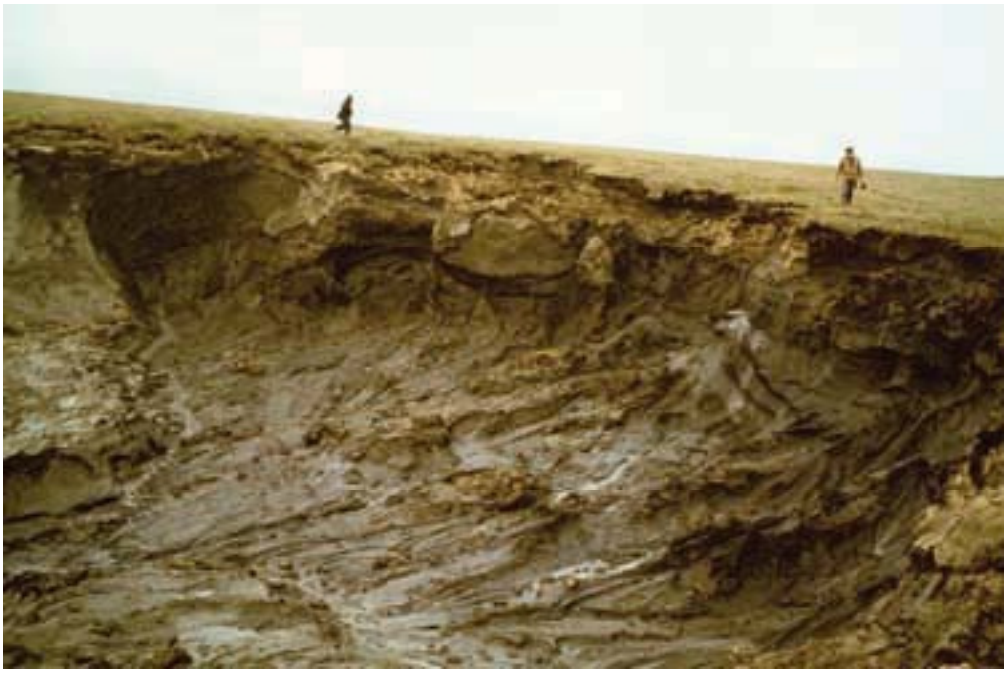
Forest boundaries will move north and agriculture will benefit from a longer growing season. Land animals, including moose, caribou, reindeer, small mammals and birds will be affected by changes in the snow cover.

Likely impacts on the oil and gas industry include problems of human-made structures (pipelines, etc.) in thawing permafrost terrain, improved construction conditions after the thawing of permafrost, improved offshore exploration and production with less sea ice, increased threats from erosion to coastal installations, and threats to low coastal installations (e. g., Prudhoe Bay) due to higher sea levels.

Likely impacts on construction and transportation including thawing permafrost effects on buildings, roads, airports, sewage, and utilities, effects on freshwater resources and potable water,

stream erosion effects on bridges, improved ship transport due to less sea ice, and the possibility of trans-Arctic shipping with less sea ice. It was pointed out that permafrost melting is a destabilizing force at coastal port cities and towns and this could interfere with the notion of improved and/or transport-Arctic shipping. It was also mentioned that barrier islands and lagoon ecosystems are very vulnerable to coastal erosion and sea level rise.

A variety of severe impacts on discontinuous permafrost terrain are predicted to occur from a 3°C warming of permafrost. These include severe impacts on coastal processes, thaw lakes, table and base permafrost melting, thaw settlement, slope instability, solifluction (the downward movement of soil and rock caused by weather), and effects on engineered infrastructure. Some effects on continuous permafrost terrain are also expected, including moderate to severe impacts on vegetation and associated economic and social effects.



This active thermokarst (where the surface collapses after underground ice melts) is an example of the results of thawing permafrost (photo by Tom Osterkamp).

The impacts on land, including forestry, agriculture, parks and wildlife, are likely to include insect outbreaks and more fire damage due to a warmer and drier climate.

The effects of climate change on the native subsistence culture are a cause for great concern. Changes in sea ice conditions that affect ranges and abundance of seals, walrus, whales, and fish, and climate changes that affect caribou and moose migration, could put severe stresses on the native subsistence way of life. These would be added to existing stresses such as exposure to air, water and food-borne contaminants that concentrate in this region.

Subsistence lifestyles, such as this whaling camp at the ice edge, could be affected by climate change (photo by Don Schell).

Changes in sea ice conditions that affect ranges and abundance of seals, walrus, whales, and fish, and climate changes that affect caribou and moose migration, could put severe stresses on the native subsistence way of life.

**About the Workshop**

The workshop stressed that climate change is not a future problem, but rather is one being dealt with right now in Alaska. For example, major roads have to be rebuilt from scratch every six years due to permafrost thawing. Climate change is already rapidly underway in Alaska.

About 100 people attended the workshop. Non-governmental organizations (NGOs) were fairly well represented but industry was not ( e. g., no representatives from the petroleum industry attended). Natives were represented to a small extent, and the organizers concluded that they needed to reach out to them more. In general, it was felt that there was a need for additional recruitment to bring more stakeholders in, and this was partly a problem of the short time frame. More personal contact is probably needed, utilizing phone calls rather than letters. In addition, the four-day length of the meeting may have presented problems for some invitees. The workshop was not considered to be a one time event, but rather a long term process that needs to involve all stakeholders and all people concerned with the impacts of climate change.

# Central Great Plains Regional Workshop on Climate Change Impacts

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The evidence for climate change is becoming more compelling, yet most regions of the United States do not have a strategy to deal with the potential impacts of climate change. In the Central Great Plains region ( i. e., the Kansas, Nebraska, Wyoming and eastern Colorado area), the potential impact of climate change is anticipated to affect winter snowfall, growing season rainfall amounts and intensities, minimum winter temperatures, and summer time average temperatures. The combined effect of these changes in weather patterns and average seasonal climate will affect numerous sectors critical to the economic, social and ecological welfare of this region. In order to better understand the regional implications of these changes and to evaluate coping strategies, the Office of Science and Technology Policy (OSTP) for the President and the U. S. Global Change Research Program (USGCRP) sponsored a regional workshop to begin to assess these impacts. A workshop on climate change impacts on the Great Plains dealing with issues facing conservation, ranching and farming in four states: Colorado, Wyoming, Kansas and Nebraska, was organized in May 1997 at the Sylvan Dale Ranch in Colorado. The workshop's objectives were to:

Climate change is anticipated to affect winter snowfall, growing season rainfall amounts and intensities, minimum winter temperatures, and summer time average temperatures.

(1) Understand the scope of potential climate change impacts on critical sectors in the Central Great Plains;

(2) Identify current constraints to environmental, economic, and social well-being in the region; and

(3) Develop a framework of coping strategies for mitigation and adaptation to environmental changes.

**Stakeholders invited to the workshop from the region included:**

- Citizens (farmers, ranchers, hunters, recreationists)
- Private Business (agribusiness, seed developers, irrigation suppliers, crop insurers)
- Land Managers (agricultural extension, water conservationists, park rangers, rural planners)
- Non-Governmental Organizations (NGOs) (Cattleman's Association, The Nature Conservancy, Sierra Club)
- Scientists (social scientists, climatologists, ecologists, economists, agronomists, wildlife biologists, hydrologists)
- Government Agencies (legislators, rural planners, county planner, regional conservancy groups, and Federal, state and local governments)

Key questions for the stakeholders included: What do people worry about regarding climate change? And what do they need to know that isn't known about climate change? Most of the public's information is at a very broad level and doesn't deal specifically with their community. Downscaling information from general circulation models (GCMs) brought up many questions regarding increased droughts, intensification of the hydrologic cycle, and rainfall patterns. A regional context was welcomed by the workshop attendees and helped add a local perspective to this global issue.

The workshop was structured to address these questions into four thematic breakout groups. These thematic areas were social issues, water resources, soil resources, and biological resources. The working groups' charge was to consider: what issues are of concern in this area presently; identify current conditions and trends; how climate change or increased climate variability might affect those issues/trends; what research is needed to prepare for and understand climate change consequences; and what coping strategies are available or needed to deal with climate change effects in this area. The working groups focused on:

Downscaling information from GCMs brought up many questions regarding increased droughts, intensification of the hydrologic cycle, and rainfall patterns.

- **Social:** vulnerability/risk of communities, social/political structures to offset impacts, economic and political strategies for coping
- **Water**: water quantity and quality and how these may effect human and ecological conditions (e. g., how might future climate scenarios effect the Rocky Mountains, a major source of water for Great Plains river systems)
- **Soil:** soil erosion/fertility, carbon storage, salinization
- **Biology:** plant/animal community change (native and introduced species), invasive weed and pest outbreaks, special crop/livestock breeds

Information provided to participants included data on temperature and precipitation changes in the 1900-1990 time series from the U. S. climate record, with a focus on the Central Great Plains. These data reveal large interannual variability, including a drought in 1933 and cooler and wetter conditions in 1958, bringing context to current changes. Participants were also presented with model results of temperature and precipitation changes forecast for various regions for transient climate change scenarios under different forcings. When sulfate aerosols were included, modeled results still indicate that more warming and more drought can be expected, but to a lesser extent than without sulfates.

Some of the key regional characteristics identified by the stakeholders as affecting the response to climate change include increased competition for water resources, major human transformations of land resources, temperature and precipitation restricting land use options, population shifting from rural to urban centers, trade centers thriving, high market variability, water availability and quantity declining, an increase in high-tech farm enterprises, and the fact that agriculture and livestock are major land uses. The vulnerability to climate change impacts is high for conservation and ranching interests, and moderate for farming interests which may be able to offset some of the impacts through technological advances. The following trends are anticipated to continue in the Great Plains:

- Increased size and reduced number of farms
- Increased importance of technology to achieve those increases
- Increased livestock and mixed cropland-livestock operations
- Continued water competition between agricultural and urban uses
- Population shifts out of rural areas

The primary land use that has transformed the Great Plains grassland has been agriculture. Over 90 percent of the land is in farms and ranches, and 75 percent is cultivated. There are five major production systems in the Great Plains: range live stock, crop fallow, groundwater irrigation (aquifer-dependent), river valley irrigation (snowmelt-dependent), and confined livestock feeding. Great Plains agriculture is land-extensive and uses relatively few chemical inputs and labor per unit of land. Interspersed with rangeland are dry land fallow, wheat growing (an important area for this worldwide), irrigated and dryland corn in the eastern part of the region, and integrated poultry and pork production with grain producing (a growing economic enterprise in this region). Climate patterns in the region are warmer in the south and cooler in the north, and these temperature regimes define the vegetation: short grass steppe in the south, cool-season very productive rangeland grassland and spring wheat in the north. The rainfall pattern is more east-west: a meter of annual rainfall in the eastern part and 270-300 mm in the more arid western part. Native grassland systems are characterized by high carbon storage (7.5 kgC/m2) in the wetter and cooler northeastern portions, but agricultural practices in the region lead to losses of soil carbon of 50 percent compared to grassland systems, as seen in Figure 2.8. Wildlife concerns include biological interaction between domestic animals and indigenous wild grazers, fires, and transition zones.

Over 90 percent of the land is in farms and ranches, and 75 percent is cultivated. The vulnerability to climate change impacts is high for conservation and ranching interests

Ranching is a significant land use in the region, and its vulnerability to climate change impacts is high (Penn State photo).

Water resources are scarce in the region, and are subject to great competition among the various users; e. g., urban demand for drinking water competes with water use for agriculture and wildlife conservation. Climate warming may severely impact the wetland areas of the region, bringing about severe consequences for migratory and local water fowl and other wildlife populations. Climate change may also cause greater crop damage due to increased drought stress resulting from higher growing season temperatures. The loss of soil from these croplands may be increased by the lack of plant cover. Ranchers in the region may not be able to support the current number of animals on the existing rangelands due to reduced dryland pasture production and lack of water resources for their animals.

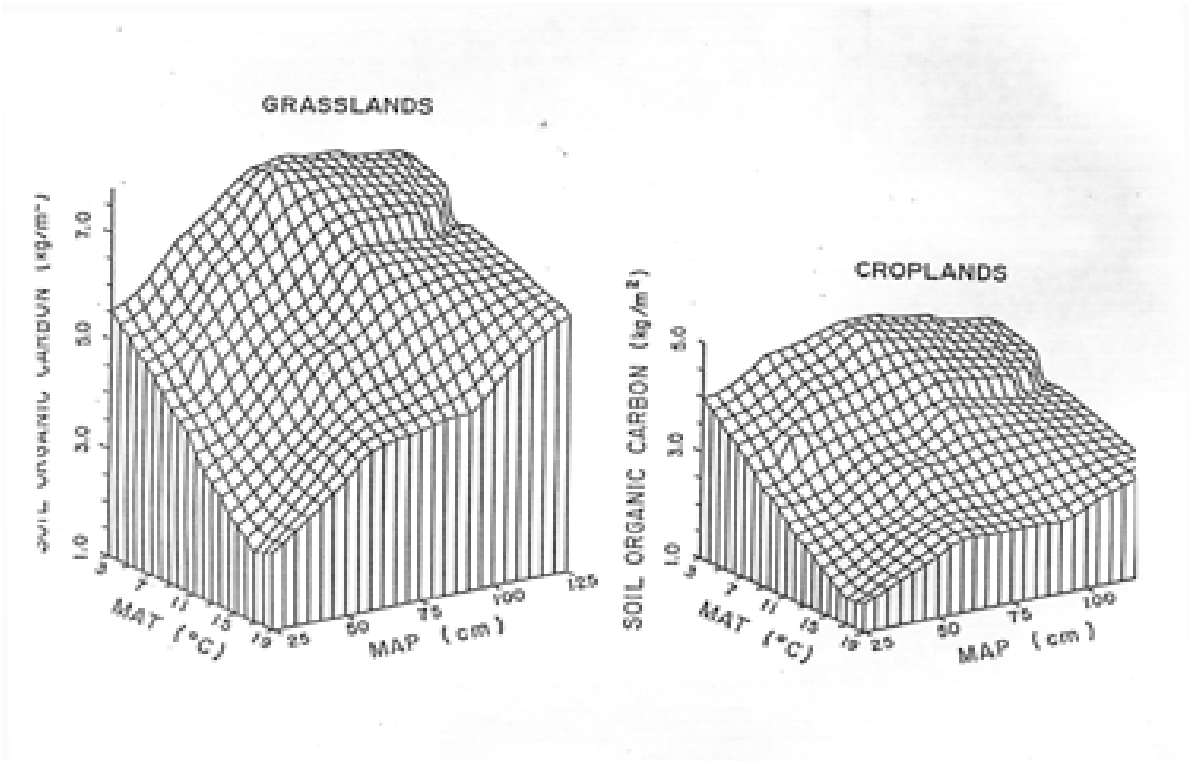


**Figure 2.8**
Soil carbon in native grasslands compared to agricultural croplands.

The diverse water needs of the region compound the difficulty in managing water use among the various sectors. The assessment therefore must involve members of the water use and supply sectors to better understand the competing water needs among agriculture, urban and industrial uses, and natural ecosystems. Understanding of the survival needs of aquatic systems under current demands and climate is incomplete. Water apportionment decision making between aquatic ecosystems and human needs must be more clearly assessed. We must begin to evaluate the effects that projected climate change will have on Great Plains aquatic ecosystems. This evaluation should also consider agricultural demands and water management. Changes in land use and climate will affect water quality, so, e. g. , we need to know how to best manage livestock wastes during extreme precipitation events.

Change in demographics, especially the aging or "graying" of the population and the migration to urban centers, is a real concern for people of this region. There has been a continued shift in the population from primarily rural to increasingly urban (see Figure 2.9). The number of ranchers and farmers is decreasing and half of those remaining are 55 years or older. The social-economic environment of the Great Plains is characterized by risk and marginality. Since the time of settlement, the variable and dry climate has made it difficult for people to live off the land. Agriculture is still the dominant lifestyle in this region in spite of the fact that narrowing profit margins are leading to consolidation into fewer and larger farms (see Figure 2.10).

The east to west gradient of declining moisture has determined the crop production pattern for the area. The variability of this climate has been somewhat overcome through the use of technology, such as fertilization, irrigation, and new crop varieties. Most farmers are grain producers, but increasingly, farm cash receipts are coming from livestock operations moving into the area. Sixty percent of the cattle industry is now concentrated in three Great Plains states, attracted by the dry climate, which allows feedlot cattle to thrive, and the open space far from population centers that allows for waste disposal. Figures 2.9, 2.10 and 2.11 illustrate changes in the Great Plains over the past century.

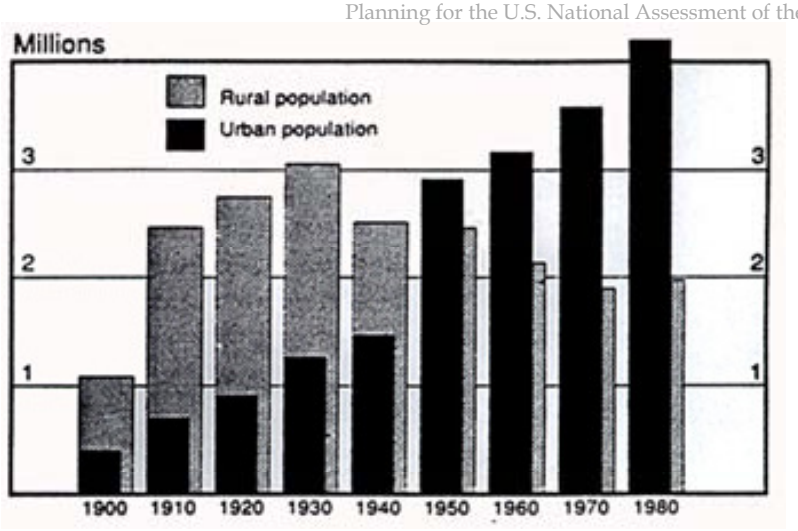


**Figure 2.9 (above)**
Great Plains urban and rural population per square mile. Source: U. S. Census Bureau
Agriculture is still the dominant lifestyle in this region in spite of the fact that narrowing profit margins are leading to consolidation into fewer and larger farms.

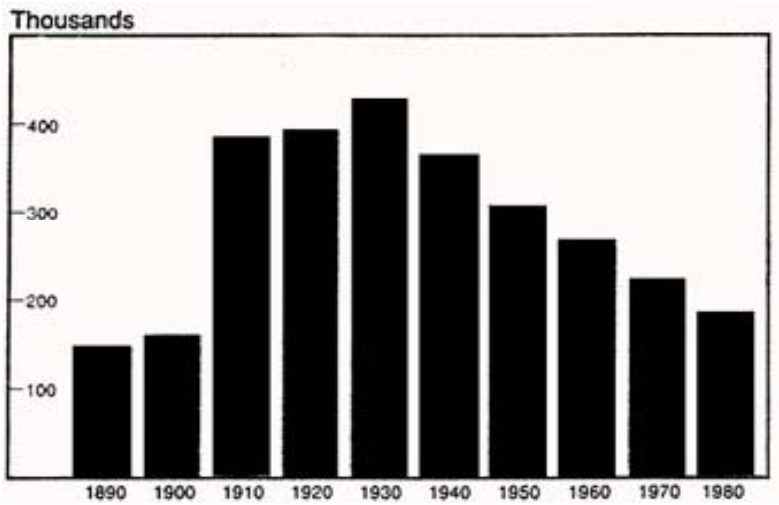


**Figure 2.10 (above)**
Total number of commercial farms on the Great Plains
Sources: U. S. Census Bureau and state statistics

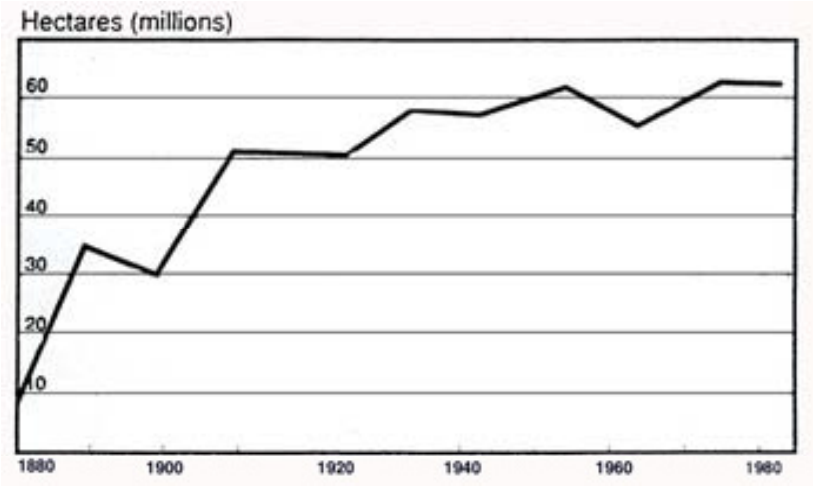


**Figure 2.11**
Total Great Plains cropland. Sources: U. S. Census Bureau and state statistics

An increased number of noxious weeds, greater pest outbreaks, increased rate of aquifer use, and loss of wetlands for water fowl may result from increased temperatures in the region.

Associated with climate change will be a number of indirect effects that will modify the ecological integrity of many ecosystems in the region. An increased number of noxious weeds, greater pest outbreaks, increased rate of aquifer use, and loss of wetlands for water fowl may result from increased temperatures in the region. The economic and aesthetic costs of these changes have not been evaluated within the region. Strategies for mitigating or adapting to these changes have yet to be developed. The diverse communities which populate the Great Plains are sensitive to changes in habitat and climate patterns. Many of the species which thrive in the Great Plains have adapted to the variable rainfall patterns and the warm, moist summers. The agricultural and livestock industries have also adapted to these climate regimes. Changing climate patterns will cause changes in habitat extent and species mixtures for crops and livestock activities. As climate changes, the expansion of areas invaded by weeds and other pests may occur. Our understanding of what effects exotic species have on habitats and how climate change will affect invasability of different habitats needs to be included in the assessment activity.

Changing climate patterns will cause changes in habitat extent and species mixtures for crops and livestock activities.

The impact of climate change on habitat and biodiversity needs to be better understood and assessed. Species inventories and other information organized into data bases which are supported and maintained is needed to effectively monitor species and communities. There is a need to design experiments to test hypotheses over long time periods and to evaluate vegetation and faunal assemblages, including predator-prey relationships, environmental controls on community structure, and the impact of changing landscape heterogeneity on habitat integrity.

Agricultural and rangeland ecosystems play an important role in soil conservation and land management. Agricultural management has produced beneficial systems incorporating the use of grass/legume mixtures in dryland crop rotation, different cropping systems to improve soil carbon levels and reductions of trace gas emissions, improved water management, and integrated farming analysis to evaluate changes in farm management and conservation of natural resources. These efforts need to be extended relative to changes in climate in different regions of the Great Plains.

Assessment of rangeland ecosystem relationships to livestock dynamics and invasive species relative to rangeland condition is needed. The issue of the role that the diversity of both plant and animal components of rangeland ecosystems play in maintaining good rangeland condition needs to be evaluated. Studies of climate change and carbon dioxide changes on vegetation and animal dynamics need to be evaluated relative to the ecosystem level response to these changes. Evaluation of various management strategies for coping with climate change, such as altering the frequency and intensity of grazing, is needed to develop strategies that promote sustainable rangeland use.

The role of disturbance in modifying ecosystem and habitat characteristics needs to be evaluated in a more integrated context which includes scenarios of climate change as well as other human perturbations. The human-induced changes to natural systems related to extraction of coal, gas, and other mineral resources impact water, air and land resources and should be studied. The impact of these changes to ecosystems and how they may be reclaimed under a changing climate needs to be evaluated .

In summary, the list of issues identified by the stakeholder discussions include:

**Social Issues:**

- Economic profit variability
- Government policies/subsidies
- Government regulations (e. g., environmental and water laws)
- Air quality
- Waste
- Human health concerns
- Farmig options, constraints to diversification
- Urban development, population shifts

**Water Issues:**

**Supply:** storage, infrastructure, control, wetlands preservation

The most contentious issue of all arose around the resolution between supply and demand and who has first rights to water in the region. How will climate change affect supply, and how will that altered supply be allocated within the region? It was felt that a regional approach would be needed to solve this problem as it could not be handled by the current system of state water boards. Regional water review boards were thus identified as a needed mechanism.

**Demand:** aquatic ecosystems needs versus agricultural demands/management

**Quality:** salinity, contamination

How will climate change affect water supply, and how will that altered supply be allocated within the region?

It was pointed out that the vast majority of water use was by agriculture; for example, 93.3 percent of consumptive water use in Colorado in 1985 was for agriculture.

**Soil Issues:**

- Soil degradation/quality, soil organic matter depletion, salinity, erosion
- Land management practices, constraints
- Disturbance regimes (fires, mining)
- Mitigation: fallow, diversity, livestock integration, legumes

**Biological Issues:**

- Invasive species response to land uses
- Predator/prey dynamics
- Habitat fragmentation/change
- Native biodiversity maintenance
- Crop plant gene pool maintenance
- Livestock germ plasm maintenance
- Recreation and fish and wildlife resources

Action is now needed to promote understanding of the relative importance of the possible effects of greenhouse gases on temperature and precipitation. Delineation of the relative significance and impacts of the respective mechanisms is needed. Land use change will affect greenhouse mechanisms and is thus important to controlling net greenhouse gas emissions from the Great Plains and the effect of these emissions at the global level. Based on the workshop outcome, plans for an assessment activity are being developed that will involve broader input

from other stakeholder groups (such as those from the oil and gas extraction industry; natural gas extraction accounts for more greenhouse gas emissions in Kansas than do feedlots) and to further develop our understanding of possible coping strategies.

Information issues were also identified by workshop participants, such as how to better disseminate what we know about environmental change. A strong need was identified for effective, credible, relevant information. The transfer of this information was seen as critical. Greater education is needed, as are connections and cooperatives. The use of technology as well as including farmers as a resource were also stressed. Data needs include better weather forecasting and adaptive management strategies across all sectors. A dialogue must be developed between government agencies at all levels, the research community and stakeholders.

Land use change will affect greenhouse mechanisms and is thus important to controlling net greenhouse gas emissions from the Great Plains and the effect of these emissions at the global level.

The workshop proved the value of the stakeholder dimension to this process and reflects how this process is different from past climate change assessments. The evaluation of stakeholder involvement is summarized in the following points:

(1) It is very helpful and even necessary to get good representation of thoughtful stakeholders. Success at this depends on personal contact and developing networks of experts, local businesspeople, farmers, etc., who have mutual trust. It is important to then support these people.

(2) It is important for non-scientists to receive materials well before the workshop so they can participate more effectively and feel more comfortable. This information must be in a form that is accessible to them.

(3) Starting with presentations by experts can stifle participation of stakeholders, adding to their reluctance to speak up. Instead, the organizers began their workshop by asking stakeholders for their views first. Expert contributions came later.

(4) Keep the focus on what people in the region are concerned about; look for terms and organizing concepts that people can relate to and care about.

The workshop showed that it is possible to have a breakthrough, to overcome initial suspicions, and to have stakeholders leave with new information and ideas about their role in the national effort to deal with the climate change problem. The workshop also provided insight into what the stakeholders view as current vulnerabilities:

- They are less concerned about gradual drying or changes in extreme weather events than of the forecast that variability will increase.
- A narrow range of conditions is needed for the precision farming that has become very common and which has made the farmer less adaptive and resilient.
- A key question is how farmers can become more resilient and adaptive, including financially.
- There is concern that climate change may lead to the emergence of pests and diseases and change the ecological balance that relates to the lives of organisms that cause farmers trouble. An increase in pesticide use could result from such changes.
- Changes in external markets are important to farmers in this region since they impact local prices and the relative ability of the region to compete economically . For example, the feedlot business could migrate south to Mexico under some climate change scenarios.

- The increasing frequency of flooding and droughts over the last decade is of great concern to people in the region and they want to know more about why this is happening.
- There was general interest in the idea that some people could benefit from climate change, bringing a competitive dimension to discussions of coping strategies.

The sense of the discussions at the workshop was that transboundary issues are important and climate factors influencing the balance of resources and economic forces are important to the welfare of the region. These include issues of water distribution, export markets and competitors, and population migration (bringing growing ethnic diversity), to name a few. Also, the change from local ownership to large multinational ownership of businesses undermines the ability of the region to cope since important decisions are being made outside of the region. This region is important to the rest of the country because a great deal of the nation's food comes from the Great Plains. Economist Mark Drabenstott of the Federal Reserve Bank discussed this point in his talk about the economic factors affecting agronomic systems in the Great Plains at the workshop.

Transboundary issues are important and climate factors influencing the balance of resources and economic forces are important to the welfare of the region.

# Pacific Northwest Regional Workshop on Climate Change Impacts

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The Northwest Council on Climate Change met in a Mexican restaurant every two weeks and this informal approach broadened the reach of the effort into a wider stakeholder community.

The Pacific Northwest regional workshop was a science-based workshop on the impacts of climate change. It involved individuals and organizations with operational responsibilities in the states of Washington, Oregon and Idaho. A unique feature of this effort was the establishment of the Northwest Council on Climate Change by Blair Henry. The council met in a Mexican restaurant every two weeks and this informal approach broadened the reach of the effort into a wider stakeholder community. The workshop participants included academics, representatives from various government entities at all levels, community representatives, and some limited participation from industry.

**Ingredients of Success**

There were six key ingredients in the success of this workshop:

(1) White house sponsorship and high level participation

(2) Adequate funding by co-sponsors: NOAA Office of Global Programs and NASA Mission to Planet Earth

(3) Close connections with a wide variety of stakeholders in the region for hydrology/ water resources, forests, aquatic ecosystems, and coastal activities

(4) Organization of the Northwest Council of Climate Change by Blair Henry and the participation of elected and agency officials, the state of Washington, the cities of Seattle and Burien, the business community, and some media

(5) Substantial support from the steering committee drawn largely from the Northwest Council on Climate Change and supplemented by participants from Idaho and the U. S. Forest Service representative from Oregon

(6) Individual connections in Oregon and Idaho which helped identify additional potential participants

**The Climate Scenario**

The workshop utilized the Max Plank Institute's coupled ocean-atmosphere general circulation model (a conservative, middle-of-the-road model consistent with IPCC predictions) interpolated to the regional scale. This model was used to describe a plausible scenario (not a prediction) for climate change in the region; the group then assessed the probable impacts, given this scenario.

In general, the scenario is one of warmer, wetter winters and warmer, drier summers. It includes an annual average temperature increase of 1.1°C (2°F) by 2020 and 2.5°C (4.5°F) by 2050, more warming in winter than summer, and continued temperature increases beyond 2050, even if greenhouse gas concentrations in the atmosphere are stabilized by that time. The scenario assumes that average wintertime precipitation increases and average summertime precipitation decreases, though these changes are less certain than those in temperature. A sea level rise of 50 centimeters (20 inches) by 2100 is assumed (with a range of 20 to 86 cm), with interim rises of 7 cm (3 in.) by 2020 and 20 cm (8 in.) by 2050.

Other potential changes include a decrease in the daily temperature range, more extremely hot days and fewer extremely cold days, and an increase in precipitation intensity and extreme rainfall events. These are less certain than the projections of average changes in temperature and precipitation and may or may not apply specifically to the Pacific Northwest. Important unknowns involve storm frequency and intensity, changes in El Niño events, and potential surprises and nonlinearities in the climate system.

**Vulnerabilities**

**Hydrology and Water Resources**

The group then assessed vulnerabilities in each sector. For hydrology and water resources, there were mainly minus signs. The one positive feature appears to be for flood control in systems in which the peak flows occur in the Spring as a result of heavy snowmelt, i. e., the Columbia itself. They projected that less water will be available when needed, and that more will come as winter precipitation, leading to more deliberate spillage from reservoirs in controlled river systems due to lack of storage capacity. They anticipate lower summer flows, and increased failure to meet minimum streamflow requirements needed to protect fisheries. Increased competition among major water users and an increase in legal battles over water rights are also foreseen as hydropower producers, irrigators and those concerned about fisheries protection fight over shrinking supplies.

Increased competition among major water users is foreseen as hydropower producers, irrigators and those concerned about fisheries protection fight over shrinking supplies.

With respect to floods, they anticipate that flood susceptibility in the Columbia (i.e., interior Northwest) would decline somewhat because floods there tend to come mostly from Spring snowmelt and there will be less snow. On the western sides of the Cascades, however, most floods are fall-winter events with some component of rain -on-snow. This rain-on-snow component might well increase as a result of warmer temperatures. In that case, there would be the potential for snowmelt to occur from higher elevation areas which are not usually affected in the current climate. While western slope basins may experience more winter floods, the effects may be very different for different basins.

They anticipate a reduced ability to meet multi-use objectives in systems with a variety of constraints as well as reduced operating flexibility and ability to respond to interannual and intra-annual variability in flow in heavily constrained systems (such as the Snake, Yakima and Cedar Rivers). In addition, moderate elevation basins could experience radical shifts in total system storage and flow regime due to snow pack shifting to higher elevations. Suburban development potential and the ability to respond effectively to increasing urban and suburban water demand may be affected. Glacial melting may influence low-flow hydrology in some areas.

**Forests and Rangelands**

Increased drought stress is anticipated, which increases tree susceptibility to pest outbreaks and fires. Increasing risk of wildfires and fire intensity is expected, as is an increase in pest outbreaks as warmer temperatures expand pest ranges and accelerate pest life-cycles. Forest

zones may shift up in elevation and northward, reducing the areal extent of productive forest land and making lower elevation, currently dry locations inhospitable to forests. A loss of biodiversity is expected, resulting from environmental shifts outpacing species migration rates, and a loss of habitat due to catastrophic disturbances and fragmentation. Ecological reserves, with their fixed boundaries, are especially vulnerable. Tree seedlings are especially sensitive to temperature increases and may not be able to establish and grow in the same place under altered climatic conditions. Forest ecosystems would consist of new combinations of species (a possible opportunity). Rangelands would experience increased invasion by exotic species, an increase in wildfires, and decreased forage quality.

**Aquatic Ecosystems**

Freshwater fisheries, especially in small rivers and lakes, are most vulnerable to climate change. Salmon migration and spawning would be harmed by decreased summer and fall runoff in west-side rivers. Fish habitat and egg-smolt survival may be harmed by increased wintertime river flows. It will become more difficult to provide adequate water flow for fish protection in the Columbia River Basin. A loss of wetland habitat is anticipated, as well as a loss of coastal habitat for outmigrating salmon, spawning oceanic species, animals, and sea birds. It is anticipated that the effect will be much like that of a continuous and positive El Niño event in which mackerel migrate north and eat young salmon, and seagulls and muirs flock to the mouth of the Columbia and devour fish released from hatcheries because there is not enough for them to eat off shore.

Inundation of coastal areas, increased loss of wetlands, increased erosion rates and events, loss of animal habitat, and increased saltwater intrusion into freshwater aquifers are anticipated.

On the positive side, there may be stimulation of growth and expansion of ranges of warm-water species especially near current northern boundaries of species' ranges.

The Pacific Northwest Workshop group believes that effects of climate change on marine fisheries will most likely be felt via impacts to North Pacific atmospheric circulation (and consequent changes in ocean circulation patterns) rather than on any direct heating of the ocean.

**Coastal Activities**

Mostly negative consequences are expected in this arena, exacerbated by inappropriate land use. The Pacific Northwest Workshop group anticipates inundation of coastal areas, beaches, wetlands, and estuaries due to sea level rise, increased loss of wetlands between existing and future coastal development and rising seas, landward shoreline migration, increased erosion rates and events, loss of habitat for migratory birds, fish, shellfish and water fowl, and increased saltwater intrusion into freshwater aquifers. Landslides and bluff failures could result due to increased wintertime precipitation and any increase in frequency and/or intensity of ocean storm events or changes in storm direction. Increased coastal flooding events are expected due to sea level rise, an altered hydrological/precipitation cycle, and any increase in future storminess. Different parts of the coast are vulnerable to different effects: erosion, flooding/inundation and physical oceanographic changes. Consequences that could be either positive or negative include altered productivity of coastal systems, changes in species distributions and abundances, and impacts on ecological processes and functions.

**Agriculture and Grazing Lands**

Agriculture shows the most positive results of any sector, though there are still more negatives than positives. On the negative side, decreased irrigation water supply coincident with increased water need in warmer, drier summers is expected, along with increased competition for water between agriculture, power production and fisheries. Other negative effects may be decreased grazing/rangeland productivity and shorter range season due to drier summers, decreased forage nutritive quality, increased agricultural and livestock pests, stimulated weed growth, increased

crop heat stress and decreased yield stability, and decreased production from marginal dryland areas. Economics may force low-cost margin crops and farms from the system as demand for water increases and/or energy prices increase. Increased flooding and soil saturation in low-lying river valleys or coastal areas west of the Cascades could occur. And there may be social impacts on rural communities where agricultural production is disrupted.

On the positive side, there may be an extended growing season due to increased temperature and improved crop growth and yields due to increased carbon dioxide. Productivity in the Pacific Northwest may increase (from more growing degree days and increased CO2) while productivity in other regions may decrease. There is a possibility of greater crop diversity. The enhanced-CO2 anti-transpirant effect (in which leaves' stomata remain more closed and so lose less water) may increase water efficiency in dryland areas. Winter wheat production may improve and there may be increased productivity in irrigated areas due to the possibility of double cropping or longer maturing crops.

**Human Health**

The least data are available on the subject of human health effects and so there is more uncertainty in the projections of impacts, though most appear to be negative. The possibility exists for increased photochemical smog production due to altered weather patterns (ozone production depends on incident sunlight, with sunnier days leading to more smog production, and atmospheric circulation patterns which concentrate or disperse pollutants and/or ozone precursors). Changes in the patterns of infectious diseases are anticipated, resulting from an expansion of pest ( e. g., ticks) ranges and/or acceleration of pest life-cycles. Diseases may migrate via human population migration. Increased water-borne health problems may result from contamination of drinking water by saltwater intrusion, leaks from underground hazardous material storage tanks or landfills with rising water tables in coastal areas, increased paralytic shellfish poisoning events (linked to warmer than average sea surface temperatures), and a possible increase in freshwater cyanobacteria in calm water expanses such as lakes and reservoirs. Mental health concerns stem from the possibility for profound social and economic distress in subsequent generations. Changes that could be either positive or negative include a possible decrease or increase in mortality due to changed incidence of high-risk air masses and potential changes in air-borne allergens that cause hay fever and asthma.

A loss of biodiversity is expected, resulting from environmental shifts outpacing species migration rates, and a loss of habitat due to catastrophic disturbances and fragmentation.

**Energy**

In the energy sector it is anticipated that there will be decreased capacity for hydroelectric power production in the Columbia River basin and that this will result in more frequent, longer lasting and larger failures of the power system to meet current levels of demand, and a decrease in the reliability of meeting energy production requirements. Competition for water resources would increase among hydropower production, irrigation supply, and fisheries protection and this will be exacerbated by demand increases due to population growth. The possibility for increased energy costs would impact industries such as aluminum production in the Pacific Northwest which depends on a cheap and dependable source of electricity. In addition, future national and international agreements may limit carbon dioxide emissions, impact the transportation, energy production and energy utilization sectors. On the positive side, there could be increased opportunities for development of alternative energy sources and associated technologies and an increased market for energy-efficiency technologies.

**Urban Centers**

Impacts foreseen for urban centers include decreased reliability of energy supplied by hydroelectric power production, flooding and landslides, environmental impacts on buildings and infrastructure, public health concerns stemming from increased air pollution and water-

borne health problems, altered sewage treatment plant outfall hydraulics and drainage issues, especially in coastal areas, and increased uncertainty in planning for meeting future energy and water demand. There are also possible negative impacts to primarily resource-based economics (forests and fish) and a possibility for decline in "quality of life" factors including skiing and other recreation and tourism. On the positive side, there may be an opportunity for stimulating economic growth by attracting alternative energy and energy efficiency industries. Effects that could be either positive or negative include impacts to the economy of the Pacific Northwest versus economic impacts to other regions, and human population migration to the Pacific Northwest from other more stressed parts of the world.

**Interconnections**

The above summary details potential climate change impacts to the various sectors, but it is important to recognize that none of these changes will occur in isolation. Impacts to one sector may trigger subsequent changes across other dimensions. It is anticipated that climate change will be manifested most directly through changes to the hydrologic cycle of the Pacific Northwest, and this cycle is the hub that unites all the sectors discussed above. Figure 2.12 demonstrates this interconnectedness and the complications added by secondary impacts.

Changes in the patterns of infectious diseases are anticipated, resulting from an expansion of pest ranges and/or acceleration of pest life-cycles.

**Transboundary Issues**

A number of important transboundary issues were identified:

- Population migration - pressure on urban centers, disease vectors
- Canada relations - reservoir storage, hydroelectric power, salmon migration
- Climate drivers - El Niño-Southern Oscillation, Pacific Decadal Oscillation
- Impacts of climate change-driven atmospheric changes on Northwestern Pacific circulation and ecosystems
- Energy - relative decline of hydroelectric power, shift to alternative fuels, impacts of national emissions control regulations

**Adaptation and Management Responses**

(1) Since so many activities are water-dependent, improved watershed management would yield benefits across several sectors (reducing competition and conflict, increasing efficiencies, streamlining planning processes, increasing use of conservation and re-use technologies, managing forest density for water balance, choosing drought tolerant agricultural species, and reducing energy demand).

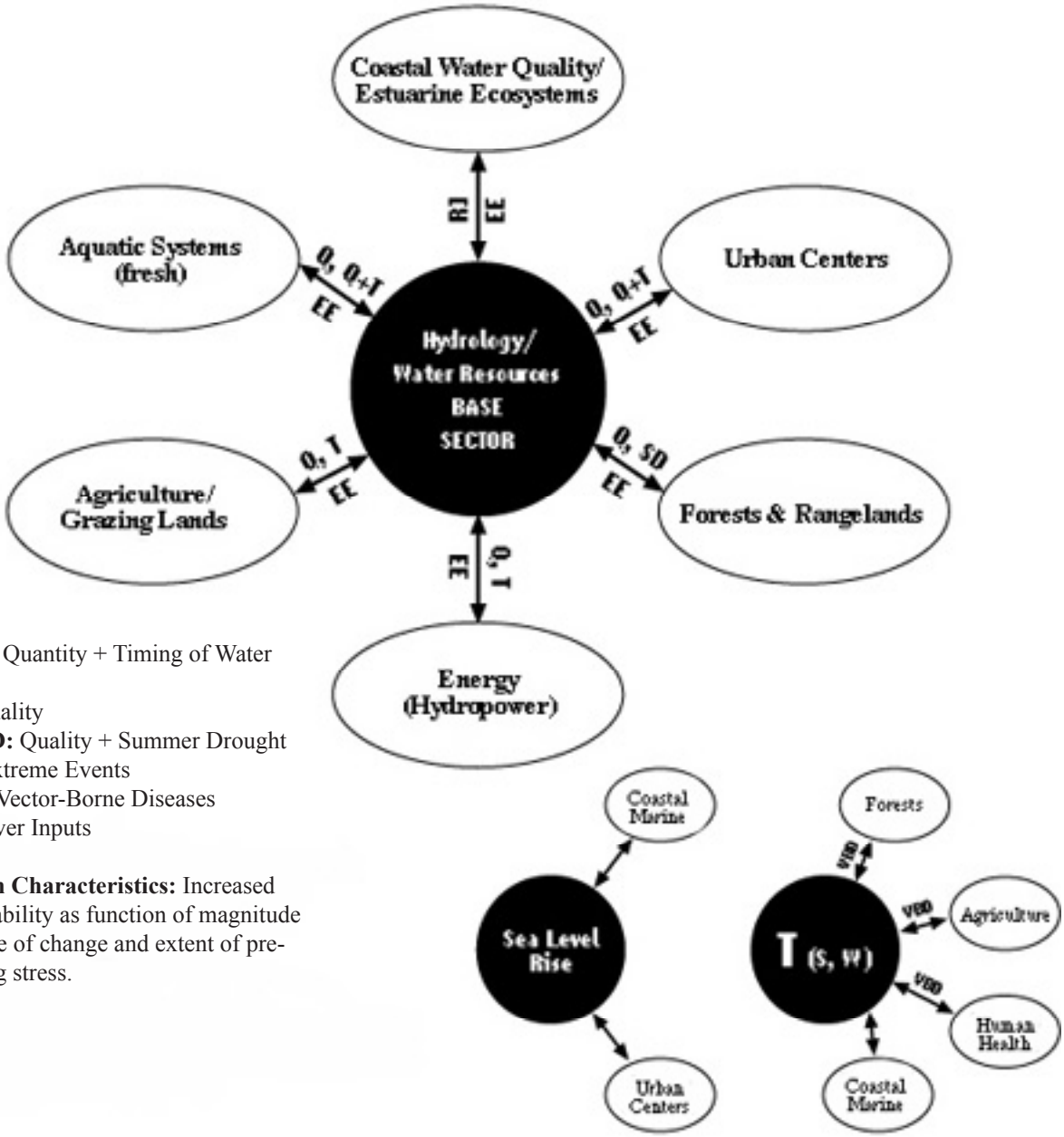
(2) Tapping new sources of water and/or increasing storage could involve increasing ground water withdrawal, recharging aquifers, and negotiating for use of increased Canadian storage.

(3) Adaptive management would incorporate climate change scenarios in future planning and use longer temporal and larger spatial scales in planning processes.

(4) Diversification to ensure future resiliency would include planting forest species with known broad physiological responses to climate parameters, increasing crop and crop systems' diversity and resiliency, connecting water supply systems with different characteristics to increase robustness and flexibility of water resources systems, and practicing precautionary fisheries management.

(5) Increasing within-sector cooperation and sharing would include developing a database of incidences of climate-related diseases and mapping the ecological ranges of disease reservoirs and vectors, and sharing results of global monitoring of trends in forest conditions and climate-related forest stress.

## Primary Impacts: Sectors




**Q + T:** Quantity + Timing of Water Supply
**Q':** Quality
**Q + SD:** Quality + Summer Drought
**EE:** Extreme Events
**VBD:** Vector-Borne Diseases
**RI:** River Inputs

**Comon Characteristics:** Increased vulnerability as function of magnitude and rate of change and extent of pre-existing stress.

**Major Implication:**
Increased competition and conflict over access to water supply.

**Figure 2.12**
This diagram illustrates how a variety of impacts flow from changes in hydrology and water resources.

(6) Develop new technologies, particularly alternative energy systems.

(7) Improve methods of conflict resolution across sectors, especially regarding property rights.

(8) In coastal zones where sea level rise is of concern, choose among adjustment, protection, retreat, and abandonment, making these choices relevant to the context.

**Research Needs**

(1) The primary objective of research should be a more detailed and effective linkage of global and regional climate dynamics in order to better understand how changes at the global level might or might not be reflected at the regional level.

(2) Whatever the dynamics of the linked global/regional climate system, research should focus on how patterns of regional climate change would impact ecosystems and human activities in the eight sectors.

(3) It should also focus on how the sectors are interconnected to better describe how changes in hydrology/water resources would have ripple effects across the other sectors.

In the future, the region should be defined in an ecological, rather than a political sense, to facilitate a watershed approach.

In planning for a regional science assessment the organizers felt that the scope of this initial group should be expanded to include the four missing sectors and that a collaborative, inter-university research program should be created for the region. They further feel that the U. S. Global Change Research Program (USGCRP) should link U. S. regional assessments to Intergovernmental Panel on Climate Change (IPCC) 5-year assessments but with a 1-year lag. In the future, they felt that the region should be defined in an ecological, rather than a political sense, to facilitate a watershed approach (i. e., the entire Columbia and Puget Sound Basins).

In conclusion, the organizers point out that it was important to this workshop's success that they did not get into the question of blame and they did not debate whether climate change is already happening. The group simply agreed on a statement that climate change is a significant problem that requires attention. Substantive discussion and elucidation of the impact pathways through which climate changes will be felt in the region was made possible by the adoption of a specific and realistic scenario for future climate change.

Rising sea levels are anticipated to have negative consequences in the coastal zone (photo by Gunter Weller).

# Southeast Regional Workshop on the Impacts of Climate Variability and Change

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The Southeast regional workshop was held in June 1997 and was sponsored by the National Aeronautics and Space Administration (NASA), the U. S. Geological Survey (USGS), and the National Oceanic and Atmospheric Administration (NOAA). The purpose of this workshop was to examine the impacts of climate variability and potential vulnerability to future climate change in nine states: North Carolina, South Carolina , Alabama, Georgia, Tennessee, Mississippi, Louisiana, Arkansas, and Florida. Representation by economic sectors varied widely, and as a result, coverage of issues varied as well. For example, the forestry and coastal fisheries sectors were not represented; therefore, gaps in the findings and recommendations exist in those areas.

Regarding El Niño events and their impacts, a little information to stakeholders can result in huge benefits.

At the workshop, Jim O'Brien demonstrated the enormous effects that El Niño and its opposite, called El Viejo or La Niña, have on the climate variability of the southeastern U. S. When there is an El Niño in the winter, for example, the Southeast can expect a reduction in hurricanes and tornadoes, more rain, cool temperatures, and an adverse effect on Florida's crops. (This reduction in hurricanes also reduces the water supply, and in Florida, where the population increases by 1000 people per day, hurricanes are badly needed for the water they bring.) On the other hand, when there is a cool tropical Pacific Ocean (an El Viejo or La Niña), the region can expect more hurricanes, forest fires in the coastal regions of the Carolinas and in south Florida, and adverse effects on many crops (see Figure 2.13).

Regarding such events and their impacts, a little information to stakeholders can result in huge benefits. In South Florida, for example, the devastating effects of wild fires that result from El Viejo events can now be ameliorated because they are often known about in advance. Similarly, crops can be timed to coordinate with weather events if these events are predicted and this knowledge is communicated to local farmers. Taking advantage of El Niño forecasts in this way has a potential impact of $250 million per year. Tornado forecasts can save many lives through increased preparedness. Improved precipitation and temperature forecasts have enormous economic benefits for large power producers, and better short-term (48-72 hour) forecasts are helpful for utility load management decisions.

El Niño and its opposite, called El Viejo or La Niña, have enormous effects on the climate variability of the southeastern U. S.

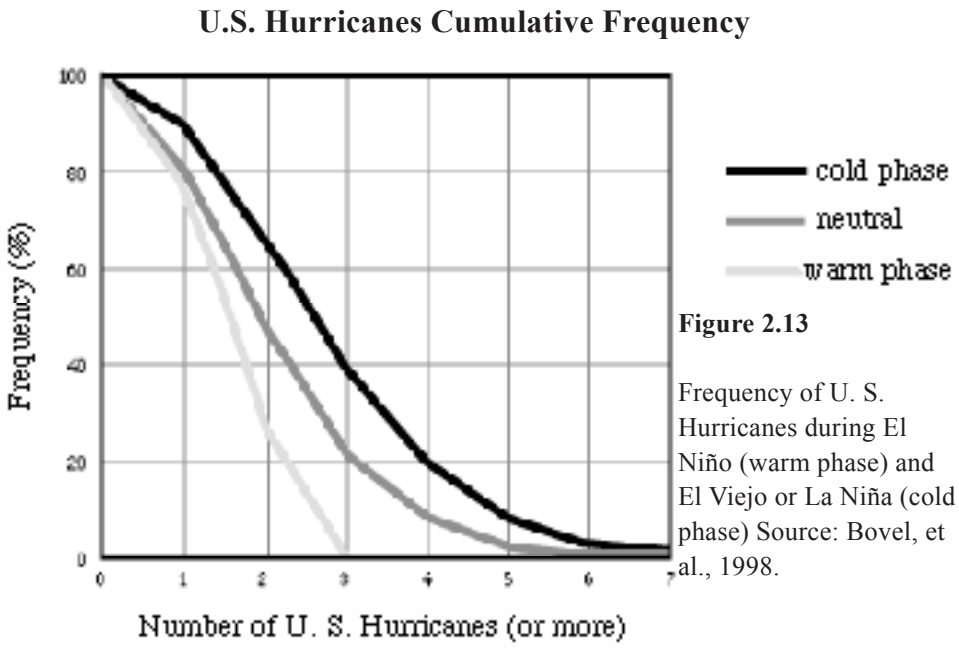



**Figure 2.13**

Frequency of U. S. Hurricanes during El Niño (warm phase) and El Viejo or La Niña (cold phase) Source: Bovel, et al., 1998.

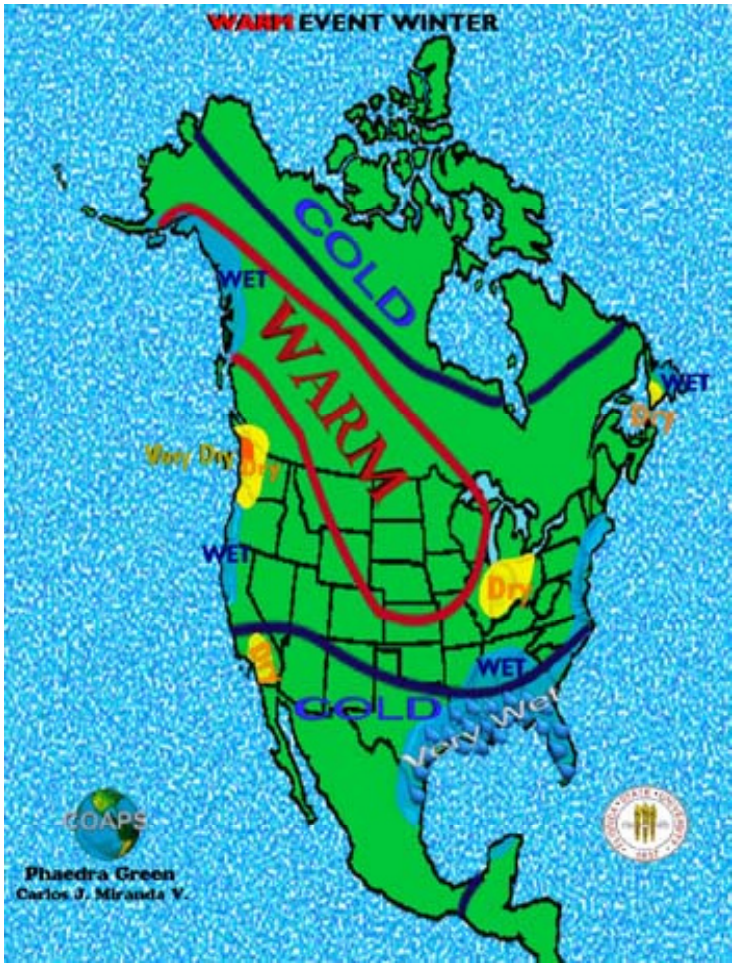



**Figure 2.14**

Temperature and precipitation effects of El Niño (warm phase) in winter in North America. Source: Green, et al., 1997 (see references).

Four basic themes emerged from the workshop. First, the regional infrastructure is already

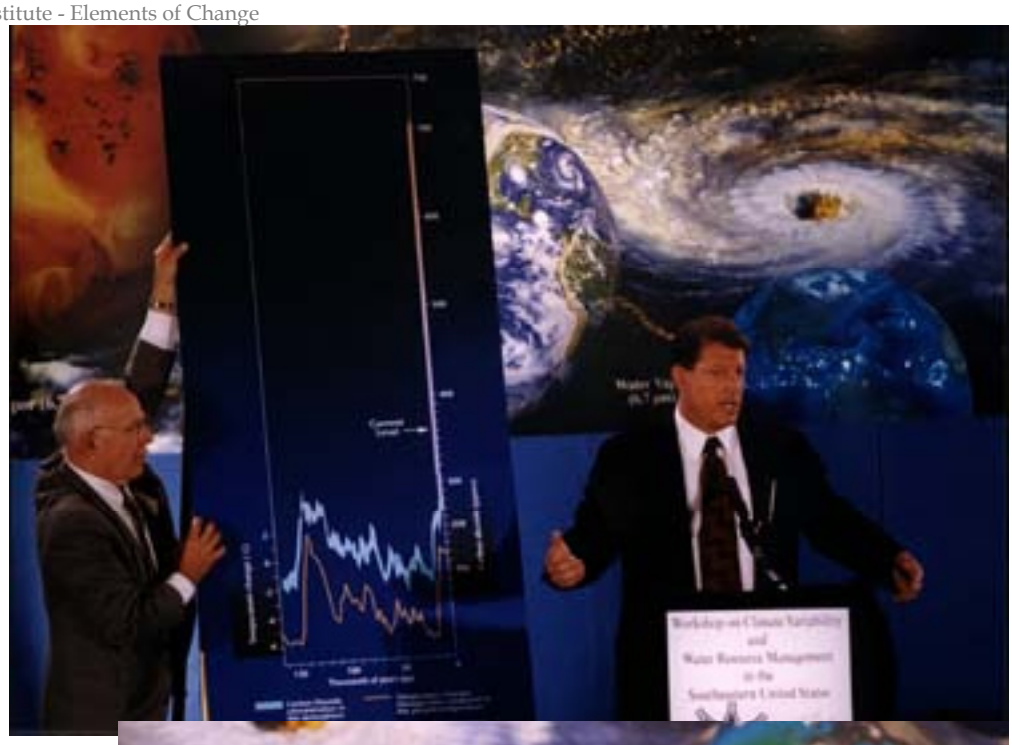
being stressed by resource limitations and near-term weather and climate variations. Meeting day-to-day operations already consumes most of the time and budget of regional stakeholders (such as water and utility managers, park rangers, and coastal management personnel) in the absence of climate-related issues. If the magnitude of climate variability increases or there are more frequent extreme events, these systems will be stressed even further.

Second, although climate predictive skills are improving, especially for short-term forecasts (up to 72 hours) and data are currently available or emerging from the climate community, this information is not widely used by the regional stakeholders (such as farmers, agricultural extension agents, and utility and water managers). There has been inadequate communication of climate risk at the regional and local levels. There is considerable uncertainty at these levels about the nature and extent of climate variability and future climate change. Decision makers at these levels are interested and want additional information on climate change and variability that will help them obtain answers to questions about the magnitude, timing and potential costs of climate impacts. The workshop highlighted new approaches and data emerging from the climate research community such as the use of El Niño/El Viejo data to predict seasonal and interannual climate variability for use in agriculture, water management, hazards management (e. g. , tornadoes and hurricanes) and coastal zone planning. It is anticipated that this workshop and follow-on efforts will help mold these approaches for better use by regional stakeholders

Regional stakeholders are generally unable to make effective use of the information, data and products currently available from the climate research community.

Third, regional stakeholders are generally unable to make effective use of the information , data and products currently available from the climate research community. A clearer understanding of the products that are or will soon be available is greatly needed. Because individual researchers generally don't communicate their results directly to decision makers, an effort is required to identify scientific results that can be useful to the public and private sectors and can contribute more directly to near-term economic and societal applications. One cause of the current deficiency in this area is that existing delivery or distribution systems ( e. g., county extension programs for agriculture) are not generally linked to the outputs of the climate research community.

Fourth, stronger partnerships among federal and academic researchers, regional, state and local stakeholders, and the private sector are needed to adopt and incorporate advanced scientific results, technology, and data products into everyday decision making. Better linkages are required between researchers and regional stakeholders to better define the needs of a broader user community and to identify scientific results that can meet those needs. As was mentioned earlier, the benefits of getting predictive information to those who need it at the local level can be enormous.



**Vice President Al Gore addresses the Southeast Regional Workshop**

**Key Findings and Recommendations**

**Water Resources**

Findings

The overriding water resource issue in the Southeast is that the demand for water is beginning to exceed the available supply and competition among water users is intensifying. This competition for water is exacerbated by climate variability and change.

As water conflicts in the Southeast have intensified, it has become apparent that there are inadequate mechanisms for the equitable allocation of water. Since most of the important water issues are not of a technical nature, but are political, social and institutional issues, a major concern is how to develop flexible and adaptive institutions , legal frameworks, and problem solving mechanisms to allocate water among its competing uses.

Demand for water is beginning to exceed the available supply and competition among water users is intensifying. This competition for water is exacerbated by climate variability and change.

Recommendations

Bridges are needed between information regarding future climate variability and change and the information required to understand trade-offs among different water management alternatives. An example of such a bridge would be a hydrologic model that can translate climate information into streamflow, water levels and soil moisture . Decision support systems are also needed.

There is also a need for demonstration or pilot projects to assure that appropriate linkages are made among water resources stakeholders, water system operators, government agencies, and the scientific community. The Global Water and Energy Cycle Continental-scale International Project, which is about to be initiated in the Southeast is encouraged to undertake such pilot projects to accelerate the development of models and information related to the prediction of precipitation, soil moisture, and streamflow and to test their value to the water resources community.

To better allocate water and resolve water conflicts, innovative supply side management (e. g., water credits, pricing strategies, etc.) integrated basin management using multi-governmental and stakeholder teams to solve problems, and flexible institutions and mechanisms for resolving conflict are needed.

**Agriculture**

Findings

Because agriculture in the Southeast is productive yet diverse both in systems and stresses and because irrigation is not as prevalent as in other parts of the country, the effects of climate variability and change on agriculture can be amplified in this region.

The heterogeneous nature of topography, soil structure and quality, and climate is unique in the Southeast. The interrelationships among these characteristics and their roles in sustaining productivity is not well understood.

Recommendations

In the agricultural sector, a need exists to develop, validate, and evaluate new technology capabilities such as climate forecasting, use of remotely sensed data, biophysical modeling, and precision agriculture using a multidisciplinary approach that includes producers, researchers, government agencies, farmers and others in the private sector.

There is a need to explore the transfer and communication of relevant information on climate variability/change over a full spectrum of temporal and spatial scales to users and user-specified applications. This may be best realized through the support of demonstration or pilot projects with the county extension system or similar outreach programs.

**Urban Areas and Human Health**

Findings

Air quality is a major concern of urban areas and it contributes to a host of environmental and human health problems which can be exacerbated by climate variability and change.

Air quality is a major concern of urban areas and it contributes to a host of environmental and human health problems (e. g., secondary air pollutants such as tropospheric ozone and chronic and acute respiratory diseases). These problems can be exacerbated by climate variability and change.

Urban heat islands, land use changes, and urbanization in general contribute both to air quality degradation through their influence on photochemical processes and to the local and regional climate (e. g. elevated air temperatures, altered precipitation patterns, changes in surface albedo, etc.).

Recommendations

Data are needed to identify susceptible populations that will be affected by changes in climate extremes and variability, to correlate respiratory health with air quality changes resulting from climate variability, and to evaluate the cost of local and regional climate variability on urban areas for urban planners and decision makers.

Improved education of both the public and decision makers and effective communication by scientists to the public on the effects of climate variability and change on urban areas and human health and on how urban areas affect local and regional climate is essential in developing mitigation strategies.

**Coastal Areas**

Findings

Populations on and near the coast of the southeastern U. S. grew by over 70 percent over the past 30 years leading to complex social and economic concerns related to mitigating the impact of climate variability and change such as sea level rise, storm surges and extreme events.

The potential range of climate-related impacts on ocean and coastal resources has been fairly well documented but a comprehensive assessment of the magnitude of environmental and economic costs associated with coastal impacts and hazards is still lacking.

Recommendations

Better compilations of life history data for coastal ecosystems and improved understanding of carrying capacities for sensitive species are needed so that managers can better understand the range of impacts and assess mitigative actions. These data need to be merged with socioeconomic and climate variables to improve our understanding of and ability to communication the potential impacts.

The current natural systems approach, which relies on biogeographical provinces, needs to be expanded to include climatic relationships. Further, various controlled-use sites (e. g., National Wildlife Refuges, National Estuarine Research Sites) in the region should be linked to develop a baseline reference system for studying change.

**Parks and Public Lands**

Findings

The Southeast region is forecast as the fastest growing in the country. U. S. population has grown at a rate of about 6.7 percent over the past five years, while the Southeast has grown by close to 10 percent over the same period. Florida and Georgia populations have grown at an even greater rate. This rapid growth causes expansion of stresses on parks and public lands (introduction of non-native invasive species, habitat fragmentation, island biomes, water and air quality issues), while at the same time, current fiscal conditions are placing stress on public land managers. Managers are not well-equipped to deal with extreme climate events and they have specific information needs related to decadal climate fluctuation, storm predictability , and extreme events.

Recommendations

There is a need to develop firm federal policy on infrastructure in public areas so as not to exacerbate or expand development pressures from outside the public area or create more fragmented systems.

Regional cooperation among federal, state and local agencies and the private sector needs to be encouraged for maintenance of community continuity to allow for adaptive change in habitats and biological communities. Southern Appalachian Assessment might serve as an example of multiagency cooperation for integrated planning and development of information for use in local and regional decisions.

Populations on and near the coast of the southeastern U. S. grew by over 70 percent over the past 30 years leading to complex social and economic concerns related to mitigating the impact of climate variability and change.

**Extreme Climate Events**

Finding

Extreme climate/weather events have a considerable impact on stakeholders in the Southeast associated with sectors that include energy, emergency management, and water resources. The Southeast is becoming increasingly vulnerable to extreme events including hurricanes, floods, droughts, ice storms, heat waves, and tornadoes because of rapid population growth and development in vulnerable coastal locations.

Recommendations

There is a need to maintain and extend our ability to collect, analyze, and disseminate data related to climate over the long term. In the case of extremes, such data have a demonstrable relationship to decision making. Given that societal and environmental problems associated with climate extremes are complex, data must also be collected on non-climate factors (e. g., social and economic impacts and causes).

Bridge-building may increase to develop processes to determine what climate information and tools would be of use to stakeholders. Existing organizations such as the National Climate Data Center, Regional Climate Centers, and State Climatologists should be used to enhance the linkage between climate science and regional stakeholders.

The Southeast is becoming increasingly vulnerable to extreme events because of rapid population growth and development in vulnerable coastal locations.

**Education**

Finding

Since education cuts across each of the breakout topics, there are many opportunities for the educational community to contribute to the climate research agenda, to use scientific results to enhance educational programs, and to educate future generations of teachers to implement Earth systems science programs.

Recommendation

From the educational perspective, the most important recommendation is to promote the adoption and expansion of existing programs, such as Global Learning and Observations to Benefit the Environment (GLOBE), that involve students and their teachers in data collection, manipulation and interpretation. The upcoming The Global Water and Energy Cycle Continental-scale International Project in the Southeast was suggested as a candidate program for establishing a partnership between the scientific and educational communities to demonstrate this approach.

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Green, P. M., D. M. Legler, C. J. Miranda V, and J. J. O'Brien, 1997. The North American Climate Patterns Associated with the El Niño-Southern Oscillation, COAPS Project Report Series 97-1, Center For Ocean-Atmospheric Prediction Studies, Florida State University, Tallahassee, Florida. The complete report can be found at http:/ /www.coaps.fsu.edu/lib/booklet

# The Remaining Regions

After presentations about and discussion of the four regional workshops that had already taken place, brief presentations were made by the organizers of the other regional workshops that were scheduled to occur in the coming months.

A number of common themes emerged from these presentations including:

* the need to engage a wide variety of stakeholders in this process,
* the need to set climate change impacts in the context of existing stresses, and
* the importance of improving communication between scientists and the public.

In addition, several issues emerged that were common to nearly all regions, such as:

* the importance of anticipated changes in water resources, and
* the currently increasing impacts of climate variability and extreme events.

Several issues emerged that were common to nearly all regions, such as the importance of anticipated changes in water resources.

The remaining regions include:

* Southwest/Colorado River Basin
* New England
* Middle-Atlantic
* Northern Great Plains
* Rocky Mountains and Great Basin
* Gulf Coast
* Southwest/Rio Grande River Basin
* Hawaii and Pacific Islands
* California
* Metropolitan East Coast
* Great Lakes
* Appalachians
* Caribbean/Southern Atlantic Coast
* Eastern Midwest
* Southern Great Plains
* Tribal Lands

The schedule of regional workshops is presented in Table 2.2.

# Introduction to Sectoral Working Group Reports

**What Sectoral Assessments Should be Pursued?**

Several proposals for sectoral breakdowns were discussed by the AGCI group. To test the potential viability of using a breakdown of issues into consequence sectors, working groups were organized to consider the types of issues that would arise based on a division into ten possible sectors:

One scheme focused sectors around a set of topics driven by major needs of individuals and society.

* Agriculture
* Coastal Zone
* Extreme events
* Forests
* Freshwater Ecosystems and Wetlands
* Grasslands and Arid Lands
* Parks and Public Lands
* Public Health
* Urban Areas
* Water Resources

Other areas raised for possible inclusion as sectors included the service sector (insurance, banking, etc.), the extractive sector (mining, oil, etc.), tribal lands, energy, and environmental security.

Based on discussions subsequent to the reports from these working groups, a second way of covering the topics was proposed. This scheme focused sectors around a set of topics driven by major needs of individuals and society. Each category was to be very broadly conceived. These topics were:

1) food availability (farming, ranching, fresh water, marine, fishing, aquaculture, erosion, land quality, CO2 enhancement)

2) water availability (quality, quantity, agricultural, municipal and industrial use, habitat effects, allocation, management, runoff)

3) human health (public health, disease vectors, heat stress, natural hazards, air and water quality)

4) forest products availability (forests, timber and pulp production, fire management, shifts in tree species, wildlife, recreation)

5) ecosystem goods and services (grasslands, arid lands, freshwater aquatic systems, wetlands, migrating species, marine life, wildlife, coastal ecosystems, public lands, parks, reservations, protected areas, conservation, tourism, montane regions, endangered species, biodiversity, water purification, permafrost)

6) urban societal infrastructure or cities and communities or human habitat (urban environments, rural settlements, flow of goods, links to natural hazards, insurance, real estate, equity, indigenous people, systems and institutions, housing )

7) energy availability (energy supplies, demand, systems, natural resource extraction and mining, oil, coal, natural gas, renewable energy sources, transportation , heating, commercial and residential needs, international implications, coastal issues, utility deregulation, green marketing)

with the possible addition of:

8) national and international economies (jobs, broad economic issues, economic growth mechanisms, flows of goods and services, financial mechanisms and instruments)

9) natural hazards and extreme events (floods, hurricanes, fire, connections to El Niño and other climate phenomena)

Other alternative organizational schemes were also proposed, including one based on:

(1) water availability

(2) food availability

(3) energy availability

(4) ecosystems and endangered species

(5) quality of life (human health, coasts, migration, storms, transport)

Note: Since the AGCI workshop, the National Assessment Synthesis Team has decided to focus most of its attention on five sectors: Agriculture, Water, Coastal Zone, Health, and Forests. Each of these sectors is to be very broadly interpreted, so that, for example, forests covers everything from biodiversity to recreation to lumbering to rural communities. Because of these broad interpretations, these five topics encompass virtually all of the many sectors discussed by the group in Aspen.

Since the AGCI workshop, the National Assessment Synthesis Team has decided to focus most of its attention on five sectors: Agriculture, Water, Coastal Zone, Health, and Forests.

Brief reports from the AGCI sectoral working groups follow.

# Agriculture

When assessing the impacts of climate change on U. S. agriculture, it is important to bear in mind their close connections to international markets and other trends that are controlled far from the region being farmed.

This sector would deal with the important areas of food and fiber production. When assessing the impacts of climate change on U. S. agriculture, it is important to bear in mind their close connections to international markets and other trends that are controlled far from the region being farmed. Some of the global and national drivers of regional agricultural systems include supply, demand and pricing, changes in comparative advantage, government programs, multinational agro-business, and international food distribution.

**Current Stresses Include:**

* climate variability
* pests/diseases (including invasive exotic species)
* air pollution
* water supply (declining aquifer levels, droughts, floods, etc.)
* soil quality (erosion, salinity, toxicity, etc.)
* urban-rural land competition
* changing farm structure
* fiscal risk (e. g., capital depreciation)

**Additional Stresses Brought About by Climate Change Include:**

* frequency and magnitude of extremes versus means
* shifts in the magnitude and timing of critical climate resources ( e. g., soil moisture, growing season lengths)
* pests and pathogens, especially shifting zones and timing
* elevated carbon dioxide effects
* changes in nitrogen deposition
* soil erosion, particularly following downpours
* mapping out agricultural potential
* comparative advantage changes

**Potential Coping Mechanisms Include:**

* information dissemination, defining roles of private sector, agricultural cooperative extension, etc.
* directing technological innovation
* soil/nutrient/water conservation programs
* applying new technologies (e. g., bio. tech., breeding, precision agriculture, integrated pest management)
* altering pest management systems

* shifting crop species and cropping zones
* more flexibility in government programs
* market mechanisms
* increasing carbon sequestration

**Potential Surprises Include:**

* new diseases and pests emerging, especially resistant strains
* multiplicative effects of human management and environmental change may be great; the whole may be greater than the sum of its parts
* anticipated rise in productivity may fail to materialize
* world market changes (e. g., what will happen in Africa or China and how will this affect the U. S.'s comparative advantage)
* positive potential surprises such as biotechnology breakthroughs
* additional unforeseen surprises

Multiplicative effects of human management and environmental change may be great; the whole may be greater than the sum of its parts.

# Coastal Zone

This sector includes all ecological and physical impacts from climate change in the coastal zone out to 200 miles. It encompasses fish and fisheries (including those that migrate through this zone), marine mammals, turtles, corals, mangroves, coastal forests, aquaculture, wetlands, and tidal influences. An increasing portion of the human population inhabits the coastal zone. This sector is important in providing:

- water filtration and cleansing
- habitat for fish, birds and mammals, including about 70 percent of marine fishery species which spend part of their lives in this zone
- breeding ground for land mammals and anadromous fish that reproduce in bays and estuaries
- food source for humans
- coastal protection: mangroves and corals protect barrier islands and coast line from storm damage
- economic base: fisheries, recreation, tourism, transportation, mineral extraction , oil and gas extraction

In the case of the interaction of climate variability and overfishing, the root stock of particular fish species can be at stake.

**Current Stresses Include:**

- pollution, both point and non-point source
- subsidence (e. g., 2.5 inches (6.4 cm) per year in New Orleans)
- human population growth
- coastal erosion
- storm surges
- increasing ultraviolet radiation (UV) due to ozone depletion
- overfishing
- upstream development (water diversions impact timing, quantity and quality of water reaching coast as well as sedimentation changes)
- nutrient loading and other pollution from agriculture
- contaminants
- oil spills, other hydrocarbons, spills from big transportation systems
- climate variability (at interannual and decadal time scales)

There is pronounced decadal as well as seasonal and interannual climate variability which is far in excess of expected climate change. Variability in water temperature, salinity, circulation patterns, currents, and sea level rise all have dramatic impacts on these coastal ecosystems. Mobile species and immobile ones show differential responses to climate variability (e. g., for migratory birds, short term variability can have large impacts). Natural variability also has substantial impacts on ecosystem structure. Other stresses, such as overfishing, interact with natural variability to create larger impacts than either would alone. In the case of the interaction of climate variability and overfishing, the root stock of particular fish species can be at stake.

**Additional Stresses brought about by Climate Change Include**

These impacts can be characterized as being primarily from changes in temperature, precipitation, sea ice loss, and sea level rise. Impacts in these four categories are outlined below. In reality, however, there are numerous interactions of these elements with each other and with existing stresses.

**Temperature**:

- changes in migration timing, routes and food availability along the path way (e. g., the 2° C average increase in temperature of the Columbia River has caused salmon to return a month earlier, and shad, coho and other species to return a week earlier than normal)
- changes in fish distribution, with a generally northward shift (reaching the lethal limit for some species without migration opportunities)
- reduction in winter mortality for some species
- changes in algal composition (effects on dinoflagellates, cyanobacteria, red tides, and range and intensity of toxic algal blooms)
- potential spread of the organism that causes cholera
- pathogen increases
- temperature responses of invasive exotics: could enhance harmful species ; perturbed environments are more invasible and temperature change is a perturbation; rapidly reproducing species are less economically valuable
- changes in reproductive cycles (birds' breeding cycles are strongly affected by temperature)
- stratification changes effect mixing and this effects species
- surprise thresholds beyond which changes can occur in ecosystem structure

**Precipitation**:

- changes in amount and timing of river flows, which also affects population migration and reproduction
- storms can overload sewage treatment capability, especially in urban environments (there are thresholds in the human system; waste processing has a limit; more extreme events will dramatically change the composition of runoff as system capacities are exceeded and nutrient loading and pollution will increase)
- fish egg oxygenation and nest destruction affected by flows
- salinity change affect reproduction
- runoff changes effect feeding of estuaries and breeding cycles
- timing of winter and spring precipitation are most critical; amounts fall as rain versus snow are key to storage and availability issues; effects of extreme events; and the combined effects of temperature, precipitation and timing changes
- effects of precipitation on the seasonal hydrological cycle
- ability of wetlands to migrate and at what rate (a combined effect of temperature, precipitation and sea level rise)
- salt water intrusion (in estuarine systems the extent of salt water intrusion is a function of net stream flow)

Additional stresses brought about by climate change in include changes in fish distribution, with a generally northward shift (reaching the lethal limit for some species without migration opportunities).

**Sea Ice Loss:**

- loss of sea ice impacts marine mammals greatly, as well as algae under ice and the animals that graze on the algae (important component of the food chain)
- changes in seasonal snow cover impacts life cycle of ducks and geese
- sea ice loss leads to coastal erosion
- sea ice loss increases the destructive impacts of storm surges
- shipping season could increase
- fishing season could expand

**Sea Level Rise:**

- migration of wetlands curtailed by efforts to protect the built environment (if wetlands can't migrate inland, they will be lost)
- wetlands loss impacts all coastal plants and animals (loss of seal pupping and turtle beaches, loss of marsh habitat)
- storm frequency and intensity change combined with sea level rise will have negative effects
- salt water incursions into aquifers and breeding areas
- salinity changes will affect species mix
- increased stresses on port towns and cities, and oil extraction industry

Impacts to fisheries and other economic sectors may be small nationally but large locally.

**Major Overall Impacts:**

- fisheries and other economic impacts may be small nationally but large locally
- subsistence economies will experience major changes
- sea level rise will have large impacts on coastal communities

**Potential Coping Mechanisms Include:**

- Improve resource and coastal management, and ecosystem research and monitoring ;
- Control invasive species more effectively;
- Implement fishery management that recognizes shifting species ranges and abundances;
- Conduct research on management systems and on aquatic ecosystems;
- Increase control of non-native fishes and other non-native aquatic and marine species;
- In coastal areas, integrate the management of fisheries with other uses of coastal zones;
- Develop long-term monitoring systems to distinguish between natural environmental variability, effects of human disturbances, and climate change;
- Monitor health problems (e. g., red tides, cholera) that could be sensitive to climate change and harm fish stocks and/or consumers.
- Consider sea level rise projections when capital infrastructure needs to be renewed.
- Consider changes storm surges and variability in building coastal protection devices such as sea walls and barriers.
- Control future development in sensitive habitats.
- Place value on sediment load somewhat equal to flood protection when planning levees for flood control and commercial purposes.

- Use better assessment tools including information services such as Geographic Information Systems (GIS) and remote sensing to determine and protect sensitive areas, for planning purposes and decision making purposes.
- Improve water management, including controlling point and non-point sources of pollution.
- Build consideration of downstream water quality and quantity issues into Federal Energy Regulatory Commission (FERC) licensing procedures.
- In future development, consider impacts of coastal erosion, storm surges, sea ice, etc.
- Reduce existing stresses e. g., overfishing, overdevelopment of coastal areas, damage to coral reefs from human activities, pollution, destruction of habitat, etc.
- If predictions of increased use of pesticides under climate change come to pass, the coastal problems will be exacerbated.
- Develop methods for valuing ecosystem services.
- Reduce damage to coral reefs from human activities.
- Implement international treaty on ozone protection to protect coral reefs from bleaching from UV-B exposure.
- Improve forecasting of extreme weather events.

Reduce existing stresses, e. g., overfishing, overdevelopment of coastal areas, damage to coral reefs from human activities, pollution, and destruction of habitat.

# Extreme Events and Climate Variability

Due to the nature of the subject matter, this working group report follows a format somewhat different from the other sectors.

Climate variability and extreme events already have a wide variety of impacts on society. Extreme events are defined by this working group as those that exceed society's elasticity. Experience with natural disaster reduction can teach important lessons for coping with climate change. Building societal resilience with regard to climate variability and extreme events will go a long way toward addressing the climate change challenge.

Current understanding of links between climate change, climate variability and extreme events is inadequate.

The group suggested that existing tools are not fully utilized and are inadequate to meet future challenges. In particular, new information technologies are not fully exploited and the current understanding of links between climate change, climate variability and extreme events is inadequate.

**Factors that are Changing How Impacts are Experienced Include:**

* population growth
* urbanization
* economic growth
* technological advance
* ecosystem management

Coping mechanisms in place are of varying effectiveness and are generally tuned to the current climate.

There is currently great public interest in this area, in part as a result of the ongoing national focus on extreme events and in part as a result of the national dialogue being facilitated by the Federal Emergency Management Administration (FEMA) through its National Mitigation Strategy and its 2000-page assessment of natural hazards.

# Forests

The forest sector working group defined two sub-sectors: unmanaged and managed forests. Within managed forests, there are two additional categories, commercial and urban.

Current Stresses Include:

* pests
* drought
* air pollution
* harvest practices
* demographics
* fire
* invasive species

**Additional Stresses brought about by Climate Change Include:**

| Impact | Consequence Areas |
|---|---|
| temperature warming<br>and change in precipitation | species migration<br>species dominance<br>productivity<br>ecosystems services<br>tourism<br>recreation |
| increasing pollutants | forest decline |
| rising carbon dioxide | rising water efficiency<br>allocation<br>carbon sequestration<br>growth |
| nitrogen deposition | positive and negative effects |
| habitat fragmentation | decline in ability of forests to migrate |
| climate change | greater vulnerability in fire, drought, pests, and winds |
| changes in species composition | invasive species<br>natural competition changes |

**Potential Coping Mechanisms Include:**

For Managed Systems:

* planted species replacement
* genetic variants of species
* changing planting regimes - density, timing, rotation
* biomass production (7-10 years)
* precision forestry
* reforestation/afforestation projects
* fertilization

**For Non-Managed Systems:**

* wildlife corridors, zoning, land purchasing for species preservation
* fire management
* facilitate appropriate species through seeding and preparation
* pollution control
* invasive species control
* introduction of wildlife species
* managed access
* maintain biodiversity

Additional impacts from climate change would act to increase the stress that is already on the system.

**Tundra**

Climate impacts on arctic and alpine tundra were also discussed briefly by this working group. Existing stresses include the effects of warming, toxic contaminants, nitrogen deposition, and human pressures like tourism and hunting. Additional impacts from climate change would act to increase the stress that is already on the system. Coping strategies would need to be national in scope; little can be done locally. Mitigating species habitat constraints with land set asides was one example suggested. The group also discussed the example of making greater use of already heavily used lands and leaving the least used ones alone.

# Freshwater Ecosystems/Wetlands

This sector would deal with the important areas of all types of plant and animal species in fresh water systems, including both natural systems and those managed to supply human needs. This sector would include wetlands, migrating species, fisheries, hatcheries, etc.

Key issues of concern involve potential feedback effects, tolerances, quantifying needs, economic and social implications, legal implications, and adaptations. A central question is: How do critical ecosystem functions relate to goods and services valued by humans?

How do critical ecosystem functions relate to goods and services valued by humans?

**Current Stresses Include:**

- societal consumption
- societal wastes
- physical manipulation
- exotic invasions

**Additional Stresses brought about by Climate Change Include:**

- water balance changes
- physical and temperature changes
- biological changes
- ultraviolet radiation changes
- upstream watershed processes

**Potential Coping Mechanisms Include:**

- Relieve current stresses since they are already highly influencing aquatic system integrity.
- Natural systems have little buffers; more active management is needed.
- Set priorities for water resources management.

# Grasslands and Arid Lands

With regard to arid lands, it is important to remember that most land ownership is public, but most water use is private.

Grasslands and arid lands are of many types and generally must be treated with regional resolution. Their regional systems include the North, Central and South Great Plains, the Southwest, Central California, Central Florida, Palouse, and the Great Basin.

Arid Lands include the Mojave, Sanoran, Chihuahua, Great Basin, Colorado Plateau, and Chaparel. When thinking about arid lands, it is also important to remember that most land ownership is public, but most water use is private.

Tundra regions of North America are in Alaska and Canada.

**Current Stresses Include:**

- population shifts (absolute and ethnic composition)
- economic restructuring (NAFTA, etc.)
- technological change
- values (cultural, environmental, etc.)
- consumption changes
- environmental changes
- institutional changes

**Additional Stresses Brought About by Climate Change Include Changes in the Following Critical Variables:**

- seasonal distribution of precipitation (onset, intensity, duration)
- amount of precipitation
- temperature
    - growing season length
    - frost-free days
    - last frost day
    - minimum and maximum temperatures
    - extreme events (frequency and magnitude)
- drought index
- soil moisture
- El Niño Southern Oscillation (ENSO) characteristics
- biotic thresholds

Multiple stresses already drive changes in the availability and distribution of water, land and energy. Climate change will add additional drivers and affect existing ones as these drivers interact with climate change variables.

**In evaluating climate change impacts, it will be important to consider the context of other key questions affecting grasslands and arid lands. These include:**

- How will climate change interact with critical drivers to change grasslands and arid lands?
- What is the future of government subsidies?
- How will water rights be resolved?
- If the characteristics of ENSO change, how will different systems change?

**Key information needs for undertaking an assessment of the consequences of climate change on grasslands and arid lands include:**

- synthesis of historical trends
- new studies of contemporary sectors (e. g. , pests/disease)
- analog studies of historic climate periods under contemporary sectoral conditions
- analog studies with scenarios of critical economic/social/technological trends
- a suite of GCM simulations including:
    - fully coupled transient runs
    - with GHG forcing and sulfates
    - which are regionally downscaled
    - and topographically realistic
    - with monsoonal patterns captured
    - and ENSOs resolved

How will climate change interact with critical drivers to change grasslands and arid lands?

# Parks and Public Lands

Public lands contain important natural resources vital to the economy through grazing, mining, agriculture, recreation, and tourism.

This sector would include national parks, forests, monuments, sanctuaries, preserves, military bases, and all state and federal lands. This sector is important because public lands:

- include a significant portion of the nation's land representing a wide range of landscapes and ecosystems
- contain important natural resources vital to the economy through grazing, mining, agriculture, recreation, and tourism
- protect unique ecosystems and flora and fauna
- serve as a major source of freshwater
- provide unique experiences to the public

**Current Stresses Include:**

- increased development, recreation, economic uses
- fragmentation of habitat (especially surrounding land)
- air and water pollution
- vulnerabilities to exotic invasive species and pests
- altered disturbance and hydrologic regimes
- climate variability

**Additional Stresses brought about by Climate Change Include:**

- increased climate variability
- accelerated sea level rise and glacier melting
- increased competition for water and land
- accelerated spread of exotic species, pests and diseases
- accelerated habitat loss and loss of biodiversity
- changes to fundamental ecosystem processes

**Potential Coping Mechanisms Include:**

- developing tools and policies for managing frequency and intensity of disturbances (e. g., controlling grazing and erosion, limiting access, restoring natural cycles such as fires and floods, creating buffer zones and wildlife migration corridors)
- expanding efforts to curtail or mitigate exotic species and diseases
- emphasizing ecosystem approaches, enhance corridors and linkages among lands
- developing adaptive management strategies
- expanding biological inventories, monitoring and research
- expanding public education efforts

# Public Health

This sector would include all issues relating to human health, ranging from the health of individuals to general issues of societal health. It would also include issues such as changes in land use that may present trade-offs for public health. Some current examples of this include:

| Action | Positive | Negative |
|---|---|---|
| reforestation | aesthetics, carbon sink | Lyme disease<br>La Crosse encephalitis |
| wetland reclamation | wildlife habitat<br>endangered species protection | eastern/western equine encephalitis |
| prairie dog habits | prey for raptors, black-footed ferret | bubonic plague |

Changes in land use may present trade-offs for public health.

**Current and Foreseen Stresses Include:**

- population growth
  - urban density
  - expansion to new environments
  - poverty
  - health care and immunization
  - sewage and waste disposal

- social and behavioral changes
  - changing hygiene (e. g., hand and food washing)
  - "religious" behaviors/customs
  - poverty (urban and rural)
  - water use (wells, water treatment)

- dispersal (of diseases and vectors)
  - human travel (business, pleasure, migration)
  - shipping and commerce (air, sea, land)

- infrastructure
  - inadequate monitoring and surveillance
- severe weather
  - heavy rain (toxins, water-borne disease)
  - drought (dust-borne agents, water storage)

**Potential for climate change to moderate or amplify current stressors**

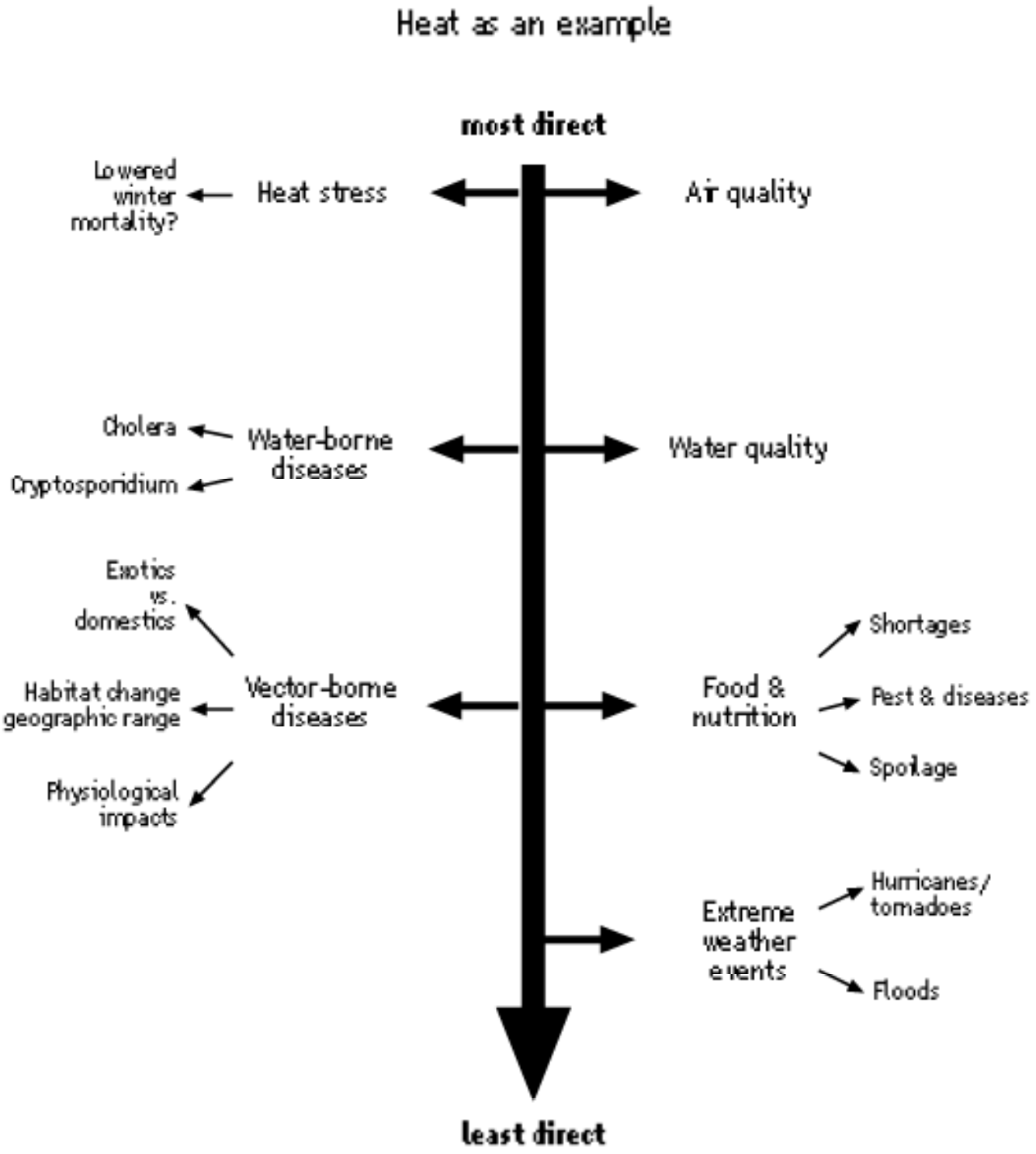


**Figure 2.15**

Additional Stresses brought about by Climate Change: Heat is used in Figure 2.15 as an example to illustrate the potential impact of climate change and variability on public health. Impacts range from the immediate effects of heat stress and air quality changes to more indirect impacts via effects on food sources and nutrition and on vector-borne disease.

In addition, there are a number of diseases that are likely to be affected by climate change and variability, including:

- Water-borne diseases
  - Cholera
  - Cryptosporidiosis

- Vector-borne diseases (vectors include rodents, ticks, mosquitoes)
  - Viruses
    - St. Louis encephalitus
    - Dengue
    - Hantavirus
  - Bacteria
    - Bubonic plague and other plagues
    - yme disease
  - Protozoa
    - Malaria

Several key questions were identified relating to climate variability and public health. Vector-borne disease provides an example of the range of issues. At the basic physiological level, there is a positive impact of temperature on development rates of pathogens in their vectors while there is a negative impact on vector survival. Thus, there is an optimal temperature for a given vector/pathogen pair. It is important to know if future temperatures are likely to be lower than, equal to, or higher than those current-day optima (and, perhaps, how rapidly higher temperature optima could be selected).

It is important to know how climate change may impact the habitats of vectors and vertebrate hosts of these agents of human disease.

At a much larger scale, it is important to know how climate change may impact the habitats of vectors (especially larval habitats) and vertebrate hosts of these agents of human disease. When birds are the normal vertebrate hosts (as with several mosquito-transmitted encephalitis viruses), changes over very large or widely separated areas (as with migratory birds) and habitat types may need to be considered. Preliminary examination of animal case reports for several vector-borne diseases suggests the potential for case reduction would be considerable.

**Potential Coping Mechanisms Include:**

- monitoring, surveillance and communication
  - local/regional collection
  - national coordination

- improved access to services
  - local infrastructure
  - national support

- resiliency: building a public health infrastructure
  - local
  - national (post-disaster)

- education and training
    - local
    - national (support, advanced training)

- research

    - impacts of climate variation
    - basic ecology and epidemiology
    - data set collection, including cost-benefit analyses

- pollutant reduction

    - allergies, asthma
    - greenhouse gas reduction

The working group also offered suggestions on bringing together stakeholders from the local, state, regional and national levels through a variety of professional health associations.

In the category of potential surprises it was mentioned that although it seems counter intuitive, warming could actually increase winter-related deaths due to cold, as complacency can occur when overall weather is warmer. For example, in Tallahassee, Florida, more people die from cold during winters that are warmer than usual.

Although it seems counter intuitive, warming could actually increase winter-related deaths due to cold, as complacency can occur when overall weather is warmer.

# Urban Areas

This sector would focus on where the people are. Eighty percent of the people in the U. S. live in urbanized areas on roughly 20 percent of the U. S. land area. The urban sector exists in a context dominated by external connections and complexity. An analysis of climate change effects will be characterized by important second and third order impacts.

Eighty percent of the people in the U.S. live in urbanized areas on roughly 20 percent of the U. S. land area.

This working group discussed the vulnerabilities of urbanized areas to climate change, including built infrastructure, institutional infrastructure, social infrastructure, human services (comfort, convenience, mobility, land housing, energy, water, waste disposal, health, security, and recreation), and key linkages such as communication and transportation. Issues of concern include quality of life, the fluxes and flows of dynamic systems, the time frames of decision making, and interdependence.

**Current Stresses Include:**

- population, demographics, real estate development, congestion
- aging physical infrastructure
- deteriorating environmental quality, health problems
- social stresses: security, diversity, equity, social net, shrinking public sector budgets
- economic stresses: economic restructuring, poverty

**Additional Stresses brought about by Climate Change Include:**

**First order vulnerabilities to climate change and variability**

- sea level rise, storm surges, coastal erosion
- extreme events: floods, hurricanes, tornadoes, fire, etc.
- other climate-related variabilities: heat waves, droughts, blizzards
- disease vectors and epidemics
- water availability/cost and quality

**Second order vulnerabilities**

- reductions in air quality
- health impacts: heat stress, air pollution, water-borne diseases
- greater effect of overall impacts of certain segments of the population: the poor, elderly, young, and those in risk prone areas and situations
- infrastructure costs of changes in temperature and precipitation regimes: e. g., changes in energy requirements, or costs of coping with sea level rise

**Third order vulnerabilities**

- impacts of shifts in regional comparative advantage
- impacts on consumers and local businesses of climate change abatement policies
- political and social tensions

**Potential Coping Mechanisms Include:**

- information and education
- making institutions more adaptive
    - longer design horizons
    - win-win potentials
    - improvements in resiliency
- engineering/physical infrastructure investments
- regulatory initiatives
    - land use control
    - building standards
    - water conservation

Special attention should be paid to coastal areas in regard to all of the above.

The working group expressed concern about the capacity of existing government structures to handle the new stresses outlined above. For example, the capacity may not exist to handle interjurisdictional issues that may arise. They believe that if urban areas begin by developing systems for dealing with climate variability, they will thus be improving their resilience to climate change as well, e. g., building codes designed to withstand extreme events will also help deal with climate change impacts.

Vulnerabilities of urbanized areas to climate change include built infrastructure, institutional infrastructure, social infrastructure, human services, communication, and transportation.

# Water Resources

This sector would include issues of water supply (surface and ground water, precipitation, runoff, and water system management), aquatic ecosystems (natural and altered rivers, lakes, and wetlands), hydrologic extremes (floods and droughts), and coastal resources. Both water quality and quantity aspects would be considered, as the two are intertwined in most water resource issues. See Figure 2.16 for average consumptive use and renewable water supply by region.

The current situation in water management is reflected in the following:

- considerable information exists and is available, but is underutilized
- local and regional problems include aging infrastructure, costly investments, average demands exceeding former yields, inefficient use, increasing conflicts among competing uses, institutional rigidity in dealing with new perspectives and values with regard to ecosystem management and watershed perspectives
- problems are being addressed across the U. S.; about 300 watershed studies are underway with a more multi-objective view
- legislation has been drafted in response to recommendations following the Mississippi floods; for example, a drafted law would allow the Army Corps of Engineers to buy and restore wetlands rather than rebuilding levees after a flood
- legal and institutional changes are slow regarding water rights, appropriation, market pricing of water, legal constraints on water allocation, federal, state and local assignment of responsibility
- a disconnect exists between federal water policies and local land use management decisions that affect flood plains and water use
- nationally, water withdrawals in the U. S. have dropped since 1980, even in the face of rising population

Problems include aging infrastructure, costly investments, demands exceeding yields, inefficient use, increasing conflicts among competing uses, and institutional rigidity.

**Current Stresses Include:**

- failure and aging of water infrastructure
- increasing water-based recreational use and conflicts with established uses
- increasing demands for instream flows (e. g., to protect endangered species or restore aquatic ecosystems)
- interannual variability
- effects of floods and droughts
- increasing population and economic growth
- rapid urban growth, especially in coastal areas
- increasing competition between water uses
- declines in aquatic species due to degraded water quality and loss of habitat (including diminished flows)
- reduction in extent of wetlands
- seawater intrusion into coastal aquifers
- physical modifications of estuarine systems
- excessive nutrient inputs and other pollutants to estuaries

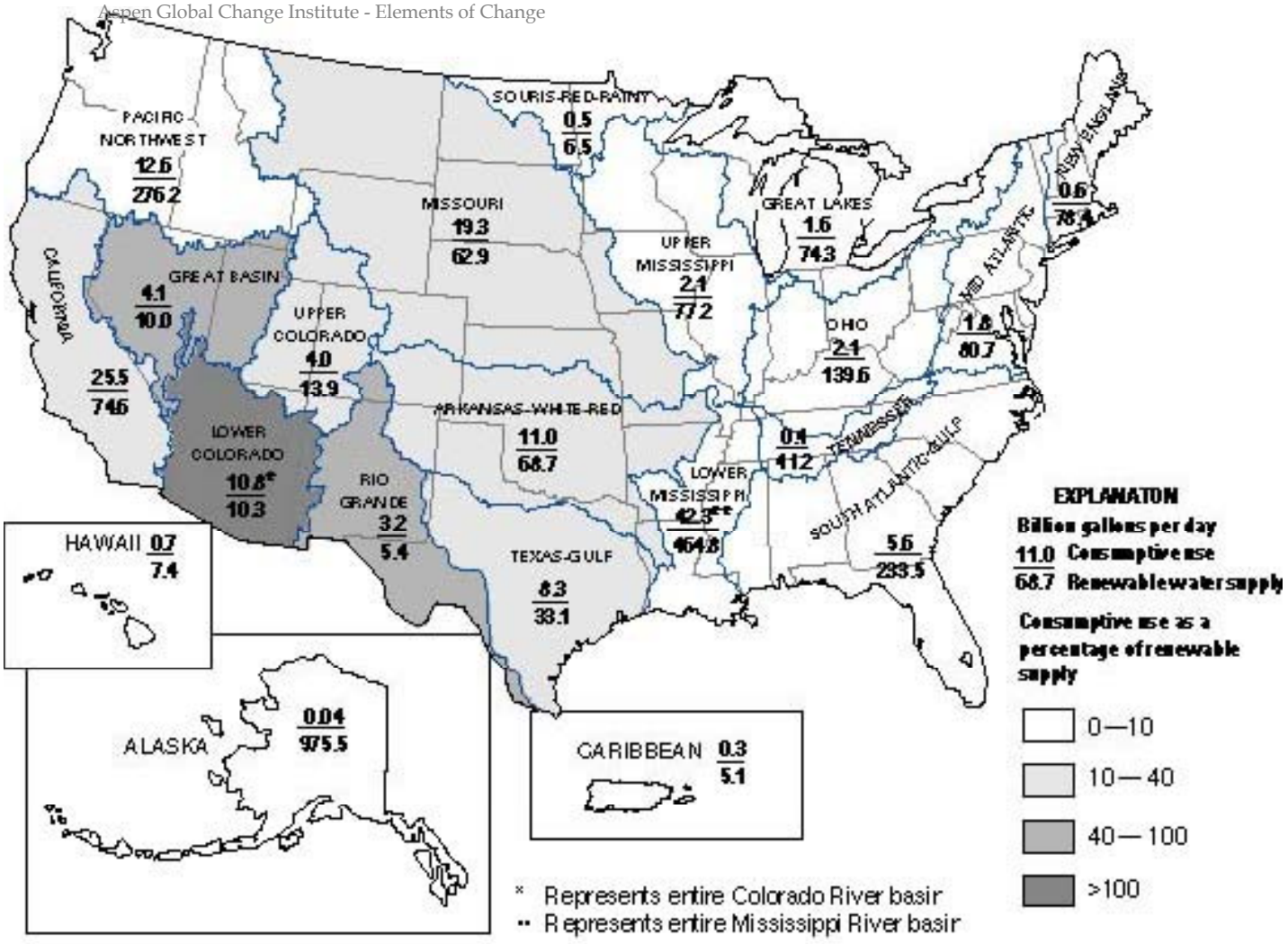


**Figure 2.16**

To provide background to this discussion of water resources in the U.S., these numbers indicated, in billions of gallons per day, average consumptive use and renewable water supply, by water resources region. The shading indicates consumptive use as a percentage of renewable supply.

**Additional Stresses brought about by Climate Change Include:**

- changes in amount, frequency, and intensity of precipitation affecting magnitude and timing of runoff
- changes in magnitude and frequency of floods and droughts
- intensification of the water cycle, including increased evaporation, precipitation and streamflows
- increases in amounts of water needed for irrigation, industrial process cooling and domestic uses
- increased evaporative losses from water supply systems
- lowered surface water and soil water storage amounts
- changes in mean flows, flow variability and water temperature in aquatic habitats
- changes in extent and timing of ice cover on rivers and lakes
- sea level rise and associated impacts

- changing river discharges
- shrinkage of mountain glaciers
- reduction in areal extent of continuous and discontinuous permafrost
- decreased proportion of precipitation falling as snow, leading to reductions in spring runoff and increases in winter runoff, reducing the effective storage capacity of snow pack as a natural reservoir
- erosion of shorelines and associated habitat caused by rising sea level (in the past, estuaries and coastal wetlands could migrate inland, but human infrastructure has diminished this possibility in many places)
- increased salinity in estuaries and freshwater aquifers
- altered tidal ranges in rivers and bays
- changes in sediment and nutrient transport
- increased coastal flooding

**Potential Coping Mechanisms Include:**

- developing water management strategies that are robust to a wide range of possible climatic conditions
- continuing attempts to model future climate
- developing river basin simulation models that are able to predict flow conditions from the first principles of climate, topography, land use, and engineering
- developing robust observational systems to provide current data on temperature, precipitation, stream flow, and ground water conditions to managers on a real time basis
- permanent evacuation of some flood prone areas
- enhanced flood warning and evacuation planning
- flood proofing of structures
- creation of additional natural storage through restoration or creation of wetlands
- better maintenance of levees

The working group suggested that more attention be paid to boundary problems both between states and between the U. S. and Canada. In addition, they felt that more attention should be paid to where water is being overdrafted and diminishing ground water supplies, and in places where ecosystem impacts are large, such as the Everglades.

A decreased proportion of precipitation falling as snow would lead to reductions in spring runoff and increases in winter runoff, reducing the effective storage capacity of snow pack as a natural reservoir.

# Decisions, Products and Proposals from the AGCI Meeting on Preparing for a U. S. National Assessment of Climate Change Impacts

The national assessment consists of three primary components:

- regional assessment processes (18 at present)
- sectoral assessment processes (10 considered in Aspen, now 5)
- a synthesis process

Baseline and scenario documents will provide input into these processes, as needed. A strengthened research program, as well as outreach mechanisms will also be of critical importance to the process.

Philosophically, the assessment will emphasize a new paradigm, with a focus on process that comes from the bottom up. It will also aim for scientific excellence, openness, full participation, transparency, relevance to decision making, and adequate communication mechanisms.

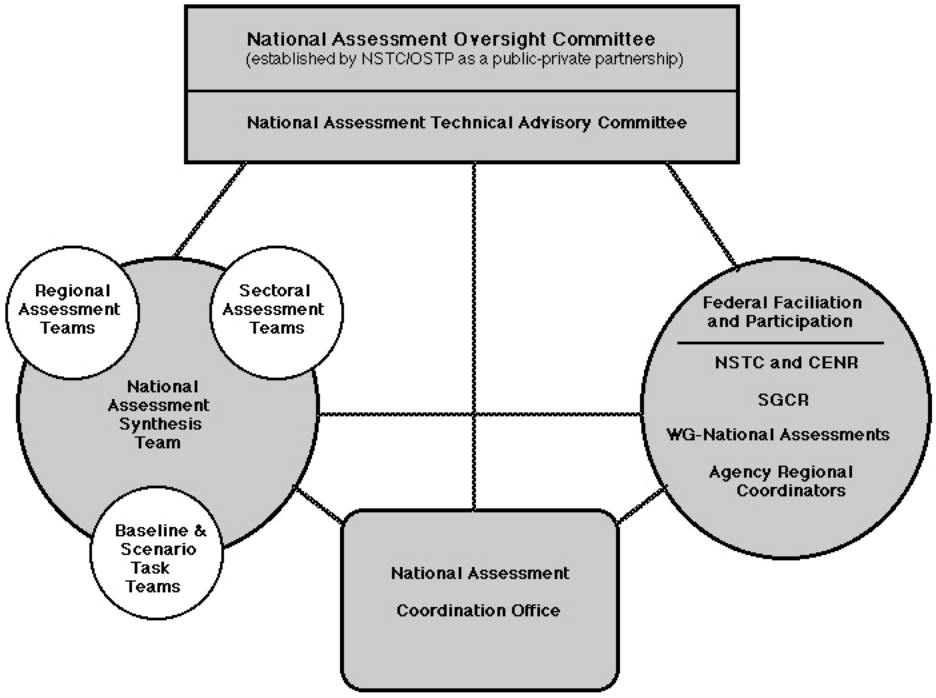


**Figure 2.17**
Assessment Organizational Stucture

# Objectives of the National Assessment Process

Designed to be transparent and participatory, the national global change assessment process will be pursued through a set of regionally-organized research, communication and education activities combined with a parallel and complimentary set of sectoral research, analysis and communication activities, and a synthesis of the results of these regional activities in the context of an integrated look at the implications of global change at a national level, aiming to:

- develop a more complete understanding by the scientific community, government, private industry, and the public of the local, regional, national, and international implications of global change in the context of other existing and potential environmental, economic and social stresses and opportunities;
- establish and maintain a continuing, interactive dialogue among interested groups and individuals engaged in exploring the challenges and opportunities associated with global change.

The aim is to develop a more complete understanding of global change in the context of other existing and potential environmental, economic and social stresses and opportunities.

With an initial focus on climate variability and change, the national global change assessment process will address the following objectives:

**Information for Decision Making**

- gather or produce useful information for coping with the consequences of global change;
- identify relevant decision making frameworks and key information needs and explore the challenges and opportunities associated with the integration of information on climate variability and change;
- take advantage of existing and emerging scientific insights and technological capabilities for sustainability (economic, social and environmental);
- work with existing institutions and organizations to support iterative, integrated decision making at and across local, regional and national levels;
- periodically produce and disseminate reports on the current state of knowledge of global change and its implications to support decision making.

**Research to Support the Generation of Useful Information**

- catalyze the production of scientifically rigorous assessments of the impacts and consequences of global change at the local, regional and national levels;
- identify affected communities, sectors, and ecosystems and clarify their vulnerability to climate variability and change, where vulnerability is defined as

sensitivity to variability and change as well as some measure of the ability of those systems to adapt;

- support the exploration, understanding and rigorous evaluation of adaptation and other coping strategies (including voluntary actions) to reduce the vulnerability of affected communities and sectors and take advantage of opportunities;
- establish and enhance interactions among diverse research communities to generate ideas and develop research priorities which encourage cross-disciplinary collaboration and scientific partnerships designed to support practical applications .

**Public Understanding and Education**

- communicate the results of current and evolving global change research through partnerships with existing formal and informal educational organizations, institutions and programs;
- increase public understanding of the implications of global change research;
- educate the scientific community on the needs, questions and concerns of affected communities and sectors at the local, regional, national, and international levels.

Jerry Melillo addresses the Aspen Public and AGCI Participants (photo by PaulGrabhorn)

# Principles of the National Assessment

(1) Scientific excellence

(2) Relevance to societal decision-making

(3) Participatory stakeholder involvement

(4) Publicly credible process (objective, transparent)

(5) Efficient use of taxpayer resources

(6) All components contributing to the whole effort

AGCI Working Group discussions (photo by Paul Grabhorn)

# Baseline Scenarios and Scoping Papers

The process will facilitate the communication of evaluated information to the public and private sectors, the conduct of research to develop new understanding, and the translation of new understanding into usable knowledge for stakeholders.

A set of proposed products will be created as inputs into the assessment process. They are meant to develop and provide some common assumptions for the sectoral and regional assessments.

**Time frame:** current conditions to 2050
**Domain:** nationally consistent, regionally relevant
**Completion of review draft:** Spring 1998
**Objective:** to develop common assumptions to assist the sectoral and regional teams as needed

**(1) Socio-economic projections**

- demographic scenarios (including population growth, immigration, demographic shifts, per capita resource use estimates, etc.)
- economic projections (including Gross Domestic Product growth rate for next 50 years)

**(2) Resource use: key assumptions**

- Water use
- Land use changes (urbanization, etc.)
- Ecosystem trends

**(3) Technology: key assumptions**

- Energy
- Bioenergetics
- Transportation

**(4) Climate**

- Historical trends (observed, reconstructed)
- GCM-based scenarios (adjusted to finer regional resolution through the use of nested models or other techniques)
- Meteorological regimes

# Steps in the Regional Assessment Process

The goal of the national global change assessment process is to improve understanding by the public, business, government, and scientific communities of the local, regional, national, and, where relevant, international implications of global change in the context of other current and potential future environmental, economic, and social stresses and opportunities.

The process will facilitate the communication of evaluated information to the public and private sectors, the conduct of research to develop new understanding, and the translation of new understanding into usable knowledge for stakeholders.

The assessment process will include several key elements, including:

- building an ongoing dialogue between stakeholders and the research community
- periodic reporting of results from the assessment activities, and
- identifying potential options that could be pursued and new information needed to build resilience and expand the set of options.

The regional component of the national assessment process will involve the following activities:

- Identification of critical issues and stakeholders;
- Preparation and assembly of white papers and other background materials as a resource for the region;
- Convening a scoping workshop;
- Preparing a summary workshop report covering four topics:

  (1) Identify current stresses affecting the region, its natural resources and economic sectors.

  (2) Consider how climate variability and change might either amplify or dampen these stresses or create new ones (including possible surprises).

  (3) Identify new information that would allow people and organizations to think better about the linkage between current stresses and climate variability and climate change.

  (4) Identify win-win coping strategies that will help address the stresses created by climate variability and climate change as well as by non-climate stresses.
- Regional Assessment Report: During 1997-98, refine and expand the summary workshop report, possibly including analyses using scenarios, additional research, etc., and then publishing a first Regional Assessment Report. Broad review and refinement of

Identify win-win coping strategies that will help address the stresses created by climate variability and climate change as well as by non-climate stresses.

the report will continue into 1999.

- National Assessment Workshop: The goal of the November 1997 workshop will be to finalize the design of the national assessment process and establish a stakeholder dialogue at the national level to complement and promote the dialogue being established at the regional levels. This workshop is a step in the assessment process; it is understood that not all of the regional workshops will be held before this workshop and so continuing evolution of regional involvement will occur.
- The National Assessment will include Regional Assessment Reports from all regions (currently 18), Sectoral Reports (estimated to be 5), Synthesis Reports on broad societal and climatic trends (estimated to be 5 or so), and an executive summary that will provide an integrated presentation of the consequences of climate variability and change for the United States and its regions and sectors.
- Iterations: The assessment will be an ongoing process among all the stakeholder communities and will include public outreach and education activities, research and translation of research results for use by policymakers, and a continuing exploration of coping strategies. New reports will be issued periodically to document increased understanding.
- Sustaining the Dialogue: An infrastructure will be established that will provide for a two-way information interchange that will enhance the ability of stakeholder groups to take informed actions and research communities to develop more usable information.

The first step will include identification of key stakeholder groups, critical concerns within the region, description of climate factors affecting the stakeholder groups, information needs, coping strategies, and research issues.

**Steps for Each Assessment to Follow**

Regional and sectoral assessments can rely on a mixture of nationally-derived scenarios of trends in climate (current trends and projections) and other critical scenarios and the use of regionally-specific scenarios defined by regional stakeholders.

The process of conducting the analysis of climate change impacts will build from the information gathered at the regional scoping workshops. Three steps are envisioned:

- The first step will include identification of key stakeholder groups, critical concerns within the region, description of climate factors affecting the stakeholder groups, information needs, coping strategies, and research issues.
- The second step will involve a sensitivity analysis of the major points emerging from the step one. After refining initial findings with the help of modeling and analysis relative to national sectoral efforts, the teams will evaluate first order effects, and also indirect or second and third order effects and cross-sectoral impacts. The extent of new computational analysis will vary among the regions depending on the availability of resources within the region. All analyses should be "translated" for accessibility to all stakeholders.
- The third step will involve linkage of regional perspectives with scenarios. Scenario identification should be nationally consistent and regionally relevant. The timeframe of analysis is current conditions to 2050. Baseline scenarios will be provided and future scenarios will be developed and applied for parameter themes including socioeconomic, resource use, technology, and climate.

# Oversight and Working Bodies in the National Assessment Process

## The National Assessment Leadership Team (NALT)

### Mission

The NALT's mission is to facilitate, coordinate, guide, and sustain a scientifically and technologically rigorous assessment of the impacts and consequences of climate change and variability at the regional, sectoral and national levels; and to assure that the knowledge, insights and products obtained from the assessment are useful and essential inputs to addressing the consequences of and coping strategies for dealing with climate change and variability.

The NALT's mission is to facilitate, coordinate, guide, and sustain a scientifically and technologically rigorous assessment of the impacts and consequences of climate change and variability and to assure that the products are useful.

### Goals/Objectives

- ensure scientific and technical rigor of assessments at all levels
- provide intellectual leadership for the assessment process
- enhance the quality and effectiveness of regional assessment efforts
- develop and implement an open process for peer review
- ensure technical and logistical support for maintaining regional efforts
- determine most effective approach for providing a national assessment
- facilitate production of an initial national assessment and the process to produce it
- identify research, outreach, education and communication agendas
- oversee production of updates as new understanding emerges
- work with the stakeholder and user community to communicate and foster understanding and recognition of the assessment process and results (including work with resource managers and others to ensure implementation of results)
- convene and empower the sectoral and synthesis teams
- ensure coordination among regional, sectoral and synthesis efforts and transfer of knowledge between them
- implement an independent evaluation and ongoing refinement of the process
- organize periodic national fora

### Membership

- The NALT will be comprised of 12 members having interests and experience in the preparation of policy-relevant assessments and having a range of regional, sectoral and disciplinary backgrounds.
- They will serve for three years in staggered terms.
- The National Assessment Coordination Office (NACO) Director (appointed by the chair of the Subcommittee on Global Change Research) is an ex-officio member and serves as the Executive secretary for the NALT.

• The NALT chair will be nominated by interested stakeholder groups. Selection will be made by the Oversight Committee in consultation with the Director of the NACO and the national assessment working group.

• Members of the NALT will be nominated by interested stakeholder groups in the regions, federal government, etc., and will be selected by the NALT chair in consultation with the Director of the NACO and the national assessment working group.

**Support**

Financial and logistical support will be provided by the NACO (about 3 staff people). Program staff from the various agencies of the U. S. Global Change Research Program form the National Assessment Working Group. The Oversight Committee, comprised of public and private sector representatives, will ensure the intellectual quality and integrity of the process.

Be flexible and innovative. Look for opportunities to engage a number of regional partners.

## Regional Network Coordination Offices

The proposed regional network coordination "office" would serve as the focal point for implementation of the regional research, assessment, communication and education components of the national assessment process. In this context, "office" is used to represent a set of functions and activities which can be undertaken through either a centralized or distributed approach but some full-time, dedicated staff will be required. The working group suggests the following general considerations in establishing these regional capabilities:

• Be flexible and innovative.

• Look for opportunities to engage a number of regional partners in undertaking the identified functions (shared versus single-institution ownership, "host" versus "owner").

• Pursue multi sponsorship and cost-sharing from the outset.

• Wherever possible and appropriate, take advantage of existing capabilities, organizations and institutions.

• Recognize the need for this "office" to coordinate activities and communicate within the region, among regions, and with the national level.

In this last context, the working group recommends that the national assessment working group consider the establishment of a task force (or some other mechanism) to facilitate communication with and support for the regional network. In this context, the working group identified the following critical functions and activities for the network coordination "office:"

• Providing a two-way bridge between the global change research community and interested individuals and organizations in the region (including the public): assisting in the identification of current and potential opportunities to take advantage of existing and emerging scientific insights and technological capabilities including assisting in the transformation (interpretation) of research results into usable information which can be applied to practical problems .

• Translation, communication, education and outreach: activities related to increasing public understanding of the implications of global change, identifying and engaging new stakeholders, supporting formal and informal education programs (training and materials development, etc.)

• Building and sustaining the network of scientists and interested individuals and organizations within the region, including the proactive engagement of initial and new stakeholders, and sustaining an iterative dialogue within the region.

As part of the above activities, they should:

- seek and ensure full involvement (scientists, stakeholders, public and private sectors)
- establish key partnerships
- leverage existing capabilities
- secure required resources (money, people, institutions)
- hold post-workshop meetings, roundtables, etc.
- contribute to intra-region communications (world wide web, newsletters, etc.)
- coordinate regional responses to requests for proposals and other opportunities
- serve as a focal point for communication of regional insights, research results and information needs among the regions and to the national level
- serve as an information clearinghouse, facilitating access to publicly-available regional and national data sets and research results, and making data purchases where necessary to address critical regional needs
- coordinate development of periodic reports on regional implications of global change and regional contributions to periodic national assessment reports
- serve as a regional research incubator by stimulating a bottom-up development of research ideas to address regional needs and facilitating support for priority projects; consider providing seed money for critical projects in some regions

Provide a two-way bridge between the global change research community and interested individuals and organizations in the region.

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