

NATIONAL ASSESSMENT OF THE POTENTIAL CONSEQUENCES OF CLIMATE VARIABILITY AND CHANGE FOR THE UNITED STATES

Paul V. Dresler

Chairman, USGCRP National Assessments
Working Group, and Department of the Interior,
U.S. Geological Survey, Washington DC

Michael C. MacCracken

Executive Director, National Assessment
Coordination Office, and Lawrence Livermore
National Laboratory, Livermore, California

Jerry M. Melillo

Co-Chairman, National Assessment Synthesis Team,
and Marine Biological Laboratory
Woods Hole, Massachusetts

Anthony Janetos

Co-Chairman, National Assessment Synthesis Team, and
National Aeronautics and Space Administration

ABSTRACT

The first U.S. National Assessment of the Potential Consequences of Climate Variability and Change for the United States is being conducted under the auspices of the U.S. Global Change Research Program (USGCRP). The USGCRP was established through the Global Change Research Act of 1990 (P.L. 101-606) and mandated through the statute with the responsibility to undertake periodic scientific assessments of the potential consequences of global change for the United States. The goal of the National Assessment is to analyze and evaluate what is known about the potential consequences of climate variability and change for the nation in the context of other pressures on the public, the environment, and the nation's resources. The conduct of the national assessment process will involve a broad spectrum of

stakeholders from state, local, tribal, and Federal governments; business; labor; academia; non-profit organizations; and the general public. The assessment will link research by scientists to specific needs of the stakeholders, and will provide planners, managers, organizations, and the public with the information needed to increase resilience to climate variability and cope with climate change. The national assessment will be comprised of three components: (1) National synthesis, (2) Sectoral analyses (agriculture, forestry, water resources, human health, and the coastal zone), and (3) Regional analyses. To facilitate comparison, integration, and synthesis of each of the assessment components, all regional, sectoral, and synthesis analyses will use a common set of scenarios for climate change

and changes in socio-economic conditions. Specific responsibilities have been defined for oversight of the components of the national assessment and for coordination activities. A National Assessment Synthesis Team (NAST) will provide overall intellectual oversight of the national assessment process and has responsibility for the development of the Synthesis Report. A National Assessment Working Group under the auspices of the USGCRP has lead responsibility for organizing and sponsoring the sectoral analyses and oversight and coordination responsibilities for regional analyses. A National Assessment Coordination Office has been established to facilitate coordination of the entire national assessment process. The National Assessment Synthesis Report is targeted for completion by January 1, 2000, and is intended to satisfy the mandate for an assessment defined in P.L. 101-606 and serve as part of the U.S. contribution to the IPCC Third Assessment Report.

INTRODUCTION

Climate variability and change present both opportunities and challenges for the United States – its people, environment, and economy. To better understand the sensitivity of natural and human systems to climate in the context of other pressures on the public, the environment, and the Nation's resources, the first U.S. National Assessment of the Potential Consequences of Climate Variability and Change for the United States is being undertaken. Issues addressed through the assessment are intended to be those of most relevance and concern to managers, policy makers, and the public. Therefore, the national assessment process will involve a broad spectrum of stakeholders from state, local, tribal, and Federal governments; business; labor; academia; non-profit organizations; and the general public. The assessment will link research by scientists to specific issues and needs of the stakeholders and will provide planners, managers, organizations, and the public with the information needed to increase resilience to climate variability and cope with climate change. The assessment is founded on the principles of scientific excellence and openness, and will be integrative and iterative.

The national assessment is being conducted under the auspices of the U.S. Global Change Research Program (USGCRP). The USGCRP was established through the Global Change Research Act of 1990 (Public Law 101-

606) and mandated through the statute with the responsibility to undertake periodic scientific assessments of the potential consequences of global change for the United States. The USGCRP assessment activities will help strengthen two of the five central purposes of the USGCRP which have been emerging only slowly (SGCR 1997); in particular to analyze the environmental, socio-economic, and health consequences of global change and to support state-of-the-science assessments of global environmental change issues. These purposes will complement and build upon the USGCRP efforts to observe and document changes in the Earth system, to understand why these changes are occurring, and to improve predictions of future global change. It is this overall package of activities, with research and assessment focused both nationally and internationally, which will fulfill the requirements of the USGCRP.

The first National Assessment will analyze and evaluate what is known about the potential consequences of climate variability and change for the United States over the next 25-30 years, and also over the next 100 years. Results of the national assessment will be integrated and synthesized to form the basis of a National Assessment Synthesis Report which is intended to satisfy the USGCRP mandate for an assessment report under Public Law 101-606. Products of the national assessment will also form the basis of the United States contribution to the Intergovernmental Panel on Climate Change (IPCC) Third Assessment. In order to meet the scheduling requirements of the IPCC, products of the national assessment must be available early in the year 2000.

NATIONAL ASSESSMENT GOAL

The overall goal of the National Assessment is to analyze and evaluate what is known about the potential consequences of climate variability and change for the nation in the context of other pressures on the public, the environment, and the nation's resources. Analysis and evaluation will be derived from the extant scientific literature and from new studies done specifically in support of the national assessment process.

Fundamental questions that are to be addressed through the assessment include: (1) What are the current environmental stresses and issues that form the backdrop for potential additional impacts of climate variability and

change; (2) How might climate variability and change exacerbate or ameliorate existing problems; (3) What coping options exist that can build resilience to current environmental stresses, and also possibly lessen the impacts of climate change; and (4) What are the priority research and information needs (near- and long-term) that can better prepare managers, policy makers, and the public to reach informed decisions related to climate variability and change?

APPROACH TO THE NATIONAL ASSESSMENT

The national assessment process is 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. Environmental and natural resource issues of most concern to stakeholders at both regional and national scales will be identified and the information acquired through the nation's investment in research and development will be applied to understand what implications climate variability and change pose from an environmental, economic, and social perspective. The knowledge and understanding gained through these analyses should have significant implications for current environmental and natural resource management approaches and provide a sound scientific foundation to guide future resource management decisions and better adapt and cope with the vagaries of climate variability and projected future climate changes.

The consequences of climate variability and change are not ubiquitous for the nation or its peoples. Regional variations in precipitation and temperature together with projected changes in sea level, storm intensity and frequency, and other climatically associated impacts identified by the IPCC will pose different concerns for the people, businesses, and environments, which are highly dependent upon their geographic location within the country. Therefore, to fully assess the potential consequences of climate variability and change, the national assessment is implementing the assessment at both regional and national scales.

Regional Assessments

Regional assessment activities will focus on the issues of most importance at a regional scale across the United States. Twenty regions have been identified which span the nation with some degree of geographic overlap encompassing every state and territory including one region that is focused on the unique issues of native peoples and their homelands. Regional workshops have been held to initiate a dialogue among stakeholders to identify the environmental issues of most concern to the regions. Each workshop region has been invited to conduct further analysis of the issues they have identified in the context of the national assessment goal. Table 1 lists the primary and secondary issues identified by the regions and ones that they are most interested in understanding the potential consequences of climate variability and change and exploring possible adaptation and coping strategies to better address the issue today while developing resilience for future climate change.

The regional analyses are to be performed by teams of experts from both public and private sectors and the spectrum of stakeholder communities from within the region. Most regions will form regional assessment steering or advisory groups comprised of representatives from the diverse group of regional stakeholders. These steering groups will work closely with the scientist that are conducting the analytic analysis to assure the issues and results of the assessment are relevant, responsive, and interpretable by the stakeholders of the region. In carrying out the regional assessments, it is expected that for some issues regions may choose to link or integrate their analyses with that of another adjoining region. These combinations of regions may be possible without losing the richness and diversity created by the more detailed individual regional focus. It is recognized that not all regional assessment teams may have the full scientific capacity and infrastructure necessary to conduct a thorough quantitative analysis for their regional assessment. Where possible, specific expertise such as analytic model analysis, which may not exist to a sufficient capacity within all regions, will be linked through the network of regions to meet individual regional assessment needs. In this way, the overall scientific capacity of the regions will be enhanced and strengthened through the regional assessment process.

Table 1: Sectors/Issues to be Addressed in Each Regional Assessment

| REGION | Agriculture | Coastal/Marine | Forests | Health | Water | Ecosystems/Wildlife | Air Quality | Urban Issues/Comm.Planning | Tourism/Recreation | OTHER ISSUES |
|----------------------------|-------------|----------------|---------|--------|-------|---------------------|-------------|----------------------------|--------------------|---|
| Alaska | | | | | | | | | | Fisheries, transportation (land and sea), subsistence |
| Appalachians | | | | | | | | | | Energy |
| California | | | | | | | | | | Fire damage |
| Eastern Midwest | | | | | | | | | | Industry, transportation |
| Great Lakes | | | | | | | | | | Commerce, infrastructure, economy |
| Great Plains - Central | | | | | | | | | | |
| Great Plains - Northern | | | | | | | | | | Grasslands |
| Great Plains - Southern | | | | | | | | | | |
| Gulf Coast | | | | | | | | | | |
| Metropolitan East Coast | | | | | | | | | | Land use, infrastructure |
| Mid-Atlantic | | | | | | | | | | |
| Native Homelands | | | | | | | | | | Subsistence, sovereignty, economic sustainability |
| New England | | | | | | | | | | Skiing, energy and utilities |
| Pacific (including Hawaii) | | | | | | | | | | Planning, coastal hazards |
| Pacific Northwest | | | | | | | | | | Energy, marine ecosystems |
| Rocky Mtn./Great Basin | | | | | | | | | | Skiing, ranching, industry (incorporated in urban) |
| South Atlantic/Caribbean | | | | | | | | | | Urbanization, insurance |
| Southeast | | | | | | | | | | Land use, change |
| Southwest - Colo. River | | | | | | | | | | |
| Southwest - Rio Grande | | | | | | | | | | Population pressure |
| TOTAL | 16 | 13 | 12 | 12 | 12 | 16 | 13 | 6 | 8 | 5 |

Sectoral Assessments

Sectoral assessment activities will focus on a key subset of issues that are national in scope and of importance to the services and goods on which people, society and the economy of the nation depend. Five sectors have been identified for purposes of the first national assessment: agriculture, water resources, forestry, human health, and the coastal zone. Each sectoral assessment will be conducted by a diverse team of nationally recognized focus issue experts that will conduct a comprehensive quantitative analysis of the consequences of climate variability and change from environmental, economic, and social perspectives for each sector under consideration. Each sectoral assessment team will also identify a technical point of contact within each of the regions that share an interest in the issue under consideration. Thus, as in the case of the water resource sector, water resource managers and researchers from each region are invited to provide input to the sector assessment team on the particular concerns, conditions, and vulnerability of the resource from their region's perspective. This information should prove valuable in providing a national perspective on the consequences of climate variability and change on water resources with regional resolution. This approach will further facilitate the development over time, as in the case of the water resources sectoral assessment, of a national network of water resource managers and researchers that may better share new research findings and link this information to the development and application of effective and efficient management approaches.

National Synthesis

One of the principal products of the national assessment will be a national assessment synthesis report. The National Assessment Synthesis Report will identify the potential consequences of climate variability and change, identify where our knowledge is sound, and where there are major uncertainties, and draw conclusions to the extent knowledge allows about the underlying regional and sectoral sensitivities to the changes one might expect to see, and how those sensitivities compare to other stresses on the overall system. The National Assessment Synthesis Report is meant to be targeted at issues of importance to policy makers in Congress and the Administration, state and local governments, and

decision-makers in the private sector, where many important investment decisions must also be made. The Synthesis Report will not itself be an analysis of alternative policies, but it will provide the scientific foundation on which policy analyses could be based. The National Assessment Synthesis Report will serve as the USGCRP response to Public Law 101-606 that mandates they prepare and submit to the President and the Congress periodic assessments of the implications of global change for the nation.

The preparation of the National Assessment Synthesis Report together with overall intellectual guidance and leadership for the national assessment is the responsibility of the National Assessment Synthesis Team (NAST). The NAST is chartered under the Federal Advisory Committee Act (FACA) and is comprised of nationally recognized scientists drawn from government, academia, and the private sector and which reflect the disciplinary depth and breadth necessary for the conduct of this first national assessment.

SCENARIOS: A COMMON FRAMEWORK FOR ANALYTIC ANALYSIS

To promote consistency and coherence across the regions and sectors, and facilitate their integration into a national synthesis report, a series of common climate and socio-economic scenarios will be employed by all assessment participants.

Scenarios for Climate Variability and Change

With respect to developing scenarios for climate change and variability to use in estimating the potential consequences on present and future economic, environmental, and societal conditions, several approaches will be used.

- A historical climatology of the United States covering the 20th century will be used to examine the potential consequences of continuation of past climatic trends and future occurrence of past climate variations. Regional, sectoral, and synthesis assessment teams will analyze the implications of repeating a 1930's drought or 1990's mid-western flood on the

ecosystems, human infrastructure, and economy of today and tomorrow;

- General circulation model simulations extending to 2100 of two types will be used for purposes of the assessment. The first type will be model simulations that have been carried out assuming a 1% per year increase in greenhouse gas concentrations, both with and without changes in aerosol concentration (simulations by the Canadian Climate Center and the Hadley Centre are being provided). The second type will be a set of simulations comparing the climatic response for “business-as-usual” growth in greenhouse gas concentrations with the response assuming stabilization of greenhouse gas concentrations (simulations by the National Center for Atmospheric Research); and
- Region- or sector-specific scenarios designed to facilitate analysis of the limits of vulnerability of regions and sectors, exploring these in relation to plausible future climate conditions. Assessment teams will be asked to identify perceived thresholds, both environmental and social, that if exceeded would cause serious implications for the region or sector. These thresholds would then be identified and assessed for their likelihood to occur based on the suite of climate model predictions that are available from all sources.

Socio-Economic Scenarios

The approach will involve providing a two-by-two matrix in which to consider the potential consequences of climate variability and change. The rows will consider the cases where the impact of climate changes are high or low for a particular sector or region when compared with other natural and human impacts that are occurring in a region. The columns would consider cases in which changes in a particular region or sector are likely to have high or low significance in the broad sweep of natural, social, and economic activities in that region.

Projected changes in demography, economics, and other key national, social, and economic indicators have been developed by the National Association of Planners, a recognized authority for such projections frequently used by the business community in their planning efforts, and

will be made available to all assessment teams. These projections of socio-economic conditions provide the best estimates of how the nation is expected to develop economically, demographically, and technologically over the next 50 years.

In addition to the scenarios listed above, each assessment team is invited to use other scenarios, models, and assumptions that may be applied to assess the potential consequences of climate variability and change for their region, sector, or for the nation. Scientific excellence and openness should guide the assessment process with assessment participants being encouraged to identify where our knowledge is sound, and where there are major uncertainties, and draw conclusions to the extent knowledge allows.

NATIONAL ASSESSMENT REVIEW PROCESS

The scientific credibility of the national assessment is assured by requiring an open and inclusive process that encourages the participation of the most qualified scientific, technical, and socio-economic experts. Assessment reports are expected to fairly represent the range of expert opinion about particular issues, with careful recognition of risks and uncertainties. Draft and final assessment reports will be subject to an open and wide-reaching review process, and accommodation will be made for well-documented and reviewed alternative interpretations.

Relevance to the needs of policymakers is ensured by the continuing and close involvement of stakeholders and decision-makers. Internal and external evaluation processes will 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.

Review is critical for establishing the overall credibility and responsiveness of the national assessment process and its constituent reports. There are several levels at which review is appropriate: technical peer review and editorial review. Each product of the national assessment, regional, sectoral, and national synthesis assessment reports will undergo a rigorous review process. Because there are multiple products envisioned for the national assessment process, review mechanisms

are proposed for those products other than the National Assessment Synthesis Report. The NAST proposes a three-tiered review process for the National Assessment Synthesis Report. The first level is technical peer review. At this level technical experts drawn from public and private organizations and the general public, will be asked to review the draft Synthesis Report for scientific and technical accuracy and validity. Provisions will also be made for a general public comment period at this stage. The NAST will be responsible for responding to and documenting its response to all written review comments.

The second level of review envisioned for the National Assessment Synthesis Report is editorial responsiveness. The Subcommittee on Global Change Research (SGCR), charged with responsibility for the USGCRP under Public Law 101-606, will identify a high-level committee of governmental and non-governmental experts whose responsibility will be to ensure the Synthesis Report is appropriately responsive to its overall charge. Further, the review committee will ensure that the NAST has responded appropriately to the technical review comments it has received. Of course, should technical errors remain in the report, this committee will also have the purview to recommend changes to NAST.

The third level of review for the National Assessment Synthesis Report is explicitly governmental. The governmental review will focus on verification that all review steps have been satisfactorily completed and that the report meets the needs of the government to satisfy the mandates set forth under Public law 101-606.

Reviews of other outputs of the national assessment process will depend upon the nature of the particular output. Sectoral and regional assessment reports will be widely reviewed for technical merit and responsiveness to stakeholder issues utilizing both a solicited technical and public review process. They will also include a review of assessment team responsiveness to review comments. The national assessment process emphasizes scientific publication of as much of the regional and sectoral work as possible where normal scientific peer-review processes are envisioned to be sufficient. In addition, for each product a summary report should be prepared that is designed to convey assessment findings to land and resource managers, decision-makers, and the general public.

MANAGEMENT OF THE NATIONAL ASSESSMENT PROCESS

The parent body within the US Government for the National Assessment is the Committee on Environment and Natural Resources (CENR), which is a subsidiary body of the National Science and Technology Council, chaired by the President. The CENR has delegated responsibility for oversight of assessment activities to its Subcommittee on Global Change Research (SGCR), the parent committee for the USGCRP. The SGCR has broad responsibilities for research planning and coordination among the Federal agencies. With respect to the National Assessment, the SGCR has been charged with overall coordination, implementation, and sponsorship of the national assessment process.

Specific responsibilities have been defined for oversight and coordination of national assessment activities. The National Assessment is envisioned as a broad-based process that includes structured interaction with a range of regional and sectoral experts and stakeholders.

The NAST is to provide overall intellectual oversight of the national assessment process and has specific responsibility for the National Assessment Synthesis Report, for defining national scenarios, for providing advice and oversight of the sectoral analyses, and for recommending guidelines for the regional analysis templates. The NAST and the SGCR National Assessments Working Group (NAWG) are jointly charged with producing templates for both regional and sectoral analyses.

Individual agencies, in cooperation with the SGCR/NAWG, have lead responsibility for organizing and sponsoring the sectoral analyses under the guidelines established by the NAST and SGCR/NAWG. Each sectoral team will be composed of both public and private participants.

SGCR/NAWG has primary oversight and coordination responsibility for the regional analyses. Regional assessments are sponsored by the individual NAWG member agencies. To help address issues and questions that transcend individual regions (e.g., water resources, ecosystem migration), an Inter-Regional Forum comprised of representative members of the regional assessment teams has been established. The Inter-

Regional Forum provides a mechanism to facilitate the sharing of information, methods, data, and findings across regions and to efficiently provide a regional interface with the sectoral assessment teams and the NAST.

A National Assessment Coordination Office (NACO) has been established to facilitate communication and coordination among all assessment bodies and participants. NACO will provide a framework within which the efforts of the large numbers of local, regional, and Federal participants can interact with the national assessment process in ways that provide useful insights and results for the National Synthesis, and promote development of stakeholder networks. A web page (<http://www.nacc.usgcrp.gov>), newsletter ("Acclimations"- available at the web site), and internet reflector work groups for regional and sectoral assessment teams are examples of mechanisms the NACO has established and maintains to carry out their charge.

PARTICIPATION BY THE WATER RESOURCE RESEARCH AND MANAGEMENT COMMUNITIES

One of the most important consequences of climate variability and change will be impacts on water resources, including both the natural hydrologic system and the complex water-management schemes built to alter and control that system (Gleick 1998). Table 1, a compilation of the principal issues identified by regional stakeholders participating in the assessment process, indicates water resource issues will be addressed in sixteen of the twenty regional assessments. Questions raised to the water resource community encompass fundamental concerns regarding water quantity, availability, and quality under changing climatic conditions. These concerns were raised while recognizing that even under a static climate, our nation's water resource management institutions are challenged. To effectively manage the nation's water resources we must address the resource demands of a growing population, increased requirements for in-stream to support aquatic ecosystems, identify and reduce point and non-point sources of contamination, protect our ground water reserves, and meet statutory water allocation requirements.

Though there remains high uncertainty in future climate scenarios at regional and sub-regional scales, the potential implications of climate variability and long-term climate change for the water resource community pose serious concerns that warrant the careful analysis called for through the national assessment. Changing climatic conditions and the associated potential changes in evapotranspiration, human-demand, and saltwater intrusion to name but a few require active engagement by water resource managers and scientists in the national assessment process.

Resource managers and scientists are needed to participate in interpreting and analyzing of the projections of climate change made by global and regional (nested) models. While important progress is being made in improving models, there remain important uncertainties and only ranges of future changes can be estimated. There is an important role for analysis in determining the consistency of simulations in projecting changes in major climatic features (e.g., implications of changing precipitation patterns, soil moisture, runoff) that tend to determine a region's water resource.

It is also essential that managers and scientists contribute to our understanding of the vulnerability of regions or sectors to future climate change and the resources' sensitivity to past change and variations. Water resource managers and scientists can play important roles by developing and interpreting historic records of the region's climate and participating in analyses of how these affect the region's water quantity and quality and how the condition of the resource influenced the region's environment and socio-economic activities.

Similarly, the water resource community must be engaged in the determination of possible adaptation and coping strategies that might be employed under a changing climate to improve society's resilience to the natural year-to-year fluctuations in the climate. Water resource managers and scientists are requested to participate in a public discussion and analysis about our water resources: its current condition and vulnerability to climate variability and change; and the development of future adaptation and coping strategies. Education activities, both traditional and informal, are vital to helping the public, governmental and business leaders, and others who will be affected by climate change and variability to

prepare and cope in ways that make society safer and more efficient.

These are only starting points. We invite you to help in these and many other ways. The assessment process is intended to be empowering rather than prescriptive, and we ask your help in making this so.

REFERENCES

Gleick, P. 1998. *The World's Water 1998-1999*. Island Press, Washington, D.C.

SGCR, 1997: *Our Changing Planet, The FY 1998 U. S. Global Change Research Program*. Available from the

Subcommittee on Global Change Research, Washington, D.C. (Web: <http://www.usgcrp.gov>).

Acknowledgments: The authors are grateful for the many suggestions about organizing the USGCRP national assessment activity. The frameworks for the conduct of assessment and the issues to be addressed were developed in partnership with participants in the regional workshops, the sector assessment teams, representatives of the federal agencies, and participants in the 1998 summer workshop held at Monterey, California.