Setting the Stage

1. Introduction

prepared by

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The Nation and the National Assessment Process

Climate affects many aspects of life in the US. Year-to-year variations are reflected in such things as the number and intensity of storms, the amount of water flowing in our rivers, the extent and duration of snow cover, and the intensity of waves that strike our coastal regions. Science now suggests that human activities are causing the climate to change. Although the details are still hazy about how large the changes will be in each region of the country, changes are starting to become evident. Temperatures have increased in many areas (Figure 1.1), snow cover is not lasting as long in the spring, and total precipitation is increasing, with more rainfall occurring in intense downpours. These changes appear to be affecting plants and wildlife. There is evidence of a longer growing season in northern areas and changing ranges for butterflies and other species. The international assessments of the Intergovernmental Panel on Climate Change (http://www.ipcc.ch) project that these changes will increase over the next 100 years.

The Global Change Research Act of 1990 [Public Law 101-606] gave voice to early scientific findings that human activities were starting to change the global climate:

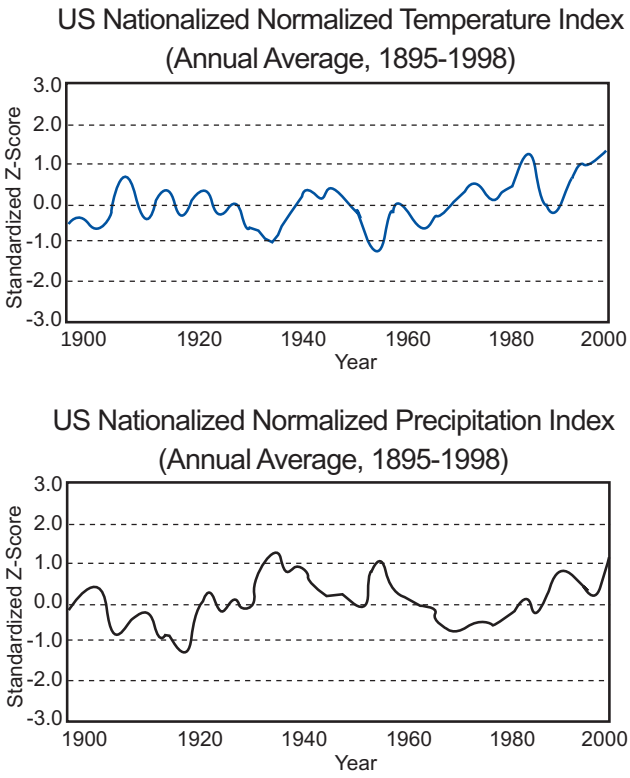

Figure 1.1: Temperature (upper) and precipitation (lower) trends for the US for the period 1900-2000. Source: National Climate Data Center, Tom Karl [1-1].

> "(1) Industrial, agricultural, and other human activities, coupled with an expanding world population, are contributing to processes of global change that may significantly alter the Earth habitat within a few generations;
>
> (2) Such human-induced changes, in conjunction with natural fluctuations, may lead to significant global warming and thus alter world climate patterns and increase global sea levels. Over the next century, these consequences could adversely affect world agricultural and marine production, coastal habitability, biological diversity, human health, and global economic and social well-being."

To address these issues, Congress established the US Global Change Research Program (USGCRP) and instructed the Federal research agencies to cooperate in developing and coordinating "a comprehensive and integrated United States research program which will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural process of global change." Further, the Congress mandated that the USGCRP:

> "shall prepare and submit to the President and the Congress an assessment which
>
> • integrates, evaluates, and interprets the findings of the Program and discusses the scientific uncertainties associated with such findings;
>
> • analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity;
>
> • analyzes current trends in global change, both human-induced and natural, and projects major trends for the subsequent 25 to 100 years."

The USGCRP's National Assessment of the Potential Consequences of Climate Variability and Change, which is focused on the question of why we should care about and how we might effectively prepare for climate variability and change, is being conducted under the provisions of this Act (Figure 1.2).

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. The National Assessment process has been broadly inclusive, drawing on inputs from academia, government, public and private sectors, and interested citizens. Starting with broad public concerns about the environment, the Assessment is exploring the degree to which existing and future variations

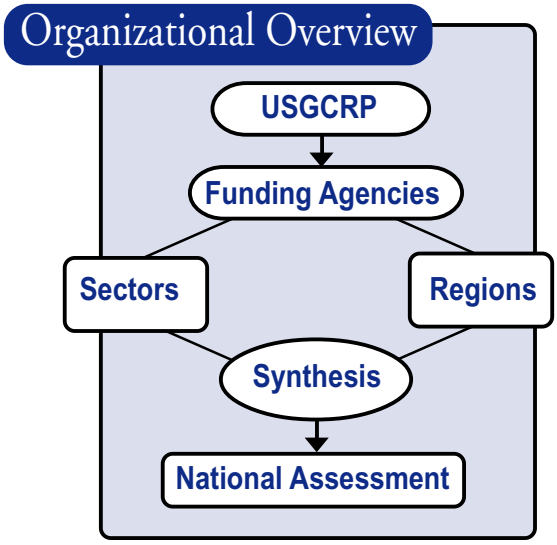

Figure 1.2: Organizational overview for the National Assessment.

and changes in climate might affect issues about which people care. A short list of questions has guided the process as the Assessment has focused on regional concerns around the US and national concerns for particular sectors:

> – What are the current environmental stresses and issues that form the backdrop for potential additional impacts of climate change?
>
> – How might climate variability and change exacerbate or ameliorate existing problems? What new problems and issues might arise?
>
> – What are the priority research and information needs that can better prepare the public and policy makers for reaching informed decisions related to climate variability and change? What research is most important to complete over the short term and over the long term?
>
> – What coping options exist that can build resilience to current environmental stresses, and also possibly lessen the impacts of climate change?

Three National Assessment Components

Regional Analyses

The National Assessment includes regional, sectoral, and synthesis activities.

Workshops and assessments are being conducted to characterize the potential consequences of climate variability and change in regions spanning the US. A total of 19 workshops (Figure 1.3) were held around the country, with the Native Peoples/ Native Homelands workshop being national in scope rather than regional. To date, 16 of these groups are preparing assessment reports. The reports from these activities address the interests of those in the particular regions by focusing on the regional patterns and texture of changes where people live. Most workshop reports are already available and assessment reports will start to become available in early 2000.

Figure 1.3: Sectors and regions in the National Assessment.

Sectoral Analyses

Workshops and assessments are being conducted to characterize the potential consequences of climate variability and change for major sectors that cut across environmental, economic, and societal interests. The sectoral studies analyze how the consequences in each region affect the Nation, making these reports national in scope and of interest to everyone. The sectors being addressed in this first phase of the ongoing National Assessment include Agriculture, Forests, Human Health, Water, and Coastal Areas and Marine Resources. Sectoral assessment reports will be made available in 2000.

National Overview

The National Assessment Synthesis Team has responsibility for summarizing and integrating the findings of the regional and sectoral studies and then drawing conclusions about the importance of climate change and variability for the United States. Their report will be available during 2000.

Each of the regional, sectoral, and synthesis activities is being led by a team comprised of experts from both the public and private sectors, from universities and government, and from the spectrum of stakeholder communities. Their reports have all gone through an extensive review process involving other experts and other interested stakeholders and are available on request (see http://www.nacc.usgcrp.gov). The assessment process is supported in a shared manner by the set of USGCRP agencies, including the Departments of Agriculture, Commerce (National Oceanic and Atmospheric Administration), Energy, Health and Human Services, and Interior, plus the Environmental Protection Agency, National Aeronautics and Space Administration, and the National Science Foundation. Through this involvement, the USGCRP is hopeful that broad understanding of the issue and its importance for the Nation will be gained and that the full range of perspectives about how best to respond will be aired.

The Region and the Regional Process

The Great Lakes region has been a leader in certain areas of agriculture and industry for the better part of this century. The nickname "The Industrial Heartland" is well earned. Additionally, the Great Lakes themselves are an important resource for transportation as well as recreation [1-2]. Changes in lake levels in past years have affected the way people live, work, and recreate in the region. Periods of high water, like that which occurred in the 1980s, can be beneficial for shipping, but can be detrimental for lakefront property owners – especially during stormy periods. Periods of low water, like that which occurred in the 1990s, can be detrimental to shippers, requiring them to carry lighter loads, but attractive to people looking to build vacation homes near the lakes. Understanding what lake levels will do in the future is information that many people would like to have. While many meteorological factors are involved in understanding what lake levels will do in the future, an overarching concern is how climate change will affect lake levels. Thus, there is strong motivation to understand how climate change will affect the Great Lakes region.

Despite the concerns that many people who live in the region (i.e., the region's stakeholders) have regarding not just the potential impacts that climate change will have on lake levels but also regarding other aspects or sectors within the region, little attention has been paid. For example, telling stakeholders that temperatures will increase by so many degrees and that precipitation will increase by so many inches per year is inadequate for their purposes. These stakeholders have individual needs that are driven by their professional and personal interests – needs that can not be answered by degrees of mercury or inches of water. These stakeholders want to know whether they can ship goods the way they used to, or whether they can build their dreamhouse on the shores of Lake Michigan, or whether they can continue to enjoy their birdwatching or leafpeeping activities. Answering these types of questions requires a different type of approach that extends beyond the numbers that climate models

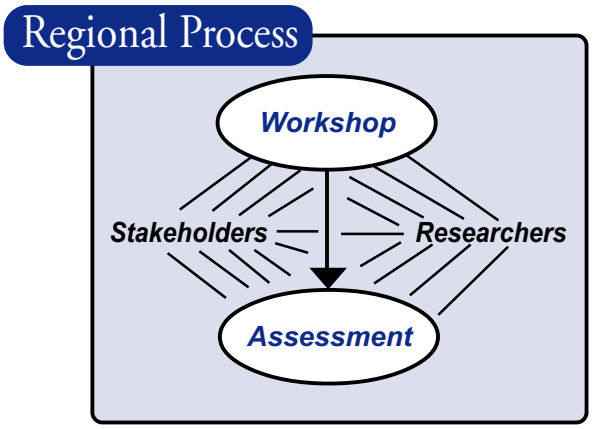

Figure 1.4: The Great Lakes Regional Assessment process.

can provide. Answering these questions takes a coordinated effort between the stakeholder and research communities.

In the Fall of 1997, planning began for a workshop that would initiate a relationship between the stakeholders and researchers in the Great Lakes region (Figure 1.4). The workshop was to be one of the 19 regional workshops that were being sponsored by the USGCRP. The workshop would address several questions, including how climate change would impact certain sectors. Thus, a key piece of information was knowing which sectors were important. While this could have ideally been addressed at the workshop, it was decided to choose broadly defined sectors beforehand and then let the workshop attendees decide what aspects specifically within each of the sectors were highly important. To this end, a steering committee was chosen to identify the sectors that would be discussed at the workshop. The steering committee consisted of people from academia, government, environmental interest groups, and industry.

Over one hundred people from academia, government, environmental interest groups, and private industry attended the workshop, which was held at the University of Michigan during May 4-7, 1998. A series of invited talks ensured that participants had some common knowledge as they divided into breakout groups to discuss the above mentioned four assessment questions and how they related to important regional sectors: water resources (WRES), agriculture (AGRI), water ecology (WECO),

land ecology (LECO), economy (ECON), infrastructure (INFR), and human health (HLTH). The discussions from the breakout groups were summarized and used to determine some of the more important concerns regarding climate change (impacts) in the Great Lakes region. Although the discussions regarding stresses and the impact of climate change on those stresses were obviously sector-dependent, two common themes arose from all sector-breakout groups. One was that better models – not just better regional climate models – but better coupled models of climate and streamflow, for example, or climate and agricultural yields, as another example, need to be developed for the region. Another common theme was that stakeholders and the general public need to be better informed (educated) regarding the potential impacts of climate change [1-3].

The choices for which sectors, and what aspects within those sectors to assess, and what goals to accomplish was decided by members of the workshop steering committee with input from the workshop results (Figures 1.4 and 1.5). Identifying members for the Great Lakes Regional Assessment Team with sufficient interest, expertise, and availability to address the most important aspects proved challenging and in some instances the choices for what to investigate were adjusted.

Great Lakes Assessment

Water Resources – Impacts of climate change on Great Lakes water levels

Water Ecology – Impacts of climate change on streamflow, fish populations, and productivity

Land Ecology – Impacts of climate change on vegetation (bio-productivity), coniferous forest distributions, and bird migrations

Agriculture – Impacts of climate change on alfalfa, maize, and soybean production

Quality of Life – Impacts of climate change on respiratory disorders, recreation, shipping and energy consumption

Figure 1.5: Sectors that were examined in the Great Lakes Regional Assessment.

Part of the Great Lakes Regional Assessment strategy also involved engaging researchers from other institutions in the Great Lakes region. For example, while the University of Michigan hosted the Upper Great Lakes Workshop, and is the Central Headquarters for the Great Lakes Regional Assessment effort, other institutions have certainly collaborated. Because the bottom line of this assessment is to get the message about climate change impacts across to the stakeholders throughout portions of an eight-state region, it was deemed advantageous to involve researchers from The University of Minnesota (Minneapolis-St. Paul, Minnesota), The University of Wisconsin-Milwaukee (Milwaukee, Wisconsin), The Illinois State Water Survey (Champaign-Urbana, Illinois), Michigan State University (East Lansing, Michigan), the Army Corps of Engineers (Buffalo, New York),The Great Lakes Environmental Research Laboratory (Ann Arbor, Michigan), The Center for Environmental Policy, Economics and Science (CEPES), (Ann Arbor, Michigan), and of course from the University of Michigan (Ann Arbor, Michigan).

All the researchers involved in the National Assessment, not just those from the Great Lakes region, were asked to follow some "loose" guidelines regarding their assessment. One guideline was to use some of the latest output from General Circulation Models (GCMs). Prior to the mid 1990s, most climate change simulations by GCMs did not include effects from aerosols, which people believe to be the reason why the global temperature has not risen more rapidly, given the amount of additional CO_2 that is in the atmosphere. The presence of aerosols effectively increases the albedo, and reflects some of the sun's energy back to space. At the time, output from GCMs that included aerosols was available from the Canadian Coupled-Climate Model (CGCM1), and from the Hadley Centre Climate Model (HadCM2). These models have slightly different parameterization schemes for many of the sub-grid scale processes

[1-4, 1-5]. A summary of their temperature and precipitation output for the Great Lakes region is provided in the next chapter. Researchers were encouraged to examine output from both models – although time constraints prevented many from doing so. In the Great Lakes region, it was decided to focus more on analysis of output from the Hadley Model, owing to the fact that the Great Lakes were not included in the Canadian Model simulations. Some researchers in the Great Lakes region did examine output from the Canadian model as well, because of additional concerns. The climate scenario output from the models were available in several forms. Daily output from the Canadian model (3.75° latitude by 3.75° longitude) and from the Hadley model (2.5° latitude by 3.75° longitude) was available for sea-level pressure, winds, temperatures, and geopotential heights at selected pressure levels, as well as surface maximum and minimum temperatures and precipitation. Climate scenario output was also available from the VEMAP (Vegetation/Ecosystem Modeling and Analysis Project) process as monthly means and daily values [1-6] at 0.5° x 0.5° resolution. The attraction to some researchers for using VEMAP output stemmed from its higher spatial resolution and more realistic (ranges of) daily temperature and precipitation values. The VEMAP monthly means were simply interpolated directly from the GCM monthly means. The daily values, however, were created in a more complicated way. Rather than use the daily output directly from the GCMs, the GCM monthly means were processed through a *weather generator* program [1-6], that created more realistic daily variations than the GCM could. Daily VEMAP output at each point was created using parameter values that were climatologically appropriate for that particular region. As a result, there was no attempt to assure that the fields were spatially correlated. The VEMAP fields consisted of surface maximum and minimum temperatures, precipitation, and some surface moisture and radiation fields. No sea-level pressure, wind, or geopotential height information was available in VEMAP form.

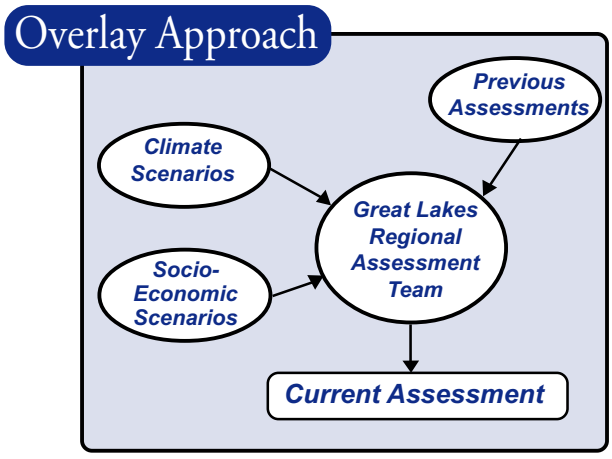

Figure 1.6: The overlay approach used by many investigators during the Great Lakes Regional Assessment.

Researchers were also asked to consider future socioeconomic scenarios. This consideration was less straightforward than that of climate change. However, the strategy in the end was to make an attempt to account for changes in population, landuse, and overall wealth when considering the impacts of climate change on a particular sector. The socioeconomic data was provided on a series of three CD-ROMs from NPA Data Sources, Inc. [1-7].

Owing to severe time constraints, most researchers used an overlay approach (Figure 1.6) for assessing impacts. An overlay approach means that researchers evaluated the impacts from climate change as indicated from (quantitative) output from the GCMs by interpolating or extrapolating results from previous assessments. The overlay approach provided a simple, efficient, and accurate means to evaluate climate impacts from the newly available model output in most instances. However, one fundamental constraint of this approach is that the accuracy of the new results is inherently limited by the accuracy of the old results. Unfortunately, there was little time for a more fundamental approach, e.g., refining existing or developing new impacts assessment models – like stakeholders had suggested at the workshop. The specific approaches used by the different researchers are described in more detail in chapters 4-8.