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Acclimations

Newsletter of the U. S. National Assessment of Climate Variability and Change

Assessment Deals with Scientific Uncertainty

By Jerry Melillo, The Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA

The central goal of the National Assessment is to explore the potential consequences for the United States of climate changes, whether due to long-term trends in temperature and precipitation or short-term fluctuations and changes related to patterns of variability. We all recognize that impacts depend on the nature and extent of change in the biogeophysical system and the capacity of human societies to anticipate and respond to these changes. Consequently, when we assess impacts, we have to make assumptions about the future of the climate system, ecological systems, and socioeconomic systems.

Any thoughtful assessment of climate-change impacts must be done with the recognition that our prediction capabilities are limited for these three interrelated systems. Although our understanding of the climate system has progressed rapidly in recent years, we cannot yet accurately predict the rates and magnitudes of changes in local temperature and precipitation patterns. Despite substantial progress in short- and intermediate-term predictions of El Niño events, improvements are still needed to enable predictions of future changes in the variability of climate, particularly at small spatial scales. Extant ecological, social, and economic models can provide a general sense of the direction of changes, but are similarly limited and cannot adequately predict the fine-scale responses to climate changes in major "sectors" such as forestry, agriculture, and water resources. And finally, as a research community we are in the very early stages of interactively coupling the climate, ecological and socioeconomic systems to explore dependencies and feedbacks among them.

We have designed an approach to the National Assessment that allows consideration of these uncertainties. With respect to future climate, we are asking the regional and sectoral teams involved in the Assessment to consider a small number of "what-if futures." In addition, we have urged that the teams consider the alternative climate futures in the context of a short list of key socioeconomic dimensions. Some of this work will be done through new modeling studies. We are also encouraging each team to make use of the special insights of regional or sectoral experts who may be able to identify important feedbacks between systems not apparent from the current generation of modeling studies.

This issue of Acclimations focuses on climate science and predictions. Among the articles are overviews of the climate and socioeconomic scenarios that we are using in the National Assessment. In many ways, these scenarios are the foundation for subsequent analysis and synthesis. They provide a common framework from which comparisons of potential impacts on regions and sectors can be derived.

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The next issue will focus on Education, Outreach, and Stakeholder Interactions

Putting Together Winter Forecasts for U.S. Temperatures and Precipitation - - La Nina and Long Term Trends

By Robert E. Livezey, Climate Prediction Center, NCEP/NWS/NOAA

The official seasonal forecasts for the United States for January through March 1999 (Fig. 1) made in mid-December 1998 by the National Weather Service's Climate Prediction Center (CPC) are excellent examples of a new approach to making these and longer-lead predictions. This approach is more physically-based than previous methods because it starts with an assessment of what aspects of climate variability are most important to the current situation, which in turn dictates to the forecaster the tools to bring to bear on the problem. From time to time this can lead to sharply focused, high-confidence predictions, so-called "forecasts of opportunity", which were not previously feasible (or defensible) with statistical techniques that attempted to treat all factors simultaneously and indirectly. This strategy was used to make the highly successful forecasts for the winter of 1997-98 possible.

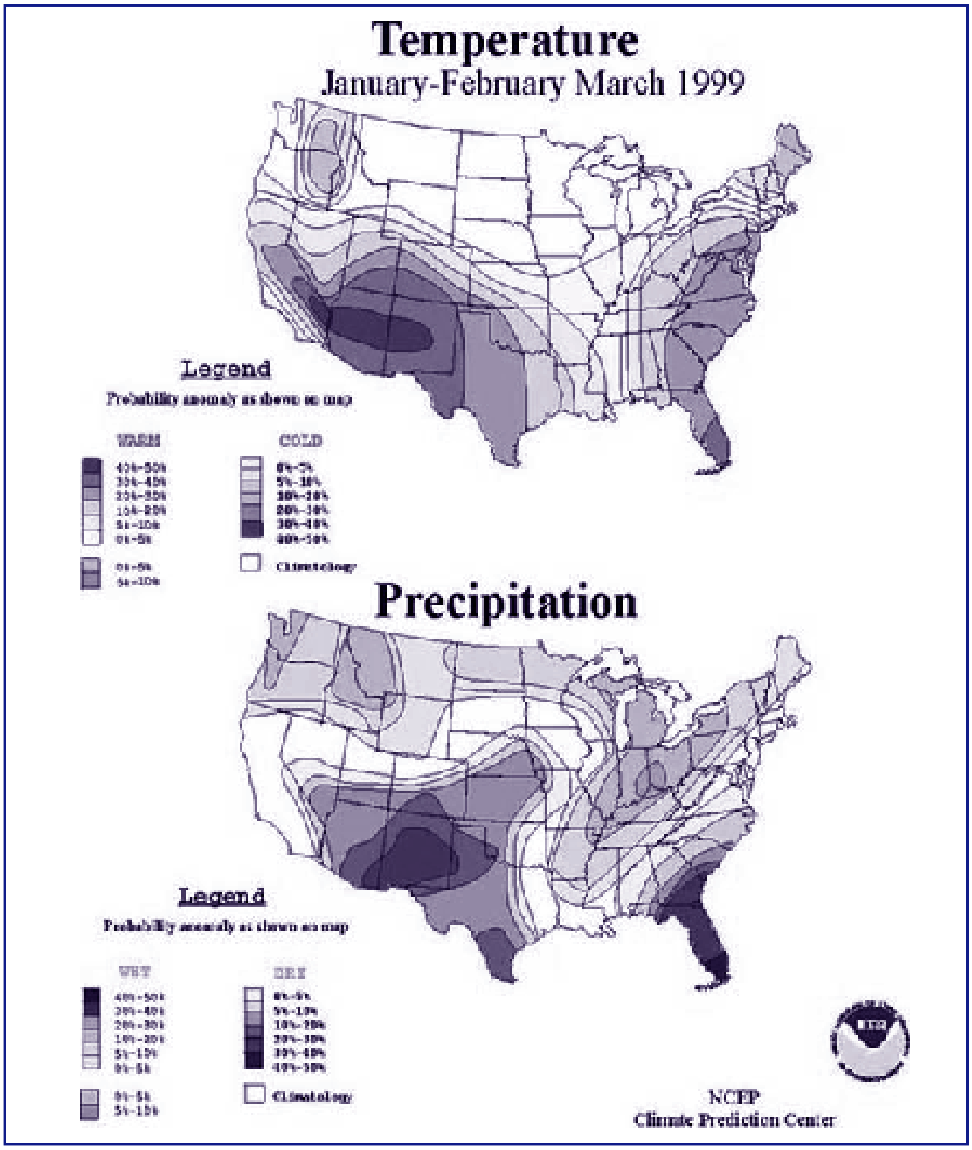

Fig. 1 Climate Prediction Center forecasts of mean seasonal temperatures and precipitation for January through March 1999 made for the United States in mid-December 1998.

The forecast process begins with a prediction of the state of the El Nino/Southern Oscillation (ENSO) - one of the most important factors controlling year to year changes in average winter conditions and also the most predictable. ENSO refers to multi-year shifts in sea surface temperatures (SSTs) in the central equatorial Pacific Ocean. When these waters are substantially warmer than normal, the condition is called El Nino, and when they are colder than normal, the condition is referred to as La Nina. El Nino and La Nina are important to wintertime North America because much of the energy which drives the global wind and weather systems is converted from the Sun's energy by extensive rain systems over the tropical Pacific. El Nino stokes up this engine while La Nina puts the brakes on it. In either case, the implications for the North Pacific subtropical jet stream and weather patterns north and east of the jet are dramatic. In a rough sense, La Nina's effects are the opposite of El Nino's - not only locally in the Pacific but also remotely over North America. For example, during January through March in the U.S., La Nina usually brings drier than normal conditions to the Southwest and Southeast where it is usually wet with an El Nino, and wetter than normal in the Pacific Northwest and the

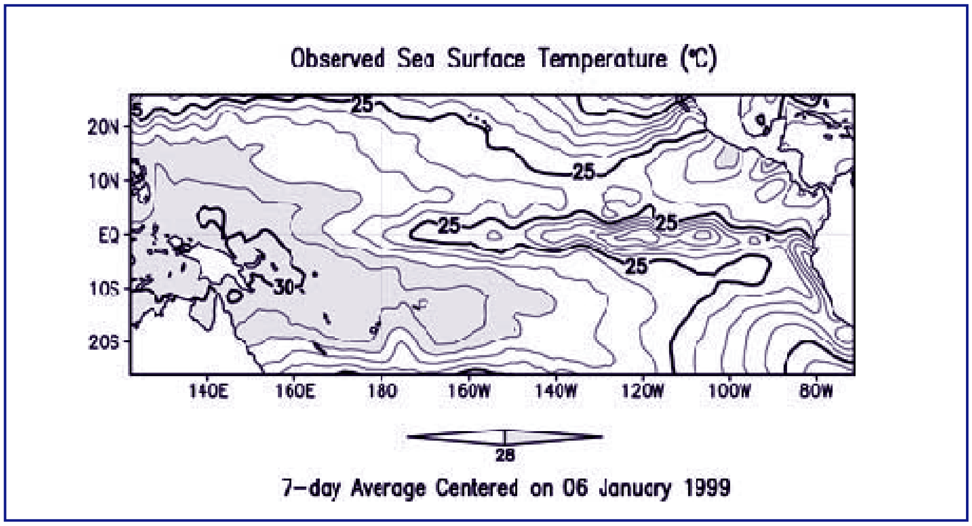

Fig. 2 Global sea surface temperatures in degrees celsius for the period 3-9 January 1999.

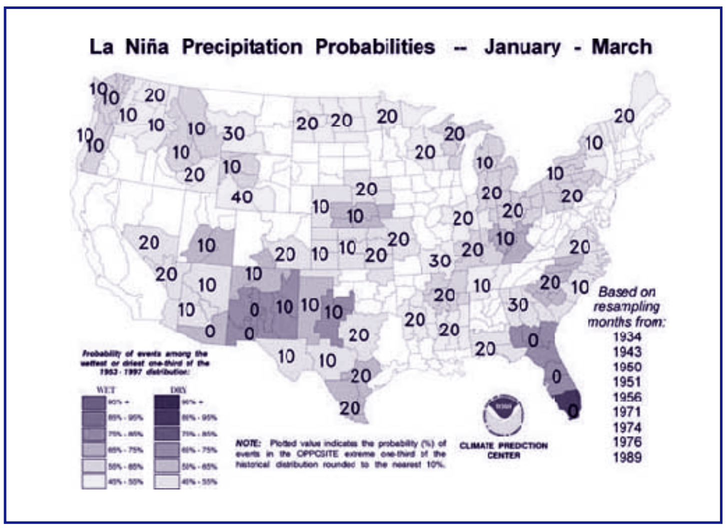

Fig. 3 Chances of January through March being among the wettest or driest one-third of years in the historical recor d during a moderate strength La Nina.

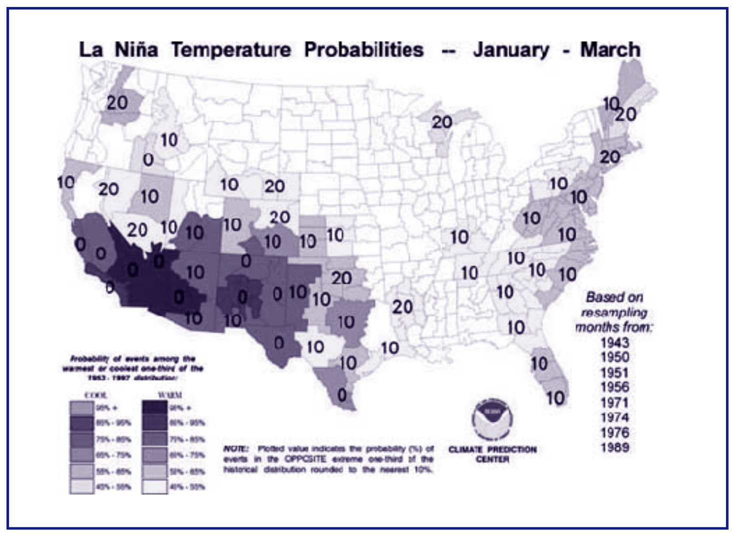

Fig. 4 T rends since 1965 of mean January through March temperatures.

Ohio Valley where El Nino implies relatively dry conditions.

Last spring and early summer the 1997-98 El Nino was replaced by La Nina (Fig. 2), which subsequently intensified to at least moderate strength by the time CPC forecasters sat down in mid-December to make the forecasts for January through March 1999. Because of agreement between two statistical models and a highly sophisticated computer model of the coupled ocean / atmosphere, they were able to predict with a high degree of confidence the continuation of this moderately strong La Nina in the equatorial Pacific Ocean for at least several more months.

To account for the presence of the La Nina, the seasonal forecasters consulted a chart that shows estimates based on records back to the 1930s of how likely precipitation will be to fall amongst the wettest or driest thirds of historical observations given a moderate to strong La Nina. This chart (Fig. 3) formed the principal basis for forecast precipitation patterns and probabilities (Fig. 1), because all other factors had either small (compared to La Nina) or indeterminate effects. In contrast, at least two other factors had important implications for the temperature forecast.

The first of these factors is long-term trends that may be associated with global warming. While the existence of real upward trends in both wintertime temperature and precipitation have been demonstrated, only the former is thought to be strong enough to significantly distort an expected La Nina pattern. In the absence of temperature trends, the conventional scenario for a La Nina U.S. winter would be for warmer than normal in the southeast and south central regions, along with colder than normal in the Northwest and along the west coast and the western and central Canadian border. Strong warming trends (Fig. 4) over the last 30 or so years throughout the western United States might modify this picture substantially. CPC scientists believe this was part of the reason for more of the country experiencing warmer than normal conditions last winter than expected from El Nino alone.

Consequently, a chart (Fig. 5) corresponding to that for precipitation (Fig. 2) was developed for January through March U.S. temperatures to account for both the

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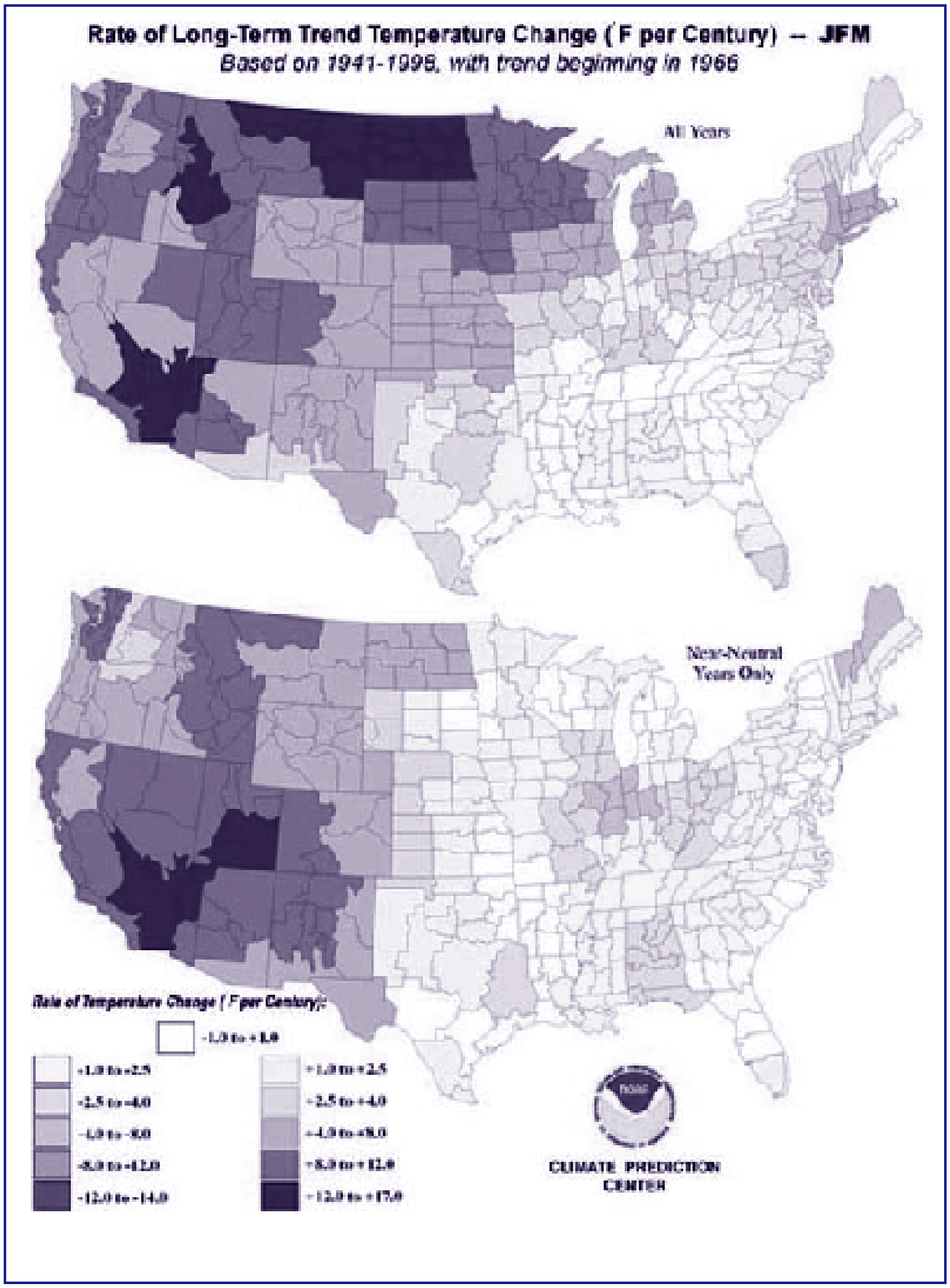

Fig. 5 Chances (adjusted for long-term trends) of January through March being among the warmest or coldest one-third of years in the historical record if a La Nina of at least moderate strength is in place in the tropical Pacific

La Nina and observed trends since the mid-1960s. This information led to prediction of a much larger area of warmer than normal conditions encompassing all of the Southwest and extending to the west coast, and substantially reduced area and probabilities for colder than normal conditions in the Northwest and along the western U.S./Canadian border (Fig. 1). However, the forecasters reduced the

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probabilities of relatively warm conditions along the California coast compared to those inland, because of the expected persistence of cold coastal waters. This cold pool was the second factor used to modify the temperature forecasts.

Other factors also impact seasonal averages and some play their most important roles only at certain times of the year. Two very important factors for the cold half of the year are weather patterns over the Northern Hemisphere's two extratropical ocean basins independent of ENSO. These are characterized respectively by the North Pacific Oscillation (NPO) and the North Atlantic Oscillation (NAO). Often these weather systems are long-lived and accompanied by distinct SST patterns in their respective ocean basins. Either system will distort an expected La Nina scenario in known ways. Unfortunately, these systems sometimes undergo big swings lasting a few weeks - changes that are unpredictable more than a week or so in advance, but are significant enough to spoil a seasonal forecast. A good example was a short-lived shift in the NAO last winter, which not only contributed to the record New England ice storm in early January but also supplied enough precipitation in the eastern Ohio Valley to negate the El Nino effect for the season. For this year's forecast there were no indications that the forecast should be adjusted for either pattern.

Ultimately, CPC is striving to produce forecasts of not only seasonal averages but also aspects of within-season variability through use of computer models of the entire coupled global ocean/atmosphere system. The goal is to simultaneously account for ENSO, trends, long-term shifts in the NAO or PDO, and other factors such as soil-moisture feedbacks (important in the warm part of the year) in physically consistent ways. In the meantime, seasonal forecasts will be approached in a manner that takes full advantage of current insight into the phenomena relevant to the problem.

For more information:
CPC's full suite of products and information is available on the web at http://nic.fb4.noaa.gov

NOAA's Office of Global Programs Coordinates Climate and Global Change Research

Within the National Oceanographic and Atmospheric Administration (NOAA), the Office of Global Programs (OGP) has lead responsibility for the agency's Climate and Global Change Program. The Climate and Global Change Program represents NOAA's contribution to the on-going national and international programs that are designed to improve our ability to observe, understand, predict, and respond to changes in the global environment. The OGP program builds on NOAA's mission requirements and longstanding capabilities in global change research and prediction. NOAA has the primary responsibility within the Federal Government to routinely provide climate forecasts and products to the Nation. OGP assists in this capacity by sponsoring focused scientific research, within approximately eleven research elements, all aimed at understanding climate variability and its predictability. Through studies in these areas, researchers coordinate activities that jointly contribute to improved predictions and assessments of climate variability over a continuum of time scales from season to season, year to year, and over the course of a decade and beyond.

NOAA's Climate and Global Change Program is an integral part of the interagency U.S. Global Change Research Program, and works to achieve an important objective of global change--understanding the global climate system. As part of NOAA's contribution, OGP also guides NOAA's effort in spearheading the multinational initiative to establish an International Research Institute and associated regional applications centers to generate and disseminate forecast guidance. This initiative is made possible because of new scientific advancements in predicting temperature and precipitation patterns associated with El Nino variations, and promotes the generation and dissemination of forecast information.

The NOAA Climate and Global Change Program is currently funding research in the following areas:

Aerosols - research to improve the capabilities for predicting the role of anthropogenic aerosols in forcing climatic change.

Atlantic Climate Change Program (ACCP) - climate variability related to the North Atlantic Oscillation and the Atlantic tropical sea surface temperature "dipole".

Atmospheric Chemistry - global monitoring, process-oriented laboratory and field studies, and theoretical modeling to improve the predictive understanding of the concentrations and interactions of atmospheric trace gases that influence the Earth's chemical and radiative balance.

Climate Change Data and Detection - data and information management support (i.e., data assembly, processing, inventory, distribution and archiving), and documentation of the quantitative character of observed climate variations and changes.

Climate Dynamics and Experimental Prediction - utilizing the climate model developed by the NOAAGeophysical Fluid Dynamics Laboratory to study climate variability and change.

Climate Observations - ocean, atmosphere, and land surface climate observations, measurement systems and techniques.

Economics and Human Dimensions of Climate Fluctuations - aimed at understanding how social and economic systems are currently influenced by fluctuations in short-term climate (seasons to years), and how human behavior can be (or why it may not be) affected by improved predictions of climate variations.

Education - development and dissemination of climate and global change information for teachers, students, and educational institutions.

GEWEX Continental Scale International Project (GCIP) - NOAA's contribution to the GEWEX Continental scale International Project, emphasizing scale integration of hydrometeorological processes in climate models and transfer of representations of these processes into climate models either through a nested model approach or improved land surface schemes.

Global Ocean - Atmosphere - Land System (GOALS) - to understand global climate variability on seasonal-to-interannual time scales; to determine the extent to which this variability is predictable; to develop the observational theoretical, and computational means to predict this variability; and to foster the development of experimental predictions within the limits of proven feasibility.

Ocean-Atmosphere Carbon Exchange Study (OACES) - part of NOAA's contribution to the completion of the NOAA/DOE/NSF-sponsored Global Ocean Carbon Dioxide Survey and a continuing effort to improve our understanding of the role of the ocean in sequestering the increasing burden of anthropogenically-derived carbon dioxide in the atmosphere.

Paleoclimatology - utilization of paleoclimate data to develop an understanding of the seasonal to century-scale variability and predictability of the ENSO and African/Asian monsoon systems, the ocean thermohaline system and its relation to global change, and the hydrologic system at regional to global scales, as it relates to the above.

OGP's participation in these areas has assisted NOAA in augmenting the state of science in the United States, guiding the direction of NOAA's research efforts, and providing valuable scientific data and information for practical use and social and economic benefit.

For more information,
See the NOAA Office of Global Programs web site at http://www.ogp.noaa.gov.

Assessment Methods I: Climate Scenarios

By Eric Bar ron, The Pennsylvania State University

Pennsylvania State University Climate model predictions provide the estimates that have stimulated much of the national and international debate concerning the importance and the nature of future climate. These model projections provide estimates for many of the climatic variables of importance to society, and hence, the model predictions provide a key framework for assessing the impacts of climate change. Because of limitations in understanding and in computational resources, and because we cannot know precisely what emissions will occur, the climate models employed by scientists around the world have different characteristics and simplifications. Therefore, these models provide somewhat different simulations of the future climate. Consequently, the model predictions are said to only provide an estimate, or "scenario", of possible future climates. The first U.S. National Assessment is based on a climate information strategy of providing a physically-consistent climate foundation for regional and sector assessments to be utilized by every team, with the opportunity for teams to perform additional independent analyses.

The strategy for providing climate scenarios for regional and national impact assessment is based on several key needs. First, a historical climate record is needed in order to have a basis for assessing the importance of climate and climate change. Second, the range of future climates used in the assessment process must be sufficiently broad to reflect the levels of uncertainty in models and in our projections of how society may evolve. Third, the assessment must reflect the range and character of natural variability (like El Nino) and a sense of the spatial variability of climate. Fourth, the period of model predictions must overlap with the period of historical observations in order to evaluate the capabilities of the models. Finally, the assessment process should include opportunities to determine thresholds or limits in human and ecosystem adaptability. The selection of the set of climatic information for the assessment must also recognize both time and human constraints. For these reasons, the climate scenarios being provided to each team form a minimum basis for their assessment. The historical data sets available for the U.S. Assessment include:

(1) The United States Historical Climatology Network (HCN) data set, which is maintained by the National Climatic Data Center and contains monthly averaged maximum, minimum, and mean temperature and total precipitation data for 1200 of the highest quality observing stations in the continental United States for the period 1895 to 1997;
(2) The Daily Historical Climatology Network data set, which contains observations for 187 high-quality stations in the contiguous U.S. for the 1910-1997 time period and observations for 1000 stations in the contiguous USAfor the 1948-1997 time period;
(3) The VEMAP (Vegetation/Ecosystem Modeling and Analysis Project) spatially-uniform 1° x 1° record (1895-1993), which is based on 8000 HCN and U.S. Forest Service and Bureau of Land Management Sno-Tel stations for high elevation precipitation.

Each of the climate simulations is based on models that include both the ocean and the atmosphere, and for which the atmospheric greenhouse gas concentrations and sulfate emissions evolve with time. Climate simulations that will be used for the U.S. Assessment include those from the United Kingdom's Hadley Centre for Climate Prediction and Research (HADCM2) and the Canadian Centre for Climate Modeling and Analysis (CGCM1). Model simulations using the National Center for Atmospheric Research Climate System Model (NCAR CSM) and Department of Energy Parallel Climate Model (DOE PCM) runs are also expected to become available to the synthesis team for examination. Variables that will be provided to the assessment teams include surface air temperature, maximum and minimum surface air temperature, total precipitation, soil moisture, solar radiation, wind speeds, humidity, and sea-level. The model output will be provided for each region for the periods 2025-2034 and 2090-2099.

As for all simulations, the model simulations adopted by the assessment process have limitations. Foremost are questions whether these limited models will provide sufficient richness to describe the character of natural variability or the appropriate magnitude of climate response needed to achieve a realistic analysis of climate impacts. Because of this and other limitations, an assessment approach is being encouraged that also allows individual regions or sectors to consider "what if" cases that reflect educated guesses based on the nature and importance of specific regional and sector vulnerabilities. For example, given its importance, the southwestern region might consider intensification or weakening of the monsoonal circulation as a thought experiment in an effort to define or understand regional or sectoral pressure points or high levels of vulnerability.

The historical and model data provide an encompassing basis for assessing climate impacts. The historical record indicates that the greatest U.S. warming over the last century has occurred in the northeast and southwest. The southeast is one of the handful of places in the world indicating some cooling. The historical record also indicates that the U.S. has experienced modest increases in precipitation, with the exception of the precipitation decreases in the upper Great Plains area and parts of Alaska. The climate models predict warmer temperatures throughout the world for increased greenhouse gas concentrations. The amount of warming more than doubles over the United States in both models between the two periods of study (2025-2034 and 2090-2099). The HADCM2 model predicts a greater than 4° C mean annual near-surface temperature increase over the western U.S. in 2095, whereas CGCM1 indicates a greater than 6°C increase over the central U.S. for the same interval. The total annual precipitation ratios for the decade 2025-2034 and 2090-2099 indicate that both models predict increasing precipitation throughout most of the world as a direct effect of warmer temperatures. On an annual average basis, both models indicate rather modest mean annual precipitation differences for the U.S., with the exception of a large predicted increase in the precipitation off the California coast. On a seasonal basis, however, the changes are larger.

Assessment Methods II: Socio-Economic Scenarios

By Ted Parson, Havard University

The National Assessment will culminate in the preparation of a Synthesis Report which integrates the inputs from regional and sectoral assessment teams. The potential complexity of this task is enormous, given the number and variety of these inputs. Therefore, the National Assessment Synthesis Team (NAST) has spent significant time at their early meetings in 1998 generating guidelines for the regions and sectors to use while conducting their assessments. These guidelines are intended to help manage the complexity of the task, and to maintain a level of consistency among the products of regional and sectoral teams.

Because climate impacts happen to people, economies, and societies, the consequences of a specified climatic change or pattern of variability depend on the character of the society that lives with the climate. Consequently, assessing impacts requires making assumptions about the future character of American population, land use, economic activity, uses of natural resources, technology and institutions.

But finding a defensible and useful way to make these assumptions poses major challenges. The characteristics of societies and economies that shape climatic impacts can be intensely detailed, fine-grained, and coupled, and may be specific to particular locations. The particular socio-economic characteristics that most strongly shape climate impacts and vulnerability in a particular domain or region are not obvious a priori and cannot be calculated through analysis. Moreover, the impacts of changes in climate and adaptations to them will be jointly determined with response measures to mitigate human contribution to climate change, and with the other large-scale economic, social, and technological trends that will shape future society. In the face of such complexity, and with the limited time available, a useful and defensible assessment of impacts of climate change and variability requires massive simplification.

To make the complexity of their projections manageable, each regional and sectoral team has been asked to make two fundamental simplifications. First, rather than examining all dimensions of impacts and vulnerability in their region or sector simultaneously, they have been asked to choose a few specific domains that they judge likely to be most important, or most illustrative, of patterns of impact in their region or sector. (For example, the Pacific Northwest team is examining climate impacts on freshwater flows in the Columbia Basin, and consequently on the multiple sectors and activities that depend on these flows. The human health sectoral team is examining climate-induced heat stress risks in major midwestern cities such as Chicago.)

Second, for each domain they are examining, the teams are identifying a small number of key socio-economic factors that in their judgement are likely to have the strongest and most direct influence on impacts and vulnerabilities. They are then examining the impacts of specified climate scenarios under alternative assumptions for these key socio-economic factors. By focusing on a few key factors directly linked to climate impacts, the teams should be able to avoid the overwhelming complexity that would follow from having to tell the full story of how the factors came to have these values. For example, if a forestry study decides that commercial forest-product demand is a key factor determining impacts, they can proceed to assume high and low values for demand without having to specify what combination of demographic, market, and technological factors caused demand to be high or low.

Given these guidelines, the basic approach being taken to impact assessment is as follows. Afew alternative socio-economic scenarios are created by jointly varying the chosen socio-economic factors between their high and low values, combining values of different variables expected to be associated with high, and with low, vulnerability to impacts. While particular studies vary in their structure, typical analyses consider from two to four distinct socio-economic cases. A specified climate scenario is being imposed on each of these cases, and its effects measured relative to the present climate. This difference will provide a first-order illustration of potential climatic impacts. How this difference varies among alternative climate scenarios will illustrate variation of impacts due to uncertainty in climate. How the difference varies among alternative socio-economic scenarios will illustrate the socio-economic determinants of vulnerability. How it varies with specific hypothesized responses -- changes in management, policy, institutions and infrastructure -- will illustrate key decisions that may help influence adaptive capacity.

To provide consistent socio-economic assumptions, the assessment is providing teams with projections from a commercial regional economic model. The model provides annual population and economic projections at fine spatial scales -- annual population by sex for 5-year age cohorts, and employment and income for 13 sectors, at the level of states, counties, and metropolitan areas. Separate high, middle, and low projections are being provided, of which the "low" and "high" projections combined low and high assumptions for population, labor force participation, and productivity growth.

For population, the three scenarios use the US Census Bureau's assumptions for fertility and mortality, but apply a wider range of assumptions for future net immigration. The scenarios also vary rates of labor-force participation by older workers (55 years and over), with the low scenario holding participation at present levels while the middle and high scenarios extended recent trends of increasing participation. Finally, the scenarios assume varying annual rates of growth in economic output per worker -- 0.6%, 1.2%, and 2.4% per year in the low, middle and high scenarios.

Look to future issues of Acclimations for reports from the regions and the sectors on the use of socioeconomic scenarios in their assessments.

Changing Conditions for the Great Plains in the Next Century

Dennis Ojima, Colorado State University

The potential impact of climate changes in the Central Great Plains region (i.e., the Colorado, Kansas, Nebraska and Wyoming area) is anticipated to affect winter snowfall and snow-melt, growing season rainfall amounts and intensities, minimum winter temperatures, and average summer 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 response to the call for regional assessments of these impacts, an assessment strategy has been developed which provides greater stakeholder involvement as well as scientific input.

The social and economic characteristics of the Great Plains have changed dramatically over the past 50 years. People have made changes in the manner in which they manage their lands; farm and ranch sizes are becoming larger; populations have become more concentrated in community centers or cities; and farm income is no longer the sole source of rural income for most families in the Great Plains. In addition, the population age structure is changing, and there are growing concerns regarding recruitment of new farmers and ranchers to continue the land productivity of the region. These changes in social and economic features of the Great Plains will determine the long-term sustainability of this critical agricultural region as climate changes.

The diverse water needs of the region compound the difficulty of managing water use among the various sectors. Water availability must be determined before development plans in this region are initiated. Therefore, the assessment needs to involve members of the water use and supply sectors to better understand the competing water needs among the agricultural sectors, urban and industrial uses, and natural ecosystems. Current understanding of the water needs of aquatic ecosystems under both current and projected conditions is incomplete. Water apportionment decision-making between aquatic ecosystems and human needs must be more clearly understood and evaluated. These issues need to include how best to address agricultural demands and overall water management. And changes in land use and climate will also affect water quality. For example, we need to know how to best manage livestock wastes during extreme precipitation events.

Projections by some of the general circulation models indicate that both annual average temperatures and total annual precipitation will increase over the region. However, the seasonal patterns are not uniform. For example, one model projects a 4°C increase is projected for the winter period at the end of the next century for the Colorado-Wyoming area. This warming, coupled with about a 50% increase in winter precipitation, would greatly modify the amount and timing of snow-melt from the Rocky Mountains. During the summer, minimum temperatures are projected to increase while maximum temperatures would be less affected. The change in minimum temperatures may affect plant communities by increasing the amount of cool season plant species. The hydrological cycle may also be affected, resulting in more intensive storm activity. Whether or not the plant community will be able to accommodate these changes in growing season climate or hydrological patterns is a matter of concern among stakeholders who depend on these weather patterns for their livelihood.

Changes in plant communities may also result from shifting weather patterns. The diverse plant communities and ecosystems that populate the Great Plains are sensitive to changes in habitat and climate patterns. Many of the species which have adapted to 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 weeds and pests may occur. Our understanding of what effects the exotic species have on habitats and how climate change will affect susceptibility of different habitats to invasion needs to be included in the assessment activity

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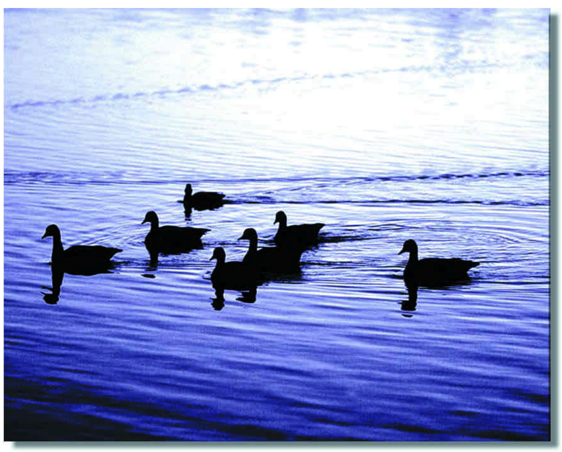
Is Climate Changing Where the Wild Things Are?

Lynne Carter, USGCRP

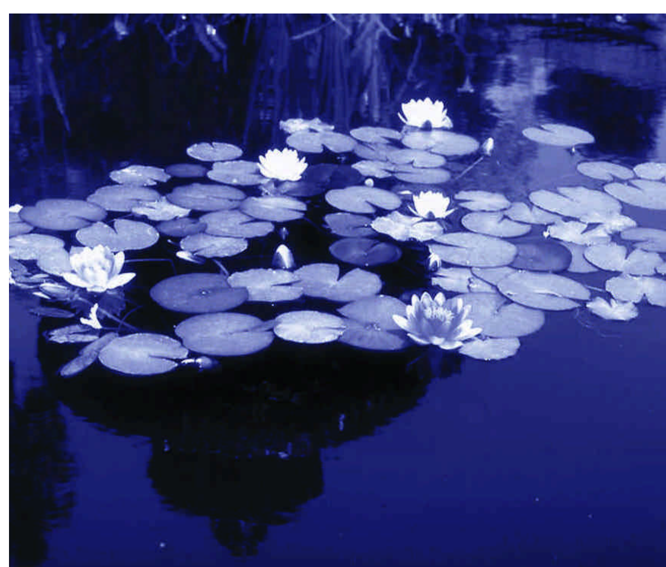
The questions posed by the conference entitled Is Climate Changing Where the Wild Things Are? can be interpreted in at least two ways and the answer to both seems to be "Yes." A dozen wildlife scientists studying a range of organisms made presentations focused on these concerns at a conference sponsored by the US EPA and co-sponsored by 19 groups interested in the outdoors, which was held at the National



Zoo in Washington, DC, Oct. 7-8, 1990. Most of what they presented suggests that the locations where the wild things are are indeed changing.

According to Professor Camille Parmesan of the National Center for Ecological Analysis and Synthesis, University of California, Santa Barbara, the home territories of butterflies like the North American Edith's Checkerspot and 9 of 14 species of European butterflies have shifted north by 92 km and 200 km, respectively. Professor Terry Root, of the University of Michigan, has found that, of the 27 species of migratory birds that she studied, all (but one) seem to be arriving in Michigan earlier (8 species arrived 1-2 months earlier) in the spring than representatives of those species from some 30 years ago. Additionally, earlier egg-laying dates for birds in England have been documented as well as an observed upslope migration of some mountain dwelling birds in Costa Rica. Even changes in the abundance of invertebrate species documented in a rocky intertidal community are believed to be due to changes in water temperature, likely as a result of climate changes. Mr. Sagarin, of Hopkins Marine Station, Pacific Grove, CA, compared surveys taken in Monterey Bay between 1931-33 and 1993-96, which show that 10 of 11 southern species of invertebrates increased in abundance, while 6 of 8 northern species decreased in abundance. Professor Magnuson, of the University of Wisconsin, Madison, expects similar changes in fresh water fishes; it is likely that warm water fishes will expand their ranges while cool and cold water fishes "will do more poorly or be lost."

While these changes in ranges and schedules of wildlife arrivals may seem insignificant, they could have serious ecological consequences due to the complex interdependencies of many ecosystems. Dr. Jeff Price of the American Bird Conservancy presented sensitivity analyses which suggested that breeding distributions of some North American birds will undergo range shifts and, unless all the components of an ecosystem shift at the same rate, there could be impacts on, for example, forest health. The example he used was "a loss of insectivorous birds that feed on spruce budworms could lead to insect outbreaks of increased severity and frequency." Other potentially serious concerns related to changes in species distribution and other components of the ecosystem include the potential for a loss of coordination between the timing of food availability and need. For example, the maturation of the food source (plant, insect) may become out of sync with an organism's life history (e.g. egg-laying and hatching of birds and feeding of young). These secondary effects demonstrate just how interconnected biological systems are.



For the Prairie Pothole Region (PPR) of the Northern Great Plains, the concern of Professor Lisa Sorenson of Boston University is "how anticipated changes in the hydrologic regimes of wetlands. . . will affect populations of prairie-nesting waterfowl, birds that are dependent on shallow wetlands for breeding." While the potholes produce only 10% of the North American breeding habitat, they produce 50-80% of the continent's ducks. Because the size of breeding duck populations has historically correlated with the number of ponds counted in May, if the projected warming / drying shown by many of the climate models occurs, then it is possible that the mean duck population could be reduced by nearly 50%

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Global Climate Change Q&A

Prepared By: Rob Quayle, Tom Peterson, and Tom Karl, National Climatic Data Center, Asheville, N.C. 28801.*

Q. What is the greenhouse effect, and is it affecting our climate?

A. The greenhouse effect is unquestionably real, and is, in fact, essential for life on Earth. It is the result of heat absorption by certain gases in the atmosphere (called greenhouse gases because they absorb radiation) and emission downward (thus exerting a "trapping" influence). Water vapor is the most important greenhouse gas, followed by carbon dioxide and other trace gases. Without the greenhouse effect, the temperature of the Earth would be about zero degrees F (-18°C) instead of its present 57°F (14°C).

Q. Are greenhouse gases increasing?

A. Human activity has been increasing the concentration of greenhouse gases in the atmosphere (mostly carbon dioxide from combustion of coal, oil, and gas; plus a few other trace gases). There is no scientific debate on this point. At rates of increase observed over the past few decades, the concentration of carbon dioxide will be double that of pre-industrial levels by about 2050.

Q. Is the climate warming?

A. Global surface temperatures have increased about one degree F (0.3 to 0.6°C) since the late-19th century, and about one half degree F (0.2 to 0.3°C) over the past 40 years (the period with the most credible data). The warming has not been globally uniform. That some areas (including parts of the southeastern U.S.) have cooled is not unexpected due to the somewhat chaotic behavior of the climate when changes are still small. The recent warmth has been greatest over North America and Eurasia between 40 and 70°N. Warming, assisted by the record El Nino of 1997-1998, has continued right up to the present.Trends can vary greatly depending on the period over which they are computed. Temperature trends in the lower troposphere (between about 2,500 and 18,000 ft.) from 1979 to the present, the period for which Satellite Microwave Sounding Unit data exist, are small and seem to be unrepresentative of longer term trends and trends closer to the surface. Furthermore, there are small unresolved differences between radiosonde and satellite observations of tropospheric temperatures, though both data sources show near zero trends. If one calculates trends beginning with the commencement of radiosonde data in the 1950s, the data suggest that there has been a slight warming. There are statistical and physical reasons (e.g., short record lengths, the transient differential effects of volcanic activity and El Nino, and boundary layer effects) for expecting differences between recent trends in surface and lower tropospheric temperatures, but the exact causes for the differences are still under investigation. Recent research suggests that the mid-tropospheric temperatures may actually be warming after additional corrections for satellite orbital decay.An enhanced greenhouse effect is expected to cause cooling in higher parts of the atmosphere because the increased "blanketing" effect in the lower atmosphere holds in more heat. Cooling of the lower stratosphere (about 30-35,000 ft.) since 1979 is shown by both satellite Microwave Sounding Unit and radiosonde data, but is larger (and probably exaggerated because of changes in instrumentation) in the radiosonde data.There has been a general, but not global, tendency toward reduced diurnal temperature range (the difference between high and low daily temperatures) over more than 40% of the global land mass since the middle of the 20th century. Cloud cover has increased in many of the areas with reduced diurnal temperature range.Relatively cool surface and tropospheric temperatures, and a relatively warmer lower stratosphere, were observed in 1992 and 1993, as a result of the 1991 eruption of Mt. Pinatubo. The surface warming reappeared in 1994. A dramatic global warming, at least partly associated with the record El Nino, began in mid-1997 and continues as this is written. This warming episode is evident from the surface to the top of the troposphere.Indirect indicators of warming such as borehole temperatures, snow cover, and glacier recession data, are in agreement with the more direct indicators of relatively rapid warming during this century.

Q. Are El Ninos and La Ninas related to Global Warming?

A. El Ninos and La Ninas are not caused by global warming. Clear evidence exists from a variety of sources (including archaeological studies) that these phenomena have been present for hundreds, and some indicators suggest maybe millions, of years. However, it has been hypothesized that warmer global sea surface temperatures can enhance the intensity of El Ninos and La Ninas, and it is also true that El Ninos have been more frequent and intense in recent decades.

Q. Is the climate becoming more variable or extreme?

A. On a global scale there are few indicators of sustained trends in climate variability or extremes. This perhaps reflects inadequate data and a dearth of analyses. However, on regional scales, there is clear evidence of changes in variability or extremes.This perhaps reflects inadequate data and a dearth of analyses. However, on regional scales, there is clear evidence of changes in variability or extremes.In areas where drought or excessive precipitation usually accompanies an El Nino, these anomalies have been more frequent and intense in recent years. Other than areas with El Nino-related drought and the few areas with longer term trends to lower rainfall (e.g., the Sahel), little evidence is available of changes in drought frequency or intensity.In some areas there is evidence of increases in the intensity of extreme rainfall events, but no clear global pattern has emerged because global observations are limited. Despite the occurrence in recent years of several regional-scale extreme floods, there is no clear evidence of wide-spread changes in flood frequency, but there is evidence of an increase in mean precipitation and extreme precipitation events in recent decades in many mid and high latitudes. This difference may reflect the limited number of flood frequency studies, definition problems, and/or difficulties in distinguishing the results of land use changes from meteorological effects.There is some evidence of recent (last few decades) increases in extreme extratropical cyclones over the North Atlantic and North Pacific. Intense tropical cyclone activity in the Atlantic appears to have decreased over the past few decades. Elsewhere, changes in observing systems confound the detection of trends in the intensity or frequency of extreme synoptic systems.There has been a clear trend to fewer extremely low minimum temperatures in several widely-separated areas in recent decades. Widespread significant changes in extreme high temperature events have not been observed. And there is some indication of a decrease in day-to-day temperature variability in recent decades.

Q. How important are these changes in a longer-term context?

A. For the Northern Hemisphere summer temperature, recent decades appear to be the warmest since at least about 1400AD, and the warming since the late 19th century is unprecedented over the last 600 years for which we have data. Earlier data are insufficient to provide reliable hemispheric temperature estimates. Ice core data suggest that the 20th century has been warm in many parts of the globe, but also that the significance of the warming varies geographically, when viewed in the context of climate variations of the last millennium.Based on the incomplete evidence available, the projected warming of 2 to 7°F (1-3.5°C) over the next century would be unprecedented in comparison with the best available records from the last several thousand years. In the past, large and rapid climatic changes affecting the atmospheric and oceanic circulation and temperature, and the hydrological cycle, occurred during the last ice age and during the transition towards the present Holocene period (which began about 10,000 years ago).

*(This material was based on the 1995 Intergovernmental Panel on Climate Change report (http://www.usgcrp.gov/ipcc/html/preports.html) and subsequent material.)

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Agricultural and rangeland ecosystems play an important role in soil conservation and land management. The agricultural management have 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 needs to be carried out. 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 the 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 including alteration of changes in frequency and intensity of grazing is needed to develop strategies that promote sustainable rangeland use.

The Great Plains Assessment team is now striving to promote understanding of the relative importance of the possible effects of changes in greenhouse gas concentrations, temperature, and precipitation in the region. The team is preparing climate analyses, environmental evaluations of impacts, and a survey of coping strategies to better understand the potential opportunities and stresses this region may undergo. A stakeholder meeting will be held March 21-24, 1999 in Colorado to take stock of the range of climate change impacts on critical sectors of the region.

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email: dennis@nrel.colostate.edu

Calendar

Assessment Sponsored Meetings:

Agriculture Sector Workshop
Washington, DC January 21-22, 1999
(Contact: Justin Wettstein, wettstein@usgcrp.gov)

National Assessment Annual Meeting
Atlanta, Georgia April 11-14, 1999
(Contact: Melissa Taylor, mtaylor@usgcrp.gov)

Southern Great Plains Workshops
Texas Early 1999
(Contact: Robert Harriss, harriss@tamu.edu)

Meeting of the National Assessment Synthesis Team
Location: TBD June 7-8, 1999
(Contact: Melissa Taylor, mtaylor@usgcrp.gov)

Meeting of the National Assessment Synthesis Team
Location: TBD July 8-11, 1999
(Contact: Melissa Taylor, mtaylor@usgcrp.gov)

Related Meetings:

American Association for the Advancement of Science (AAAS)
Anaheim, California January 21-26, 1999
(Contact: see web site at http://www.aaas.org/meetings/scope/ or Ryan Strowger, (202)326-6736; rstrowge@aaas.org)

Wetlands and Climate Change Workshop
Laurel, Maryland February 3-4, 1999
(Contact: Jon Kusler, (518)872-1804; aswmi@aol.com)

IPCC: WGIII Expert Meeting on Mitigation
Denmark February 1999
(Contact: ipccweb@usgcrp.gov)

IPCC: WGIII Expert Meeting on Economic Impacts of Climate Change
The Hague, The Netherlands March 1999
(Contact: ipccweb@usgcrp.gov)

Maine Global Climate Change Conference
Lewiston, ME April 6-8, 1999
(Contact: Pam Person; (207) 469-6770; phppwp@aol.com)

1999 Summit on Leadership Fusion for a Healthy 21st Century
San Francisco, CAApril 17-20, 1999
(Contact: Health Forum, (888) 887-8072)

The President's Council on Sustainable Development-National Summit
Detroit, MI May 2-5, 1999
(Contact: www.sustainableamerica.org or call (888) 333-6878)

AWRA: Potential Consequences of Climate Variability and Change to Water Resources of the United States
Atlanta, Georgia May 10-12, 1999
(Contact: American Water Resources Association, (703) 904-1225; awrahq@aol.com)

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Other issues discussed at the meeting include the following:

- How can the science community help planners and managers who need information, knowledge, and assistance?
- In what ways can support for study of specific/local issues (e.g. greenway development) be increased?
- Planners and managers need to understand that not all local problems are caused locally and that some problems have an origin that is outside of the local area.
- The prescription cannot be the same for all sorts of problems (for example, connections can be a problem that leads to lake invasions by non-native species, but greenways are important as migration corridors for many species that shift homes with the seasons).
- Some approaches for dealing with particular problems are transferable, while others are inappropriate.
- Research programs should include study of physiological stresses that are not immediately lethal but slowly decimating to a population/community.
- The effect of temperature on toxins can be a potential time bomb because toxicity levels of some toxins increase with temperature.
- There are likely thousands of studies of long-term changes being carried out, but which are not being collected, summarized, published, or related to the well-known studies that frequently form the only basis for assessment.

At least two important themes emerged from this gathering of wildlife scientists. One is that there may be reasons to be critical of particular studies of one species, but the collection of studies (and their findings) conducted on many different species in many different habitats around the globe provides important collective evidence of the effects of climate change. The other theme relates to our means for addressing issues of scientific uncertainty and the necessity to "think outside the box" of the 90% confidence interval, particularly when discussing these issues and their possible consequences in terms of public policy analysis and decision-making. Norman Meyers noted that while the scientific community needs to be careful about sounding the alarm regarding climate change, undue caution can be reckless behavior. In light of the often resulting policy paralysis, he suggested that it is "better to be roughly right than to be exactly wrong," especially because the stakes are potentially so high.

Assessment News Bits

Synthesis Team:
- The first edition of the Synthesis Team Bulletin ("NAST NOTES") was distributed in January 1999.Synthesis Team Liaisons are working closely with their counterparts in regions and sectors to identify issues and develop first drafts of the report sections.

Federal Working Group (NAWG):
- The Subcommittee on Global Change Research approved a charge to its National Assessment Working Group to develop a strategy for the Post-2000 phase of the National Assessment. This will begin with a survey and consultation phase.

Scenarios:
- In late January, the Canadian climate model data (CGCM1) was re-released, and the Hadley model data (HADCM2) was released. These can be accessed from the main web site.
- The NCDC Climate Epochs Data Set is now linked to the web site.
- On February 5, NPAData Services, Inc. distributed a CD-ROM to the regional and sectoral chairs containing annual historical data through 1997 and three economic projections scenarios: high, baseline, and low growth - to 2025 (this was for the Economic database; the growth projections of the Demographic and Household databases will come soon, as well as all three extending to 2050).

Sectors:
- The Agriculture Sector held a workshop January 21-22 in Washington D.C. to review current understanding and discuss assessment strategy.
- Representatives of the water and coastal sectors participated in a USGS-sponsored Climate Change and Wetlands Workshop in Patuxent, Maryland.

Other:
- The National Assessment's Blue Ribbon Review Panel is being formed as a subcommittee to PCAST: the President's Council on Science and Technology. Further information is expected by late February.
- ASpecial Issue of "Climate Research" (Volume 11) was published, with articles on global change impacts and adaptation. Several articles were drafted by National Assessment participants.

National Assessment Data and Scenario Products

National Assessment Coordination Office
U. S. Global Change Research Program
400 Virginia Avenue, SW, Suite 750
Washington, DC 20024

Newsletter of the U.S. National Assessment of the Potential Consequences of Climate Variability and Change

The *Newsletter of the U.S. National Assessment of the Potential Consequences of Climate Variability and Change* is published by the U.S. Global Change Research Program, 400 Virginia Avenue, SW, Suite 750, Washington, DC 20024, and is available on the World Wide Web at http://www.nacc.usgcrp.gov or by writing to the above address. Articles, other submissions, and suggestions are welcomed, and should be sent to :

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