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MARSHALL INSTITUTE STUDY CHALLENGES "FLAWED" GLOBAL WARMING ASSESSMENT

WASHINGTON, D.C. — The U.S. National Assessment of climate change won't provide policymakers or the public with useful information because it relies on computer climate models that are incapable of making accurate regional predictions of global warming, according to a study released today by the George C. Marshall Institute.

The study's author, Dr. David Legates, who is Associate Professor of Climatology in the Center for Climatic Research at the University of Delaware, noted that "these models, which are intended to describe climate only on a very large scale, are currently used by the National Assessment to describe possible scenarios of regional climate change in the U.S."

"Because current models cannot accurately represent the existing climate without manipulation," Legates noted, "they are unlikely to render reliable global climate scenarios or provide useful forecasts of future climate changes in regions of the United States as small as the Midwest, West or South."

The study explains how General Circulation Models (GCMs) work and why the attempt to forecast complex climate factors such as atmospheric changes, the interaction of land, sea, and air, and the role of clouds in climate is so difficult. The strengths and weaknesses of climate models are discussed and the report shows how GCMs are used to answer important questions about global warming.

The two climate models used in the U.S. National Assessment are then described with reference to their similarities and differences. The limitations of these models — the Canadian Global Coupled Model and the Hadley Climate Model from Great Britain — are outlined with emphasis on their inability to provide useful regional scenarios of climate change.

The Marshall report concludes with an analysis of how well these two models reproduce the present-day climate as a benchmark for their ability to predict future climate.

Key findings in the report include:

- Our incomplete understanding of the climate system and our inability to represent this imperfect understanding mathematically limit the usefulness of the current GCMs.

[redacted]

- The two models have significant problems in representing the land surface: for example, the western United States is represented simply as one large slope beginning at the Pacific Ocean and descending into the Great Plains, so that the role of the coastal plain, the most densely populated area of the western states, is ignored.
- It is common practice to "tune" GCMs to make them represent current conditions more accurately, but the very fact that the GCMs need this manipulation casts serious doubt on their ability to predict future conditions. Because all factors are interconnected in climate modeling, an error in one field will adversely affect the simulation of every other variable.
- To reduce complexity and computational time, GCMs treat surfaces as uniform and average the flows of moisture and energy between the land surface and the atmosphere over large areas. But the extensive variability of the land surface and the effects that even small-scale changes can have make modeling land-surface interactions quite difficult.

The National Assessment itself recognized that both models that it selected provide a more extreme climate change scenario than other models that were available and that had been developed in the U.S. Both models offer incomplete modeling of the effects of individual greenhouse gasses, including water vapor and atmospheric sulfates. The CGCM1 in particular fails to model sea ice dynamics and offers a simplistic treatment of land-surface hydrology.

Predicted temperature increases over various regions of the United States differ considerably between the two models; these predictions fail to correspond with observed precipitation variability and contradict each other. In general, the Hadley model simulation is closer to the observed climate in the United States than the Canadian simulation, although both models produced considerable differences from observations. This, again, casts serious doubt on the models' ability to simulate future climate change. Given these uncertainties, the report concludes, using the available GCMs to assess the potential for climate change in specific regions is not likely to yield valid and consistent results.

GCMs can provide possible scenarios for climate change, but at the present level of sophistication, they are not reliable enough to be used as the basis for public policy. Using GCMs to make predictions about local climate change in the United States is deeply flawed, and can only lead to deeply flawed policies.

The U.S. National Assessment of the Potential Consequences of Climate Variability and Change for the Nation intends to "provide a detailed understanding of the consequences of climate change for the nation." The Assessment's findings, called the National Assessment Synthesis Report, will be published in the near future.

The George C. Marshall Institute is a not-for-profit science and public policy research group located in Washington, D.C. Detailed information on the Institute can be obtained on its web site (marshall.org) or by calling 202-296-9655.

EDITORS NOTE: To arrange an interview with Dr. Legates or obtain a copy of the study, contact Jeffrey Salmon or Mark Herlong at the Marshall Institute at 202/296-9655.

United States Department of the Interior

Office of the Deputy Secretary
Washington, D.C. 20240
202-208-6291

October 23, 2000

To: Roger Ballentine 456-1736

From: David J. Hayes

Thyis is the executive summary for the report. They have been holding it for an event.

Dave

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Executive Summary of the Water Sector Report of the National Assessment

Introduction

The water resources of the United States of America, like the water anywhere on the planet, are an integral part of the global hydrologic cycle. Precipitation originates as evaporation from land and the oceans. Soil moisture is used by plants, which return more moisture to the atmosphere. Water that does not evaporate or transpire or seep into aquifers runs off to form the nation's streams and rivers. Snow stored in winter in the mountains provides water for rivers and deltas in the spring and summer. Storms bring extra moisture; droughts arise from protracted periods of low rainfall – all as part of our natural climate.

Over the past century, the United States has built a vast and complex infrastructure to provide clean water for drinking and for industry, dispose of wastes, facilitate transportation, generate electricity, irrigate crops, and reduce the risks of floods and droughts. This infrastructure has brought tremendous benefits, albeit at a substantial economic and environmental cost. To the average citizen, the nation's dams, aqueducts, reservoirs, treatment plants, and pipes are largely invisible and taken for granted. Yet they help insulate us from wet and dry years and moderate other aspects of our naturally variable climate. Indeed they have permitted us to almost forget about our complex dependences on climate. We can no longer ignore these close connections.

The scientific evidence that humans are changing the climate is increasingly compelling. Complex impacts affecting every sector of society, including, especially, the nation's water resources, now seem unavoidable.

This report summarizes the conclusions of the substantial body of literature on the implications of both existing climate variability and future climate change for U.S. water resources. We have identified nearly 1,000 relevant peer-reviewed studies, and that number grows larger every day. As a result, this report must be considered just a snapshot in time, a summary of what we think we know, do not know, and would like to know at the beginning of the 21st century. In the coming years, we hope and expect that our understanding of the impacts of climate changes for U.S. water resources will improve, as will our understanding of the ability of existing and new technologies, policies, economic tools, and institutions to help us mitigate and adapt to those impacts.

Many uncertainties remain; indeed, we expect that uncertainties will always remain. The nature and intensity of future greenhouse gas emissions depend upon future decisions of governments and individuals, the speed of deployment of alternative energy systems, population sizes and affluence, and many more factors. The models that simulate the role of these gases in our atmosphere are imperfect. There are significant limitations in the ability of climate models to incorporate and reproduce important aspects of the hydrologic cycle. Many fundamental hydrologic processes, such as the formation and distribution of clouds and precipitation, occur on a spatial scale smaller than most climate models are able to resolve. Regional data on water availability and use are often poor. Tools for quantifying many impacts are imperfect, at best. We thus know much less about how the water cycle will change than we would like in order to make appropriate decisions about how to plan, manage, and operate water systems.

At the same time, not everything is uncertain. The research done to date tells us many things, both positive and negative, about how hydrology and U.S. water resources could be affected by climate variability and changes. We have learned important things about the vulnerability and sensitivity of water systems and management rules, and we are exploring the strengths and weaknesses of technologies and policies that might help us cope with adverse impacts and take advantage of possible beneficial effects.

In many cases and in many locations, there is compelling scientific evidence that climate changes will pose serious challenges to our water systems. The good news is that where climate changes are minor or where other factors dominate, the impacts on U.S. water resources may be low. In some regions and for some issues, climate changes may even reduce the risks and stresses imposed by growing populations, industrialization, and land-use changes. The bad news is that a growing body of evidence suggests that certain aspects of our water resources are very sensitive to both climate and to how we choose to manage our complex water systems. Making changes in management of these systems requires understanding what changes would be most effective and then applying the will and direction of those responsible. Coping or mitigating other kinds of impacts, even if possible, may prove very costly in dollars, environmental health, and even human lives. We also note that most impacts studies have been done using information from global climate models that evaluate the effects of increases in greenhouse gas concentrations up to particular levels. At this point in time, there is no reason to believe that increasing concentrations will stop at these levels. Greater and greater impacts would be expected to result from ever increasing levels of climate change.

It is vital that uncertainties not be used to delay or avoid taking certain kinds of action now. Prudent planning requires that a strong national climate and water research program be maintained, that decisions about future water planning and management be flexible, and that the risks and benefits of climate change be incorporated into all long-term water planning. Rigid, expensive, and irreversible actions in climate-sensitive areas can increase vulnerability and long-term costs. Water managers and policymakers must start considering climate change as a factor in all decisions about water investments and the operation of existing facilities and systems.

A continued reliance solely on current engineering practice may lead us to make incorrect – and potentially dangerous or expensive – decisions. The United States has hundreds of billions of dollars invested in dams, reservoirs, aqueducts, water-treatment facilities, and other concrete structures. These systems were designed and for the most part are operated assuming that future climatic and hydrologic conditions will look like past conditions. We now know this is no longer true. Accordingly, two of the most important coping strategies must be to try to understand what the consequences of climate change will be for water resources and to begin planning for and adapting to those changes.

Conclusions

More than two decades of research into the implications of climate change for water resources have improved our understanding of possible impacts and points of vulnerability. Many critical issues and some clear and consistent results have been identified. Taken together, the current state-of-the-science suggests a wide range of concerns that should be addressed by national and local water managers and planners, climatologists, hydrologists, policymakers, and the public. Many climate changes are expected. We summarize below some of those with the greatest implications for the hydrologic cycle and U.S. water resources, using a consistent set of terms to denote levels of confidence. Sidebar ES-1 lists the common terms of uncertainty used here.

The Nature of Expected Climate Changes

- Global-average and U.S.-average surface temperatures will continue to increase above recent historical levels unless there are substantial changes in both U.S. and international energy and land-use patterns (very high confidence). As greenhouse-gas emissions continue into the future, the size of these temperature increases will become larger over time.

Sidebar ES-1: Measuring and Reporting Uncertainties

There are many different ways of assessing, defining, and describing uncertainties. Below we list two quantitative approaches and two qualitative approaches that have helped guide this assessment. The terms used in the text were adopted from these scales, but we note that much more work is needed to both reduce the overall uncertainties about the effects of climate change as well as to better describe the uncertainties that will inevitably remain.

Quantitative Scales for Assessing Uncertainties

IPCC Confidence Terms	Probability or Confidence Limit
Very High Confidence	1.00 to 0.95
High Confidence	0.95 to 0.67
Medium Confidence	0.67 to 0.33
Low Confidence	0.33 to 0.05
Very Low Confidence	0.05 to 0.00

Source: Moss and Schneider (1999).

Common Language Terms	Probability or Confidence Limit
Very likely or very probable	>90%
Likely or probable	67 to 90%
Possible	34 to 66%
Unlikely or some chance	10 to 33%
Little chance or very unlikely	< 10%

Source: USGCRP (2000).

Qualitative Scales for Assessing Uncertainties

Qualitative Terms (three levels)	
High Confidence	Wide agreement, multiple findings, high degree of consensus, considerable evidence
Medium Confidence	Consensus, fair amount of information, other hypotheses cannot be ruled out conclusively
Low Confidence	Lack of consensus, serious competing ideas, limited evidence in support

Source: IPCC (1996b).

Qualitative Terms (four levels)	
Well established	Multiple lines of evidence, models consistent with observations
Established but incomplete	Models incorporate most known processes, one or more lines of evidence, observations somewhat consistent but incomplete
Competing explanations	Different models produce different results or incorporate different key processes
Speculative	Conceptually plausible ideas that have received little attention, or that are laced with difficult-to-reduce uncertainties

Source: Moss and Schneider (1999).

- The regional and seasonal pattern of temperature increases across the U.S. will vary (very high confidence). Researchers have low confidence in estimates of detailed regional departures from these larger-scale changes.

- As atmospheric greenhouse-gas concentrations continue to rise, global average precipitation will increase (very high confidence).

- There will be changes in the timing and regional patterns of precipitation (very high confidence). Researchers have low confidence in projections for specific regions because different models produce different detailed regional results.

- Temperature increases in mountainous areas with seasonal snowpack will lead to increases in the ratio of rain to snow and decreases in the length of the snow storage season (very high confidence). It is likely that reductions in snowfall and earlier snowmelt and runoff would increase the probability of flooding early in the year and reduce the runoff of water during late spring and summer. Basins in the western United States are particularly vulnerable to such shifts.

- Average precipitation will increase in higher latitudes, particularly in winter (high confidence). Models are inconsistent in other estimates of how the seasonality of precipitation will change.

- Increases in annual average runoff in the high latitudes caused by higher precipitation are likely to occur (high confidence).

- Research results suggest that flood frequencies in some areas are likely to change. In northern latitudes and snowmelt-driven basins, research results suggest with medium confidence that flood frequencies will increase, although the amount of increase for any given climate scenario is uncertain and impacts will vary among basins.

- Research results suggest that drought frequencies in some areas are likely to change. The net risks to society from such changes have not been evaluated and specific projections of where such changes will occur are speculative. Models project that the frequency and severity of droughts in some areas could increase as a result of regional decreases in total rainfall, more frequent dry spells, and higher evaporation. Models suggest with equal confidence that the frequency and severity of droughts in some regions would decrease as a result of regional increases in total rainfall and less frequent dry spells.

- Higher sea levels associated with thermal expansion of the oceans and increased melting of glaciers will push salt water further inland in rivers, deltas, and coastal aquifers (very high confidence). It is well understood that such advances would adversely affect the quality and quantity of freshwater supplies in many coastal areas.

- Water-quality problems will worsen where rising temperatures are the predominant climate change (high confidence). Where there are changes in flow, complex positive and negative changes in water quality will occur. Specific regional projections are not well-established at this time because of uncertainties in how regional flows will change.

- Increased atmospheric carbon dioxide will affect the use of water by vegetation (high confidence), but hydrologists have low confidence in the net effects of this and other competing influences. Increasing CO_2 concentrations in some circumstances can reduce the rate of transpiration from certain plants. This in turn would tend to increase runoff since less water is returned directly to the atmosphere by such vegetation, allowing a greater share of precipitation to reach streams or aquifers. Rising CO_2 concentrations can also increase plant growth, leading to a larger area of transpiring tissue and a corresponding increase in transpiration.

- The southern boundary of continuous permafrost is projected to shift north by 500 kilometers over the next 50 years due to warming projected by GCMs. A 5° C warming in Alaska would eventually melt virtually all of the subarctic permafrost in Alaska (medium confidence), which would affect more wetland area than currently found in the rest of the United States.

- While we note that some climate scenarios can produce conditions that might reduce stresses on certain ecosystems, experience with ecosystem dynamics strongly suggests that perturbing ecosystems in any direction away from the conditions under which they developed and thrive will have adverse impacts on the health of that system. Aquatic ecosystems can be highly sensitive to hydroclimatic factors, particularly water temperature, water quality, the probability of extreme events, and flow volumes, rates, and timing. Determining the impacts on particular species or ecosystems will require additional region-specific, and ecosystem-specific, research.

- Ecologists have high confidence that climate warming will produce a shift in species distributions northward, with extinctions and extirpations of temperate or cold-water species at lower latitudes, and range expansion of warm-water and cool-water species into higher latitudes.

- A growing number of studies suggest that climate changes will increase the frequency and intensity of the heaviest precipitation events, but there is little agreement on detailed regional changes in storminess that might occur in a warmed world.

- Contradictory results from models support the need for more research, especially to address the mismatch between the resolution of models and the scales at which extreme events can occur. This issue should be regularly revisited in later assessments.

What are the Major Impacts of Climate Variability and Change on U.S. Water Resources?

The current state-of-the-science suggests that plausible climate changes, projected by general circulation models, raise a wide range of concerns that should be addressed by national and local water managers and planners, climatologists, hydrologists, policymakers, and the public.

- Detailed estimates of changes in runoff due to climate change have been produced for the United States using regional hydrologic models of many specific river basins. In spite of many remaining uncertainties, model results suggest that some significant changes in the timing and amount of runoff will result from plausible changes in climatic variables (high confidence).

- With few exceptions, we have low confidence that we can determine specific changes for specific regions. In the arid and semi-arid western United States, it is well established that relatively modest changes in precipitation can have proportionally large impacts on runoff.

- Research indicates that U.S. watersheds with a substantial snowpack in winter will experience major changes in the timing and intensity of runoff as average temperatures rise (very high confidence). Reductions in spring and summer runoff, increases in winter runoff, and earlier peak runoff are all common responses to rising temperatures. The ability of existing systems and operating rules to manage these changes has not been adequately assessed.

- Research to date suggests that there is a risk of increased flooding in parts of the U.S. that experience large increases in precipitation (medium confidence). The Intergovernmental Panel on Climate Change concluded in 1996, and we concur, that: "the flood related consequences of climate change may be as serious and widely distributed as the adverse impacts of droughts" and "there is more evidence now that flooding is likely to become a larger problem in many temperate regions, requiring adaptations not only to droughts and chronic water shortages, but also to floods and associated damages, raising concerns about dam and levee failure."

- Non-linear or threshold events are likely to occur, but are difficult to project. Examples include a fall in lake level that cuts off outflows or separates a lake into two separate parts, an increase in flood intensity that passes specific damage thresholds, and exceedance of water-quality limits.

- Relative sea-level rise adversely affects groundwater aquifers and freshwater coastal ecosystems (high confidence). Rising sea level causes an increase in the intrusion of salt water into coastal aquifers. Shallow island aquifers (such as those found in Hawaii, Nantucket, Martha's Vineyard, and along the southeastern seaboard) together with coastal aquifers supporting large amounts of human use (such as those in Long Island, New York, and central coastal California) are at greatest risk. Other impacts of sea-level rise are likely to include changes in salinity distribution in estuaries, altered coastal circulation patterns, destruction of transportation infrastructure in low-lying areas, and increased pressure on coastal levee systems.

- Climate changes have the potential to alter water quality significantly by changing temperatures, flows, runoff rates and timing, and the ability of watersheds to assimilate wastes and pollutants. Global and regional increases in air temperature, and the associated increases in water temperature, are likely to lead to adverse changes in water quality, even in the absence of changes in precipitation. Changes in precipitation can lead to both positive and negative impacts on water quality. The net effect on water quality for rivers, lakes, and groundwater in the future depends not just on how climate might change but also on a wide range of other human actions.

- Lakes are known to be sensitive to a wide array of changes in climate. Even small changes in climate can produce large changes in lake levels and salinity. As air temperatures increase, fewer lakes and streams in high-latitude areas will freeze to the bottom and the number of ice-free days will increase, leading to increases in nutrient cycling and productivity. Other effects of increased temperature on lakes could include higher thermal stress for cold-water fish, improved habitat for warm-water fish, increased productivity and lower dissolved oxygen, and degraded water quality.

- The direct effects of climate change on freshwater ecosystems will be complex, depending on the nature of the change, the system affected, and the nature and scope of intentional interventions by humans. Work across the United States suggests a wide range of serious concerns for ecosystems, with changes in vegetation patterns, possible extinction of endemic fish species already close to their thermal limits, declining area of wetlands with reductions in waterfowl populations, concerns about stream health, and major habitat loss.

- Researchers express concern for the limited ability of natural ecosystems to adapt or cope with climate changes that occur over a short time frame. This limited ability to adapt to rapid changes may lead to irreversible impacts, such as extinctions. While some research has been done on these issues, far more is needed.

- Little work has been done on the impacts of climate change for specific groundwater basins, or for general groundwater recharge characteristics or water quality. Some studies suggest that some regional groundwater storage volumes are very sensitive to even modest changes in available recharge.

What are the Major Impacts of Climate Variability and Change on Managed U.S. Water Systems?

Climate change will affect the availability of water in the United States, as well as its quality, distribution, and form. Climate change will also affect the complex infrastructure and systems in place to manage the nation's water and existing climate variability. There is a growing literature about how different climate changes may affect the infrastructure and complex systems built to manage U.S. water resources (http://www.pacinst.org/CCBib.html). Research has been conducted on potential impacts over a wide range of water-system characteristics, including reservoir operations, hydroelectric generation, navigation, and other concerns. At the same time, significant knowledge gaps remain and far more research is needed. Priorities and directions for future work should come from water managers and planners as well as from the more traditional academic and scientific research community.

- Large changes in the reliability of water yields from reservoirs could result from small changes in inflows (high confidence).

- In some watersheds, long-term demand growth will have a greater impact on system performance than climate changes. Uncertainties in projecting future water demands complicate evaluating the relative effects of these two forces. Overall regional impacts will further depend upon the economic, institutional, and structural conditions in any region.

- Variability in climate already causes fluctuations in hydroelectric generation. Climate changes that reduce overall water availability will reduce the productivity of U.S. hydroelectric facilities. Reliable increases in average flows would increase hydropower production. Changes in the timing of hydroelectric generation can affect the value of the energy produced. Specific regional impacts are not well-established.

- Dynamic management strategies can be effective in mitigating the adverse impacts of climate change, but such policies need to be implemented before such changes occur to maximize their effectiveness.

- Climate change will play a role in power production from conventional fossil fuel and nuclear power plants by raising cooling water temperatures and reducing plant efficiencies (medium confidence). In some circumstances, higher water temperatures will constrain plant operations.

- Water-borne shipping and navigation are sensitive to changes in flows, water depth, ice formation, and other climatic factors. A warming would increase the potential length of the shipping season on some northern lakes and rivers that typically freeze in winter. Decreases in river flows could reduce the periods when navigation is possible, increase transportation costs, or increase the conflicts over water allocated for other purposes. Changes in storm frequency or intensity would affect Great Lakes navigation. Research done to date suggests that the net effects of climate change may be to increase shipping and navigation costs in the Great Lakes region (medium confidence).

- Research in specific watersheds has shown that some major U.S. river basins are so heavily developed, with such complicated overlapping management layers, that their ability to adapt to changes in climate may be compromised.

All of the physical and ecological impacts of climate change will entail social and economic costs and benefits. On top of the uncertainties in evaluating both climate change and potential impacts, evaluating the economic implications of the diverse impacts is fraught with additional difficulties, and few efforts to quantify them have been made. Ultimately, however, comprehensive efforts to evaluate costs will be necessary in order to assist policymakers and the public in understanding the implications of both taking and not taking actions to reduce or adapt to the impacts of climate change.

The socioeconomic impacts of a greenhouse warming look very different depending on which climate projections are used, and on the methods and assumptions adopted by the researchers. The results published to date are a valuable guide for future assessments but policymakers should have low confidence in specific quantitative estimates. Some results are described below:

- Even given the uncertainties, research indicates that the possible economic impacts of reductions in flow could be very large and that some U.S. water systems are highly sensitive to climate. Under some climate scenarios, the additional costs imposed by climate changes are considerably larger than the additional costs imposed by future population growth, industrial changes, and changing agricultural water demands.

- The contrasting hydrologic implications of the two climate models used for the National Assessment indicate that the direction and size of many socioeconomic impacts are uncertain and likely to vary among regions.

- The upper end of the costs on U.S. water resources imposed by climate changes described in some studies is on the order of 0.5 percent of the nation's total gross domestic product.

- There are many opportunities to adapt to changing hydrologic conditions, and the net costs are sensitive to the institutions that determine how water is managed and allocated among users.

Is Climate Change Already Affecting the Nation's Water Resources?

There is a very high degree of confidence in the scientific community that unchecked increases in atmospheric greenhouse-gas concentrations will eventually lead to changes in the Earth's climate, including the variability of that climate. Despite gaps in data, inadequate and uneven climate and hydrologic monitoring, short collection periods, and biases in instrumental records, there is an increasing amount of evidence that indicates some changes are already occurring.

The evidence that humans are changing the water cycle of the United States is increasingly compelling. Some of the observed changes with the most relevance for U.S. hydrology and water resources are summarized here:

- The United States has, on average, warmed by two-thirds of a degree C since 1900 (very high confidence).

- Permafrost in the Alaskan arctic is beginning to thaw (very high confidence).

- Mean sea level has risen between 10 and 20 centimeters since the 1890s (very high confidence).

- Mountain glaciers are melting at rates unprecedented in recorded history (high confidence).

- Arctic ice thickness has declined significantly from levels recorded in the mid-20th century (high confidence). A comparison of these trends with model estimates reveals that the observed decreases are similar to model projections and that both trends are much larger than would be expected from natural climate variability.

- Vegetation is blooming earlier in spring and summer and continuing to photosynthesize longer in the fall (medium confidence).

- Snow and ice cover are decreasing and melting earlier, on average, while total annual snowfall in the far northern latitudes is increasing (medium confidence). Field surveys show that snow cover over the Northern Hemisphere land surface since 1988 has been consistently below averages over the last quarter century, with an annual mean decrease in snow cover of about 10% over North America. These changes have been linked to the observed increases in temperature.

- There is evidence of historical trends of both increasing and decreasing precipitation in different parts of North America since 1900.

Average precipitation over the contiguous U.S. has increased by about 10% since 1910. The intensity of precipitation has increased for very heavy and extreme precipitation days. There is medium confidence in average U.S. results but low confidence in any particular regional changes.

- The timing of runoff in snowmelt-dominated rivers in the western U.S. appears to be changing (medium confidence), with a decrease in spring runoff and an increase in winter runoff. The causes of these changes are not completely understood.

Effects on Other Sectors

Five separate sectoral reports have been prepared for the National Assessment. In addition to this one on water, work is available on agriculture, human health, coastal ecosystems, and forests (see http://www.nacc.usgcrp.gov). None of the indicated impacts on these sectors is independent of what happens to U.S. water resources and water systems. Yet truly integrated analysis of possible impacts has not yet been done. We urge further work on the combined synergistic effects of climate change on the United States and we offer below a few comments on some critical issues.

Human Health

There are direct and indirect links between water availability and quality and human health. Changes in climate will affect the viability of disease vectors like mosquitoes that carry malaria or dengue fever. The transport of water-borne pathogens such as *Cryptosporidium* is known to be affected by changes in precipitation and runoff intensities and by land-use practices. The distribution of *Vibrio cholerae*, the bacteria responsible for cholera, is affected by climate, including El Niño frequency and intensity, temperature, and ocean salinity.

No clear evidence is available yet to conclude how climate change will ultimately affect these factors or to suggest any climate-related change in the incidences of these kinds of diseases in the United States, but we urge more research and careful monitoring of water-related disease vectors and data.

Agriculture

Recent studies of U.S. agriculture suggest that overall production of food may not be seriously threatened by climate changes as currently projected by GCMs. Indeed, in the climate scenarios evaluated for the National Assessment the net economic effects of changes in agriculture were generally positive, although there were substantial regional differences and some regions suffered production declines. The overall results showed a decline in water demand for irrigation, largely because of the differential effects of climate change on productivity of irrigated versus non-irrigated crops, and the assumed positive effects on plants of higher levels of CO_2. At the same time, there are serious caveats that accompany the research done to date, including some related to water availability and quality. Reliable information on changes in storm frequency and intensity is not yet available. Integration of indirect effects of climate change on hydrology and water into agroclimatic models has not yet been widely done, particularly effects of pests, soil conditions, disease vectors, and socioeconomic factors. Even less work has evaluated the impacts of changes in climate variability for agriculture. Integrating these and other links between water and food should remain a high priority for researchers.

Forests

Research suggests that climate change can lead to dramatic long-term changes in forest health and distribution. These factors depend partly on how precipitation and runoff patterns will change. But changes in forest conditions will, in turn, have locally and regionally important effects on runoff, soil erosion, soil salinization, groundwater quality, and more. These effects have not been adequately assessed.

Coastal Ecosystems

Impacts of climate change on water resources will have a wide range of consequences for coastal ecosystems. Ecosystem health will be affected by changes in the quality and quantity of freshwater runoff into coastal wetlands, higher water temperatures, extreme runoff rates or altered timing, and the ability of watersheds to assimilate wastes and pollutants. The net effect on coastal systems depends not just on how climate might change but also on a wide range of other human actions, including construction and operation of dams that trap sediments and nutrients, water withdrawal rates and volumes, disposal of wastes, and more.

Higher average or a greater range of flows of water could reduce pollutant concentrations or increase erosion of land surfaces and stream channels, leading to more sediment and greater chemical and nutrient loads in rivers and coastal deltas. Lower average flows could reduce dissolved oxygen concentrations, reduce the dilution of pollutants, reduce erosion, and increase zones with high temperatures. For almost every source or water body, land use and agricultural practices have a significant impact on water quality. Changes in these practices, together with technical and regulatory actions to protect water quality, can be critical to future water conditions.

Other Impacts

The impacts of climate change on U.S. water resources have the potential to affect international relations at the nation's northern and southern borders, where shared watersheds can lead to local and international political disputes. International agreements covering these shared waters do not include provisions for explicitly addressing the risks of climate-induced changes in water availability or quality.

A change in flood risks is one of the potential effects of climate change with the greatest implications for human well-being. Few studies have looked explicitly at the implications of climate change for flood frequency, in large part because of the lack of detailed regional precipitation information from climate models and because of the substantial influence of both human settlement patterns and water-management choices on overall flood risk.

Climate change is just one of a number of factors influencing the hydrological system and water resources of the United States. Population growth, changes in land use, restructuring of the industrial sector, and demands for ecosystem protection and restoration are all occurring simultaneously. Current laws and policies affecting water use, management, and development are often contradictory, inefficient, or unresponsive to changing conditions. In the absence of explicit efforts to address these issues, the societal costs of water problems are likely to rise as competition for water grows and supply and demand conditions change.

Recommendations

Coping and Adaptation

There are many opportunities to reduce the risks of climate variability and change for U.S. water resources. The nation's water systems are highly developed and water managers have a long history of adapting to changes in supply and demand. Past efforts have been focused on minimizing the risks of natural variability and maximizing system reliability. Many of the approaches for effectively dealing with climate change are little different than the approaches already available to manage risks associated with existing variability. Tools for reducing these risks have traditionally included supply-side options such as new dams, reservoirs, and pipelines, and more recently, demand-management options, such as improving efficiency, modifying demand, altering water-use processes, and changing land-use patterns in floodplains. This work is going on largely independently of the issue of climate change, but it will have important implications for the ultimate severity of climate impacts.

Sole reliance on traditional management responses is a mistake: first, climate changes are likely to produce

– in some places and at some times – hydrologic conditions and extremes of a *different nature* than current systems were designed to manage; second, climate changes may produce similar kinds of variability but *outside of the range* for which current infrastructure was designed and built; third, relying solely on traditional methods assumes that sufficient time and information will be available before the onset of large or irreversible climate impacts to permit managers to respond appropriately; and fourth, this approach assumes that no special efforts or plans are required to protect against surprises or uncertainties.

The first situation could require that completely new approaches or technologies be developed. The second could require that efforts above and beyond those currently planned or anticipated be taken early. Complacency on the part of water managers, represented by the third and fourth assumptions, may lead to severe impacts that could have be mitigated or prevented by cost-effective actions taken now.

As a result, we make the following observations and recommendations:

- *Prudent planning requires that a strong national climate and water monitoring and research program should be maintained, that decisions about future water planning and management be flexible, and that expensive and irreversible actions be avoided in climate-sensitive areas.*

- *Better methods of planning under climate uncertainty should be developed and applied.*

- *Governments at all levels should re-evaluate legal, technical, and economic approaches for managing water resources in the light of potential climate changes.* The federal government should require all federally owned and operated water systems to begin assessing both climate impacts and the effectiveness of different operation and management options.

- *Improvements in the efficiency of end uses and the intentional management of water demands must now be considered major tools for meeting future water needs, particularly in water-scarce regions where extensive infrastructure already exists.* We note the IPCC conclusion that "water demand management and institutional adaptation are the primary components for increasing system flexibility to meet uncertainties of climate change."

- *Water managers should begin a systematic reexamination of engineering designs, operating rules, contingency plans, and water allocation policies under a wider range of climate conditions and extremes than has been used traditionally.* For example, the standard engineering practice of designing for the worst case in the historical observational record may no longer be adequate.

- *Cooperation between water agencies and leading scientific organizations can facilitate the exchange of information on the state-of-the-art thinking about climate change and impacts on water resources.*

- *The timely flows of information among the scientific global change community, the public, and the water-management community are valuable.* Such lines of communication need to be developed and expanded.

- *Traditional and alternative forms of new supply, already being considered by many water districts, can play a role in addressing changes in both demands and supplies caused by climate changes and variability.* Options to be considered include wastewater reclamation and reuse, water marketing and transfers, and even limited desalination where less costly alternatives are not available and where water prices are high. None of these alternatives, however, is likely to alter the trend toward higher water costs.

- *Prices and markets are increasingly important for balancing supply and demand.* Because new construction and new concrete projects can be expensive, environmentally damaging, and politically controversial, the proper application of economics and water management can provide incentives to use less and produce more. Among the new tools being successfully explored are tiered rates, water banking, and conjunctive use of groundwater.

- *Even without climate change, efforts are needed to update and improve legal tools for managing and allocating water resources.* Water is managed in different ways in different places around the country, leading to complex and often conflicting water laws.

Research Needs

Records of past climate and hydrological conditions are no longer considered to be reliable guides to the future. The design and management of both structural and non-structural water-resource systems should allow for the possible effects of climate change, but little professional guidance is available in this area. Further research by hydrologists, civil engineers, water planners, and water managers is needed to fill this gap, as is broader training of scientists in the universities.

- More work is needed to improve the ability of global climate models to provide information on water-resources availability, to evaluate overall hydrologic impacts, and to identify regional impacts.
- Substantial improvements in methods to downscale climate information are needed to improve our understanding of regional and small-scale processes that affect water resources and water systems.
- Information about how storm frequency and intensity have changed and will change is vitally important for determining impacts on water and water systems, yet such information is not reliably available. More research on how the severity of storms and other extreme hydrologic events might change is necessary.
- Increased and widespread hydrologic monitoring systems are needed. The current trend in the reduction of monitoring networks is disturbing.
- There should be a systematic reexamination of engineering design criteria and operating rules of existing dams and reservoirs under conditions of climate change.
- Information on economic sectors most susceptible to climate change is extremely weak, as is information on the socioeconomic costs of both impacts and responses in the water sector.
- More work is needed to evaluate the relative costs and benefits of non-structural management options, such as demand management and water-use efficiency, or prohibition on new floodplain development, in the context of a changing climate.
- Research is needed on the implications of climate change for international water law, U.S. treaties and agreements with Mexico and Canada, and international trade in water. Can "privatization" affect vulnerability of water systems to climate change?
- Little information is available on how climate changes might affect groundwater aquifers, including quality, recharge rates, and flow dynamics. New studies on these issues are needed.
- The legal allocation of water rights should be reviewed, even in the absence of climate change, to address inequities, environmental justice concerns, and inefficient use of water. The risks of climate change make such a review even more urgent.

Background: Last night and this morning, there were major media (TV and newspaper) stories on the draft findings of the IPCC (Intergovernmental Report on Climate Change). The IPCC, which is the most authoritative source of independent, scientific information on climate change, was established in 1988 in by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) in response to the concerns of many nations, including the U.S., about the possible effects of human activities on the global climate system.
This report is the third major assessment report produced by the IPCC (previous reports were issued in 1990 and 1995). Thousands of the world's leading climate experts participated in the report. IPCC assessment reports are produced through an open and rigorous process that includes extensive scientific and government review (lasting more than two years in the case of the Panel's comprehensive assessments).

The draft report concludes there is stronger evidence for a human influence on climate than there was at the time of their last report in 1995. They also estimate that global temperatures will increase more over the next century-3-11 degrees F (instead of 2-6 degrees F, which was their previous estimate). Such a conclusion from several thousand scientists in 50 countries is indeed a strong statement, although much of the justification for these findings has already appeared in the scientific literature in recent years.

What does the government think about this report? Do you support the findings?

This report is currently in final Government review, and it is not appropriate for us to comment on the draft findings at this time. The report has already undergone two major reviews, so the results are unlikely to change, but the report will not be "officially" final until it is accepted next year in a formal intergovernmental meeting.

The U.S. is very supportive of the IPCC process. We see the IPCC reports, which are drafted and reviewed by thousands of the world's leading climate scientists, as the most authoritative source of independent scientific information on climate change. There has clearly been a good deal of progress in climate change science over the last few years, and we expect that the IPCC Third Assessment report will reflect this progress.

What is the international scientific consensus on climate change and what is the Administration doing in response?

There is a strong scientific consensus that climate change is occurring, that the rate of climate change is accelerating, that that human activities play a role in causing climate change, and that climate change will have serious impacts. That is why the President and Vice President have vastly increased funding for overall efforts to fight climate change. That is why Administration programs emphasize the development of clean energy technologies that can reduce greenhouse gas emissions while keeping our economy strong. That is why the Administration supports an international treaty to find cost-effective ways to fight global warming.

Did the Administration leak this report to build support for its climate change policy proposals?

No. We don't know how the press obtained copies. However, the report has been widely distributed. It was sent to all the lead authors, accredited NGOs (non-governmental organizations), and 110 governments, so it is not surprising that the media has managed to gain access to the results. The U.S. government received its copy only yesterday.

Paul Bledsoe
10/25/2000 05:10:54 PM

Record Type: Record

To: See the distribution list at the bottom of this message

cc:
Subject: Pollution Adds To Global Warming

Wednesday October 25 4:54 PM ET
Pollution Adds To Global Warming

By H. JOSEF HEBERT, Associated Press Writer

WASHINGTON (AP) - New evidence shows man-made pollution has ``contributed substantially'' to global warming and the earth is likely to get a lot hotter than previously predicted, a United Nations (news - web sites)-sponsored panel of hundreds of scientists finds.

The conclusions by the Intergovernmental Panel on Climate Change, the most authoritative scientific voice on the issue, is expected to widely influence climate debate over the next decade.

The report's summary, a copy of which was obtained by The Associated Press, was being distributed to government officials worldwide this week.

It is the first full-scale review and update of the state of climate science since 1995 when the same panel concluded there is ``a discernible human influence'' on the earth's climate because of the so-called ``greenhouse'' effect caused by the buildup of heat-trapping chemicals in the atmosphere.

Today, the panel says in its new assessment that ``there is stronger evidence'' yet on the human influence on climate and that it is likely that manmade greenhouse gases already ``have contributed substantially to the observed warming over the last 50 years.''

And the scientists, in revised estimates, conclude that if greenhouse emissions are not curtailed the earth's average surface temperatures could be expected to increase from 2.7 to nearly 11 degrees Fahrenheit by the end of this century, substantially more than estimated in its report five years ago.

It attributes the increase - from a range 1.8 to 6.3 degrees Fahrenheit warmer in the 1995 assessment - mainly to a reduced influence now expected to be played by sulfate releases from industry and power plants. Such releases, which tend to have a cooling influence, will likely dramatically decline in industrial countries because of other environmental concerns, the scientists maintain.

``What this report is clearly saying is that global warming is a real problem and it is with us and we are gong to have to take this into account in our future planning,'' said Kevin Trenberth, head of climate analysis section at the National Center for Atmospheric Research.

``It definitely reinforces what we were able to say in 1995,'' added Tom Wigley, a climate scientist at the center in Boulder, Colo. ``It shows the previous projects (in 1990 and 1995) were conservative.''

Wigley, who did not participate in crafting the latest findings, was a key author of the 1995 report's section about the human impact on climate.

The IPCC's third assessment report is expected to get final approval at a United Nations conference early next year. While some wording will certainly be changed by government policy-makers, the central scientific conclusions may not be altered, several scientists who have been involved in the process, said Wednesday.

Michael Oppenheimer, an atmospheric physicist at Environmental Defense, said the latest assessment ``reinforces the mainstream scientific consensus" about global warming. Its new estimates of warming poses ``a risk of devastating consequences within this century."

Three years ago industrial nations tentatively agreed to curtail the release of greenhouse gases - mainly carbon dioxide from burning fossil fuels - to below 1990 levels as a first step to address global warming.

But none of the major industrial countries has yet ratified the agreement, crafted in Kyoto, Japan in 1997. Skeptics argue that the science has yet to be conclusive and that computer models used to predict future climate is not reliable enough to warrant a dramatic, and possibly very expensive, shift in energy use to curtail carbon emissions into the atmosphere.

The issue also has crept into the presidential campaign. Vice President Al Gore (news - web sites) has argued the science is clear and steps need to be taken soon to begin reducing greenhouse emissions. His Republican rival, Gov. George W. Bush (news - web sites), has not dismissed global warming, but urges a cautious approach and believes the science still needs to be proven.

The IPCC panel's summary of a voluminous technical report covering 14 chapters attempts to provide the most current state of scientific understanding of the climate system and potential for future warming.

While there are still uncertainties, the IPCC scientists say that there is an ``increasing body of observations" that provide a ``collective picture of a warming world" that cannot be solely explained by natural forces.

``Emissions of greenhouse gases and aerosols due to human activities continue to alter the atmosphere in ways that affect the climate system," the report says.

Various findings of the last five years have reinforced the IPPC's 1995 determination that climate change warrants top-level attention by government policy makers.

Among the findings that suggest climate change already is underway, according to the summary:

- Warming over the last 100 years ``is likely to be the largest of any century during the past 1,000 years" when fully analyzed the 1990s are likely to be the warmest decade with 1998 the warmest year of the 20th century.

-There has seen ``a widespread retreat of mountain glaciers in nonpolar regions" and a decline in sea-ice and snow-covered areas since over the past 50 years.

-Sea level rise has been 10 times greater in the last 100 years than the average rate over the last 3,000 years. The oceans have become warmer over the last 50 years.

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On the Net:

National Center for Atmospheric Research: http://www.ncar.ucar.edu

National Assessment of Climate Change
Press Guidance (October 5)

Background:

The first National Assessment of the potential consequences of climate change for the United States--mandated by Congress and tasked to the National Science and Technology Council (NSTC)---is in the final stages of revision after 3 years of workshops, research, and analyses. On October 3, Senator James Inhofe, Representatives Joseph Knollenburg and Jo Ann Emerson, and a group of conservative interest groups filed a lawsuit against President Clinton and Neal Lane (Assistant to the President for Science and Technology). The suit seeks to prevent publication of the report by charging that the assessment activity has violated various aspects of the FACA and the US Global Change Research Act of 1990 (the authorizing legislation of the U.S. Global Change Research Program). The suit will be announced today at a 1:30 p.m. press conference in the Capitol. The assessment report was developed by the National Assessment Synthesis Team, an independent team of government, academic, and private sector experts chartered under the Federal Advisory Committee Act by NSF.

Talking Points

- The National Assessment report has been prepared by a team of authors that includes industry, government, environmental, and academic scientists charted under the auspices of the Federal Advisory Committee Act. **The entire process has been open to the public.**

- Climate change poses challenges and opportunities for our nation. The national assessment process was undertaken to identify and analyze the potential consequences of climate change for our country.

- The assessment is taking place under the U.S. Global Change Research Program (USGCRP), which is mandated by the Global Change Research Act of 1990 to undertake scientific assessment of the potential consequences of global change.

- The major product of the assessment will be a report titled *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change,* which will draw together regional and sectoral analyses of the potential consequences of change to provide a national picture.

- All materials have been publicly available during the preparation of the report, meetings have been open to the public, and there have been numerous opportunities for participation and comment by interested parties, including the 60-day public comment period requested by the Congress.

- The nation's leading climate scientists and many concerned citizens and stakeholders have taken part in the assessment process. An Independent "Blue Ribbon Panel" that includes several Nobel Laureates has overseen the entire process. They approved the assessment plans and have monitored the scientific integrity of the process, including assuring the responsiveness of the authors to comments received.

- The report has been through multiple levels of review over the last 12 months, including scientific peer-review and technical review by USGCRP agencies. Over **300 sets of comments** totaling about **850 pages** were received in the two rounds of technical review. The National Assessment Synthesis Team made major revisions to the draft in response.

- From June 12 – August 11, the document was posted for a 60-day public comment period, as requested by Congress. The posting was announced in the *Federal Register*, with the document available over the Web. Over 33,000 different users accessed the document during the formal 60-day review period. About 300 sets of comments (about 200 pages) were received.

- Copies of all comments and the author's responses are publicly available from the National Science Foundation.

- The report is undergoing final revisions, after which it will be reviewed one last time by agencies before being submitted to the President and the Congress.

Questions and Answers:

What is your response to the complaint in the lawsuit?

We have reviewed the complaint and fully expect it to be dismissed.

Isn't the Administration trying to gain support for its climate change policy agenda by scaring people with this assessment?

No. Conducting assessments of the potential impacts of global change, including climate change, is mandated in the authorizing legislation of the U.S. Global Change research program. The purpose of this assessment is to begin to identify the potential vulnerabilities of the U.S to climate change, to identify possible options for coping with change, and to determine where further research can help answer important questions.

What is the relationship between this National Assessment and activities related to implementing the Kyoto Protocol?

These are separate activities. The National Assessment is looking at *potential impacts* of climate change on various regions of the US, the possible vulnerability of US agriculture, coastal zones, forests, human health, and water resources, and at strategies to cope with change. The Kyoto Protocol is primarily concerned with *mitigation* of climate change through emissions reductions.

Paul Bledsoe
10/03/2000 10:38:10 AM

Record Type: Record

To: See the distribution list at the bottom of this message

cc:

Subject: New York Times: Debate Rises Over a Quick(er) Climate Fix

Debate Rises Over a Quick(er) Climate Fix

By ANDREW C. REVKIN

sharp new debate has sprung up among atmospheric scientists over where to aim efforts to stave off the prospect of global warming from the buildup of heat-trapping greenhouse gases in the atmosphere. Some say the main target should be carbon dioxide, the most common greenhouse gas, while others say the most practical solution is to focus first on less common, but more powerful, substances possibly influencing climate, like methane, ozone and soot.

The debate comes just as negotiators from more than 150 countries are preparing to head to The Hague next month to put flesh on the bones of the 1997 Kyoto Protocol, a treaty outlining commitments by industrialized countries to reduce their greenhouse emissions and help poor countries avoid new emissions as their economies grow.

The argument for attacking the less common greenhouse ingredients is mainly based on the idea that these substances contribute to harmful air pollution as well as climate change — and so an easier case can be made to policy makers and the public to clean them up.

They are also relatively easy to attack with existing or developing technologies, whereas carbon dioxide can still generally be reduced only by burning less fuel.

Proponents of this strategy, most notably Dr. James E. Hansen, an influential NASA climate expert, say that cutting carbon dioxide, at least in the short term, is a far more daunting task because it is a basic byproduct of burning coal and oil. In other words it is a basic byproduct of almost every aspect of modern life.

But there are problems with focusing on other heat-trapping substances, as well, other scientists say. Soot and the other greenhouse gases, they argue, constitute an extraordinarily complex brew whose influence on climate and interactions with each other and with clouds and other atmospheric ingredients are still poorly understood.

"When you add in their chemical interactions, most scientists' eyes glaze over, it's so complicated," said Dr. Michael Oppenheimer, an atmospheric chemist who is chief scientist of Environmental Defense, a private conservation group.

The debate was spurred last August, when Dr. Hansen and a team of his colleagues at NASA's Goddard Institute for Space Studies, which is based in Manhattan, published "Global Warming in the 21st Century: An Alternative Scenario," in The Proceedings of the National Academy of Sciences.

In the paper, they said that deep cuts in carbon dioxide emissions were probably impossible in the short run, while the other gases and soot were already targets because of their contribution to old-fashioned pollution. In its conclusion, the team used a word rarely found in studies of global warming: "optimistic."

The analysis has since been criticized by some longtime colleagues of Dr. Hansen and embraced by industry groups and elected officials who have long voiced doubt about the science behind climate change and the need for big cuts in fossil fuel use.

Just last Thursday, for example, Dr. Hansen's findings were repeatedly cited by Republican senators holding a hearing questioning the need for the Kyoto Protocol, which has been signed by more than 100 countries but has yet to be ratified by any industrial powers. Many of the treaty's provisions focus on cutting carbon dioxide.

Dr. Hansen's critics, including many influential experts on the atmosphere and climate, say that emissions of all of the gases should be curtailed wherever this is possible and not too expensive but that cutting carbon dioxide must still be a top priority.

For his part, Dr. Hansen said that both sides in the debate had largely either misrepresented or misinterpreted his study. He said the fundamental goal was simply to find the most efficient — and politically and economically palatable — way to cleanse the atmosphere of human effluents that have the biggest impact on climate.

He said he still hoped that once the dust settled, policy makers from all parts of the spectrum might find merit in the proposal.

"I think it may be possible to get conservatives and liberals to agree on common-sense steps that slow down the climate experiment," Dr. Hansen said.

The "climate experiment" to which he referred is a substantial rise in the amount of greenhouse gases released into the air by human activities since the start of the Industrial Revolution. So far, the insulating effect of these gases is the equivalent of turning on two one-watt Christmas tree light bulbs over each square yard of the earth's surface.

That does not seem like much additional energy, Dr. Hansen said, but as a comparison he and others have calculated that the extra wattage accounting for the difference between the last ice age and current equable conditions is 6 to 9 watts per square yard.

If greenhouse gas concentrations continue to rise, the human-caused increase in energy bathing the surface could exceed four watts per square yard, a rise that begins to approach the change from the last ice age until now. That is bound to jog climate, Dr. Hansen said.

Dr. Hansen, besides being a respected climate scientist, is an inveterate pot stirrer who in the sweltering summer of 1988 told a Senate committee "it is time to stop waffling" about climate change, adding that signs had emerged that humans were causing some of the global warming measured in the 20th century.

His new analysis is clearly intended to provoke his peers to re-examine assumptions made over the last 10 years, particularly by the Intergovernmental Panel on Climate Change, a body of hundreds of scientists working together under the auspices of the United Nations to assess global warming and possible responses. Their first update in five years is due in January.

Most atmospheric scientists have long recognized that more than a dozen greenhouse gases and various kinds of particles emitted by combustion and industry affect the flow of energy to and from the earth. (Most particles reflect sunlight like a parasol, cooling the planet; carbon soot tends to absorb energy and heat up.)

But for the last decade, carbon dioxide has been the main target of climate experts and diplomats trying to stabilize climate. Its concentration in the atmosphere has risen by a third from levels seen before the Industrial Revolution; once added to the air, it takes many decades to disappear; and levels could double from pre-industrial amounts by the end of the new century, scientists project. Also important, it is relatively easy to measure the emissions and their sources and "sinks," and processes that remove them from the air are fairly well understood.

But Dr. Hansen noted that carbon dioxide emissions are not continuing their relentless climb at anywhere near the pace set in the last century, as fuels are used more efficiently and dirty ones, like coal, are supplanted by cleaner ones, like natural gas.

Rather than seeking relatively costly additional cuts in carbon dioxide now, he said, the best return on an environmental investment in the short term would be to look at the other greenhouse culprits on his list. Then, later in the new century, when technologies have matured that offer sources of energy without new streams of carbon dioxide, the emphasis can shift back to that gas.

Here is his thinking on the best targets for action now.

First there is black carbon — microscopic soot particles released from inefficient diesel engines, unfiltered power plants or burning forests. These tiny particles, besides harming lungs, absorb heat and also — like other particles in the air — form seeds for cloud droplets. They tend to make clouds darker, Dr. Hansen says, reducing clouds' tendency to reflect sunlight and make the earth's surface cooler.

He said that if continuing efforts to reduce conventional pollution from fossil-fuel burning spread from wealthy countries to developing countries, the amount of this heat- trapping substance in the air would quickly drop.

Methane is on most lists of priorities for reducing the greenhouse effect, and Dr. Hansen said it had, if anything, been underplayed as an important target. Methane comes both from natural sources like bogs and from a host of human sources, including coal mines, leaking pipelines, landfills, belching cattle and rice paddies.

Dr. Hansen's study concluded that efforts to shift to rice-farming methods where fields are drained more frequently could cut releases. Also, his team pointed to Australian research showing that changing feeding patterns or mixing certain anti- gas additives in feed for tropical cattle cut by 40 percent their release of this gas without interfering with growth. With two billion cows, sheep, and goats belching away — half of them in the tropics — there is plenty of potential to cut into the greenhouse effect, he and supporters say.

Finally, the Goddard analysis emphasizes the importance of reducing ozone, an evanescent gas that is not on the list of greenhouse gases considered under the Kyoto Protocol because it is not directly produced by human activities.

Ozone, a poisonous molecule consisting of three oxygen atoms, is continually formed and destroyed when sunlight hits air, particularly when that air is laden with nitrogen oxides, hydrocarbons, or other emissions from burning fuels or forests. This is the lung-searing brew called smog.

Separately, ozone is formed high in the stratosphere, where it shields the planet from harmful radiation. Wherever it exists, it traps heat.

Dr. Hansen said that as with carbon soot, as China, Mexico and other industrializing countries start to enact pollution controls to cut smog, they will also indirectly be lessening their greenhouse impact.

But other scientists say the situation is not that clear-cut. One reason ozone has largely been left out of greenhouse equations so far is that its relationships with other greenhouse gases and other compounds in the air are almost impossibly complex.

For example, extremely reactive hydroxyl radicals, OH, which are created as ozone encounters other compounds, destroy methane molecules. In essence, one greenhouse gas eats the other.

"OH is the detergent of the atmosphere, scrubbing everything," said Dr. Monika Mayer, a research scientist in the climate program at the Massachusetts Institute of Technology. She published a study last month in The Journal of Geophysical Research — Atmospheres in which she and several colleagues concluded that future trends for ozone and methane would largely cancel each other out.

Generally, she said, models show that although ozone should increase in cities, on average around the globe levels should drop, and this will allow methane to persist longer in the air because there will be fewer hydroxyl radicals there to destroy it.

The effects of all of this on climate, she concluded in the paper, are likely to be a wash.

Dr. Ralph J. Cicerone, an atmospheric scientist and chancellor of the University of California at Irvine, said he agreed with Dr. Hansen that the complexity of chemistry in the atmosphere should not deter efforts to cut ozone, methane and other substances that contribute both to pollution and climate problems.

He pointed to recent work showing that although levels of ozone and nitrogen oxides, which help create ozone, have been dropping over the United States and western Europe, they are relentlessly rising elsewhere.

One study, Dr. Cicerone said, showed that nitrogen oxide concentrations in China, South Korea, Taiwan and Japan rose 60 percent from 1987 to 1998. There is plenty of concrete benefit to be gained, with little of the potential pain that might come from putting the same effort into reducing carbon dioxide emissions.

But other scientists fear that any shift away from reducing burning of coal and oil would only impede long- term progress toward limiting the human influence on climate.

"The most important thing is to stabilize all these emissions," said Dr. Thomas P. Ackerman, chief scientist in the Energy Department's atmospheric radiation measurement program in Richland, Wash. "And there's no way you're going to do that without attacking the fossil-fuel problem. We're a society that likes to have simple solutions, but there are no easy answers here."

For his part, Dr. Hansen seems satisfied simply to have nudged the climate debate toward considering partial, common-sense solutions that he feels have been neglected.

He added that one way to spur interest would be to illustrate the other harmful qualities of the greenhouse ingredients on his list up close and personal.

Maybe, he said, it would make sense to "lock people in a room with a good bit of ozone and black carbon in the air until they come up with some positive ideas."

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SCIENCE

- Sound science shows that man made climate change is a real and inevitable threat to our long-term health and economic vitality
- Science tells us the concentration of greenhouse gases (ghgs) is **30 percent higher** than is was as the start of the industrial revolution. The concentration is expected to reach twice the current levels by 2010-a level not seen in 50 million years
- Theory and models suggest increase in ghgs could warm the earth about 2-6.5 degrees Farenheight. The last Ice Age was about 9 degrees F cooler!
- Ice cores and other data show 1990 was the hottest decade on record, and 1997 the hottest year on record until it was beaten by 1998

Talking Points on Hansen's Paper on Climate Change Scenarios

NASA's Jim Hansen (who announced "climate change is here" at a hearing held by Senator Gore during the hot summer of 1988) published a paper in the Proceedings of the National Academy of Sciences that suggests that controlling greenhouse gases other than Carbon Dioxide (CO_2), such as methane and black soot aerosols, may be the best short-term approach to climate change mitigation.

KEY POINTS WE NEED TO MAKE: We agree that greenhouse gases other than CO_2 are very important in combating climate change. Indeed, the Hansen study gives us additional hope that we can combat global warming effectively by fighting the other greenhouse gases along with CO_2. In addition, the Clinton-Gore Administration is responsible for the inclusion of all GHGs in the Kyoto Protocol. However, the study should not be misinterpreted to mean that reducing CO_2 emissions is unimportant. In fact, the Hansen study emphasizes the need to fight CO_2 as well.

- **The Hansen study itself emphasizes that CO_2 is dominant in the long-term.** Hansen's paper says (Page 1, para 4) "This ... does not alter the desirability of limiting CO_2 emissions, because the future balance of forcings (the heat-trapping effect of gases) is likely to shift toward dominance of CO_2 over aerosols."

- **The Administration is responsible for the inclusion of all GHGs in the Kyoto Protocol.** By focusing greater attention on the non-CO_2 GHGs, Hansen's article underlines the importance of the Administration's position of controlling all greenhouse gases. The Vice President fought for this "basket of gases" approach in Kyoto. The Administration's Climate Change Action Plan, Climate Change Technology Initiative, and International Clean Energy Initiative all include actions to control the non-CO_2 greenhouse gases.

- **CO_2 has a much longer lifetime in the atmosphere than aerosols, and contributes much more to total radiative forcing than other GHGs, so it will remain the key GHG to reduce.** Sharply reducing aerosol emissions will quickly eliminate their cooling effect (in months), but CO_2 released to the atmosphere, with an atmospheric lifetime of a century or more, will continue to cause large radiative warming. Hansen acknowledges this problem (p.4, para 2), calling the radiative cooling by aerosols a "Faustian bargain" that "cannot continue indefinitely" ... due to the... "detrimental effects of aerosols, including acid rain and health impacts". Further, CO2 itself contributes about twice as much radiative forcing as the next most important GHG, methane.

- **We need to help develop clean energy infrastructures at home and abroad.** Hansen's argument that one can focus on non-CO_2 GHGs ignores the huge investments in and long lifetimes of fossil-fuel-based energy infrastructure (power plants last 50 years, buildings 50-80 years). If CO_2 is not addressed until 2050, then all of the infrastructure built till that time will continue to produce CO_2 for decades, e.g. out until 2100 and the levels of CO_2 in the atmosphere will cause serious climate change.

- **Hansen Paper Assumes Sharp Cuts in CO2 that may not materialize.** Hansen's assumptions of *baseline* growth in CO_2 concentrations is at the low end of projections and is likely to require substantial cuts in CO_2 emissions to achieve; near-term action would include increasing energy efficiency and decarbonizing fuels (Hansen, p.4), including use of non-CO_2 emitting supplies such as renewable energy. The Administration's Climate Change Technology Initiative, Bioenergy Initiative, and International Clean Energy Initiative include actions to reduce CO_2 in the near-term and develop technologies with long-term payoffs as well.

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KEY POINTS WE NEED TO MAKE: We agree that greenhouse gases other than CO_2 are very important in combating climate change. Indeed, the Hansen study gives us additional hope that we can combat global warming effectively by fighting the other greenhouse gases along with CO_2. In addition, the Clinton-Gore Administration is responsible for the inclusion of all GHGs in the Kyoto Protocol. However, the study should not be misinterpreted to mean that reducing CO_2 emissions is unimportant. In fact, the Hansen study emphasizes the need to fight CO_2 as well.

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Further Background:

Key points in the Hansen article:
Hansen's model indicates that largest radiative forcing (heat-trapping effect) over the last 150 years has come from increases in CO_2 increases. But this warming effect has been largely offset by the cooling effect of **white** aerosols (a form of pollution) released by fossil fuel combustion during this time.

The warming of the last 150 years can thus be seen as the result of CO_2 effects minus **white** aerosol effects plus the effects of other non-CO_2 greenhouse gases (GHGs) and **black** aerosols. The total climate forcing over the last 150 years appears to be approximately equal to the forcing over that time by non-CO_2 greenhouse gases alone. In the next 50 years, it appears that a strategy of holding CO_2 emissions growth rates roughly constant combined with very large reductions in the emissions of other greenhouse gases and **black** aerosols could reduce the human-induced warming expected from **business as usual** by about 66% (i.e., 1 W/m2 instead of the 3 W/m2 expected under BAU). The authors argue that a strategy of focusing on pollution, especially aerosols and tropospheric ozone (produced from oxidation of, among other gases, methane), which have human health and ecological impacts, should appeal to both developed and developing world nations.

Questions and Answers:

Q: Doesn't this paper show that near-term efforts to reduce CO_2 are unnecessary and misguided?

A: No. The fact that other GHG's are important does not mean that we don't need to do anything about CO_2. Achieving the scenario outlined in the Hansen paper requires major reductions in emissions of non-CO_2 GHGs, black aerosols, AND major reductions from BAU growth in CO_2 emissions. Holding CO_2 concentrations to an addition 75 ppm by 2050 as Hansen suggests, would require a major effort in the near-term (this is at the lowest end of the IPCC scenarios for BAU). The Administration is making necessary near-term efforts by promoting investments in energy efficiency and renewable energy R&D. Finally, as we limit aerosol pollution to protect health and ecosystems, the cooling effects of aerosols will also be reduced, making CO_2 control a necessity. Reducing long-term CO_2 emissions requires taking action in the near-term, because of the long atmospheric lifetime of CO_2 and the long-lifetime of CO_2 producing technologies, such as power plants (50 years), buildings (50-80 years). If CO_2 is not addressed until 2050, then all of the infrastructure built till that time will continue to produce CO_2 for periods of 40 years or more, e.g. out until 2100 and the levels of CO_2 in the atmosphere will cause serious climate change.

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A: The cooling effects of the white aerosols is short-lived (months) and the warming effect of CO_2 is long-lived (a century or more). Aerosol pollution has direct negative effects on human health, agriculture, and natural ecosystems (acid rain). As CO_2 continues to accumulate, it takes more and more aerosols to offset CO_2 induced warming, which increases these effects. Increasing or even maintaining air pollution to limit greenhouse warming is not a real solution. Hansen said in his article (page 4), , "The approximate global balancing of aerosol and CO_2 forcings in the past cannot continue indefinitely. As long-lived CO_2 accumulates, continued balancing requires a greater and greater aerosol load. Such a solution, we have argued, would be a Faustian bargain. Detrimental effects of aerosols, including acid rain and health impacts, will eventually limit the permissible atmospheric aerosol amount and thus expose latent greenhouse warming."

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The paper by NASA's Jim Hansen in Proceedings of the National Academy of Sciences, asserting that the fossil-fuel burning sources of CO2 have "offset" their global warming impact by emitting atmospheric aerosols, has ignited debate over whether control of non-CO2 gases provides a better approach to combating climate change than CO2-based strategies. The US has, in fact, advocated for control of all greenhouse gases, both domestically and internationally. The Climate Change Action Plan (CCAP), begun in 1993 and updated in 1995, takes the "basket of gases" approach common to the Kyoto Protocol and includes voluntary measures aimed at reducing both CO_2 and non-CO_2 greenhouse gases, the latter comprising more than 15 percent of the United States 1990 baseline inventory of greenhouse gases (on a global warming potential basis). All told, the CCAP consists of over forty programs that are combining a variety of public- and private-sector approaches aimed at reducing emissions profitably while stimulating greater energy efficiency, commercializing renewable-energy technologies, and improving U.S. industrial, agricultural, and forest productivity. CCAP programs which cover non-CO_2 gases fall into three groups: 1) methane programs, which includes programs for control and recovery of methane from landfills, agricultural practices, and natural gas and coal resource utilization; 2) nitrous oxide programs to improve efficiency of nitrogen fertilizer use (aimed at reducing N_20 emissions from microbial activity in soil); and 3) hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur-hexafluoride (SF_6) programs, which include: partnerships with industries to utilize pollution prevention measures and develop alternatives to these most potent of greenhouse gases.

Greenhouse Gas	CCAP Program	Goal	MMTCE in 2000[a]	MMTCE in 2010[a]
Methane	Natural Gas STAR	reduce pipeline leaks, etc.	14.0[b]	4.2
	Landfill Methane Recovery	capture and use landfill gas emissions		12.0
	Coalbed Methane Outreach	raise awareness of potential to capture coalbed methane profitably		3.2
	RD&D for Coal Mine Methane (sharp funding cuts)	investigate and apply such technologies		[illegible]
	RD&D for Landfill Methane (sharp funding cuts)	investigate and apply such technologies		
	AgSTAR Program	capture methane released from manure mgmt. systems		1.8
	Ruminant Livestock Efficiency Program	reduce methane from dairy and beef industries		2.2
Nitrous Oxide	Improve Efficiency of Fertilizer Nitrogen Use	reduce emissions caused by microbial activity in soil	5.3	5.3
CFCs, HFCs, PFCs, SF_6	Significant New Alternatives Program	restrict use of aerosol propellants with highest global warming potential	14.5[b]	23.1
	Environmental Stewardship Initiative (added 1995)	partner with semiconductor industry to reduce PFCs		10
	HFC-23 Partnerships	capture HFC-23 emitted as byproducts of HCFC-22 production		5.0
	Voluntary Aluminum Industrial Partnerships	reduce PFCs emitted as byproducts of aluminum production		2.4
TOTALS			**33.8**	**69.2**

[a]Source: Climate Action Report: 1997 Submission of the United States of America Under the UNFCCC, unless otherwise noted.
[b]EPA FY2001 Annual Plan

Paul Bledsoe
07/18/2000 12:49:45 PM

Record Type: Record

To: See the distribution list at the bottom of this message

cc:
Subject: Seattle Times: Study finds CO2 may reduce nutritional value of some food

Posted at 12:00 a.m. Pacific; Tuesday, July 18, 2000

Carbon dioxide makes leaves less healthful for bugs

by David Poulson
Newhouse News Service

PELLSTON, Mich. - In a northern Michigan forest clearing, carbon dioxide flows through a tangle of tubes into 42 chambers made of PVC pipe and plastic wrap.

Sensors sniff the chambers every five minutes, sending air samples to separate tanks that are analyzed every half-hour. A computer ensures that the carbon dioxide inside the chambers is twice that found outside.

But the bugs in this sophisticated experiment that mimics global industrial pollution are, well, the bugs.

"We go on grasshopper patrol and if they're around, we remove them from the gene pool," said David Karowe, a researcher at the University of Michigan's Biological Station. "We've hated them the last three years because they get in the chamber and eat our plants."

But they don't get much of a meal.

What Karowe and other researchers are finding is that while plants grow faster in the carbon-dioxide-rich air that cars, power plants and factories may produce in coming decades, the nutritional value of their leaves drops dramatically.

It is an important observation as politicians, scientists, environmentalists and industries wrestle with global climate change from so-called greenhouse gases.

To what degree such industrial emissions cause the Earth to warm and disrupt its weather is under intense debate. But there is little question that concentrations of one of those emissions - carbon dioxide - have increased since the dawn of the industrial revolution in 1750. A monitor in Hawaii has measured a more than 19 percent increase since 1959, and some scientists project a doubling from pre-industrial levels in 75 years.

There is no question that carbon dioxide spurs plant growth.

"In a sense, it's a fertilizer," said Chip Knappenberger, a climatologist with New Hope Environmental Services, which advises industry groups on climate change issues. "These guys who grow stuff for a living in greenhouses like to boost their carbon dioxide."

But Karowe has found that caterpillars eating plants grown in his chambers munch about 50 percent more food and grow 15 percent more slowly than those fed a regular diet.

"It's like we'd have to eat two lunches and another half a dinner, but we wouldn't grow as much," said Karowe, a biology professor at Western Michigan University.

What sounds like a dieter's dream could be a nutritionist's nightmare.

This year Karowe is looking at how grasses that provide basic foods - like wheat, corn, sorghum and oats - could be affected by increased carbon dioxide.

"Agriculture is largely the science of making grasses work for us," he said. "We eat their seeds."

But the direct effect on the food we eat is unclear.

Sylvan Wittwer, retired director of Michigan State University's Agricultural Research Station, credits increasing carbon dioxide with boosting crop and forest production between 10 percent and 12 percent. It also increases nutritional value, he said.

Wittwer, who has written a book on the subject, bristles when the gas is called a pollutant.

"The benefits are unmistakable," he said.

And Karowe said that while leaves may be less nutritious, plants may devote their energy to keeping their seeds - the stuff people eat - healthy for reproduction.

There are also uncertain implications for chain reactions throughout complex ecosystems. Caterpillars chewing food grown in air high in carbon dioxide damage more leaves and excrete more waste. Both prompt chemical signals that parasitic wasps home in on.

That means more dead caterpillars. It also means that new wasps that hatch from eggs laid in the caterpillars do poorly on their nutrient-starved hosts.

And the caterpillars that do survive develop more slowly, perhaps producing butterflies long after plants that need them for pollination have blossomed.

What else might happen is difficult to say as the impact pulses through upper levels of food webs and even into aquatic ecosystems.

Nancy Tuchman, another researcher at the Pellston station and a biology professor at Loyola University in Chicago, grinds up aspen leaves grown in chambers similar to Karowe's.

She feeds them to micro-organisms that typically eat dead leaves in streams. Those in turn are fed to the larvae of mosquitoes and black flies gathered from nearby streams.

Both the micro-organisms and the larvae grow much more slowly than those eating more typical fare, she said.

Some may view mosquitoes that grow 60 percent more slowly as a huge benefit. But how that affects other organisms - say the trout that eat mosquitoes - is difficult to predict.

Tuchman notes that her experiments are but a tiny piece of the vast, unknown consequences of a worldwide increase in carbon dioxide.

"If all the plants are altered on a global level, then it's certainly going to affect all the organisms on Earth," she said. "No one is going to escape."

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TESTIMONY OF

J.D. MAHLMAN, DIRECTOR
GEOPHYSICAL FLUID DYNAMICS LABORATORY
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

BEFORE THE

COMMITTEE ON COMMERCE, SCIENCE,
AND TRANSPORTATION
UNITED STATES SENATE

HEARING ON:

THE SCIENCE BEHIND GLOBAL WARMING

May 17, 2000

UNCERTAINTIES IN CLIMATE CHANGE MODELING

Mr. Chairman:

My name is Jerry Mahlman. I am the Director of the Geophysical Fluid Dynamics Laboratory of NOAA. For over thirty years our Laboratory has been a world leader in modeling the earth's climate. I will evaluate scientific projections of climate change as well as their current uncertainties.

We have long known that buildups of atmospheric carbon dioxide and other gases have the potential to warm earth's climate, through the so-called "greenhouse" effect. Today, I will discuss modeling the climate changes due to these increasing greenhouse gases for a time around the middle of the century.

- Because I speak with credentials as a physical scientist, I do not offer personal opinions on what society should do about these projected climate changes. Societal actions in response to greenhouse warming involve value and policy judgements that are beyond the realm of climate science. Indeed, I would encourage your skepticism whenever you hear a climate scientist's prediction being accompanied by a policy opinion.

At the onset, please recognize that a major international effort to assess climate warming was completed in 1996. This is "The IPCC Assessment". This was the most widely accepted assessment ever on climate change. The 2001 IPCC Assessment will be completed soon. I expect only small changes in its major conclusions, mainly concerning some important increases in scientific confidence.

I strongly recommend your use of the IPCC assessments as a foundation for your own evaluations. I also recommend their use as a point of departure for evaluating the credibility of opinions that disagree with them.

My information is derived from the strengths and weaknesses of climate models, climate theory, and widespread observations of the climate system. Climate models have improved in their ability to simulate the climate and its natural variability. Unfortunately, important uncertainties remain due to deficiencies in our scientific understanding and in computer power. However, significant progress is expected over the next 10 years.

However, let me say at the outset: None of the uncertainties I will discuss can make current concerns about greenhouse warming go away. This problem is very real and will be with us for a very long time.

I will give my evaluation of current model predictions of climate change in the middle of the next century by setting simple "betting odds". By "Virtually Certain", I mean that there is no plausible alternative; in effect, the bet is off the books. "Very Probable" means I estimate about a 9 out of 10 chance that this will happen within the range projected; "Probable" implies about a 2 out of 3 chance. "Uncertain" means a plausible effect, but which lacks appropriate evidence. Essentially, I set the odds; you choose your bet. My analysis is presented in decreasing levels of confidence.

* **Human-Caused Increasing Greenhouse Gases (virtually certain)**

  There is no remaining doubt that increasing greenhouse gases are due to human activities.

* **Radiative Effect of Increased Greenhouse Gases (virtually certain)**

  Greenhouse gases absorb and reradiate infrared radiation. Independent of other factors, this property acts to produce an increased heating effect on the planet.

* **A Doubling of Carbon Dioxide Expected (virtually certain)**

  Almost independent of policy actions, atmospheric carbon dioxide amounts are expected to double over pre-industrial levels in this century.

* <u>Long Time to Draw Down Excess Carbon Dioxide</u> **(virtually certain)**

We know that it takes decades to centuries to produce a large buildup of greenhouse gases. Much less appreciated is that a "return to normal" from high carbon dioxide levels would require many additional centuries.

* <u>Global Surface Warming over the Past Century</u> **(virtually certain)**

The measured 20th century warming in the surface temperature records of over one degree fahrenheit is undoubtedly real. Its cause is very probably due mostly to added greenhouse gases. No other hypothesis is nearly as credible.

* <u>Future Global-Mean Surface Warming</u> **(very probable)**

For the middle of the next century, global-mean surface warming is estimated to be in the range of 2 to 6° fahrenheit, with continued increases for the rest of the century. The largest uncertainty is due to the effects of clouds.

* <u>Increased Summertime Heat Index</u> **(very probable)**

In warm, moist subtropical climates the heat index effect is expected to magnify the warming effect by about 50%.

* <u>Rise in Global Mean Sea Level</u> **(very probable)**

A further rise of 4-12 inches in mean sea level by the year 2050 is estimated due to thermal expansion of warmer sea water. Continued sea level rise is expected for many centuries, probably to much higher values.

* <u>Summer Mid-Continental Dryness and Warming</u> **(probable)**
  Model studies predict a marked decrease of soil moisture and elevated temperatures over summer mid-latitude continents. This result is sensitive to model assumptions.

* <u>Increased Tropical Storm Intensities</u> **(probable)**
  A warmer, wetter atmosphere will likely lead to increased intensities of tropical storms, such as hurricanes. We still know little about changes in the number of hurricanes.

* <u>Increased Numbers of Weather Disturbances</u> **(uncertain)**
  Although many speak of more large-scale storms, there is still no solid evidence for this.

* <u>Global and Regional Details of the Next 25 Years</u> **(uncertain)**
  The predicted warming up to now is not yet large compared to natural climate fluctuations. On these shorter time scales, the natural fluctuations can artificially reduce or enhance apparent measured greenhouse warming signals, especially so on regional scales.

Even though these uncertainties are daunting, important advances have already been achieved in observing, understanding, and modeling the climate. Today's models can simulate many aspects of climate and its changes. Although major progress has been made, much more needs to be learned. More efforts are needed world-wide to provide a long-term climate measuring system. Focussed research into climate processes must be continued. Theories must be formulated and re-evaluated in the light of newer data. Climate modeling efforts must receive resources that are in balance with the broader scientific programs.

The U.S. Global Change Research Program has already made important progress on these fronts. However, patient sustained efforts will be required in the years ahead.

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Through long-term research and measurements, uncertainties will decrease and confidence for predicting climate changes will increase.

In summary, the greenhouse warming effect is quite real. The state of the science is strong, but important uncertainties remain. Finally, it is a "virtually certain" bet that this problem will refuse to go away, no matter what is said or done about it over the next five years.

Thank you, Mr. Chairman. That concludes my testimony.

Response to "Virtual Climate Alert" commentary on Ballentine letter

Ballentine: *"... global warming is ... occurring more rapidly than previously thought."*
"Virtual Climate" Response: *"There is not one paper in the refereed scientific literature within the past six months that says warming is occurring at a faster rate than predicted."*

The recent NRC report ("Reconciling observations of global temperature change", released Jan. 13, 2000), which was extensively peer-reviewed, clearly states that the rate of global warming in the last 20 years is substantially greater than the average rate during the 20th century. This was recently bolstered by a paper "The record breaking global temperatures of 1997 and 1998: Evidence for an increase in the rate of global warming?" in the March 1, 2000 issue of *Geophysical Research Letters*. Karl and his colleagues describe the increased rate of warming in the last twenty years. They also showed that the very hot years of 1997 and 1998 may mark a change point at which the Earth's surface began to heat up faster than it had in during the previous two decades, although they note that the evidence for this further upturn is not yet definitive.

Response: *"Rather, the balance of scientific evidence ... is to the contrary..."*

The UN report quoted was done in lateE 1994. While discrepancies still exist between the observed rate of change and that projected by climate models, much progress has been made in the last few years in modeling the climate. Furthermore, the Ballentine statement was describing the last twenty years of the long-term surface record. He was not comparing observations to model projections.

Ballentine: *"Reports ... found that since 1976 the planet has been warming at a rate of 0.35 deg. F per decade."*

Response: *"Integrated over the troposphere ... the planetary warming since 1976 has been a mere 0.07 deg F ..."*

Both numbers are right because they're referring to different quantities. It is the temperature increase at the surface of the Earth (where people and plants live), however, that is of far more concern to us than the warming integrated over the bottom 6-7 km of the atmosphere. That is the rate of increase Ballentine cited.

Response: *"According to NASA scientist John Christy, writing in Nature magazine, the originally forecast tropospheric warming rate [in models] was around 0.7 deg F per decade. That's ten times what has been observed. ... And a new report by the ... [NRC] recently (finally) admitted that the error casts serious doubt on the validity of current computer forecasts of global warming. Ballentine cites the NRC report, but omits reporting that fact."*

The Christy work is out of date. The most recent model work (Santer et al. in the Feb. 18, 2000 issue of *Science*) shows that current state-of-the-art models are producing simulations that are quite close to the observed trends at the surface and in the atmosphere. However, some differences still remain. With such a short time series (2 decades), however, it is impossible to uniquely attribute the remaining differences to significant errors in the models. Finally, while the NRC report does discuss uncertainties in the models, it never says that their results cast overall doubt on the validity of current computer forecasts. This is a misrepresentation of the NRC report.

Response: "*It is seriously misleading to report the temperature of "the planet" while disregarding the spatial distribution of observed warming. ... by far, the largest proportion of surface temperature warming is taking place in the coldest winter air masses of Siberia and northwestern North America. Northern Hemisphere cold-season warming outside these regions average one-tenth of what is being observed within them.*"

During the 20th century, the world as a whole has warmed, as has virtually the entire U.S. While it is true that the heating has not been uniform, it is incorrect and a twisting of the facts to imply that the increase in temperatures is concentrated in a few areas and that it is unimportant elsewhere. —

Response: "*Vital Statistics of the United States shows that winter weather mortality exceeds that of summer weather mortality by a factor of four. Therefore, warming the coldest air of winter, when accompanied by little summer warming (as has been observed) reduces overall weather-related deaths. Warming the coldest air of winter should also lengthen the high-latitude growing season.*"

First, it is important to realize that even though the warming has been and will continue to be less severe in summertime, it is the summertime heat index, which combines the effects of heat and humidity into an effective temperature, that is important. That quantity has risen significantly and is projected to rise anywhere from 5 to 15oF over the next century.

More generally, there clearly are some positive effects of global warming. Less winter weather mortality is plausibly one such effect. However, there are also negative effects (which the IPCC reports clearly delineate--diseases shifts, exacerbation of air pollution, etc). Considering just the positive effects does not give an accurate or complete picture of the impact of climate change.

Response: "*In almost every year that surface temperatures have warmed, global food production has risen. These increased crop yields result from improved technology, benign weather, and the same carbon dioxide that makes the coldest air of winter less deadly. ... as surface temperatures have warmed, the world has witnessed the greatest democratization of wealth and expansion of longevity in human history ...*"

Note that the authors of Virtual Climate Alert are now arguing that warming is causing substantial benefits, which contradicts their earlier assertion that no significant warming has occurred. Yes, the state of the world has improved greatly over the last century, and the temperature of the Earth has increased. But to argue that these are related and will continue to both be true as the planet warms at rates faster than in the last 10,000 years seems without basis.

Draft Memorandum for the President

From: Neal Lane

Re: New climate science reports

In the past week, four new scientific articles that deal with important aspects of global warming have been released. Unfortunately, the press coverage (*Washington Post*, *Philadelphia Inquirer*, *AP*, etc.) of these articles did not clearly articulated how these articles bolster the evidence for climate change, but instead presented a confusing and mixed message to the public.

The first article ("Temperature trends over the past five centuries reconstructed from borehole temperatures" by *Huang* et al. in last week's *Nature*) described measurements of temperature at various depths below the Earth's surface and inferred from this that the surface temperatures of the late 20th century are without precedent in the last 500 years. Further, the warming in the period before 1800 was minor compared to the warming afterwards. This analysis is an important verification that the Earth is indeed warming, and that this warming has accelerated in the past several decades. Unfortunately, the press coverage in the *Washington Post* focused on minor differences between this temperature record and those obtained using other methods. Some quantitative differences between these records do indeed exist, but these differences in no way invalidate or cast doubt on the reality of the warming of the Earth's surface.

The next two articles ("Interpreting differential temperature trends at the surface and in the lower troposphere" by *Santer* et al. and "Multidecadal changes in the vertical temperature structure of the tropical troposphere" by *Gaffen* et al., both in last week's *Science*) addressed differences between the trend of the temperature of the lower atmosphere measured remotely by satellites and the trend of the surface temperature measured directly by thermometers at the surface over the last 20 years. Climate skeptics have used these differences to cast doubt on the surface trends that show warming and on the veracity of computer models that are used to predict the climate. The *Santer* et al. article showed that state-of-the-art models come close to reproducing the difference in the trends, although some difference still remains. This analysis strongly supports and extends the conclusion of the National Research Council's (NRC) recent report on these temperature trends. The NRC report made a strong statement that the Earth's surface is indeed warming, that the difference in the trends was not evidence to the contrary, and that at least part of the difference in the trends was real. The *Gaffen* et al. performs additional analyses on temperatures from weather balloons to further bolster the NRC's conclusions that the surface and atmospheric temperature trends are different but not incompatible.

A fourth article ("The record breaking global temperatures of 1997 and 1998: Evidence for an increase in the rate of global warming?" by *Karl* et al., appearing March 1 in *Geophysical Research Letters*) is a statistical analysis that indicates that the spectacularly hot years of 1997 and 1998 may mark a change point at which the Earth's surface began to heat up faster than it had in previous decades. While there is still uncertainty as to whether there was an acceleration of the warming rate in the last several years over that seen in the last several decades, this article presents strong evidence that the Earth's surface is warming at a significant rate. The press coverage did not emphasize this latter point, but instead talked about the uncertainty of whether the *rate of increase* had actually accelerated.

Finally, an article in the Philadelphia Inquirer based on a press conference at the recent American Association for the Advancement of Science meeting discussed the upcoming National Assessment of Climate Change. Many points in the article were correct, but there was also an alarmist message that there is nothing we can do to stop climate change. While it is true that climate change cannot be *stopped*, the article should have stressed that there are many things that can be done to ameliorate the effects, slow the rate of change, and lessen the absolute magnitude of the effects. Additionally, the article misquoted Michael MacCracken as saying that the US "must reduce its use of fossil fuels."

Rosina M. Bierbaum 02/24/2000 09:02:38 PM

Record Type: Record

To: Roger S. Ballentine/WHO/EOP@EOP

cc: Andrew E. Dessler/OSTP/EOP@EOP

Subject: ballentine reply

Here's a first draft at a response to your "quotes" and the allegations of incorrectness! See what you think. Andy is our new addition--a first rate atmospheric scientist.

---------------------- Forwarded by Rosina M. Bierbaum/OSTP/EOP on 02/24/2000 09:02 PM ---------------------------

Record Type: Record

To: Rosina M. Bierbaum/OSTP/EOP@EOP

cc:

Subject: ballentine reply

Response to "Virtual Climate Alert" commentary on Ballentine letter

Ballentine: *"... global warming is ... occurring more rapidly than previously thought."*
"Virtual Climate" Response: *"There is not one paper in the refereed scientific literature within the past six months that says warming is occurring at a faster rate than predicted."*

The recent NRC report, which was extensively peer-reviewed, clearly states that the rate of global warming in the last 20 years is substantially greater than the average rate during the 20th century.

Ballentine: *"Reports ... found that since 1976 the planet has been warming at a rate of 0.35 deg. F per decade."*
Response: *"Integrated over the troposphere ... the planetary warming since 1976 has been a mere 0.07 deg F ..."*

Both numbers are right because they're referring to different quantities. It is the temperature increase at the surface of the Earth (where people and plants live), however, that is of far more concern to us than the warming integrated over the bottom 6-7 km of the atmosphere. Therefore, Ballentine's figure is more relevant for this debate.

Response: *"According to NASA scientist John Christy, writing in Nature magazine, the originally forecast tropospheric warming rate[in models] was around 0.7 deg F per decade. That's ten times what has been observed. ... And a new report by the ... [NRC] recently (finally) admitted that the error casts serious doubt on the validity of current computer forecasts of global warming. Ballentine cites the NRC report, but omits reporting that fact."*

The Christy work is out of date. The most recent model work (Santer et al. in the Feb. 18, 2000 issue of *Science*) shows that current state-of-the-art models are producing simulations that are quite close to the observed trends at the surface and in the atmosphere. However, some differences still remain. With such a short time series (2 decades), however, it is impossible to uniquely attribute the remaining differences to significant errors in the models. Finally, while the NRC report does discuss uncertainties in the models, it never says that their results cast overall doubt on the validity of current computer forecasts. This is a gross misrepresentation of their work.

Response: "*It is seriously misleading to report the temperature of "the planet" while disregarding the spatial distribution of observed warming. ... by far, the largest proportion of surface temperature warming is taking place in the coldest winter air masses of Siberia and northwestern North America. Northern Hemisphere cold-season warming outside these regions average one-tenth of what is being observed within them.*"

During the 20th century, virtually the entire US has warmed. While it is true that the heating has not been uniform, it is incorrect and a twisting of the facts to imply that the increase in temperatures is concentrated in a few areas and that it is unimportant elsewhere.

Response: "*Vital Statistics of the United States shows that winter weather mortality exceeds that of summer weather mortality by a factor of four. Therefore, warming the coldest air of winter, when accompanied by little summer warming (as has been observed) reduces overall weather-related deaths. Warming the coldest air of winter should also lengthen the high-latitude growing season.*"

First, it is important to realize that even though the warming has been and will continue to be less severe in summertime, it is the summertime heat index, which combines the effects of heat and humidity into an effective temperature, that is important. That quantity has risen significantly and is projected to rise anywhere from 5 to 15oF over the next century.

More generally, there clearly are positive effects of global warming. Less winter weather mortality is undeniably a positive effect. However, there are also negative effects (which the IPCC clearly delineate--diseases shifts, exacerbation of air pollution, etc). Considering just the positive effects does not give an accurate or complete picture of the impact of climate change.

Response: "*In almost every year that surface temperatures have warmed, global food production has risen. These increased crop yields result from improved technology, benign weather, and the same carbon dioxide that makes the coldest air of winter less deadly. ... as surface temperatures have warmed, the world has witnessed the greatest democratization of wealth and expansion of longevity in human history ...*"

The logical flaws in this argument are too numerous to mention. The two most significant are: 1) that the warming of the Earth over the past century (which at the beginning of their memo the authors argue didn't happen) has been responsible for the vast improvement in life on

Earth over the last century, and 2) that further warming will lead to further improvements!

It is important to remember that just because two things are correlated does not mean there is a causal relation. The state of the world has improved greatly over the last century, and the temperature of the Earth has increased. But to argue (without evidence) that these are related is ridiculous. Most of the improvements in world are the result of technological innovation, not the warming of the planet. This argument is a red herring.

VIRTUAL CLIMATE ALERT

February 22, 2000 Vol. 1, No. 11

Since its inception on January 4th, Virtual Climate Alert has been tracking and responding in real time to public distortions of the global climate change issue. A letter from President Clinton's Deputy Assistant for Environmental Initiatives, Roger S. Ballentine, clearly falls into this category. Ballentine sent his letter to the Congressional Leadership, selected utility executives, and who knows whom else with the salutation "Dear Interested Party."

Ballentine's letter and its attached "Climate Update" are misleading or inaccurate at several junctures. We detail them, below.

Ballentine "You may have noticed the steady stream of new scientific studies suggesting that global warming is ... occurring more rapidly than previously thought."

Fact There is not one paper in the refereed scientific literature within the past six months that says warming is occurring at a faster rate than predicted – and we challenge Ballentine to produce such a refereed paper.

Rather, the balance of scientific evidence (according to the United Nations Intergovernmental Panel on Climate Change) is to the contrary. In its last comprehensive report, the United Nations stated, "When increases in greenhouse gases only are taken into account, most [climate prediction models] produce a greater mean warming than has been observed." In other words, the computer models that served as the basis for the initial concern predicted too much warming.

Ballentine "Reports by...the National Climatic Data Center ... found that since 1976 the planet has been warming at a rate of 0.35 degrees Fahrenheit per decade." (Note: He re-emphasizes this claim in the appended "Climate Update.")

Fact Integrated over the troposphere – the earth's active weather zone – the planetary warming since 1976 has been a mere 0.07°F (seven hundredths of a degree) per decade, or far beneath the natural variation or "noise" in this overall region. According to NASA scientist John Christy, writing in Nature magazine, the originally forecast tropospheric warming rate was around 0.7°F (seven tenths or more than half a degree) per decade. That's ten times what has been observed.

Because, in the IPCC's words, those models "produce[d] a greater mean warming than has been observed," the integrated tropospheric warming forecast by 1997 was lowered to 0.4°F (four tenths or less than half a degree) per decade – still an egregious error. And a new report by the National Research Council recently (finally) admitted that the error casts serious doubt on the validity of current computer forecasts of global warming. Ballentine cites the NRC report but omits reporting that fact.

More Facts It is seriously misleading to report the temperature of "the planet" while disregarding the spatial distribution of observed warming. Had Ballentine consulted the latest issue of the refereed journal Climate Research, he would have noted that, by far, the largest proportion of surface temperature warming is taking place in the coldest winter air masses of Siberia and northwestern North America. Northern Hemisphere cold-season warming outside these regions averages one-tenth of what is being observed within them.

Vital Statistics of the United States shows that winter weather mortality exceeds that of summer weather mortality by a factor of four. Therefore, warming the coldest air of winter, when accompanied by little summer warming (as has been observed) reduces overall weather-related deaths. Warming the coldest air of winter should also lengthen the high-latitude growing season. Satellite data document this change, as was published in Nature magazine, three years ago.

Still More Facts In almost every year that surface temperatures have warmed, global food production has risen. These increased crop yields result from improved technology, benign weather, and the same carbon dioxide that makes the coldest air of winter less deadly. Ballentine fails to mention this.

And, finally, as surface temperatures have warmed, the world has witnessed the greatest democratization of wealth and expansion of longevity in human history – something the White House and Ballentine should have noticed.

Ballentine "As the new year and the new millennium arrived, so did increasing recognition that global climate change will be among the most important environmental issues of the new century."

Fact Just four days before Ballentine's letter, President Clinton in his State of the Union Address called global warming "the greatest environmental challenge of the new century." Might it be that in the intervening days folks in the White House realized most Americans are doing quite well despite the Administration's constant drumbeat of global warming gloom and doom and decided to move the issue down a few notches in the hierarchy of grave threats to life as we know it?

Greening Earth Society Virtual Climate Alerts are published periodically in response to news coverage of climate-change advocacy that seeks to portray weather events and hypothetical climate scenarios generated by computer-based climate models as "climate reality." Virtual Climate Alert draws upon the expertise of Greening Earth Society science advisors and is coordinated by New Hope Environmental Services of Charlottesville, Virginia.

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Hotspot References

HEAT WAVES AND PERIODS OF UNUSUALLY WARM WEATHER

1. **Lhasa, Tibet** – GISS. 1998. Goddard Institute of Space Studies. http://www.giss.nasa.gov/data/update/csci
   NCDC. 1998. National Climatic Data Center. http://www.ncdc.noaa.gov/ol/climate/climatedata.html
2. **Christchurch, New Zealand** – GISS. 1998. Goddard Institute of Space Studies. http://www.giss.nasa.gov/data/update/csci
   NCDC. 1998. National Climatic Data Center. http://www.ncdc.noaa.gov/ol/climate/climatedata.html
3. **Cairo, Egypt** – GISS. 1998. Goddard Institute of Space Studies. http://www.giss.nasa.gov/data/update/csci
   NCDC. 1998. National Climatic Data Center. http://www.ncdc.noaa.gov/ol/climate/climatedata.html
4. **Edmonton, Canada** – GISS. 1998. Goddard Institute of Space Studies. http://www.giss.nasa.gov/data/update/csci
   NCDC. 1998. National Climatic Data Center. http://www.ncdc.noaa.gov/ol/climate/climatedata.html
5. **Southern Africa** – Arntzen, J., T. Downing, R. Leemans, J. Malcolm, N. Reynard, S. Ringrose, and D. Rogers. 1996. Climate Change and Southern Africa: An exploration of some potential impacts in the SADC region. 104 pp. World Wildlife Fund, Climatic Research Unit.
6. **Central England** – Hulme, M. 1999. Climatic Research Unit at the University of East Anglia, personal communication.
7. **Glasgow, Montana, USA** – Weathervane Magazine, May/June 1998.
8. **Little Rock, Arkansas, USA** – NCDC, 1998. Climate of 1998-June Extremes. National Climatic Data Center. http://www.ncdc.noaa.gov/ol/climate/research/1998/jun/jun98.html
9. **Texas, USA** – NCDC, 1998. 1998 Summer Heat and Precipitation Extremes. National Climatic Data Center. http://www.ncdc.noaa.gov/ol/reports/texas98/texasrecords.html
10. **Florida, USA** – NCDC. 1998. Florida Wildfires and Climate Extremes. National Climatic Data Center. http://www.ncdc.noaa.gov/ol/climate/research/1998/fla/florida.html
11. **USA** – NCDC, 1998. Top weather and climate stories of 1998. 6 January 1999 Climate Prediction Center. http://www.ncdc.noaa.gov/ol/climate/research/1998/ann/top-99.html
12. **Eastern USA** – NCDC, 1999. Climate-Watch, July 1999. National Climatic Data Center. http://www.ncdc.noaa.gov/ol/climate/extremes/1999/july/extremes0799.html
13. **New York City, USA** – Zielbauer, P., 1999. Sweaty July in New York City goes down as worst ever. August 1, 1999, *New York Times*, New York City;
    NCDC, 1999. Selected U.S. city and state extremes-July 1999. http://www.ncdc.noaa.gov/ol/climate/extremes/1999/july/julyext1999.html#TEMPERATURE

SPREADING DISEASE

14. **Kenya** – Epstein, P. 1997. Climate, ecology and human health. *Consequences* 3: 3-19.
15. **Colombian Andes** – Epstein, P., H. Diaz, S. Elias, G. Grabherr, N. Graham, W. Martens, E. M. Thompson, and J. Susskind. 1998. Biological and physical signs of climate change: focus on mosquito borne diseases. *Bulletin of the American Meteorological Society* 79: 409-417.
16. **Mexico** – Epstein, P., H. Diaz, S. Elias, G. Grabherr, N. Graham, W. Martens, E. M. Thompson, and J. Susskind. 1998. Biological and physical signs of climate change: focus on mosquito borne diseases. *Bulletin of the American Meteorological Society* 79: 409-417.
17. **Tanzania** – Epstein, P., H. Diaz, S. Elias, G. Grabherr, N. Graham, W. Martens, E. M. Thompson, and J. Susskind. 1998. Biological and physical signs of climate change: focus on mosquito borne diseases. *Bulletin of the American Meteorological Society* 79: 409-417.
18. **Indonesia** – Epstein, P., H. Diaz, S. Elias, G. Grabherr, N. Graham, W. Martens, E. M. Thompson, and J. Susskind. 1998. Biological and physical signs of climate change: focus on mosquito borne diseases. *Bulletin of the American Meteorological Society* 79: 409-417.
19. **Central America** – Epstein, P. 1999. Global Warming: Health and Disease. World Wildlife Fund.

EARLIER SPRING ARRIVAL

20. **U.K.** – Beebee, T. 1995. Amphibian breeding and climate. *Nature* 374: 219-220.
21. **U.K.** – Crick, H., C. Dudley, D. Glue, and D. Thomson. 1997. UK birds are laying eggs earlier. *Nature* 388: 526.
22. **Southern England** – Hulme, M. 1999. Climatic Research Unit at the University of East Anglia, personal communication.
23. **Lake Mendota, Wisconsin, USA** – Magnuson, J., R. Wynne, B. Benson, and D. Robertson. 1999. Lake and river ice as a powerful indicator of past and present climates. *in press*. Center for Limnology, University of Wisconsin-Madison.
24. **Mirror Lake, New Hampshire, USA** – Likens, G. 1998. President/ Director, Institute for Ecosystem Studies, personal communication.
25. **Nenana, Alaska, USA** – NSIDC. 1998. The Nenana Ice Classic: Tanana River Ice Annual Breakup Dates. National Snow and Ice Data Center. Digital data available from nsidc@kryos.colorado.edu. Boulder, Colorado. NSIDC Distributed Active Archive Center, University of Colorado at Boulder. http://www-nsidc.colorado.edu/NASA/GUIDE/docs/dataset_documents/nenana_river_ice_breakup_dataset_document.html
26. **Washington, DC, USA** – Robert DeFeo, US Park Service, personal communication. Bloomfield, J. and Showell, S., 1997. *Global Warming: Our Nation's Capital at Risk.* Environmental Defense Fund, New York, NY.

PLANT AND ANIMAL RANGE SHIFTS AND POPULATION DECLINES

27. **Austria** – Grabherr, G., M. Gottfried, and H. Pauli. 1994. Climate effects on mountain plants. *Nature* 369: 448.
28. **California, USA** – Parmesan, C. 1996. Climate and species' range. *Nature* 382: 765-766.
29. **Europe** – Parmesan, C., et al. 1999. Poleward shifts in geographical ranges of butterfly species associated with regional warming. *Nature* 399: 579-583.
30. **Germany** – Irmler, U., and V. Wiese. 1997. Ecological impacts of climate change on national parks and protected areas of the world. World Wildlife Fund.

31. **Olympic Mountains, Washington, USA** – Peterson, D., R. Rochefort, R. Little, and A. Woodward. 1994. Changes in sub-alpine tree distribution in western North America: a review of climatic and other causal factors. *The Holocene* 4: 89-100.
32. **Antarctic** – Fraser, W. 1998. Antarctic Biology and Medicine Program, University of Montana, personal communication.
33. **Alaska, USA** – Markham, A. 1998. Director of Climate Change Campaign, World Wildlife Fund, personal communication.
34. **Canadian Arctic** – Gunn, A. 1998. National Recovery Team for Peary and Arctic-Island Caribou, personal communication.
35. **Monterey Bay, California, USA** – Barry, J., C. Baxter, R. Sagarin, and S. Gilman. 1995. Climate related, long-term faunal changes in a Californian rocky intertidal community. *Science* 267: 672-675.
36. **Monteverde Cloud Forest, Costa Rica** – Pounds, J.A., Fogden, M.P.L., and Campbell, J.H., 1999. Biological response to climate change on a tropical mountain. *Nature* 398: 611-615.
37. **U.K.** – Thomas, C.D. and Lennon, J.J., 1999. Birds extend their ranges northwards. *Nature* 399: 213.
38. **West Coast, USA** – Viet, R. A., J. A. McGowan, D. G. Ainley, T. R. Wahl, and P. Pyle. 1997. Apex marine predator declines ninety percent in association with changing oceanic climate. *Global Change Biology* 3: 23-28.

SEA LEVEL RISE AND COASTAL FLOODING

39. **Chesapeake Bay, USA** – Irmler, U., and V. Wiese. 1997. Ecological impacts of climate change on national parks and protected areas of the world. World Wildlife Fund. Stevenson, C. 1998. Horn Point Laboratory, University of Maryland Center for Environmental Sciences, personal communication.
40. **Bermuda** – Ellison, J. 1993. Mangrove retreat with rising sea-level, Bermuda. *Estuarine, Coastal, and Shelf Science* 37: 75-87.
41. **Senegal** – Dennis, K., I. Niang-Diop, and R. Nicholls. 1995. Sea level rise and Senegal: potential impacts and consequences. *Journal of Coastal Research, Special Issue* 14: 243-261.
42. **Oahu, Hawaii, USA** – Nunn, P. 1997. *Keimami sa vakila na liga ni Kalou (Feeling the hand of God): Human and nonhuman impacts on Pacific Island environments*. School of Social and Economic Development, The University of South Pacific, Suva, Fiji.
43. **Fiji** – Nunn, P. 1997. *Keimami sa vakila na liga ni Kalou (Feeling the hand of God): Human and nonhuman impacts on Pacific Island environments*. School of Social and Economic Development, The University of South Pacific, Suva, Fiji.
44. **American and Western Samoa** – Nunn, P. 1997. *Keimami sa vakila na liga ni Kalou (Feeling the hand of God): Human and nonhuman impacts on Pacific Island environments*. School of Social and Economic Development, The University of South Pacific, Suva, Fiji.
45. **Recife, Brazil** – Neves, C., and D. Muehe. 1995. Potential impacts if sea-level rise on the metropolitan region of Recife, Brazil. *Journal of Coastal Research, Special Issue* 14: 116-131.

CORAL REEF BLEACHING

46. **Pacific Ocean, Mexico** – see below.
47. **Pacific Ocean, Panama** – see below.
48. **American Somoa** – see below.
49. **Papua New Guinea** – see below.
50. **Philippines** – see below.
51. **Indian Ocean** – see below.
52. **Persian Gulf** – see below.
53. **Caribbean** – see below.

54. **Florida Keys, USA and Bahamas** – see below.
55. **Bermuda** – see below.
56. **Australia, Great Barrier Reef** – see below.
57. **Seychelles Islands** – see below.
58. **Galapagos** – see below.

The information for all the coral reef bleaching hotspots comes from maps and text from each of the following four sources combined:

ISRS, 1998. ISRS statement on global coral bleaching in 1997-98. International Society for Reef Studies. http://www.uncwil.edu/isrs/

NOAA, 1999. NOAA/NESDIS 1998 Coral Bleaching Hotspots. National Oceanic and Atmospheric Administration http://psbsgi1.nesdis.noaa.gov:8080/PSB/EPS/SST/retro.html

Wilkinson C, Linden O, Cesar H, Hodgson G, Rubens J, Strong AE (1999). Ecological and socioeconomic impacts of 1998 coral mortality in the Indian Ocean: An ENSO impact and a warning of future change? *Ambio* 28, 188-196.

World Conservation Monitoring Centre, 1998. The 1998 Global Coral Bleaching Incident. 4 December 1998.
http://www.wcmc.org.uk/latenews/bleaching.htm

GLACIERS MELTING

59. **Garhwal Himalyas, India** – 1998. Himalayan glacier backing off. *Science* 281: 1277.
60. **Caucasus Mountains, Russia** – Meier, M., 1998. Land ice on Earth: a beginning of a global synthesis. Unpublished transcript of the 1998 Walter B. Langbein Memorial Lecture, American Geophysical Union Spring Meeting, Boston, MA, 26 May 1998.
61. **Kenya** – Hastenrath, 1991. Climate dynamics of the tropics. Kluwer Academic Publishers, Dordrecht, Netherlands, 488 p.
62. **Tien Shen Mountains, China** – Meier, M. 1998.
63. **Austria** – Haeberli, W., and M. Beniston. 1998. Climate change and its impacts on glaciers and permafrost in the Alps. *Ambio* 27: 258-265.
64. **Andes Mountains, Peru** – Mosley-Thompson, E. 1997. Glaciological evidence of recent environmental changes. *Annual Meeting of the Association of American Geography*, Fort Worth, Texas.
65. **Glacier National Park, Montana, USA** – Meier, M. 1998.
66. **Spain** – Martinez de Pison, E., 1998. Observaciones Sobre el Estado de Los Glaciares del Pirineo Espanol. Campana 1995, In La Nieve en las Cordilleras Espanolas, Program ERHIN, Ministerio de Medio Ambiente, Madrid, Spain.
67. **New Zealand** – Chinn, T. 1996. New Zealand glacier responses to climate change of the past century. *New Zealand Journal of Geology and Geophysics* 39: 415-428.

ARCTIC AND ANTARCTIC WARMING

68. **Interior Alaska, USA** – Osterkamp, T., and V. Romanovsky. 1998. Permafrost monitoring and detection of climate change-comments. *Permafrost and Periglacial Processes* 9: 87-89.
69. **Barrow, Alaska, USA** – Springer, A. 1999. Is it all climate change? Why marine bird and mammal populations fluctuate in the North Pacific. *Biotic Impacts of Extratropical Climate Change in the Pacific, Aha Huliko'a Proceedings*, University of Hawaii.

70. **Antarctic Peninsula** – NSIDC. 1998. National Snow and Ice Data Center; Watson, R., M. Zinyowera, and R. Moss, eds. 1998. *The Regional Impacts of Climate Change: An Assessment of Vulnerability*, Cambridge University Press, Cambridge, UK.
71. **Bering Sea** – Weller, G., A. Lynch, T. Osterkamp, and G. Wendler. 1998. Climate trends and scenarios. Pages 157 in G. a. P. A. Weller, ed. *Implications of Global Change in Alaska and the Bering Sea Region: Proceedings of a Workshop*, Center for Global Change and Arctic System Research, University of Alaska, Fairbanks, Alaska.
72. **Arctic Ocean** – Bjorgo, E., O. Johannessen, and M. Miles. 1997. Analysis of merged SMMR-SSMI time series of Arctic and Antarctic sea ice parameters 1978-1995. *Geophysical Research Letters* 24: 413-416.
73. **Antarctica** – NSIDC, 1998. January 1995 Events in the Northern Larsen Ice Shelf and Their Importance. National Snow and Ice Data Center; Scambos, T. 1998. Cooperative Institute for Research in Environmental Sciences (CIRES), personal communication.
74. **Antarctica** – NSIDC, 1999. Antarctic ice shelves breaking up due to decades of higher temperatures. National Snow and Ice Data Center, 7 April 1999. http://www.colorado.edu/PublicRelations/NewsReleases/1999/35.html

DOWNPOURS, HEAVY SNOWFALLS, AND FLOODING

75. **New South Wales, Australia** – 1999. Australian Bureau of Meteorology. http://www.bom.gov.au
76. **New England, USA** – New England Regional Climate Center. Climate Impacts- 1998. http://met-www.cit.cornell.edu/climate/Impacts_06-98.html; 1998. From Yosemite to the east, it's sloshing, soaking wet. *Orlando Sentinel*, Orlando, Florida.
77. **Korea** – NCDC. 1998. Severe flooding in North and South Korea--July-August 1998 National Climatic Data Center. http://www.ncdc.noaa.gov/cgi-bin/res40.pl?page=gsod.html (go to "Data Files:Severe Events")
78. **Black Hills, South Dakota, USA** – Kocin, P., W. Gartner, and D. Graf. 1998. The 1996-97 snow season. Pages 47-54. *Weatherwise*.
79. **Texas, USA** – NCDC, 1998. Billion dollar U.S. weather disasters, 1980-1999. National Climatic Data Center. http://www.ncdc.noaa.gov/ol/reports/billionz.html
80. **Santa Barbara, California, USA** – NCDC, 1998. California Flooding and Florida Tornadoes - Feb 1998. National Climatic Data Center http://www.ncdc.noaa.gov/ol/reports/febstorm/february98storms.html#CRAIN
81. **Mount Baker, Washington, USA** – NOAA, 1999. Mt. Baker holds snowfall record, NOAA Reports. http://www.noaanews.noaa.gov/stories/s253.htm

DROUGHTS AND FIRES

82. **Florida, USA** – NCDC. 1998. Florida Wildfires and Climate Extremes. National Climatic Data Center. http://www.ncdc.noaa.gov/ol/climate/research/1998/fla/florida.html
83. **Mediterranean** – IFFN, 1995. Spain: 1994 Forest Fire Season, *International Forest Fire News* 12, (January 1995). Forest Fires in Italy 1998, *International Forest Fire News* 21, (October 1999). http://www.ruf.uni-freiburg.de/fireglobe/welcome.html#International Forest Fire News Regato, P., PhD. 1998. Forest Officer at WWF-MedPO, personal communication.
84. **Florida, Texas, Louisiana, USA** – WMO, 1999. WMO statement on the status of the global climate in 1998. World Meteorological Organization. http://www.wmo.ch/index.html

85. **Mexico** – Rodriguez-Trejo, D., and S. Pyne. 1999. Mexican fires of 1998. *International Forest Fire News* 20 (January 1999).
NRDC. 1998. Scorched Earth: impacts and implications of the 1998 fire disaster in North and Central America. Natural Resources Defense Council.
86. **Nicaragua** – A.J. de Dixmude, S.Flasse, I.Downey, P.Navarro, C.Searm, P.Ceccato, J.Williams, R. Alvarez, F.Uriarte, A.Ramos, I.Humphrey, and Z.Z'niga . 1999. Country Notes: Nicaragua: A Survey of Three Successive Recent Fire Seasons. International Forest Fire News 20 (March 1999).
NRDC. 1998. Scorched Earth: impacts and implications of the 1998 fire disaster in North and Central America. Natural Resources Defense Council.
87. **Indonesia** – International Forest Fire Management Program http://www.iffm.or.id/firerep.html
88. **Khabarovsk, Russia** – Forest Fires on the Island of Sakhalin and the Khabarovsk Krai - UNDAC (United Nations Disaster Assessment and Coordination) Mission Report. September-October 1998.
http://www.unep.org/unep/per/for_fire/rundac1.htm
BBC. 1998. Russian fires are 'world disaster.' BBC News.
http://news.bbc.co.uk/hi/english/world/asia-pacific/newsid_190000/190654.stm
89. **Eastern USA** – NOAA, 1999. Four States in Northeast Have Driest Growing Season on Record. http://www.noaanews.noaa.gov/stories/s258.htm

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A Variety of Activities for Using the Global Impacts Map "Global Warming: Early Warning Signs"

The global impacts map was designed to have a long shelf life and to be useful in a variety of outreach situations. The most important point, of course, is that the map be used as a tool for educating the public and informing policymakers and opinion leaders that global warming is very real and action is needed immediately. This map brings it all home—no matter where in the world you might call "home."

Below are suggested activities for use with the map, and a few tips to get you started.

• **Use the map in a classroom, lecture, or other academic setting**. This map is perfect for use in a variety of disciplines—physical and life sciences, as well as social sciences such as geography and political science. It is most appropriate for college level courses but can be adapted to high school use. The backgrounder materials in the SSI packet are designed for a scientific audience, which you may find useful for college level courses. In addition, UCS has prepared a set of "classroom activities" suitable for high school classes; some of these activities may be adaptable to higher grades. (To order the classroom activities, contact us at <sss@ucsusa.org>.)

• **Display the map at your workplace**. Heightened visibility for the climate change issue is critical for increasing public awareness and concern about this global problem. By displaying this attractive, eye-catching map in a prominent place—outside your office or department door, on a departmental bulletin board, in the student or faculty lounge, in the lunchroom, or just on your office wall—you are sure to attract attention. Make sure your colleagues know you are willing to answer questions and engage in conversation with them about the issue.

• **Use the map as a visual to enhance a public presentation** on the climate change impacts issue. With the map as a visual prop and the backgrounder materials to supplement your knowledge of the issue, you are equipped to make public presentations. Look for opportunities to speak within your membership institutions—such as the environmental or social issues committees in your church or synagogue, or your neighborhood association. You might seek out the science teachers in your childrens' schools and ask to make a brief presentation in their classrooms. You might also think about those groups or industries that are likely to be most affected by climate changes in your area—so-called "stakeholders"—who have a particular interest in understanding the climate issue. There may well be opportunities to speak to Rotary Clubs, business associations, or environmental/conservation groups. Finally, but not least, remember that Earth Day 2000 is rapidly approaching, and many communities are planning large-scale events. This year's theme is Clean Energy Solutions and Global Warming—the perfect place to make a global

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impacts presentation. Check out the ED2K website at <http://www.earthday.net> to find activities for your area, or check out campus activities.

• **Share the map with the media**. In order to reach the general public, working with the media is key. Here are some different ways to get the impacts map to the right people. * You could personally deliver a copy to a local environment or news reporter, giving you a chance to talk about the issue and its relevance locally. This would be especially effective if you have a working relationship with a reporter or you would like to establish one. * You could write a letter-to-the-editor or prepare an opinion editorial (op ed). Monitor your local paper for climate-related news and send in your LTE (preferably) the day the story runs. You could mention the map as a good visual source of information. An op ed is a more time intensive project and usually requires some sort of "news hook" to be relevant. Especially if you have some climate impacts expertise, however, you could fashion on op ed and ask that the map be a visual to accompany your story. * You could personally deliver and/or send a copy to a local meteorologist, asking her or him to mention the issue on the air when appropriate. * You could participate in an editorial board meeting. This tactic is best done with a community delegation—perhaps including a business person and religious leader. The delegation would impress upon the editors how serious an issue this is for your community, talk about local impacts, and discuss how adapting to and mitigating climate change can be good for your community.

• **Share the map with your elected local, state and/or federal officials**. Public officials at all levels of government need to be acting on and coordinating efforts to respond to the global threat of climate change. There is an appropriate role for all legislators, yet most public officials do not even have climate change on their radar screens—in part because they believe their constituents are unconcerned about the issue. By personally delivering a copy of the map to your mayor, state representatives, or federal congressional delegation, you begin the process of educating them on the issue while simultaneously communicating your serious concerns as a voting constituent. Establishing ongoing communication with these officials, and acting as a resource for them on the issue, would be a useful way to help ensure that policymaking is supported by sound science.

• **Share the map with relevant local, regional, and/or state administrative agency officials**. In addition to elected officials, administrative agencies are very important to the climate issue. Many of these agencies will need to deal with the day-to-day impacts of climate change in your area, and they should be factoring possible climate impacts into their planning now. Other agencies will be key to mitigating greenhouse gas emissions by promoting energy efficiency, renewable energy, and clean transportation technologies. Visit your city or state's regulatory bodies—such as planning commissions, resource agencies, environmental protection agencies, emergency or hazard management offices, etc, using the map as a "foot in the door" to meet about climate issues.

[For more detailed information on working with the media or elected officials, consult the SSI Members page on the UCS web site: www.ucsusa.org; bottom of the home page; user name–ssi; password–aristotle; click on media or legislators to get to the tool packet.]

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Hotspot Selection Criteria

The map is designed to stimulate interest in, and concern for, the impacts of global climate change on the environment and society. To ensure the integrity and usefulness of this product, the researchers/writers made every effort to conform to sound scientific principles in its research and categorization. The basic criterion for inclusion of an event or trend on the map was its consistency with global climate model projections of a world with increased levels of atmospheric greenhouse gases, as outlined in the Intergovernmental Panel on Climate Change Second Assessment Report (IPCC, 1996).

Clearly, all the processes and types of events on the map can and have occurred naturally in the past, some even during times not considered to be global warm periods. They represent complex phenomena that have multiple causal agents. Thus, while all of these are consistent with a warming climate, it is impossible to state for any *single* event that it is due to global warming. Part of the difficulty is that our scientific understanding of the connection between global climatic patterns and individual weather extremes is still incomplete. Another challenge lies in the fact that extremes—by definition—are relatively rare events. This dearth of data on extremes hinders a definitive statistical detection of regularities and trends in their occurrences. Because it is so difficult to see changing frequency patterns in the time series of any one type of event, this map was produced to show the increasingly widespread geographic occurrence of climate-related hazards and trends.

We distinguish two basic kinds of hotspots on the map. The "fingerprints" of global warming—such as heat waves, rising seas, and the melting of mountain glaciers—are indicators of the global, long-term warming trend observed in the historical record. Fingerprints are what researchers seek to detect and then to confirm that climate change is indeed underway. By contrast, "harbingers"—such as exceptional droughts, fires, and downpours, the spread of disease-bearing insects or other carriers, and widespread bleaching of coral reefs—may be directly or partly due to the warmer climate, but it is impossible to say for sure. Harbingers are events that are consistent, given our current scientific theories and models, with the kinds of impacts projected to occur as global climate change proceeds.

The overall geographic distribution of the hotspots is skewed towards North America and Europe. This is primarily because these regions have more readily accessible climatic data and more comprehensive programs to monitor and study environmental change. There are, then, more published studies and reports, particularly in the United States and Europe, from which to draw reliable data. The distribution of the events may also partly reflect the disproportionate warming observed over the mid- to high-latitude continents compared to other regions during the last century. Signals of climate change would be expected to show up first in areas with the greatest warming and in the most sensitive systems. This explanation, however, does not account for the lack of hotspots in places such as Russia, which has experienced significant warming over the last century (IPCC, 1998). Thus, the

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distribution of points on *"Global Warming: Early Warning Signs"* should not be considered to be an all inclusive representation of the distribution of actual climate-related events. Some events and trends in more sparsely populated areas may not have been detected, or they may have been observed but not reported, or they may not have been reported in the literature sources (such as non-English journals) used to create the map.

More specific guidelines for selection were developed for each of the ten categories as described below.

FINGERPRINTS

Heat Waves and Periods of Unusually Warm Weather

Hotspots in this category illustrate notably warm periods or heat waves within the last few years. Candidate events were initially gathered from news reports and climate bulletins. We then looked at National Climatic Data Center (http://www.ncdc.noaa.gov/onlineprod/gsod/climvis/gsod.html) and NASA/GISS (http://www.giss.nasa.gov/data/update/csci/) websites to obtain the actual temperature records for the city or region to: a) verify the occurrence of the heat wave or warm period; and b) place it in the context of the longer-term temperature record. We avoided using one-day records because of the inherent probability that a maximum temperature record could be broken on any given day due to internal climate variability. Only those events that were notable either in duration or geographic extent were included. Whenever possible, periods at least as long as a month (e.g., hottest March ever on record) were chosen. We also included only those locations that fall within a region that showed a warming trend over the last century, as reported in Annex A of the IPCC's Regional Impacts of Climate Change (1998).

Sea-Level Rise and Coastal Inundation

The sea level rise (SLR) data were confirmed by published journal articles. We did not include places where there were tide gauge records of a rising sea level but no information about land inundation consequences (e.g., Buenos Aires, where the shoreline is raised/hardened and thus protected from inundation); places where there was evidence of land erosion but no SLR records (e.g., the island of Geneva and other Caribbean islands); and places where subsidence or other factors (e.g., changes in river sediment deposition) were clearly the dominating influence on land erosion (e.g., New Orleans and Victoria, Egypt). Although the inundation records for the South Pacific islands are based on anecdotal evidence from local residents, we included them because these accounts are often the best and only evidence available in these very vulnerable small island nations.

Glaciers Melting

The data come from published scientific articles or personal communication with researchers. In cases where individual glaciers are cited, we confirmed, based on available data, that the majority of glaciers in that region are in retreat. Many of the events were outlined in an unpublished transcript of the 1998 Walter B. Langbein Memorial Lecture at the 1998 spring meeting of the American Geophysical Union, generously provided by Dr. Mark Meier, University of Colorado.

Arctic and Antarctic Warming

This category includes events linked to the warming temperatures observed in parts of Alaska, Canada, Siberia, and Antarctica, as published in journal articles and technical reports. Information on the break-up of the Antarctica Peninsula ice shelves also comes from the National Snow and Ice Data Center (NSIDC) website. Dr. Ted Scambos at NSIDC confirmed that the disintegration events listed on the map were unusual given our current understanding of the mechanics of ice shelves. Very large icebergs calving off other Antarctic ice shelves (e.g., Ross) were not included because they are considered to be part of the "normal" calving process.

HARBINGERS

Spreading Disease

All of the spreading disease events came from articles by Dr. Paul Epstein, Center for Health and the Global Environment, Harvard Medical School. We also spoke with Dr. Epstein directly to confirm some of the wording and use of certain locations. The goal was to find high elevation areas where the vector-borne diseases had not previously been found. (*Note:* mosquitoes are limited to certain temperatures and therefore elevations.) The focus was on the spread of these diseases (or the mosquitoes that carry them) to highland areas and previously unexposed populations. We also confirmed that the areas chosen have shown a warming trend according to the data presented by IPCC. Although some of these estimates are based on limited numbers of weather stations probably not at high elevations, they do give some indication of the temperature trend in that region.

Earlier Spring Arrival; Plant and Animal Range Shifts

These events were confirmed by published journal articles or personal communications with the researchers. Sites for which we could not find confirmation from a source other than a newspaper were not included. A clear documentation of a direct or indirect link to climate change—such as an increase in temperature or change in precipitation—was necessary for final inclusion.

Coral Reef Bleaching

We used NOAA press releases and information from their coral bleaching website to compile a list of areas that suffered bleaching episodes during the past year and a half, making sure that in every case they were associated with warm ocean temperatures. Although human activities such as pollution strongly influence bleaching, we did not attempt to separate out the relative effects of humans for different regions. Instead, we clearly state the impacts of humans on reefs in our category description.

Downpours, Heavy Snowfalls, and Floods

Events in this category are consistent with the projections for a more intense hydrologic cycle as outlined by the IPCC (1996), including more winter precipitation at mid to high latitudes and a greater portion of precipitation from heavy downpours. They are considered examples of events that would become more frequent and/or more widespread with continued global warming. For the rainfall events we confirmed that the region has been experiencing either an increase in heavy precipitation or an increase in annual precipitation, using journal articles or Annex A of the IPCC Regional Impacts report (IPCC, 1998). For flooding, we did not include events for which other factors (e.g., land clearing or wetland filling) were clearly major contributors, such as the summer 1998 flooding in the Yangtze Valley in China.

Droughts and Fires

Droughts and fires highlighted on the map are examples of events that are likely to become more frequent and widespread with global warming. Although the projections for rainfall vary considerably by region, droughts are expected to be longer-lasting and more severe because of higher temperatures and increased evaporation, even without a decrease in precipitation. Wildfires are also likely to become more frequent due to the combination of higher temperatures and decreased soil moisture in some areas, although other factors such as the availability of fuel and frequency of igniting events will also play a role. We only included on the map those wildfires that were associated with severe drought conditions, and it is clearly stated in the category description that human activities can trigger the start of fires.

References

IPCC, 1996. *Climate Change 1995: The Science of Climate Change*, (Eds J. T. Houghton, L. G. M. Filho, B. A. Callander, N. Harris, A. Kattenberg, and K. Maskell) Cambridge University Press, Cambridge, UK.

IPCC, 1998. *The Regional Impacts of Climate Change: An Assessment of Vulnerability*, (Eds RT Watson, MC Zinyowera, RH Moss), Cambridge University Press, Cambridge, UK.

Heat Waves and Periods of Unusually Warm Weather

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Heat Waves and Periods of Unusually Warm Weather

Worldwide temperature measurements, corrected for instrumental and measurement errors that result from such factors as changing instruments or urbanization, indicate that global mean annual surface temperatures have increased about 0.3 to 0.6°C during the last 150 years (Nicholls et al., 1996). Since 1975, the increase of the 5-year mean temperature is about 0.5°C—a rate that is faster than for any previous period of equal length in the instrumental record (NASA, 1999). Global surface temperatures in 1998 were the warmest since reliable instrumental measurements began, and seven of the ten warmest years occurred in the 1990s. Temperature reconstructions using proxy climate records—such as tree rings, fossil pollen, corals and ice cores—and borehole measurements indicate that the 20th century warming is unusual relative to the last 400 to 600 years (e.g., Mann et al., 1998, Overpeck et al., 1997; Pollack et al., 1998).

The observed magnitude and patterns of temperature change during the last century correspond well with model predictions when greenhouse gas, solar, and aerosol forcings are considered together (Wigley, 1999). Most of the recent warming has been in winter over the high mid-latitudes of the Northern Hemisphere continents, between 40 and 70°N (Nicholls et al., 1996). There has also been a general trend toward reduced diurnal temperature range, mostly because nights have warmed more than days. Since 1950, minimum temperatures on land have increased about twice as fast as maximum temperatures (Easterling et al., 1997). This may be attributable in part to increasing cloudiness, which reduces daytime warming by reflection of sunlight and retards the nighttime loss of heat (Karl et al., 1997). Increased soil moisture also reduces daytime warming because part of the solar energy is used to evaporate the excess moisture.

Climate model simulations predict an increase in average surface air temperature of about 2.5°C by the year 2100 (Kattenberg et al., 1996). A warming of global mean temperature will result in an increase in the frequency of warm temperature extremes at all time scales (e.g., days, seasons, and years). Regionally and locally, a small upward shift in mean temperature can cause relatively large increases in the number of extremely hot days, increasing the likelihood of "killer" heat waves during the warm season (Karl et al., 1997). In temperate climates, for example, the number of very hot days would approximately double for an increase of 2 to 3°C in average summer temperatures (Kattenberg et al., 1996). A recent analysis suggests that the number of days per year that temperature thresholds for mortality are surpassed has increased significantly over the last half-century for some US cities (Gaffen and Ross, 1998).

Increased heat waves due to climate change would cause more heat-related illness and death. It is still unclear whether the excess mortality will be offset by a decrease in deaths due to extreme cold (McMichael, 1996). Deaths due to hot weather are predominantly associated with preexisting cardiovascular and respiratory disorders, with the elderly, very young, and ill being disproportionately affected (McMichael, 1996). The degree of acclimatization (biological adaptation) of the population is important, as is the quality of housing and exposure to urban heat island effects. In 1995, nearly 500 people died during a severe heat wave in Chicago. Most were poor, elderly residents in homes or apartments without air conditioning. The unusally warm nights—during which the nighttime heat index (a measure that includes humidity) failed to drop below 89°F (32°C) for two days (Karl and Knight, 1997)—contributed to the high mortality. Continued urbanization and other socioeconomic trends can further increase the number of vulnerable persons.

References

Easterling, D.R., B. Horton, P.D. Jones, T.C. Peterson, T.R. Karl, D.E. Parker, M.J. Salinger, V. Razuvayev, N. Plummer, P. Jamason, and C.K. Folland, 1997. Maximum and minimum temperature trends for the globe. *Science* 277, 364-367.

Gaffen, D.J. and R.J. Ross. 1998. Increased summertime heat stress in the U.S. *Nature* 396, 529-530.

Karl, T.R. and R.W. Knight, 1997. The 1995 Chicago heat wave: How likely is a recurrence? *Bulletin of the American Meteorological Society* 78, 1107-1119.

Karl, T.R., N. Nicholls, and J. Gregory, 1997. The coming climate. *Scientific American*, 78-83.

Kattenberg, A., F. Giorgi, H. Grassl, G. A. Meehl, J. F. B. Mitchell, R. J. Stouffer, T. Tokioka, A. J. Weaver, and T. M.L. Wigley, 1996. Climate models - projections of future climate. In *Climate Change 1995: The Science of Climate Change*, 285-357, (Eds J. T. Houghton, L. G. M. Filho, B. A. Callander, N. Harris, A. Kattenberg, and K. Maskell) Cambridge University Press, Cambridge, UK.

Mann, M. E., R. S. Bradley, and M. K. Hughes, 1998. Global-scale temperature patterns and climate forcing over the past six centuries. *Nature* 392, 779-787.

McMichael, A.J., 1996. Human population health. In *Climate Change 1995 - Impacts, Adaptations, and Mitigation of Climate Change: Scientific-Technical Analyses*, 561-584 (Eds RT Watson, MC Zinyowera, RH Moss), Cambridge University Press, Cambridge, UK.

NASA, 1999. Global temperature trends: 1998 global surface temperature smashes record. NASA Goddard Institute for Space Studies. 16 December 1998. http://www.giss.nasa.gov/research/observe/surftemp/

Nicholls, N., G. V. Gruza, J. Jouzel, T. R. Karl, L. A. Ogallo, and D. E. Parker. 1996. Observed climate variability and change. In *Climate Change 1995: The Science of Climate Change*, (Eds J.T. Houghton, L.G.M. Filho, B.A. Callander, N. Harris, A. Kattenberg, and K. Maskell), 133-192, Cambridge University Press, Cambridge, UK.

Overpeck, J., K. Hughen, D. Hardy, R. Bradley, R. Case, M. Douglas, B. Finney, K. Gajewski, G. Facoby, A. Jennings, S. Lamoureaux, A. Lasca, G. MacDonald, J. Moore, M. Retelle, S. Smith, A. Wolfe, and G. Zielinski, 1997. Arctic environmental change of the last four centuries. *Science* 278, 1251-1256.

Pollack, H. N., S. Huang, and P.-Y. Shen. 1998. Climate change record in subsurface temperatures: A global perspective. *Science* 282, 279-281.

Wigley, T.M.L., 1999. *The Science of Climate Change: Global and U.S. Perspectives*. Pew Center on Global Climate Change, Arlington, Virginia, 48 p.

Additional Resources

NASA GISS Common Sense Climate Index – The "Common Sense Climate Index" is a measure of whether an area has experienced a temperature change that should be noticeable to most people who have lived at that location for a few decades. GISS maintains a web site with clickable maps that can be used to display the Common Sense Index for United States and world cities.
http://www.giss.nasa.gov/data/update/csci/

NCDC Extreme Weather and Climate Events – This website is a gateway to climatic data and reports on extreme weather events throughout the United States and the world.
http://www.ncdc.noaa.gov/ol/climate/severeweather/severeweather.html

National Weather Service Heat Stress Information – Describes the "heat index" and heat stress, and provides links to forecasts and further information about heat waves.
http://weather.noaa.gov/weather/hwave.html

"What Does Global Warming Mean for Your City?" A clickable map showing the potential increases in the number of hot days in selected US cities, based on an analysis using IPCC warming scenarios by NASA and Columbia University scientists.
http://www.edf.org/programs/GRAP/90Plus/

Global Warming: Early Warning Signs

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Spreading Disease

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Spreading Disease

Climate change affects the occurrence and spread of disease by impacting the population size and range of hosts and pathogens, the length of the transmission season, and the timing and intensity of outbreaks (McMichael, 1996; McMichael et al., 1996; Epstein et al., 1998; Epstein, 1999). In general, warmer temperatures and greater moisture will favor extensions of the geographical range and season for vector organisms—such as insects, rodents, and snails. This in turn leads to an expansion of the zone of potential transmission for many vector-borne diseases, among them malaria, dengue fever, yellow fever, and some forms of viral encephalitis. Extreme weather events such as heavy rainfall or droughts often trigger disease outbreaks, especially in poorer regions where treatment and prevention measures may be inadequate.

Mosquitoes in particular are highly sensitive to temperature. The mosquitoes that can carry malaria (*Anopheline* spp.) generally do not develop or breed below about 16°C, and the variety that transmits dengue fever (*Aedes aegypti*) is limited by winter temperatures below 10°C. Mosquito survival also drops at their upper temperature threshold, about 40°C. With sufficient moisture, warmer temperatures will generally cause an increase in mosquito abundance, biting rates, and activity level, and will accelerate the incubation of the parasites and viruses within them.

Warmer global temperatures will allow an expansion of the geographic range within which both the mosquito and parasite could survive with sufficient abundance for sustained transmission. Model predictions indicate that a 3°C global temperature rise by 2100 could increase the number of annual malaria cases by 50-80 million (not considering factors such as local control measures or health services) (Martens et al., 1995). The largest changes will occur in areas adjacent to current risk areas, at both higher altitudes and latitudes. In these regions, a temperature increase can convert areas that are malaria-free into areas that experience seasonal epidemics. In many cases, the affected populations will have little or no immunity, so that epidemics could be characterized by high levels of sickness and death.

Recent disease outbreaks are consistent with model projections that warmer, wetter conditions will lead to greater transmission potential at higher altitudes and elevations. Mosquito-borne diseases are now reported at higher elevations than in the past at sites in Asia, Central Africa, and Latin America (Epstein et al., 1998). This is coincident with growing evidence for significant warming at high altitude sites in tropical latitudes, as indicated for example by retreating glaciers (e.g., Fitzharris, 1996) and a 150 meter upward shift in the elevation of the freezing level (0°C isotherm) (Diaz and Graham, 1996). In New York City, an encephalitis outbreak in summer 1999 claimed three lives and prompted widespread pesticide spraying. The Centers for Disease Control have identified the West Nile virus as being responsible for this outbreak, a virus transmitted by mosquitoes that feed on infected birds (CDC, 1999a). The disease, which had not been previously documented in the Western Hemisphere, occurs primarily in the late summer or early fall in temperate regions, but can occur year round in milder climates (CDC, 1999b).

Diseases carried by rodents and other mammals may also be impacted by climate change. A recent study found a 60% rise in human plague cases in New Mexico following wetter than average winter-spring time periods (October-May) (Parmenter et al., 1999). Plague has only been in New Mexico since the 1940s, but a large increase in per capita cases occurred in the 1970s and 1980s associated with the wetter than normal conditions. The increased precipitation apparently enhances food resources for small mammals that serve as hosts for the infected fleas. The moister climate may also promote flea survival and reproduction. The study notes that if future climate conditions become more favorable for reproduction and survival of either wild mammal populations or their flea populations, then the probability of human infection via animal-flea-human contacts will likely increase.

Climate change also has the potential to impact diseases of plants and animals, and could lead to significant population declines or even extinction for some threatened or endangered species. Climate change has been implicated, for example, in the spread and emergence of marine diseases. This happens for a number of reasons—because the ranges of hosts and pathogens may change, because warming-induced stress may lower disease resistance, and because microbial and contaminant input from terrestrial sources may increase due to runoff from heavy rainfall events (Harvell et al., 1999). Higher sea surface temperatures, for example, increase the stress on corals (see *Coral Bleaching*), increasing susceptibility to infection. Similarly, a 25-year trend of warming winter temperatures along the eastern US coast has been implicated in the northward expansion of oyster diseases (Harvell et al., 1999). Forests and agricultural crops are also susceptible to the spread of pathogens, especially following extended droughts and floods. The disproportionate warming at night and during the winter (Easterling et al., 1997) may allow destructive insects and pathogens to invade forests at higher latitudes and elevations from which they are now excluded (Kirschbaum and Fischlin, 1996).

References

CDC. 1999a. West Nile-like Virus in the United States. Centers for Disease Control and Prevention, Updated 5 October 1999.
http://www.cdc.gov/od/oc/media/pressrel/r991004.htm

CDC. 1999b. Questions and answers about West-Nile Encephalitis, Division of Vector-Borne Infectious Diseases, National Center for Infectious Diseases, Centers for Disease Control and Prevention, Revised 24 November 1999.
http://www.cdc.gov/ncidod/dvbid/arbor/West_Nile_QA.htm

Diaz, H.F. and N.E. Graham. 1996. Recent changes in tropical freezing heights and the role of sea surface temperatures. *Nature* 383, 152-155.

Easterling, D.R., B. Horton, P.D. Jones, T.C. Peterson, T.R. Karl, D.E. Parker, M.J. Salinger, V. Razuvayev, N. Plummer, P. Jamason, and C.K. Folland, 1997. Maximum and minimum temperature trends for the globe. *Science* 277, 364-367.

Epstein, Paul R. 1999. Climate and health. *Science* 285, 347-348.

Epstein, P., H. Diaz, S. Elias, G. Grabherr, N. Graham, W. Martens, E. M. Thompson, and J. Susskind. 1998. Biological and physical signs of climate change: focus on mosquito borne diseases. *Bulletin of the American Meteeorological Society* 79, 409-417.

Fitzharris, B.B. 1996. The cryosphere: Changes and their impacts. In *Climate Change 1995 - Impacts, Adaptations, and Mitigation of Climate Change: Scientific-Technical Analyses*, 241-265 (Eds RT Watson, MC Zinyowera, RH Moss), Cambridge University Press, Cambridge, UK.

Harvell, C.D., K. Kim, J.M. Burkholder, R.R. Colwell, P.R. Epstein, D.J. Grimes, E.E. Hofmann, E.K. Lipp, A.D.M.E. Osterhaus, R.M. Overstreet, J.W. Porter, G.W. Smith, G.R. Vasta. 1999. Emerging Marine Diseases-Climate Links and Anthropogenic Factors. *Science 285*, 1505-1510.

Kirschbaum M.U.F. and A. Fischlin, 1996. Climate change impacts on forests. In *Climate Change 1995 - Impacts, Adaptations, and Mitigation of Climate Change: Scientific-Technical Analyses*, 95-129 (Eds RT Watson, MC Zinyowera, RH Moss), Cambridge University Press, Cambridge, UK.

Martens, W.J.M., T.H. Jetten, J. Rotmans, L.W. Niessen, 1995. Climate change and vector-borne diseases: a global modelling perspective. *Global Environmental Change* 5 (3), 195-209.

McMichael, A.J.. 1996. Human population health, In *Climate Change 1995 - Impacts, Adaptations, and Mitigation of Climate Change: Scientific-Technical Analyses*, 561-584 (Eds RT Watson, MC Zinyowera, RH Moss), Cambridge University Press, Cambridge, UK.

McMichael, A.J., A. Haines, and R. Slooff (Eds.), 1996. *Climate Change and Human Health*. World Health Organization, World Meteorological Organization, United Nations Environmental Program, Geneva, 305 p.

Parmenter, R.R. E.P. Yadav, C.A.. Parmenter, P. Ettestad, and K. L. Gage. 1999. Incidence of plague associated with increased winter-spring precipitation in New Mexico *American Journal of Tropical Medicine & Hygiene* 61 (5), 814–821.

Additional Resources

Colwell, R., 1996. Global climate and infectious disease: The cholera paradigm. *Science* 274, 2025-2031.

Division of Vector-Borne Infectious Diseases, National Center for Infectious Diseases – This site provides fact sheets, images, and world maps showing the distribution of several types of vector-borne diseases.
http://www.cdc.gov/ncidod/dvbid/dvbid.htm

Epstein, P.P., 1997. Climate, ecology, and human health. *Consequences* 3 (2), Global Change Research Information Office.
http://www.gcrio.org/CONSEQUENCES/vol3no2/climhealth.html

Epstein, Paul R. 1999. Enhanced: Climate and Health. *Science* 285, 347-348. This enhanced electronic version provides an extensive list of additional websites and literature cited on the topic.
http://www.sciencemag.org/cgi/content/full/285/5426/347

World Health Organization – Climate and Health
http://www.who.int/peh/climate/climate_and_health.htm

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Earlier Spring Arrival

The rise in mean global surface temperature during the last century has been characterized by a faster increase in minimum temperatures compared to maximum temperatures (Easterling et al., 1997). Both the overall warming and the disproportionate increase in minimum temperatures have contributed to a lengthening of the warm (growing) season, especially in mid- to-high latitudes. Many plants and animals respond to a longer growing season by changing the timing of activities associated with the arrival of spring and onset of autumn—such as flowering, leaf fall, breeding, and migration. There is growing evidence from sites in Europe and North America that such changes are occurring now.

Regional analyses show a trend toward earlier ice break-up and snow melting in spring that is consistent with the enhanced warming observed at higher latitudes (Nicholls et al., 1996). In tundra and boreal lands, river ice break-up dates are at least a week earlier compared to the last century (Fitzharris, 1996). Spring snow cover in the Northern Hemisphere declined significantly from 1988 to 1994 relative to the other seasons, coincident with a strong spring warming (Groisman et al., 1994). In the northeastern United States, the frost-free season now begins an average of 11 days earlier than in the 1950s (Karl et al., 1997). With continued global warming, many rivers in temperate regions may become ice-free or develop only intermittent or partial ice cover; in colder regions, the present ice season could be shortened by up to a month by 2050 (Fitzharris, 1996).

The life cycles of most plants and animals are critically tied to seasonal changes in temperature, precipitation, and light. The timing of bird migration and breeding is sensitive to changes in temperature, and global warming would be expected to lead to an earlier onset of those activities in the spring. Statistically significant trends toward earlier bird egg-laying and nesting have been reported for sites in Europe (Crick and Sparks, 1999; Crick et al., 1997) and the southern United States (Brown et al, 1999). The earlier nesting in Europe is attributed in part to earlier plant growth, which in turn causes earlier availability of the insects the birds feed upon (Crick et al., 1997). A trend toward earlier spring migration has also been observed for birds arriving in Michigan (Root, 1993).

Changes in European plants are consistent with the observations for birds. A recent study of European spring and autumn plant phases indicates that on average, spring events advanced by about six days and autumn events were delayed by about five days over the period from 1959 to 1993 (Menzel and Fabian, 1999). The long-term consequences of these changes are uncertain. The changing climate may impair the extent to which an animal's life cycle is synchronized with its food supply. Birds, for example, can adjust to warmer temperatures by flying to more northern areas in any given year, but the vegetation upon which they (or their prey) rely may take decades or longer to adjust (see Root, 1997).

A shorter duration of ice cover due to an earlier spring has the potential to affect the productivity, life history, and reproduction of aquatic organisms. Earlier break-up (and later freeze-up) of sea ice in the Arctic shortens the time available for feeding and rearing of certain marine mammals and may change the health or size of a population. A new study of polar bears in Hudson Bay indicates that because of earlier melting, the bears now have less time to hunt on the sea ice and must return to shore before they have adequately replenished their fat by feeding on seal pups (Stirling et al., 1999). Ice break-up in western Hudson Bay now occurs an average of three weeks earlier compared to the mid-1970s.

In temperate regions, reduced ice cover on rivers and lakes leads to increased turbulence and mixing of sediments, which can disturb incubating eggs of certain fish species (Arnell et al., 1996). On the other hand, an earlier spring ice-out lengthens the growing season of aquatic systems, and thus can increase the survival rate of young fish during the following winter. Because light attenuation by overlying ice is a major limiting factor for certain species, the shorter duration of ice cover also may alter the competitive balance of species in some systems (Arnell et al., 1996).

References

Arnell, N, B. Bates, H. Lang, J.J. Magnuson, P. Mulholland, 1996. Hydrology and freshwater ecology, In *Climate Change 1995 - Impacts, Adaptations, and Mitigation of Climate Change: Scientific-Technical Analyses*, 325-363 (Eds RT Watson, MC Zinyowera, RH Moss), Cambridge University Press, Cambridge, UK.

Brown, J.L., S. Li, and N. Bhagabati, 1999. Long-term trend toward earlier breeding in an American bird: a response to global warming? *Proceedings of the National Academy of Sciences* 96, 5565-5569.

Crick, H.Q.P. and T.H. Sparks, 1999. Climate change related to egg-laying trends, *Nature* 399, 423-424.

Crick, H.Q.P., C. Dudley, D.E. Glue, and D.L. Thomson, 1997. UK birds are laying eggs earlier, *Nature* 388, 526.

Easterling, D.R., B. Horton, P.D. Jones, T.C. Peterson, T.R. Karl, D.E. Parker, M.J. Salinger, V. Razuvayev, N. Plummer, P. Jamason, C.K. Folland, 1997. Maximum and minimum temperature trends for the globe, *Science* 277, 364-367.

Fitzharris, B.B., 1996. The cryosphere: changes and their impacts. In *Climate Change 1995 - Impacts, Adaptations, and Mitigation of Climate Change: Scientific-Technical Analyses*, 241-265 (Eds RT Watson, MC Zinyowera, RH Moss), Cambridge University Press, Cambridge, UK.

Groisman, P. Ya, T.R. Karl, R.W. Knight, and G.L. Stenchikov, 1994. Changes of snow cover, temperature, and the radiative heat balance over the Northern Hemisphere, *Journal of Climate* 7, 1633-1656.

Earlier Spring Arrival

Karl, T.R., N. Nicholls, and J. Gregory, 1997. The coming climate, *Scientific American*, 78-83.

Menzel, A. and P. Fabian, 1999. Growing season extended in Europe, *Nature* 397, 659.

Nicholls, N., G. V. Gruza, J. Jouzel, T. R. Karl, L. A. Ogallo, and D. E. Parker, 1996. Observed climate variability and change, In *Climate Change 1995: The Science of Climate Change*, 133-192, (Eds J. T. Houghton, L. G. M. Filho, B. A. Callander, N. Harris, A. Kattenberg, and K. Maskell), Cambridge University Press, Cambridge, UK.

Root, T.L., 1993. Effects of global climate change on North American birds and their communities. In Biotic Interactions and Global Change., (Eds P.M. Kareiva, J.G. Kingsolver, and R.B. Huey), Sinauer Associates, Sunderland, MA.

Root, T.L., 1997. How to approach assessing climate impacts on animals. In *Elements of Change 1996* (Eds S.J. Hassol and J. Katzenberger). Aspen Global Change Institute, Aspen, Colorado. http://www.gcrio.org/ASPEN/science/eoc96/AGCIEOC96General/AGCIEOC96Cover.html

Stirling, I. et al., 1999. Long term trends in the population ecology of polar bears in Western Hudson Bay in relation to climatic change, *Arctic* 53 (3), 292-306.

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Plant and Animal Range Shifts and Population Declines

The geographic ranges of most plant and animal species are limited by climatic factors, including temperature, precipitation, soil moisture, humidity, and wind. Any shift in the magnitude or variability of these factors in a given location will impact the organisms living there. Species sensitive to temperature may respond to a warmer climate by moving to cooler locations at higher latitudes or elevations. Although the response to warming is generally understood, it is difficult to predict how concurrent changes in other climatic factors also affect species' distributions. Despite the uncertainties, ecological models predict that the distribution of world biomes will shift as a result of the climate changes associated with increased greenhouse gases (IPCC, 1998). The distribution and size of the populations of plants and animals within those biomes will also change, with potential consequences for the functioning of ecosystems and for humans who are dependent on many ecosystem goods and services.

Global biome models have been used to evaluate the changes in vegetation distribution likely to occur with a changing climate. The models generally predict a poleward shift of the northern hemisphere taiga, boreal conifer, and temperate mixed forests belts (IPCC, 1998, Appendix C). One limitation of the global models is that the output represents a vegetation distribution that is in equilibrium with climate, a condition that is unlikely to occur in the next century. The spread of tree species involves several factors, including dispersal, regeneration on a suitable site, maturation, and seed production. If climate changes faster than trees can disperse to new, more suitable areas, the composition of the forest may change and the survival of some species could be at risk. Global-scale models are also inadequate to evaluate the indirect effects of climate, such as disturbances from pests, disease, fire, flooding, and wind damage.

Many animals are able to respond to climate at a faster rate than plants. For those animals that do not migrate, a distribution change in response to a warming trend would occur at the population level as a result of changes in the ratios of extinctions to colonizations at the northern and southern boundaries of the range. A northward range shift would thus be reflected in either a net extinction at the southern boundary or a net colonization at the northern boundary. Range shifts in areas with regional warming trends have been reported in alpine plants (Grabherr et al., 1994), butterflies (Parmesan, 1996; Parmesan et al., 1999), birds (Thomas and Lennon, 1999), marine invertebrates (Barry et al., 1995), and mosquitoes (Epstein et al, 1998). Two of those studies (Thomas and Lennon, 1999; Parmesan et al., 1999) evaluated changes at both southern and northern margins. In a sample of 35 European non-migratory butterfly species, 63% had ranges that shifted to the north by 35-240 km during the past century, and only 3% shifted to the south (Parmesan et al., 1999). The range shift parallels a 0.8°C warming over Europe during the last century, which has shifted the climatic isotherms northwards by an average of 120 km (Beniston et al., 1998).

Factors other than climate may limit the extent to which organisms can shift their ranges. Physical barriers such as mountain ranges or extensive human settlement may prevent some species from shifting to more suitable habitat. In the case of isolated mountain top species, there may be no new habitat at higher elevation to colonize. Even in cases where no barriers are present, other limiting factors such as nutrient or food availability, soil type, and the presence of adequate breeding sites may prevent a range shift. Although tree line will probably increase in elevation as climate warms, for example, soils at higher elevations are often thin and of poor quality and could be inadequate to sustain species from lower elevation sites. In coastal areas, the loss of wetlands and beaches due to sea level rise could destroy sites used by turtles, birds, and marine mammals for breeding and raising young. It should be noted that given all these potential difficulties, it is encouraging that a few species have apparently been able to shift their ranges in response to climate, as described in the studies listed above. However, the long-term impacts of these shifts on the populations and species as a whole, and the extent to which other species can adapt to changing climate, are difficult to assess at this time.

References

Barry, J., C. Baxter, R. Sagarin, and S. Gilman, 1995. Climate related, long-term faunal changes in a Californian rocky intertidal community. *Science* 267, 672-675.

Beniston, M. and R.S.J. Tol, 1998. Europe. In *The Regional Impacts of Climate Change: An Assessment of Vulnerability*, 149-185, (Eds RT Watson, MC Zinyowera, RH Moss), Cambridge University Press, Cambridge, UK.

Epstein, P., H. Diaz, S. Elias, G. Grabherr, N. Graham, W. Martens, E.M. Thompson, and J. Susskind, 1998. Biological and physical signs of climate change: focus on mosquito borne diseases. *Bulletin of the American Meteorological Society* 79, 409-417.

Grabherr, G., M. Gottfried, and H. Pauli, 1994. Climate effects on mountain plants. *Nature* 369, 448.

IPCC, 1998. *The Regional Impacts of Climate Change: An Assessment of Vulnerability*, (Eds RT Watson, MC Zinyowera, RH Moss), Cambridge University Press, Cambridge, UK.

Parmesan, C., 1996. Climate and species' range. *Nature* 382, 765-766

Parmesan, C., et al. 1999. Poleward shifts in geographical ranges of butterfly species associated with regional warming. *Nature* 399, 579-583.

Thomas, C.D. and Lennon, J.J., 1999. Birds extend their ranges northwards. *Nature* 399: 213.

Plant and Animal Range Shifts and Population Declines

Additional Resources

EPA Plant and Animal Impacts Bibliography – This site offers an extensive listing of scientific articles about the impacts of climate change on wildlife.
http://www.epa.gov/globalwarming/impacts/imp_blio.html

World Wildlife Fund Climate Change Campaign – This site is a gateway to several WWF online reports on the impacts of climate change on wildlife and protected areas.
http://www.panda.org/climate/impact.shtml

Sea Level Rise and Coastal Flooding

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Sea-Level Rise and Coastal Flooding

Worldwide measurements from tidal gauges indicate that global mean sea level has risen between 10 and 25 cm (18 cm average) during the last 100 years (Warrick et al., 1996). This rate is greater than the average of the last few thousand years estimated from geological and archaeological records; the timing of the onset of this acceleration, however, is uncertain (Gornitz, 1995; Warrick et al., 1996). There is no evidence for an acceleration of sea-level rise during this century, nor would any necessarily be expected from the observed climate change to date (Warrick et al., 1996). The IPCC Second Assessment Report estimated a sea-level rise for the next 100 years of about 49 cm, with a range of uncertainty of 20-86 cm. New emissions scenarios being prepared for an IPCC Special Report have much lower sulfur dioxide levels, which have a cooling effect via the production of sulfate aerosols. Thus, preliminary projections of sea-level rise using the new emissions data are slightly higher (Wigley, 1999). In either scenario, the projected rate of sea-level rise is at least two to four times the rate of the last century.

A major source of uncertainty about sea-level rise is the future behavior of the Greenland and Antarctic ice sheets. For example, disintegration of the West Antarctic Ice Sheet (WAIS)—which lies grounded on land below sea level—could eventually raise sea level by 4 to 6 meters (Bindschadler, 1998; Kerr, 1998; Rignot, 1998; Bindschadler et al., 1999). WAIS is presently fringed by floating ice shelves that slow the release of icebergs into the sea. Although increasing temperatures in this region would be insufficient to cause melting, the warmer air would likely bring increased snowfall. The resulting positive mass balance of the ice sheet could lead to a rapid advance, or "surge," accelerating the discharge of ice and raising sea level (Warrick et al., 1996).

Most scientists believe that collapse of WAIS within the next century is unlikely, but there is some concern for an irreversible destabilizing of the ice sheet even with relatively modest warming (e.g., Oppenheimer, 1998). A new study suggests that the modern grounding-line retreat is part of an ongoing recession that has been under way for a few thousand years (Conway et al., 1999). The authors conclude that the retreat is independent of anthropogenic warming or sea level rise but nevertheless could lead to complete disintegration of the WAIS within the present interglacial period.

In Greenland, the southern regions of the ice sheet are likely to be most susceptible to climate change and could contribute to sea-level rise through melting and runoff at the margins. Observations are insufficient to determine if the ice volume changed significantly during the past century. Recent aircraft surveys using laser-altimetry, however, indicate that between 1993 and 1998 the southeastern part of the ice sheet thinned overall (Krabill et al., 1999).

Sea-level rise in a given location will vary depending on factors such as vertical land movement, wind and pressure patterns, ocean circulation, and rate of warming. Coastal wetlands and lowlands, beaches and barrier islands, and ocean islands and atolls are especially vulnerable to rising seas. Depending on the rate of sea-level rise, the rate of vertical wetland build-up, and the capacity for wetlands to migrate inland, a 50-cm sea-level rise could inundate up to 50% of North American coastal wetlands (Shriner and Street, 1998). These areas are critical habitat for large numbers of coastal bird and fish species, and provide ecosystem services such as pollution filtration, sediment trapping, erosion mitigation, and flood control. Wetlands in most areas have been able to keep pace with historic sea-level rise by accreting sediment and growing vertically and by moving inland with the encroaching sea. But the accelerated rates projected for the next 100 years may be too fast for natural accretion and migration to keep up. Sediment deficits and development barriers are among the most important factors that limit the survival of this important coastal habitat.

Sea-level rise leads to increased coastal flooding through direct inundation and an increase in the base for storm surges, allowing flooding of larger areas and higher elevations. One study, for example, estimated that a rise in sea level of 30 to 90 cm would increase the size of the 100-year floodplain in the United States by 10,000 to 20,000 km^2 (FEMA, 1991). Put differently, storms of a given magnitude will have a shorter return interval. High tide peaks, for example, that occur once every one hundred years on average may occur every ten years, making now rare events more common. In some areas, flooding could be further exacerbated by an increase in extreme precipitation events resulting from an intensification of the hydrological cycle (see *Downpours, Heavy Snowfalls, and Flooding*). Heavy precipitation associated with coastal storms causes increased runoff and river surges that intensify the effects of storm surges from the sea. Levees and seawalls currently protect many coastal areas, but these structures have been designed for current sea level and may be overtopped in the future or undermined by increased erosion.

The costs of responding to a sea-level rise of 50 cm by 2100 are estimated at between $20 and $200 billion in the United States alone (Shriner and Street, 1998). The wide range in this estimate reflects the different options, extent, and timing of response. Adaptation measures such as the construction of bulkheads, dikes, and pumping systems can protect property, but these measures are likely to result in further loss of wetlands and beaches—with detrimental effects on fish and wildlife, recreation, and tourism. Elevation of structures and land surfaces, and land-use policies that allow shorelines to retreat naturally, are less disruptive response strategies but are challenging to implement in areas already highly developed. Maine and Rhode Island, for example, have regulations prohibiting structures that will prevent the inland migration of wetlands (Shriner and Street, 1998). Land elevation and beach nourishment are attractive options in many ways; yet they are not feasible in all locations, and they require extraordinary financial and political commitments into the indefinite future.

References

Bindschadler, Robert. 1998. Future of the West Antarctic Ice Sheet. *Science* 282, 428-429.

Bindschadler, R.A., R.B. Alley, J. Anderson, S. Shipp, H. Borns, J. Fastook, S. Jacobs, C.F. Raymond, C.A. Shuman, 1999. What is happening to the West Antarctic Ice Sheet? *EOS* 79 (22), 2 June 1998. http://igloo.gsfc.nasa.gov/wais/eos.html

Conway, H., B.L. Hall, G.H. Denton, A.M. Gades, E. D. Waddington, 1999. Past and future grounding-line retreat of the West Antarctic Ice Sheet. *Science* 286, 280-283.
FEMA, 1991. Projected impact of sea-level rise on the National Flood Insurance Program. Report to Congress. Federal Insurance Administration, Washington, DC, 172 p.

Gornitz, V., 1995. Sea-level rise: A review of recent, past and near-future trends, *Earth Surface Processes and Landforms* 20, 7-20, 1995.

Kerr, Richard. 1998. West Antarctica's weak underbelly giving way? *Science* 281, 499-500.

Krabill, W., E. Frederick, S. Manizade, C. Martin, J. Sonntag, R. Swift, R. Thomas, W. Wright, and J. Yungel, 1999. Rapid thinning of parts of the southern Greenland ice sheet, *Science* 283, 1522-1524.

Oppenheimer, M., 1998. Global warming and the stability of the West Antarctic ice sheet. *Nature* 393, 325-332.

Rignot, E.J. 1998. Fast recession of a West Antarctic glacier. *Science* 281, 549-551.

Shriner, D.S. and R.B. Street, 1998. North America in *The Regional Impacts of Climate Change: An Assessment of Vulnerability*, 253-330, (Eds RT Watson, MC Zinyowera, RH Moss), Cambridge University Press, Cambridge.

Warrick, R. A., C. L. Provost, M. F. Meier, J. Oerlemans, and P. L. Woodworth, 1996. Changes in sea level, in *Climate Change 1995: The Science of Climate Change*, 359-405, (Eds JT Houghton, LG Meira Filho, BA Calander, N Harris, A Kattenburg, and K Maskell), Cambridge University Press, Cambridge.

Wigley, T.M.L., 1999. *The Science of Climate Change: Global and U.S. Perspectives*. Pew Center on Global Climate Change, Arlington, Virginia, 48 p.

Additional Resources

Titus, J. 1998. Greenhouse effect and sea level rise: America starts to prepare. http://www.erols.com/jtitus/index.html

Titus, J. G. and V.K. Narayanan, 1995. *The probability of sea-level rise*. EPA 230-R-95-008, Environmental Protection Agency, Washington, DC.

Coral Reef Bleaching

Coral Reef Bleaching

Coral reefs are one of the most productive ecosystems on Earth, providing many critical services to fisheries, shoreline protection, tourism, and to medicine. They are also believed to be among the most sensitive ecosystems to long-term climate change (Nurse et al., 1998). Elevated sea surface temperatures can cause coral to lose their symbiotic algae, which are essential for the nutrition and color of corals. When the algae die, corals appear white and are referred to as "bleached." Water temperatures of as little as one degree Celsius above normal summer maxima, lasting for at least two to three days, can be used as a predictor of coral bleaching events (Goreau and Hayes, 1994). Studies indicate that most coral are likely to recover from bleaching if the temperature anomalies persist for less than a month, but the stress from sustained high temperatures can cause physiological damage that may be irreversible (Wilkinson et al., 1999).

In 1998 coral reefs around the world experienced the most extensive and severe bleaching in recorded history (ISRS, 1998; Wilkinson et al., 1999). Coral bleaching was reported in 60 countries and island nations at sites in the Pacific Ocean, Indian Ocean, Red Sea, Persian Gulf, Mediterranean and Caribbean. Indian Ocean corals were particularly severely impacted, with greater than 70 percent mortality reported in the Maldives, Andamans, Lakshadweep Islands, and in Seychelles Marine Park System. Unlike most previous bleaching events—in which severe impacts were limited to less than 15 m water depth—the 1998 bleaching affected corals at up to 50 m water depth. This mass bleaching followed similar but less severe events in 1987 and 1990. Prior to the early to mid 1980s, bleaching tended to be rare and localized, and corals generally recovered.

The 1998 mass bleaching was coincident with anomalously high sea surface temperatures. That year was the warmest of this century (NOAA, 1999), and tropical sea surface temperatures were the highest in the modern record (Strong et al., 1998). For many parts of the Pacific, the 1997-98 mass bleaching has been linked to the strong El Niño-induced seawater warming. The relationship between El Niño and coral bleaching is less clear, however, for the Indian Ocean, Arabian Gulf, and some parts of the Pacific (Wilkinson, 1999; ISRS, 1998). The geographic extent, regional severity, and increasing frequency of recent mass bleaching events point to an underlying global cause—namely a trend of increasing sea surface temperatures in some of the tropical oceans, driven by global warming (US Department of State, 1999).

Global mean sea-surface temperatures are projected to increase by about 1-2°C in the next century (Kattenberg et al., 1996). If the overall warming is accompanied by more frequent periods of sustained high temperatures, mass bleaching events will become more frequent and widespread. Increasing human stresses such as pollution, overfishing, soil erosion, and physical damage from boats and other recreational activities will also weaken corals, limiting their ability to adapt to climate change (Hodgson, 1999; Nurse et al., 1998).

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Furthermore, as ocean warming coincides with sea-level rise and perhaps more frequent tropical storms and El Niños (e.g., Timmerman et al., 1999), reefs are likely to experience greater coastal erosion, sedimentation, and turbidity, which would add to their demise.

References

Goreau, T. J. and R. L. Hayes, 1994. Coral bleaching and ocean "hot spots." *Ambio* 23, 176-180.

Hodgson, G., 1999. A global assessment of human effects on coral reefs. *Marine Pollution Bulletin* 38, 345-355.

ISRS, 1998. ISRS statement on global coral bleaching in 1997-98. International Society for Reef Studies.
http://www.uncwil.edu/isrs/

Kattenberg, A., F. Giorgi, H. Grassl, G. A. Meehl, J. F. B. Mitchell, R. J. Stouffer, T. Tokioka, A. J. Weaver, and T. M.L. Wigley, 1996. Climate models - projections of future climate, in *Climate Change 1995: The Science of Climate Change*, 285-357, (Eds J. T. Houghton, L. G. M. Filho, B. A. Callander, N. Harris, A. Kattenberg, and K. Maskell) Cambridge University Press, Cambridge, UK.

NOAA. 1999. Climate of 1998 annual review: global temperatures. National Climate Data Center. 12 January 1999.
http://www.ncdc.noaa.gov/ol/climate/research/1998/ann/global_temperatures.html#Global Temps

Nurse, L.A., R. F. McLean, and A.G. Suarez, 1998. Small island states. In *The Regional Impacts of Climate Change: An Assessment of Vulnerability*, 331-354, (Eds RT Watson, MC Zinyowera, RH Moss), Cambridge University Press, Cambridge, UK.

Strong, A. E., T. J. Goreau and R. L. Hayes. 1998. Ocean Hot Spots and coral reef bleaching: January – July 1998. *Reef Encounters* 24, 20-22.

US Department of State, 1999. Coral bleaching, coral mortality, and global climate change. Report to the U.S. Coral Reef Task Force. Bureau of Oceans and International Environmental and Scientific Affairs, 5 March 1999.
http://www.state.gov/www/global/global_issues/coral_reefs/990305_coralreef_rpt.html

Timmerman, A., J. Oberhuber, A. Bacher, M. Esch, M. Latif and E. Roeckner, 1999. Increased El Nino frequency in a climate model forced by future greenhouse warming. *Nature* 398, 694-696.

Wilkinson C, O. Linden, H. Cesar, G. Hodgson, J. Rubens, and A.E. Strong, 1999. Ecological and socioeconomic impacts of 1998 coral mortality in the Indian Ocean: An ENSO impact and a warning of future change? *Ambio* 28, 188-196.

Coral Reef Bleaching

Additional Resources

An Introduction to Coral Reefs - An introduction to coral reef ecology by the University of the Virgin Islands.
http://www.uvi.edu/coral.reefer/index.html

Brown, B.E., Odgen, J.C. 1993. Coral bleaching. *Scientific American* 269, 64-70.

Coral Bleaching Hotspots – NOAA uses satellite observations of sea surface temperature to predict potential coral bleaching hotspots. Individuals can also report current or past incidents of coral bleaching using an electronic form.
http://psbsgi1.nesdis.noaa.gov:8080/PSB/EPS/SST/climohot.html

Status of Coral Reefs of the world: 1998 – Electronic version of a report on the status of coral reefs in 1998, including a detailed chapter on the 1997-98 bleaching event.
http://www.aims.gov.au/pages/research/coral-bleaching/scr1998/scr-00.html

NOAA's Coral Health and Monitoring Program – A comprehensive website with coral-related web links, access to literature lists, electronic listservs, and other resources.
http://coral.aoml.noaa.gov/

Glaciers Melting

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Glaciers Melting

Glaciers exist on all continents except Australia and at virtually all latitudes from the tropics to the poles. Mountain glaciers, such as those that exist at higher elevations in the mid-latitudes and tropics, are particularly sensitive indicators of climate change. The volume of ice in a glacier—and correspondingly its surface area, thickness, and length—is determined by the balance between inputs (accumulation of snow and ice) and outputs (melting and calving). As climate changes, the balance between inputs and outputs may change, resulting in a change in thickness and the advance or retreat of the glacier. Temperature, precipitation, humidity, wind speed, and other factors such as slope and the reflectivity of the glacier surface all affect the balance between inputs and outputs. Most glaciers in the world, however, are more sensitive to temperature than to other climatic factors (Fitzharris, 1996).

There is widespread evidence that glaciers are retreating in many mountain areas of the world. Since 1850 the glaciers of the European Alps have lost about 30 to 40% of their surface area and about half of their volume (Haeberli and Beniston, 1998). Similarly, glaciers in the New Zealand Southern Alps have lost 25% of their area over the last 100 years (Chinn, 1996), and glaciers in several regions of central Asia have been retreating since the 1950s (Fitzharris, 1996; Meier, 1998). For three glaciers in the US Pacific Northwest, the seven-year average rate of ice loss was higher for the period since 1989 than for any other period studied (Hodge et al., 1998). Glacial retreat is also prevalent in the higher elevations of the tropics. Glaciers on Mt. Kenya and Kilimanjaro have lost over 60% of their area in the last century (Hastenrath, 1991; Hastenrath and Greischar, 1997), and accelerated retreat has been reported for the Peruvian Andes (Mosley-Thompson, 1997).

By contrast, losses in the Arctic have been less pronounced (0-6% in area and 1-14% in volume), partly because those glaciers are much colder and the extra meltwater refreezes in the ice mass (M. Meier, pers. comm.). Although there is considerable variability at the regional and local scales and over shorter time periods, the overall global signal shows mass loss and retreat of glaciers during the last century. For the period 1884–1978, the mean global glacial retreat corresponds to a calculated warming of about 0.7°C per century (Oerlemans, 1994).

Global compilations indicate that the wastage of mountain glaciers during the last century has raised sea level by between 0.2 to 0.4 mm/yr, or roughly 20% of the observed change (e.g,. Warrick et al., 1996; Dyurgerov and Meier, 1997). By 2100, sea level is estimated to rise by an additional 46 to 58 cm, with an estimated total range of 20 to 86 cm (Warrick et al., 1996). Over half of the change will likely be from thermal expansion of ocean water, another 30% from melting of mountain glaciers, and 10% from melting of parts of the Greenland ice sheet (Gregory and Oerlemans, 1998). If future climate change is consistent with model projections, up to one quarter of the presently existing mountain glacier ice will disappear by 2050 (Fitzharris, 1996).

The shrinking of glaciers will likely have a significant socioeconomic impact in some mountain regions, though the exact local impacts remain uncertain and will vary. Regions that lose major parts of their glacier cover will experience alterations in hydrology. The glaciers will initially provide extra runoff from melting; but as the ice diminishes, the runoff will wane. Also, because revegetation of terrain is slower at high altitudes, deglaciated areas will be subject to erosion and decreased stability, heightening the need to protect buildings, roads, communication links, and other structures. For areas dependent on tourism, uncertain snow cover during peak winter sports seasons, natural hazards such as rock and ice falls, or loss of scenic beauty are of particular concern. An example of the type of scenario that could become more frequent occurred during the warm summer of 1998, when a ski area in the Tyrolian Alps was forced to close a lift after melting ice dislodged rocks and soil, destabilizing the peak (GECR, 1998).

References

Chinn, T. 1996. New Zealand glacier responses to climate change of the past century. *New Zealand Journal of Geology and Geophysics* 39, 415-428.

Dyurgerov, M. B., and M. Meier. 1997. Mass balance of mountain and sub-polar glaciers: A new global assessment for 1961-1990, Arctic and Alpine Research, 29 (4), 379-391.

Fitzharris, 1996. The cryosphere: Changes and their impacts. In *Climate Change 1995: The Science of Climate Change*, (Eds J. T. Houghton, L. G. M. Filho, B. A. Callander, N. Harris, A. Kattenberg, and K. Maskell), 241-265, Cambridge University Press, Cambridge, UK.

GECR, 1998. Melting glacier destabilizes Austrian peak. Global Environmental Change Report, vol. X, no. 22, p. 6.

Gregory, J.M. and J. Oerlemans, 1998. Simulated future sea-level rise due to glacier melt based on regionally and seasonally resolved temperature changes. *Nature* 391, 474-476.

Haeberli, W., and M. Beniston. 1998. Climate change and its impacts on glaciers and permafrost in the Alps. *Ambio* 27, 258-265

Hastenrath, 1991. *Climate Dynamics of the Tropics*. Kluwer Academic Publishers, Dordrecht, Netherlands, 488 p.

Hastenrath, S and L. Greischar, 1997. Glacier recession on Kilimanjaro, East Africa, 1912-89. *Journal of Glaciology* 43 (145), 455-459.

Hodge, S.M., D.C. Trabant, R.M. Krimmel, T.A. Heinrichs, R.S. March, and E.G. Josberger, 1998. Climate variations and changes in mass of three glaciers in western North America. *Journal of Climate* 11 (9), 2161-2179.

Meier, M., 1998. Land ice on Earth: A beginning of a global synthesis. Unpublished transcript of the 1998 Walter B. Langbein Memorial Lecture, American Geophysical Union Spring Meeting, Boston, MA, 26 May 1998.

Mosley-Thompson, E. 1997. Glaciological evidence of recent environmental changes. *Annual Meeting of the Association of American Geography*, Fort Worth, Texas.

Oerlemans, J., 1994. Quantifying global warming from the retreat of glaciers. *Science* 264, 243-245.

Warrick, R. A., C. L. Provost, M. F. Meier, J. Oerlemans, and P. L. Woodworth, 1996. Changes in sea level, in *Climate Change 1995: The Science of Climate Change*, 359-405, (Eds JT Houghton, LG Meira Filho, BA Calander, N Harris, A Kattenburg, and K Maskell), Cambridge University Press, Cambridge.

Additional Resources

Glaciology on the World Wide Web – An excellent resource with links to sources of glaciology images and data, publications and research, and glaciology organizations. http://www-nsidc.colorado.edu/glaciology/

World Glacier Inventory – Data from over 67,000 glaciers around the world, including glacier location, area, length, orientation, elevation, and classification of type. http://www-nsidc.colorado.edu/NSIDC/CATALOG/ENTRIES/G01130.html

Diaz, H.F., M. Beniston, and R.S. Bradley, 1997. *Climatic Change at High Elevation Sites*, Kluwer Academic Publishers, Dordrecht, Netherlands, 298 p.

Global Warming: Early Warning Signs

www.ucsusa.org / www.climatehotmap.org

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Arctic and Antarctic Warming

Climate change is expected to be more rapid and severe in polar regions compared to other places on Earth. Several positive feedback mechanisms exist, particularly for the Arctic, that can amplify the impacts of anthropogenic global warming. Decreases in the extent of snow and ice cover, for example, will lower surface reflectivity (albedo). As a result, incoming solar radiation will be absorbed by the darker surfaces, thereby enhancing warming of ocean and land. Similarly, a northward shift of biomes will lead to growth of more and taller vegetation in previously sparsely vegetated areas, which also lowers albedo.

Although there is some variability among models, most projections indicate that increased CO_2 concentrations will lead to a polar warming that is greater than the global average, with more warming over land than sea and the maximum warming occurring in winter (Kattenberg et al., 1996). Already, observed temperature trends in the polar regions indicate that significantly greater warming has occurred there over the past few decades compared to the global average. Other expected changes are increased precipitation and soil moisture in winter, a reduction in the strength of North Atlantic currents, and a reduction in the diurnal temperature range.

There is substantial evidence that the Arctic climate is warming (e.g., Dickson, 1999; Weller and Anderson, 1998). Average annual temperature in the Arctic has increased by about 1°C over the last century—a rate that is approximately double that of global average temperatures (IPCC, 1998). Winter temperature trends show about a 2°C warming trend over nearly 100 years (Everett and Fitzharris, 1998). In both cases, the century-long warming is characterized by long-term fluctuations, with rapid warming in the last three decades. This recent warming has been accompanied by decreases in the extent and thickness of sea ice, increases in borehole temperatures in permafrost and permafrost thawing, and later freeze-up and earlier break-up dates for river and lake ice. Permafrost warming has been reported in Russia, China, Alaska, and western Canada (Osterkamp et al., 1998). Where the permafrost has a high ice content, extensive thaw has resulted in ground settlement of as much as 5 to 10 meters—damaging houses, roads, airports, and pipelines.

There is growing evidence that the Arctic Ocean sea-ice cover is in a period of rapid transition (see Kerr, 1999). Satellite monitoring since the 1970s has revealed a decline in the total areal extent of Arctic sea ice at a rate of about 3% per decade (Johannessen et al., 1995). A new analysis shows that the area of multiyear ice is declining more rapidly, by 7% per decade since 1978 (Johannessen et al., 1999). Furthermore, during the 1990s there were four summers in which the extent of sea ice was the smallest ever observed (USGCRP, 1999). Sea-ice thickness also appears to be declining. A study of data collected on submarine cruises shows that mean ice draft (thickness from the ocean surface to the bottom of the ice pack) for 29 stations decreased by 1.3 meters compared to 20 to 40 years ago, representing a 40% reduction in ice volume (Rothrock et al., 1999). This thinning is considered remarkable in that it occurs across the entire deep Arctic Ocean basin. Although many scientists attribute sea-ice changes to a natural fluctuation in atmospheric circulation—known as the Arctic Oscillation—recent modeling indicates that the observed ice loss trends are much larger than would be expected from natural climate variations alone (Vinnikov et al., 1999).

Evidence also exists that the Antarctic Peninsula, the northernmost section of Antarctica, is warming. Researchers from the British Antarctic Survey report a warming trend of 2.5°C since the 1940s. The 1998-99 retreat of two smaller ice shelves has been attributed to the regional warming, which has caused the annual melt season to increase by 12 days over the last 20 years (NSIDC, 1999). The shelves are apparently weakened by ponded meltwater on the surface and thus become more susceptible to fracturing. Rather than calving relatively large bergs at their front in a few major calving events, the shelves are shattering into thousands of smaller bergs that are then dispersed by storms, wind, and waves. The 1998-99 disintegration events were unusual in their magnitude—3,000 sq. kilometers were lost from the Larsen B and Wilkins ice shelves in a single year, compared to 7,000 sq. kilometers for all ice shelves in the region over the last 50 years.

Any climate change that shifts the freeze-thaw line either in time or space will cause important impacts on physical, biological, and human systems (Everett and Fitzharris, 1998). The indigenous peoples of the Arctic depend heavily on the natural resources and healthy functioning of ecosystems. The Yupik and other groups have already experienced the impacts of a changing, warming Arctic climate (USGCRP, 1999). They report delays, for example, in the formation of sea ice as well as early melt and deterioration that have delayed or decreased the length of the hunting season. They also have observed the prevalence of more rain, fog, and cloudy skies during the "drying season" (spring and summer), when traditional foods are air-dried for storage for the coming months.

Biological systems are impacted in similar ways. Lack of ice or poor ice conditions often mean that newborn seal and walrus pups do not have sufficient time to wean properly and will not survive. Sea ice also serves as a seasonal migration route for polar bear and Arctic island caribou. Heavier snowfall and freezing rain events will increase the energy expenditure of caribou and reindeer when migrating and searching for food, and could lead to significant population declines over time (Gunn and Skoglund, 1997).

References

Dickson, B., 1999. All change in the Arctic. *Nature* 397, p. 389-391.

Everett, J.T. and B.B. Fitzharris, 1998. The Arctic and Antarctic. In *The Regional Impacts of Climate Change: An Assessment of Vulnerability*, 85-103, (Eds RT Watson, MC Zinyowera, RH Moss), Cambridge University Press, Cambridge, UK.

Gunn, A.and T. Skogland, 1997. Responses of caribou and reindeer to global warming. *Ecological Studies* 124, 189-200.

IPCC, 1998. *The Regional Impacts of Climate Change: An Assessment of Vulnerability*, (Eds RT Watson, MC Zinyowera, RH Moss), Cambridge University Press, Cambridge, UK.

Johannessen, O.M., E.V. Shalina, and M.W. Miles, 1999. Satellite evidence for an Arctic sea ice cover in transformation. *Science* 286, 1937-1939.

Johannessen, O.M., M.W. Miles, E. Bjorgo, 1995. The Arctic's shrinking sea-ice. *Nature* 376, 126-127.

Kattenberg, A., F. Giorgi, H. Grassl, G. A. Meehl, J. F. B. Mitchell, R. J. Stouffer, T. Tokioka, A. J. Weaver, and T. M.L. Wigley, 1996. Climate models - projections of future climate. In *Climate Change 1995: The Science of Climate Change*, 285-357, (Eds J. T. Houghton, L. G. M. Filho, B. A. Callander, N. Harris, A. Kattenberg, and K. Maskell) Cambridge University Press, Cambridge, UK.

Kerr, R.A., 1999. Will the Arctic Ocean lose all its ice? *Science* 286, 1828.

NSIDC, 1999. Antarctic ice shelves breaking up, due to decades of higher temperatures. National Snow and Ice Data Center, 7 April1999. http://www.colorado.edu/PublicRelations/NewsReleases/1999/35.html

Osterkamp T.E., D.C. Esch, and V.E. Romanovsky, 1998. Permafrost. In *Implications of Global Change in Alaska and the Bering Sea Region. Proceedings of a Workshop, June 1997*. (Eds. G. Weller and P. Anderson) Center for Global Change and Arctic System Science, University of Alaska Fairbanks, Fairbanks, Alaska. 157 p.

Rothrock, D.A., Y. Yu, and G.A. Mayhut, 1999. Thinning of the Arctic sea-ice cover. *Geophysical Research Letters* 26 (23), 3469-3472.

USGCRP, 1999. Arctic sea-ice: changes, causes, and implications. US Global Change Research Program Seminar Series, 20 April 1999. http://www.usgcrp.gov/usgcrp/990412FO.html

Vinnikov, K.Y., A. Robock, R. J. Stouffer, J.E. Walsh, C.L. Parkinson, D.J. Cavalieri, J.F.B. Mitchell, D. Garrett, V.F. Zakharov, 1999. Global warming and Northern Hemisphere sea ice extent. *Science* 286, 1934-1937.

Weller, G. and P. Anderson (eds.), 1998. Implications of Global Change in Alaska and the Bering Sea Region. Proceedings of a workshop, June 1997. Center for Global Change and Arctic System Science, University of Alaska Fairbanks, Fairbanks, Alaska. 157 p.

Additional Resources

NSIDC Antarctic Ice Shelves and Icebergs – This website contains satellite images and information about the breakup of ice shelves in 1995 and 1998-99.
http://www-nsidc.colorado.edu/iceshelves/

Downpours, Heavy Snowfalls, and Flooding

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Downpours, Heavy Snowfalls, and Flooding

An increase in global temperatures will lead to an intensification of the hydrological cycle. This is because an increase in surface air temperature causes an increase in evaporation and generally higher levels of water vapor in the atmosphere. In addition, a warmer atmosphere is capable of holding more water vapor. The excess water vapor will in turn lead to more frequent heavy precipitation when atmospheric instability is sufficient to trigger precipitation events. Intense precipitation can result in flooding, soil erosion, landslides, and damage to structures and crops.

Parallel to the likely increase in heavy precipitation events in winter, increased temperatures will also amplify the drying out of soils and vegetation due to increased evaporation in the summer. This is likely to result in more severe and widespread droughts where and when atmospheric conditions do not favor precipitation (see *Droughts and Wildfires*).

The largest changes in precipitation are expected at mid- to- high latitudes (Kattenberg et al., 1996). Climate models predict an increase in average precipitation in winter at high latitudes due to poleward transport of evaporated moisture from lower latitudes. There is also an increase in the expected frequency and areal extent of intense precipitation over the continents. Predictions for soil moisture changes are less certain; however, models show an increase in soil moisture in high northern latitudes in winter.

Consistent with model predictions, weather observations over the last century indeed indicate an increase in precipitation over land in the high latitudes of the Northern Hemisphere (Nicholls et al., 1996). For the United States, precipitation since 1970 has averaged about 5% more than in the previous 70 years (Karl et al., 1996), and cold season precipitation has increased by almost 10% during the last century. Over the period 1950 to 1990, annual snowfall increased by about 20% over northern Canada and by about 11% over Alaska (Groisman and Easterling, 1994). An increase in snowfall was also observed in the 1960s and 1970s in China. A recent analysis indicates a trend toward increasing streamflow in most regions of the United States (Lins and Slack, 1999), consistent with the observations of a wetter climate.

Some regions have also experienced an increase in extreme precipitation events, as predicted in model simulations (Nicholls et al., 1996). Observations for the last 100 years indicate that extreme precipitation events (more than 2 inches in 24 hours) in the United States have increased by about 20% (Karl and Knight, 1998). Increases in heavy precipitation have also been reported for Japan and northeastern Australia. An increase in the intensity of precipitation increases flood potential. Although streamflow has increased significantly in the United States since the 1940s, however, there has been no increase in peak flows (Lins and Slack, 1999). Further analysis is needed to reconcile the discrepancy between the findings that the increase in US precipitation has been due primarily to an increase in heavy precipitation (Karl and Knight, 1998) and the analysis that streamflows have become less extreme (Lins and Slack, 1999).

Although it is impossible to link a particular weather event directly to increased greenhouse gases, the heavy precipitation events highlighted on the map are examples of the kind of situations that are expected to become more frequent as climate warms. The magnitude of the human influence relative to natural variability is much larger for temperature compared to precipitation and atmospheric circulation, meaning that a "fingerprint" of anthropogenic warming in precipitation records will emerge much more slowly (Wigley et al., 1999). It may be decades before an unmistakable human signal emerges from the natural background noise.

References

Groisman P.Y. and D.R Easterling, 1994. Variability and trends of precipitation and snowfall over the United States and Canada, *Journal of Climate* 7, 184-205.

Karl, T. R, R.W. Knight, D.R. Easterling, and R.G. Quayle, 1996. Indices of climate change for the United States, *Bulletin of the American Meteorological Society* 77 (2), 279-292.

Karl, T.R. and R.W. Knight, 1998. Secular trends of precipitation amount, frequency, and intensity in the United States., *Bulletin of the American Meteorological Society* 79 (2), 231-241.

Kattenberg, A., F. Giorgi, H. Grassl, G.A. Meehl, J.F.B. Mitchell, R.J. Stouffer, T. Tokioka, A.J. Weaver, and T.M.L. Wigley, 1996. Climate models - projections of future climate, in *Climate Change 1995: The Science of Climate Change*, 285-357, (Eds J. T. Houghton, L. G. M. Filho, B. A. Callander, N. Harris, A. Kattenberg, and K. Maskell) Cambridge University Press, Cambridge, UK.

Lins, H.F. and J.R. Slack, 1999. Streamflow trends in the United States, *Geophysical Research Letters* 26 (2), 227-230.

Nicholls, N., G.V. Gruza, J. Jouzel, T.R. Karl, L.A. Ogallo, and D.E. Parker, 1996. Observed climate variability and change, *in Climate Change 1995: The Science of Climate Change*, (Eds J.T. Houghton, L.G.M. Filho, B.A. Callander, N. Harris, A. Kattenberg, and K. Maskell), 133-192, Cambridge University Press, Cambridge, UK.

Wigley, T.M.L., 1999. *The Science of Climate Change: Global and U.S. Perspectives*. Pew Center on Global Climate Change, Arlington, Virginia, 48 p.

Downpours, Heavy Snowfalls, and Flooding

Additional Resources

Frederick, K.D. and P.H. Gleick, 1999. *Water and Global Climate Change: Potential Impacts on U.S. Water Resources*. Pew Center on Global Climate Change, Arlington, Virginia, 48 p.
http://www.pewclimate.org/projects/clim_change.html

NOAA National Climatic Data Center – U.S. Heavy Rainfall – This website gives 24-hour and annual rainfall records for US states along with descriptions of heavy rainfall and flooding events throughout the world since 1993.
http://www.ncdc.noaa.gov/ol/climate/severeweather/rainfall.html

NOAA Meteorological Hazards – This is a gateway for data on meteorological hazards, including floods, droughts, hurricanes, and tornadoes.
http://www.ngdc.noaa.gov/seg/hazard/resource/methaz/metchap_toc61.html

Droughts and Fires

Droughts and Fires

Warmer global temperatures are expected to cause an intensification of the hydrologic cycle, with increased evaporation over both land and water. The higher evaporation rates will lead to greater drying of soils and vegetation, especially during the warm season. Climate models also project changes in the distribution and timing of rainfall. The combination of a decrease in summer rainfall and increased evaporation will lead to more severe and longer-lasting droughts in some areas. Increasing drought frequency has the potential to affect land-based natural and managed ecosystems, coastal systems, and both freshwater quality and quantity. Increasing drought frequency also has the potential to increase the likelihood of wildfires.

Predicted changes in the regional distribution of precipitation are uncertain, primarily because the scale of most climate models is too coarse to resolve important hydrologic processes such as the formation and distribution of clouds and storms. Nevertheless, model projections suggest increased vulnerability to drought for certain areas (Kattenberg et al., 1996). Simulations using higher atmospheric CO_2 levels generally predict drier summers at northern high latitudes (e.g., Gregory et al., 1997). In these regions, less winter precipitation falling as snow and warmer temperatures leads to an earlier drying of soils in the spring, increasing the likelihood of drought. Other areas strongly affected by snow, such as mountainous watersheds, will be similarly affected. An increase in the ratio of rain to snow, accelerated spring snowmelt, and a shorter snow season will lead to more rapid, earlier, and greater spring runoff but reduced summer flow.

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The observed climate trends over the last century have been dominated by increasing precipitation, rather than by drier conditions (see *Downpours, Heavy Snowfalls, and Flooding*). Some regional decreases in precipitation have been observed, notably in parts of Africa, the Caribbean, and tropical Asia (IPCC, 1998, Appendix A). There is presently no evidence for an increase in the frequency of droughts in North America over the past century, in part because the severe droughts of the 1930's dominate the historical record (Karl et al., 1996). Studies of past drought variability in the US Great Plains, however, indicate the potential for more severe and frequent droughts in the future (Laird et al., 1996; Woodhouse and Overpeck, 1998), and human-induced warming may exacerbate this natural variability.

The environmental and ecological consequences of the summer 1999 drought in the eastern United States provide examples of situations that may become more frequent as climate changes. Without freshwater to rinse out rivers and streams, salt water encroached further up rivers in many areas of the mid-Atlantic coast (USGS, 1999). The high salt content threatened water supplies in cities that depend on freshwater from rivers and prevented farmers in some areas from irrigating their crops. Decreased freshwater runoff also led to increased salinity and low oxygen conditions in Chesapeake Bay, causing fish kills and other ecological changes. As future sea level rise shifts the saltwater-freshwater boundary farther inland, droughts will exacerbate the geographic extent and impacts of saltwater encroachment into coastal aquifers.

Susceptibility to wildfires increases during periods of drought. During 1997-98, the strong El Niño was associated with extremely dry conditions and large forest fires in many areas of the world, including Indonesia, eastern Russia, Brazil, Central America, and Florida. Although "slash-and-burn" land clearing methods and accidents triggered many of the fires, the severe drought conditions allowed them to spread out of control. Droughts have been relatively frequent since the late 1970s in some areas where drought usually accompanies El Niño events (e.g., north-east Australia) (Nicholls et al., 1996). This presumably reflects the relatively frequent El Niño events during this period. A new study suggests that climate change may produce a quasi-permanent/stable El Niño-like condition in the Pacific basin, interrupted by more extreme cold (La Nina) events (Timmerman et al., 1999). If the frequency of strong El Niños increases, the frequency and severity of droughts and forest fires may also increase, with potentially devastating effects on ecosystems if the increased fire frequency prevents the regeneration of certain species and ecosystems.

References

Gregory, J.M., J.F.B. Mitchell, and A.J. Brady, 1997. Summer drought in northern midlatitudes in a time-dependent CO_2 climate experiment. *Journal of Climate* 10, 662-686.

IPCC, 1998. *The Regional Impacts of Climate Change: An Assessment of Vulnerability*, (Eds RT Watson, MC Zinyowera, RH Moss), Cambridge University Press, Cambridge, UK.

Karl, T. R, R.W. Knight, D.R. Easterling, and R.G. Quayle, 1996. Indices of climate change for the United States. *Bulletin of the American Meteorological Society* 77 (2), 279-292.

Kattenberg, A., F. Giorgi, H. Grassl, G. A. Meehl, J. F. B. Mitchell, R. J. Stouffer, T. Tokioka, A. J. Weaver, and T. M.L. Wigley, 1996. Climate models - projections of future climate, in *Climate Change 1995: The Science of Climate Change*, 285-357, (Eds J. T. Houghton, L. G. M. Filho, B. A. Callander, N. Harris, A. Kattenberg, and K. Maskell) Cambridge University Press, Cambridge, UK.

Laird, K. R., S. C. Fritz, K. A. Maasch, and B. F. Cumming, 1996. Greater drought intensity and frequency before AD 1200 in the Northern Great Plains, USA. *Nature* 384, 552-554.

Nicholls, N., G.V. Gruza, J. Jouzel, T.R. Karl, L.A. Ogallo, and D.E. Parker, 1996. Observed climate variability and change, *in Climate Change 1995: The Science of Climate Change*, (Eds J.T. Houghton, L.G.M. Filho, B.A. Callander, N. Harris, A. Kattenberg, and K. Maskell), 133-192, Cambridge University Press, Cambridge, UK.

Droughts and Fires

Timmerman, A.J. Oberhuber, A. Bacher, M. Esch, M. Latif and E. Roeckner, 1999. Increased El Nino frequency in a climate model forced by future greenhouse warming. *Nature* 398, 694-696.

USGS, 1999. 1999 Summer drought may become century's worst – Mid Atlantic region experiencing most dramatic effects. News Release, U.S. Geological Survey. 2 August 1999.

Woodhouse, C.A. and J.T. Overpeck, 1998. 2000 years of drought variability in the central United States. *Bulletin of the American Meteorological Society* 79 (12), 2693-2714.

Additional Resources

"Climate Enhanced Wildfires of 1998" 12 January 1999, National Climatic Data Center. http://www.ncdc.noaa.gov/ol/climate/research/1998/ann/extremes_fires.html

"Florida Wild Fires and Climate Extremes" 29 June 1998, National Climatic Data Center, NOAA
http://www.ncdc.noaa.gov/ol/climate/research/1998/fla/florida.html

Frederick, K.D. and P.H. Gleick, 1999. *Water and Global Climate Change: Potential Impacts on U.S. Water Resources*. Pew Center on Global Climate Change, Arlington, Virginia, 48 p.
http://www.pewclimate.org/projects/clim_change.html

National Drought Mitigation Center – This site provides information on drought science and climatology, as well as links to additional drought-related resources.
http://enso.unl.edu/ndmc/

Trenberth, Kevin E. 1999. The extreme weather events of 1997 and 1998. *Consequences* 5(1), 3-15.
http://www.gcrio.org/CONSEQUENCES/introCON.html

Bibliography: Climate Change and Impact on US Water Resources – Over 860 citations from the peer-reviewed literature on climate change and water in the U.S., compiled by the Pacific Institute.
http://www.pacinst.org/CCBib.html

UNION OF
CONCERNED
SCIENTISTS

February 9, 2000

Roger Ballentine
Deputy Assistant to the President for Environmental Initiatives
The White House
1600 Pennsylvania Avenue, NW
Washington DC 20500

Dear Roger:

In the event you haven't seen them yet, I've enclosed a few copies of the global climate map we put together with colleagues from several other organizations. It illustrates incidences where climate change is already being felt and events that are indicative of changes to come. As you may know, the map generated a two page spread in *Time* magazine.

Also enclosed are some copies of a report on the impact of climate change on California. This report is part of series we've begun to make the issue more understandable to folks out in the states. The study was widely covered in the press out there, as you can see from the enclosed clips.

Thanks for your efforts to keep things moving over the last month!

Sincerely,

Howard Ris
Executive Director

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Los Angeles Times

THURSDAY, NOVEMBER 4, 1999

Major Climate Changes Predicted for California

■ **Ecology:** Report says warming may intensify floods, droughts and other El Nino effects. Critics question models.

By MARLA CONE
TIMES ENVIRONMENTAL WRITER

Widespread changes in California's natural resources—from major shifts in ocean life to a higher sea level that could intensify coastal flooding—are "highly certain" over the next 100 years because global warming is expected to cause temperatures to rise by several degrees statewide, a team of seven scientific experts predicted in a report to be released today.

An increase in some of the most dramatic events feared by disaster-weary Californians—wildfires, landslides, droughts and severe El Niño storms—is considered likely too, although the scientists reported them as less certain.

The findings are based on a 1995 prediction from a United Nations panel of climate experts that global temperatures will rise by two to six degrees Fahrenheit in the next century. In California, climate modelers have predicted that winters will be five to six degrees warmer and summers one to two degrees hotter.

Many scientists believe the cause of the warming of the global climate is greenhouse gases released by the burning of oil, coal and gasoline as well as other human activities. The gases trap solar energy and increase surface temperatures. Others note, however, that natural fluctuations in climate cannot be ruled out as a cause.

In the new report, which acknowledges many uncertainties, the seven scientists, mostly from Stanford University and UC Santa Barbara, described the probable scenario in California as wetter, warmer winters and drier, hotter summers. They also reported the possibility of "an amplified version" of El Niño, the wintertime phenomenon of warm ocean currents that hits California with se-

Please see WARMING, A12

WARMING

Continued from A1

vere storms.

Some changes "could shape the overall experience of living in California—enough to have a significant impact," said Christopher Field, a Stanford professor and Carnegie Institution of Washington plant biologist who specializes in global warming and served as lead author of the report. "It would not be fair to say that we saw evidence of impending total disaster. But the climate changes are important and worth thinking about and planning for."

Convened to assess the ecological impacts that projected rates of global warming could have on California, the scientists were commissioned by two science-based interest groups: the Union of Concerned Scientists and the Ecological Society of America. Their work was reviewed by a steering committee of seven other scientists.

Most climate experts agree that global warming is occurring—they estimate surface temperatures have risen one degree over the past century—but the potential impact and pace remains extremely controversial. There is considerable uncertainty about computer models that predict changes in specific regions, as the California team has attempted to do.

"The regional impacts are just beyond the ability [of computer models]. Everything is speculation," said Russell Jones, director of climate issues at the American Petroleum Institute, which represents oil companies. "Even if there is climate change, it's hard to ferret out what are the benefits and what are the damages. It's a terribly complicated subject."

One climate expert on the team's steering committee, Steven Schneider of Stanford, called the report "an antidote to the shrill pronouncements of those who claim either certain catastrophe or no big deal" from global climate change.

Also, Nobel laureate Mario Molina of the Massachusetts Institute of Technology, an atmospheric chemist, said in a statement that the study "adds to the growing evidence that climate change will bring serious impacts to some parts of the United States."

Because California's ecosystems are highly dependent on water, the report says "changes in the timing or amount of precipitation over the next century are likely to have a greater impact than changes in temperature."

When it comes to global warming, Field said, "California's environment has a couple points of special vulnerability and those are points related to water resources and wildfire."

One of the most disturbing impacts, he said, could be increased scarcity of water—already a resource that invokes intense battles in California between agricultural, urban and environmental interests.

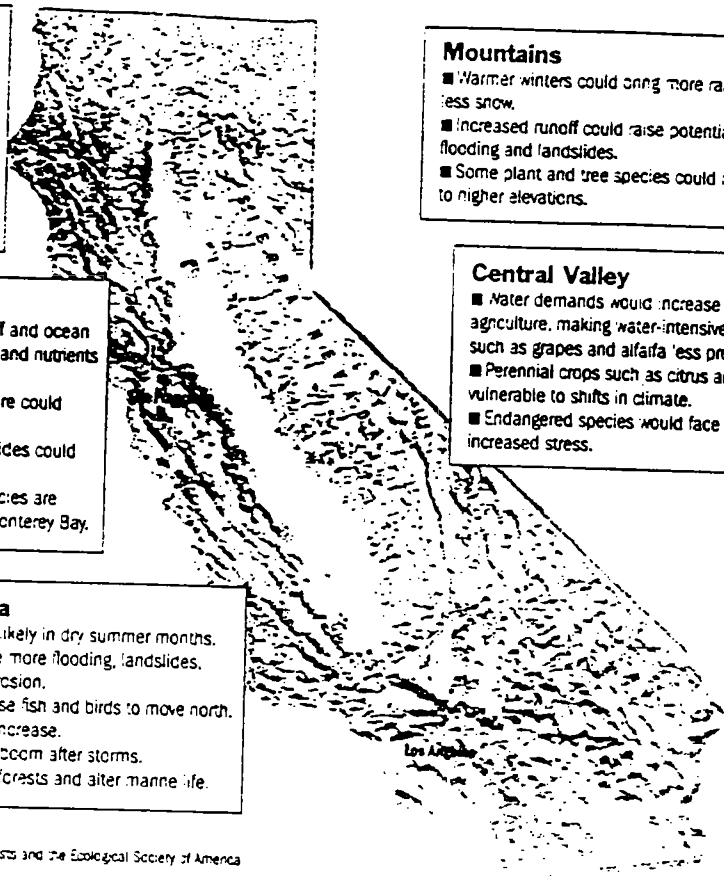
Warmer temperatures are likely to mean that more winter precipitation will fall as rain rather than snow, decreasing the Sierra snowpack that stores water, on which Californians rely year-round. Also, warmer temperatures in summer could aggravate the water losses by increasing evaporation, Field said.

The team reported that the largest ecological changes could come in the ocean, because California's marine ecosystems are more sensitive to climate change than terrestrial ones. Ocean temperature and circulation can dramatically alter the food web, from plankton and invertebrates to fish, sea birds and mammals.

Field said scientists have already documented "dramatic changes in marine communities

Changing Seasons

A group of seven scientists predicts that California's ecology—from its giant redwoods to its popular beaches—will be altered by global warming. Climate models for California project that within 50 years, winters could warm by 5 or 6 degrees while summers could warm by 1 or 2 degrees.



Northwest Coast
- Coastal fog conditions could change, which could be unfavorable for growth of old redwoods.
- Vegetation could shift to higher elevations.
- Some plant species could be threatened.

Mountains
- Warmer winters could bring more rain and less snow.
- Increased runoff could raise potential of flooding and landslides.
- Some plant and tree species could migrate to higher elevations.

The Bay Area
- Decreased summer runoff and ocean warming could alter salinity and nutrients in the bay.
- High tides that are now rare could become common.
- Beach erosion and landslides could increase.
- Warmer-water animal species are already moving north into Monterey Bay.

Central Valley
- Water demands would increase for agriculture, making water-intensive crops such as grapes and alfalfa less profitable.
- Perennial crops such as citrus are vulnerable to shifts in climate.
- Endangered species would face increased stress.

Southern California
- Fires could become more likely in dry summer months.
- Winter storms could cause more flooding, landslides, polluted runoff and beach erosion.
- A warmer ocean could cause fish and birds to move north.
- Toxic algae blooms could increase.
- Rodent populations could boom after storms.
- Storms could disturb kelp forests and alter marine life.

Source: The Union of Concerned Scientists and the Ecological Society of America

Los Angeles Times

Sacramento, CA
BEE
Sacramento
Met Area
Thursday 0 293,737
NOV 4, 1999

Global warming report: More big storms in state's future

By John D. Cox
Bee Staff Writer

A future of more frequent major storms and less reliable water supplies emerges from the first comprehensive study of the effects of global warming on California.

A report of the two-year investigation by a team of seven scientists is being released today in San Francisco and Los Angeles by the Union of Concerned Scientists and the Ecological Society of America.

"The likelihood of extreme weather events is clearly going to increase," said Norman L. Miller, research meteorologist at the Regional Climate Center at Lawrence Berkeley National Laboratory and an author of the study.

While the picture is not "gloom and doom," he said, changes that might appear gradual and benign in many areas can be especially troublesome to a metropolitan area such as Sacramento that lives on the edge of a flood threat many winters.

The report points to a variety of environmental impacts, including more landslides in the mountains and along the coast and a greater threat of wildfires. Patterns of crop and natural plant growth could change, and warming ocean temperatures could accelerate the shift away from commercial northern fish species such as rockfish to noncommercial southern species.

But it's the weather that will be noticed by most Californians.

Daytime and nighttime average temperatures may be noticeably warmer over time, the report noted, but the more dramatic changes will be the increased frequency of major storms that punctuate the long-term trend.

Although the idea of global warming remains the subject of debate in political circles, the mainstream of climate scientists regard it as established fact. The average temperature of the lower atmosphere has increased nearly 1 degree in the past century and the pace of the rise is increasing along with the buildup of industrial greenhouse gases.

Please see CLIMATE, back page, A16

Climate: Snowpack acts as big reservoir

Continued from page A1

"The dissenters are those with some special interest at this point in time," said Miller.

The argument now is about the pace of warming and its effects.

"The timing of stream-flow is going to be earlier in the season than what we know now," said Miller. This means that in the Sierra Nevada the earlier onset of melting snow could eventually intersect with the time of heavy rainfall.

Such a trend already is evident on the American River, he said, where measurements show that in the past 30 years the Sierra snowmelt is beginning earlier in the season.

"Now if that is significantly earlier, and there's a number of storms coming through, then the likelihood of flooding through the city will increase," Miller said.

Extreme storms provoked by more frequent and intense El Niño winters are likely, the report says, and a projected one-foot sea level rise will open the Sacramento-San Joaquin Delta – linchpin of the state's water system – to the threat of levee failures and flooding.

Among the environmental effects of warming, the scientists cited some that already are under way. Offshore, recent warming of the California Current has led to population declines of tiny zooplankton and seabirds known as sooty shearwaters. Since the 1970s, Southern California's kelp forests have seen a 50 percent drop in cold-water fish such as greenspotted rockfish and a similar boost in warm-water species.

Both California winters and summers will become warmer, the report said, although the winter warming is more pronounced and its implications are more profound. It cites one key climate model that projects warming of 4 degrees in the western United States by 2030-2050, which corresponds to 5 degrees in winter, 2 degrees in summer.

"Most of California's precipitation falls in winter, and in the future more of it is likely to fall as rain, less as snow, a change that is likely to lead to increased winter runoff and decreased summer stream flow," the report said.

Such shifts in seasonal precipitation patterns would be especially difficult in a state so reliant on large-scale water storage and transportation.

The warming-climate scenario of more rainfall in winter but less snowfall suggests the worst of both worlds – a greater threat of winter flooding, yet less stored water to supply the state through the long dry months of summer.

At present, the season of Sierra Nevada snowmelt begins in May, replenishing the major reservoirs after they have done double duty protecting downstream populations from winter flooding.

Losing the big snowpack sooner is like losing the storage benefits of a major reservoir in the system.

"We're a very water-dependant state," said Miller. "And we're highly vulnerable to any change in what we know is our current amount."

In addition to Miller, the researchers included Stanford University environmental scientists Christopher B. Field, Gretchen C. Daily and Pamela A. Matson, and from the University of California, Santa Barbara, biologists Steven Gaines and John Melack and environmental specialist Frank W. Davis.

The scientists noted that "although the driving forces behind greenhouse warming are global in scale," the state was not powerless to deal with its effects.

"Limiting the footprint of development on the landscape, particularly in vulnerable habitats such as wetlands and areas subject to fires, floods, and landslides, is probably the most important action Californians can take," they said.

San Luis Obispo, CA
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NOV 4, 1999

LUCE P1462
PRESS CLIPPINGS

Global warming may scorch state

Study says California can expect hard times environmentally

LOS ANGELES (AP) — Global warming could threaten California's environment, possibly creating water shortages and a higher sea level that could increase coastal flooding, according to a study on the impacts of climate change.

An increase in wildfires, landslides and droughts is also considered likely in the next century, although scientists said these are less certain predictions.

The two-year study, to be released today in Los Angeles by the Cambridge, Mass.-based Union of Concerned Scientists and The Ecological Society of America, found that anticipated warmer and wetter winters in the state and hotter summers caused by climate change pose "a range of serious challenges for the state's environment and economy."

"We reached the conclusion that the possible ecological consequences are wide reaching and of serious concern that deserves much broader discussion by policy makers and the public alike," said Frank W. Davis, a geography professor at the University of California at Santa Barbara.

Davis and six other ecological scientists from the Carnegie Institution, Stanford University, UCSB and Lawrence Berkeley National Laboratory conducted the study. A steering committee of seven other scientists reviewed their findings.

"It would not be fair to say that we saw evidence of impending total disaster," said lead author Christopher Field, a Stanford professor and Carnegie plant biologist who specializes in global warming. "But the climate changes are important and worth thinking about and planning for."

The findings are based on a 1995 prediction from a United Nations panel of climate experts that estimated global temperatures will rise by 2 to 6 degrees Fahrenheit in the next century. Researchers have predicted that by 2030 to 2050, winters here will heat up between 5 and 6 degrees and summers will warm by 1 to 2 degrees.

"These are temperature changes that are larger than we experienced in recent history," Davis said.

The report found that hotter winters will mean more rain instead of snow during winter months. Less water will be stored in snow pack and more water will immediately run off, adding to winter flooding and landslide problems in the state, Davis said.

Nobel laureate Mario Molina, an atmospheric chemist at the Massachusetts Institute of Technology who was not involved in the study, said in a statement that it "adds to the growing evidence that climate change will bring serious impacts to some parts of the United States."

Ventura, CA
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LUCE PRESS CLIPPINGS

Ventura, CA
COUNTY SUNDAY STAR
EAST COUNTY ED
Oxnard – Simi Valley – Ventura
Met Area
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LUCE PRESS CLIPPINGS

Editorials

Prudence dictates a plan for disaster

CLIMATE CHANGE: *Report gives Californians a good idea of what to expect in warmer world.*

There's not much new in the report issued last week about the likely effects of global warming on California. Since the 2,500-member Intergovernmental Panel on Climate Change concluded in 1995 that the Earth is warming as a result of human activity, there have been many conferences and scientific reports analyzing possible effects on this coastal state.

Scientists at a California Academy of Sciences meeting in October 1996, for example, forecast severe consequences for the state's water supply, as a rising sea level put pressure on fragile Delta levees and changing precipitation patterns reduced the annual snowpack. They also projected harmful effects on agriculture and natural ecosystems.

The report issued last week under the auspices of the Union of Concerned Scientists and the Ecological Society of America repeats these warnings, and adds plenty of details about others. It is a summary of hundreds of recent studies, and although it doesn't really break new ground, it is useful in that it pulls together all the data now available. It correctly notes the uncertainties inherent in the study of climate, and does a good job of suggesting what California might look like if currently observed trends continue.

It is important to keep that phrase in mind: "If currently observed trends continue."

Those with a stake in the continued use of fossil fuels — petroleum refiners, automobile manufacturers, coal and natural-gas producers — have created a huge public-relations machine with the sole purpose of persuading consumers and politicians that global warming is an unproven theory.

Because absolute certainty is unattainable in any field of science, and because climatology is a more complex study than most, much is still unknown about the degree to which human activity might be contributing to global warming. The fossil-fuel industry has seized on every uncertainty as proof that the entire notion is a fraud and that nothing need be done to decrease the production of greenhouse gases.

It is a fact, however, that atmospheric carbon dioxide levels have increased dramatically since the beginning of the industrial age. It is a fact that average global temperatures have risen in this century. It is a fact that the frequency of extreme weather events has increased in the past 25 years. It is a fact that spring snow cover has decreased in the Northern hemisphere. It is a fact that the geographic ranges of plants and animals have already begun to shift in response to changing average temperatures. These are not theorized events; they are happening now.

The argument about how much of this is due to natural fluctuations and how much is due to our appetite for fossil fuels is nearly irrelevant. It seems prudent to do what can be done now to decrease any human contribution. It also seems prudent to begin planning for the repercussions, which will be the same regardless of whether nature or humankind is to blame.

As the new report points out, California's water supply is particularly vulnerable to the sort of changes expected as temperatures rise by a degree or two. The entire system of reservoirs, dams and aqueducts is predicated on the pattern of modest winter rainfall and copious spring runoff from a huge winter snowpack. Reservoirs are drawn down in winter to make room for the spring flood, which refills them and provides a continuous supply for farms and cities during the rainless summer and fall.

Change that to heavy winter rain and anemic snowfall, and you throw the entire system out of whack. Water will have to be released all winter to keep runoff from overtopping the dams, but there will be no spring flood to refill the reservoirs.

It is not alarmist to prepare to cope with a disaster that might never occur. Nobody knows this better than Californians, who live with the omnipresent threat of earthquake, fire, flood and landslide. Hope for the best; plan for the worst. It would make a good state motto. And it's the best way to approach this topic.

Post-it® Fax Note 7671	Date 11/30/99 # of pages ▶ 2
To Susi' Moser / Camb.	From Michael / Berk.
Co./Dept.	Co.
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Thursday, November 18, 1999,
San Jose Mercury News
By Dianne Feinstein

CALIFORNIA, long in the vanguard of environmental protection, now finds itself a leader in the fight to curb global warming. Over the past two decades, our state has developed important strategies to reduce carbon dioxide emissions and other greenhouse gases. As a result, California's per capita carbon dioxide emissions are nearly 40 percent lower than the national average. Unfortunately, the U.S. government lags far behind.

If we don't act soon to combat global warming, our state, our nation, and our planet will suffer. Last year was the hottest on record and 10 of the hottest years have occurred since 1986. The earth's average temperature has risen 1.3 degrees in the last 100 years and computer models predict an increase of 2 to 6 degrees by 2100. These changes may seem small, but just a few up-ticks in temperature can produce catastrophic conditions. Amazingly, many in Congress question whether we even have a problem. In California, global warming could make water even more scarce, create further flooding, destroy certain agricultural crops and lead to more frequent and intense Sierra forest fires.

In a normal winter, California's water gets stored in snow packs until spring. But with climbing temperatures, the melting snow can often flood low-lying areas. In other areas of the state, drought conditions may worsen, thereby destroying water-dependent crops such as rice, cotton and alfalfa.

Meanwhile, sea levels could rise by a foot or more over the next century further flooding low-lying areas and greatly increasing the penetration of saltwater into the Delta which is the source of drinking water for two-thirds of the state. To combat global warming, this nation must accomplish three important tasks:

1. Improve the fuel efficiency of our vehicles: Without a doubt, improving fuel economy is the most important first step the U.S. can take to curb global warming. Today, fuel standards average 27.5 miles per gallon for automobiles and 20.7 miles per gallon for sports utility vehicles (SUVs) and light trucks. The standards have remained constant for a decade, but since many consumers have traded in their cars for SUVs, overall carbon dioxide emissions are increasing significantly. If SUVs were required to meet the same fuel economy standards as automobiles, we would prevent the emissions of 187 million tons of carbon dioxide each year and reduce the overall carbon dioxide vehicular emissions by 12 percent.

Unfortunately, some members of the House of Representatives were successful in attaching a provision to the FY 2000 Transportation Appropriations bill to prevent the Department of Transportation from even studying the issue of fuel economy standards and whether they should be raised. This was the sixth straight year that the Congress prevented any change or even the studying of the issues.

Earlier this year, 42 Senators voted to support a study of fuel economy standards, but the auto manufacturers prevailed in keeping the status quo.

2. Increase the use of renewable energy: Energy use by buildings and appliances account for a quarter of California's carbon dioxide emissions. We can solve this problem by providing necessary tax
credits and other incentives for energy efficient building and appliances.

By operating more efficiently, we not only reduce waste and pollution that contribute to global warming and other environmental problems, we also save consumers and businesses money in the process.

I have co-sponsored legislation by Vermont Sen. Jim Jeffords to promote the use of renewable fuels. To cut costs, many electric companies have increased the use of cheap and dirty coal plants at the expense of clean and efficient energy technologies. This bill would increase the use of renewable energy and attempt to phase out unclean technologies such as the burning of coal. Ultimately, consumers would see lower electricity prices. Promoting efficiency and fuel economy will go a long way toward curbing industrial sources of carbon dioxide.

3. The U.S. Senate must take up and ratify the Kyoto Protocol on climate change. This historic U.N. Framework established in 1997, aims to reduce greenhouse gases by setting emissions targets and timetables for industrialized nations. The treaty will enter into force when 55 countries representing at least 55% of global CO2 emissions sign and ratify the treaty. Even though we are only 4 percent of the world's population, we account for 20 percent of the world's energy use. We should set the pace, not reverse it.

It is time that a real debate on global warming takes place in Congress. As the world's number one contributor of greenhouse gases, it is our responsibility to show leadership. Every day we wait, we lose an opportunity to reduce the threat of global warming. It is not too much to ask the world's economic and political superpower to provide the leadership to address global warming.

Dianne Feinstein is a Democratic senator from California.

Santa Rosa, CA
PRESS DEMOCRAT
Santa Rosa – Petaluma
Met Area
Thursday D 93,016
NOV 4, 1999

In hot seat for global warming

Weather extremes could hit state hard

By JOHN D. COX
Sacramento Bee

SACRAMENTO — A future of more frequent major storms and a less reliable water supply emerges from the first comprehensive study of the impacts of global warming on California.

A report of the two-year investigation by a team of seven scientists is being released today in San Francisco and Los Angeles by the Union of Concerned Scientists and the Ecological Society of America.

"The likelihood of extreme weather events is clearly going to increase," said Norman Miller, research meteorologist at the Regional Climate Center at Lawrence Berkeley National Laboratory, and an author of the study.

While the picture is not "gloom and doom," he said, changes that might appear gradual and benign in many areas can be especially troublesome to areas that already face a flood threat many winters.

The report points to a variety of other environmental impacts, including more landslides in the mountains and along the coast, and a greater threat of wildfires. Patterns of crop and natural plant growth could change and warming ocean temperatures could accelerate the shift away from northern fish species such as rockfish to noncommercial southern species.

But it's the weather that will be noticed by most Californians.

Daytime and nighttime average temperatures may be noticeably warmer over time, the report noted, but the more dramatic changes will be the increased frequency of major storms that punctuate the long-term trend.

Although the idea of global warming remains the subject of debate in political circles, the mainstream of climate scientists regard it as established fact. The average temperature of the lower atmosphere has increased nearly 1 degree in the last century and the pace of the rise is increasing along with the buildup of industrial greenhouse gases.

"The dissenters are those with some special interest at this point in time," said Miller.

The argument now is about the pace of warming and its impact.

"The timing of stream-flow is going to be earlier in the season than what we know now," said Miller. This means that in the Sierra Nevada the earlier onset of melting snow could eventually intersect with the time of heavy rainfall.

Among the environmental impacts of warming, the scientists cited some that already are under way. Off-shore, recent warming of the California Current has led to population declines of tiny zooplankton and seabirds known as sooty shearwaters. Since the 1970s, Southern California's kelp forests have seen a 50 percent drop in cold-water fish such as greenspotted rockfish and a similar boost in warm-water species.

Other environmental shifts they expect include the expansion of grasslands into foothill shrub lands of the Coast Range and the Sierra Nevada, and the expansion of shrubs into higher elevations now dominated by forest.

Both California winters and summers will become warmer, the report said, although the winter warming is more pronounced and its implications are more profound. It cites one key climate model that projects warming of 4 degrees in the western United States by 2030-2050, which corresponds to 5 degrees in winter, 2 degrees in summer.

"Most of California's precipitation falls in winter, and in the future more of it is likely to fall as rain, less as snow, a change that is likely to lead to increased winter runoff and decreased summer stream flow," the report said.

Such shifts in seasonal precipitation patterns would be especially difficult in a state so reliant on large-scale water storage and transportation.

The warming-climate scenario of more rainfall in winter but less snowfall suggests the worst of both worlds — a greater threat of winter flooding, yet less stored water to supply the state through the long dry months of summer.

Eureka, CA
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NOV 4, 1999

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Global warming may help explain decline of salmon

By David Anderson
The Times-Standard

Global warming could be a big factor in the decline of salmon runs in California, a new report says, but the relationship is neither simple nor direct.

Timber industry representatives contend that ocean warming, not spawning stream degradation, is responsible for declines in salmon and steelhead runs. Some add that there's no hard evidence of such decline.

But members of the Union of Concerned Scientists suggest both ocean and freshwater habitat changes may be to blame.

The scientists' group today released a report on the ecological effects of global warming on California's weather, agriculture, forestry, fisheries and other aspects of the state's economy and environment. It says natural warming that started at the end of the 18th century has increased its rate markedly during the past 20 years, probably as a result of human activity.

This climate change puts stress on cool climate trees such as redwoods and Douglas fir, the report says. It also affects rainfall and stream flows, with more winter floods and drier summers. And it could accelerate the decline of salmon and other cold water species.

Norman Miller, a climatologist at the Berkeley National Laboratory, said the relationship between atmospheric warming and water temperature is not direct, as the ocean influences the air and land more than the other way around. But off California, he said, mean annual ocean temperatures have increased by 1 degree since the 1940s, and mean high summer temperatures by 4 degrees.

Biologist Steven Gaines, director of the Marine Science Laboratory at U.C. Santa Barbara, said warmer water reduces nutrients available to fish, seabirds and marine mammals. Since 1977, plankton in the south-flowing California Current have declined by 70 percent.

Off the state's central and southern coasts, he said, cold-water species have dropped by about half, while the percentage of warm-water species is increasing. During the 1997-98 El Niño, sardines and marlin appeared north to San Francisco.

The salmon question is more complex, Gaines said, because they spend only part of their lives in salt water.

"You see wide swings from year-to-year within a long-term downward trend," he

■ See WATER/A2

WATER

FROM A1

said. "But a decline so long and continuous likely means they're getting a double whammy: in fresh water during their very vulnerable juvenile stage, and again as adults in the ocean."

Following the 1982-83 El Niño, the report notes, commercial salmon fisheries as far north as Washington were hard hit.

While warming was gradual for many years, the report states, a large, abrupt rise in ocean surface temperatures occurred off California in 1976-77, and has continued ever since. It was probably caused by a shift in position and intensity of the Aleutian low pressure area, linked to large-scale atmospheric changes that may have partly human causes.

But complicating the picture further, atmospheric warming has increased the intensity of spring and summer winds on the North Coast. That produces more upwelling of cool, deep water, replacing nutrients lost because of surface warming.

"The competing effects of enhanced winds and upwelling vs. surface warming ... means that responses of ocean productivity to climate change are likely to be complex," the report concludes.

Santa Ana, CA
ORANGE COUNTY REGISTER
Anaheim – Santa Ana – Garden Grove
Met Area

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NOV 4, 1999

LUCE PRESS CLIPPINGS P1472

Global warming full of perils, report says

ENVIRONMENT: Floods, fires, landslides may become more frequent.

By PAT BRENNAN
The Orange County Register

Continued global warming in coming decades could bring a host of undesirable effects in Southern California, including more-frequent wildfires, flooding, landslides and disease outbreaks.

So says a report to be released today by the Union of Concerned Scientists, a national activist group that based its predictions on two years of research.

But other climate scientists — and the report itself — say that such predictions come with a dose of uncertainty. The report is based in part on computer models of climate, which have been improving steadily over the past decade.

"Everybody has been hustling to do regional climate assessments," said Michael Prather, an atmospheric scientist at the University of California, Irvine, who did not work on the report. "The question is, how much does the community believe them?"

Although the report acknowledges the uncertainties, it asserts that some long-term trends are likely.

For Orange County and the rest of Southern California, that may well mean warmer winters and increased rainfall. Atmospheric warming can increase precipitation by causing more water to evaporate, producing clouds and rain.

> "Everybody has been hustling to do regional climate assessments."
> MICHAEL PRATHER
> atmospheric scientist

In coastal Southern California, that could translate to increases in storm frequency or intensity.

That could make seasonal flooding and landslides worse, the report says.

Warmer, wetter winters could mean more mosquitoes and mosquito-born diseases. They also could bring a profusion of plant growth, which would increase rodent numbers and, potentially, outbreaks of hantavirus.

Summers may be somewhat warmer, as well. And a corresponding increase in the frequency of Santa Ana winds could fuel more wildfires.

Environmental reporter Pat Brennan can be reached at (714) 796-7865 or patbrennan@link.freedom.com

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SF EXAMINER

Lake Tahoe threatened by global warming

ASSOCIATED PRESS

SOUTH LAKE TAHOE — Global warming could mean more bad news for Lake Tahoe's famous clarity, according to a two-year study released last week by the Union of Concerned Scientists and The Ecological Society of America.

The report said global warming will likely create rainier winters in the Sierra thereby increasing erosion and clouding the lake.

Winter temperatures are expected to rise by 2 to 6 degrees by 2030 to 2050, creating climatic changes that may mean more rain instead of snow in the Tahoe area, the study says.

Less water will be stored in snowpack and more water will immediately run off, adding to winter flooding and erosion, the report says.

Erosion has been a contributing factor to Tahoe's alarming loss of clarity over the last three decades.

"Rain in the Sierra transports much higher concentrations of nutrients and pollutants than does snow," the report says. "A shift to more rain is likely to increase deposition of contaminants into relatively pristine mountain lakes, reducing clarity."

Visibility in the lake once reached down as far as 160 feet, the clearest waters in the world before the logging and mining that followed the Comstock mining boom near Virginia City, Nev., in 1859.

Scientists say visibility now stands at about 60 feet, and it's getting worse.

According to most scientists, greenhouse gases — from burning coal or car exhaust, for example — are to blame for the warming of the earth's surface.

Report Tells of Global Warming's Threat to State

Water shortages, floods, diseases predicted by 2050

By Glen Martin
Chronicle Staff Writer

A new report from a group of California scientists concludes that global warming will pose grave problems for the state in the coming century.

Among the possible scenarios, the scientists warn, are more warm, wet winters that could bring both flooding and water shortages in the same year, more and bigger landslides and an increase in the outbreak of exotic diseases.

"Many of the places we know and love in California are vulnerable to a changing climate," said the report's lead author, Chris Field, a plant biologist at the Carnegie Institution at Stanford University. "A variety of changes are coming, and many will have profound ecological and economic consequences."

Sponsored by the Union of Concerned Scientists and the Ecological Society of America, the two-year study is a collaborative effort by scientists from Stanford, Lawrence Livermore Laboratory, the University of California at Santa Barbara and the Carnegie Institution of Washington. It was based on new climate computer models.

But some climatologists have questioned the study, warning that even the best climate computer models are unreliable when it comes to predicting the regional impacts of global warming.

The report states that California winter temperatures are expected to rise 5 to 6 degrees and that summer temperatures will climb 1 to 2 degrees by 2030 to 2050. The warmer temperatures bode ill for California, the scientists say. Among the possibilities:

■ California could experience simultaneous floods and water shortages. There will be more wet El Niño years, but most of the precipitation will fall as rain, not snow.

The heavy storms would require that floodgates remain open to prevent dam failure. But with scant snowpack, reservoirs would not be able to fill back up.

■ Urban water shortages could become commonplace due to reduced supplies from reservoirs. And water deliveries to agriculture could be severely curtailed because of short supplies, seriously affecting the Central Valley's economy.

■ Heavy El Niño rains could increase the frequency of rodent population booms, contributing to outbreaks of hantavirus, a microbe associated with mice that has been responsible for human fatalities in the Southwest.

■ Catastrophic wildfires could increase, particularly in the southern part of the state.

The report also predicts that California's natural heritage will suffer if temperatures rise significantly. Forests will tend to migrate northward, replaced in their southern ranges by brush or grass. This could result in the degradation of many of the state's remaining old-growth forests. Woodland wildlife populations could experience increasing stress because of habitat destruction.

Reduced summer runoff would harm coastal and Sacramento River salmon runs and increase salinity in San Francisco Bay, adversely affecting estuarine fish. Expected warming of offshore waters would reduce plankton, weakening the bottom rung of the marine food chain. This could devastate game fish, sea birds and marine mammals.

But while scientists are reasonably confident about sophisticated computer modeling projections at the hemispheric and continental scale, they are much less confident at the regional level. Peter Stone, a professor of climate dynamics at the Massachusetts Institute of Technology, says while the report's temperature ranges are correct, the accuracy of the overall results is uncertain.

"I'm not saying their predictions won't happen, but they're speculative," said Stone.

The best authority on global warming predictions, said Stone, is the Intergovernmental Panel on Climate Change, established in 1988 by the United Nations and the World Meteorological Organization. They issue assessments every five years; the last one was in 1996. It concluded that there is greater confidence in climate projections on the hemispheric and continental scale than in regional projections, where the panel concluded "confidence is low." The panel also said it had more confidence in temperature projections than in projections about water supply changes.

San Francisco Examiner

Thursday afternoon
NOVEMBER 4, 1999
LATE SPORTS EDITION
TWENTY FIVE CENTS

How global warming will change California

Study predicts water crisis in next century

By Jane Kay
EXAMINER ENVIRONMENTAL WRITER

Warmer, wetter winters. Hotter, drier summers. Species disappearing and fish stocks in flux. More floods, landslides, wildfires, pests and pestilence.

Signs of the apocalypse?

Actually, those changes are likely in California's future, according to a two-year study released Thursday.

The prestigious panel of the nonprofit Union of Concerned Scientists and the Ecological Society of America concludes that shifts in temperature and rainfall over the next century will probably reduce the already scarce supply of fresh water.

"There's good evidence that the climate will change globally, and it will change in California," said Christopher B. Field, lead author and faculty member of Carnegie

[See WARMING, A-15]

♦ *WARMING from A-1*

Study: Big changes loom for climate

Institution of Washington's Department of Plant Biology on the Stanford University campus.

"The best available evidence indicates warming over the next century of 5 to 6 degrees Fahrenheit in the winter and 1 to 2 degrees in the summer," Field said. "The evidence also indicates wetter winters and probably drier summers. All the changes acting together will have a profound effect on water resources in California."

Some of the predictions of "Confronting Climate Change in California: Ecological Impacts on the Golden State," the 62-page study:

▶ Summer water shortages could intensify competition for water among cities, farms, businesses and ecosystems that depend on rivers and runoff. Grapes, cotton, alfalfa and other crops that use lots of water may reap smaller profits. Droughts could intensify economic and environmental loss from wildfires and damage to forests from pine bark beetles.

▶ Less fresh water entering the Bay would change water salinity, quality and circulation, disrupting the food chain. This could threaten the commercial supplies of anchovies and herring and endangered salmon and steelhead trout.

▶ More winter rain could cause flooding — including along 1,100 miles of Delta waterways — landslides, erosion and risks of water-borne and pest-borne diseases. A one-foot rise in sea level from melting icecaps by 2100 means that reaching high-tide peak on the lower San Joaquin River would change from an event that occurs every 100 years on average to every 10 years.

▶ El Niños, which have had a particularly dramatic effect on California's weather and economy, may increase in intensity and frequency as the climate changes. These turbulent weather patterns would amplify the impact of the rise in sea level on coastal wetlands, agriculture and housing.

Even though winters may be wetter, warmer weather means more of the precipitation would be rain that would fill rivers, the study found, instead of snow that would build a Sierra snowpack.

"That means we'll have much more winter runoff," said Field. "By the time you get into the summer, the stream flow may be less. Warmer summers increase evaporation, which will further increase water shortage."

The Intergovernmental Panel on Climate Change, a group of more than 500 scientists, concluded in 1995 that warming would increase between 2 and 6 degrees Fahrenheit in the next 100 years, the fastest pace in human history.

Most of the climate change is driven by human activities, it said, as carbon dioxide is released by burning fossil fuels, and, to a lesser degree, its removal from the atmosphere is decreased by the cutting of forests. The gas traps solar heat within Earth's atmosphere in a greenhouse effect.

Except for a few dissenting voices, scientists agree the sea level in California will rise by 8 to 12 inches in the next 100 years, two to three times the increase seen in the Pacific Ocean at San Francisco over the past 150 years.

The effects of climate change already have begun in California, some studies show.

For example, a warming of the currents off California in recent decades has been linked to population declines of zooplankton, tiny creatures at the base of the food chain, and of seabirds called sooty shearwaters.

In kelp forests off the Southern California coast, the proportion of northern cold-water fish species has dropped by half since the 1970s. The proportion of southern warm-water fish species has increased nearly 50 percent.

At least one California butterfly species, Edith's checkerspot, is shifting from the southern to the northern limits of its range, a likely consequence of rising temperatures.

Only in the last decade, with more precise models, could scientists predict the regional effects of global climate change. The predictions are still sketchy, but the scientists agree that the changes are likely to vary widely across the state.

One scenario predicts much more rain over California with dry areas to the east of the Cascades and Sierra Nevada. Winter precipitation over the coast and Sierra could rise by 25 percent or more, it showed.

Another shows the strongest warming in the northern Sierra and Central Valley, with increased drought in the southeastern corner of the state.

The state's changing climate could result in major shifts in ecosystems, the study predicts. Grassy savannahs would likely encroach on the arid foothill chaparral of the coastal ranges and the Sierra Nevada. At higher elevations, shrubs could replace forests. Off the north coast, changing current temperatures could influence the fog, which is favorable for redwood forests.

California's ecosystems are already vulnerable, sometimes whittled down to small patches harboring imperiled species.

The panel of scientists recommended limiting fossil fuel emissions. In addition, it advised limiting development to provide more breathing room for ecosystems to deal with climate changes.

"It's not all bad news, and there are some things that can be done," said Field. "We hope the study will help to consider the environmental consequence of future change, and take steps to protect these environmental values."

Ventura, CA
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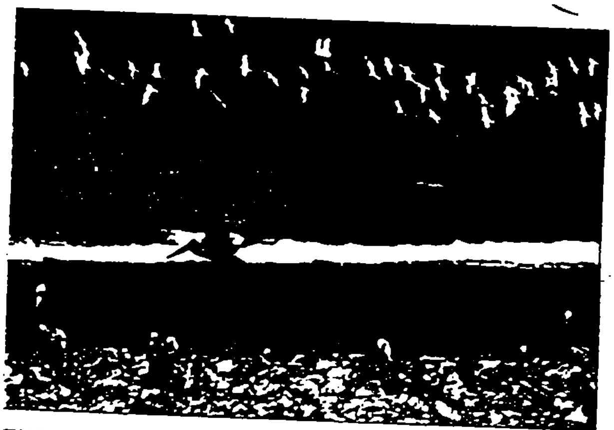
NOV 4, 1999

Southern California could suffer effects of global warming

By Brett Johnson
Staff writer

Global warming will bring profound changes in coming decades to California's diverse environments, including wetter winters with more damaging storms, drier summers with water shortages for crops and humans, less sand at the beach and acid rain that will foul pristine mountain lakes and streams.

Those are among the conclusions a panel of seven scientists — including three from the University of California, Santa Barbara, and three from Stanford University — reach in a report to be released today. Billed as the first-ever comprehensive look at effects from global warming, the study looks at coming changes in the state's 10 primary ecosystems, from the northwestern redwood forests to the Sierra to coastal areas such as Ventura County and onto the southeastern deserts.



THREATENED?
Pelicans at Surfers Point

Please see **WARMING** *on* **A10**

Simi Valley, CA
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WARMING: Opinions differ in a scientific debate gone political

Continued from **A1**

The report also suggests more wildfires in areas such as the Santa Monica Mountains. Not much of it sounds good, but the authors took pains to say it isn't alarmist, dire or reason to panic. They added, however, that the state needs to consider and plan for wide-ranging climate changes and their influence on human activity.

"Taken all together, these impacts are enough to have a serious effect on California's quality of life," said lead author Chris Field, staff scientist at the Carnegie Institution on the Stanford campus.

The two primary things needed, Field said, are limits on emissions of so-called "greenhouse" gases thought to be warming the planet, and limits on the footprint of overall human development in California.

News conferences detailing the two-year study, titled "Confronting Climate Change in California," are to be held today in San Francisco and Los Angeles. The study was directed by the Union of Concerned Scientists and the Ecological Society of America.

The authors looked at hundreds of scientific papers — more than 150 are cited in the report.

"It's a statement of reality, not a gloom-and-doom report," said co-author Steven Gaines, a biology professor and director of UCSB's Marine Science Institute. "It's an enormous synthesis of a huge amount of scientific material."

The report also is another layer on the murky debate over global warming. Although many scientists ascribe to global warming and its far-reaching effects, many others say it doesn't exist and that the climate variations are temporary, natural cycles.

Humankind's effects on the planet seem logical, noted meteorologist Rea Strange, but to make hard-and-fast statements or point blame for specific events is tough to do.

"It's a curious subject because it's always so damn political," said Strange, who runs Pacific Weather in Montecito. "Conservatives hate anyone who says man is causing any changes. But others feel very passionately on the other side.

"We see changes, certainly — glaciers have been melting for years. But no one really knows why."

But Field and other scientists involved say they had neither a political agenda nor wrote from any point of view.

Co-author Norman Miller, a climate scientist at the Lawrence Berkeley National Laboratory on the University of California campus, acknowledged natural variability and that 50-to-100-year cycles might be playing into the effects.

But, he said, the planet's temperature rose half a degree this century alone after it took from 1500 to 1900 to increase by the same amount, the last five years have been the warmest on record, and the 1990s will go down as the hottest decade ever. Those, Miller added, point to outside forces and have been well-observed and documented.

A half-degree rise doesn't seem like much, Miller noted. But if a person's body temperature increases by 1 degree, they have a fever, and if it drops 5 degrees, they're dead, he said.

The report suggests a multitude of possible effects. Sea levels could rise by a foot by 2100, or three times the historical rate as measured in San Francisco. More intense winter storms and El Niño events could bring beach losses and property damage along the coast. Winters will be wetter, but more of it will fall as rain rather than snow, meaning less snowpack in the Sierra that is crucial to summer stream flow.

Crops, such as alfalfa and cotton, that require large amounts of irrigation could be less profitable. Others, such as fruits, grapes and nuts, that live for many years will be more vulnerable to climate changes. More frequent thunderstorms over polluted areas could bring acid rain — now primarily limited to northern tier states and the East Coast — to the Sierra and other mountains.

Off our coast, Gaines said, warmer ocean temperatures have led to declines in plankton, fish, seabirds and other wildlife populations. Already, fish historically more prevalent in southern regions have moved up here, and those cold-water fish once common here have moved north. That, he added, has great ramifications in management of commercial and recreational fishing, and the resource itself.

The scientists said they deal with probabilities and not absolutes.

"These are likelihoods, but we don't know exactly how it's all going to shake out," Miller said.

The United States is the leading emitter of greenhouse gases, and other countries look to emulate its society, the scientists said. Reductions there, combined with reserves for endangered species and preservation of open space, will help keep California looking good.

"We need a little breathing room for both residents and the natural ecosystems," Field said. "I hope this stimulates some serious dialogue about the things we have in California."

Warming effects

A look at just some of the possible effects in California from global warming. It might mean less water when it's needed, and more when it's not.

- An 8- to 12-inch rise in sea levels by 2100.
- Wetter, warmer winters — as much as 6 degrees above normal — with more frequent and intense storms that could cause more property damage and beach loss in coastal areas.
- Most of that will fall as rain rather than as snowpack in the Sierra and Cascades.
- Warmer, drier summers — perhaps 2 degrees above normal — with less water for crops and human consumption.
- Higher risk of wildfire and landslides in the Santa Monica Mountains and other areas.
- At higher elevations, such as the Sierra or the Cascades, shrubs could replace forests and forests could replace tundras.
- Acid rain and more soil in runoff might turn pristine lakes and streams murky.
- Endangered, threatened or isolated species will have few options for coping or adjusting.
- Giant coastal redwoods might remain standing for centuries but be unable to reproduce.

Global warming may tarnish the Golden State

Dire report predicts that water shortages, wildfires and flooding caused by climate changes will plague California in next century.

By MELINDA BURNS
NEWS-PRESS SENIOR WRITER

A bleak report predicting dramatic water shortages, flooding, landslides, wildfires and outbreaks of insects in California for decades to come as a result of global warming will be released today by a team of Western researchers.

The report for the Union of Concerned Scientists and the Ecological Society of America depicts a state under siege in the next century as winters become warmer and wetter and the sea level rises by as much as a foot. More rain and less snow will fall, the study says, and less water will be available during the dry season, when California needs it the most. With hotter, drier summers likely, it warns there will be a greater threat of wildfires like the 1990 Painted Cave Fire in Santa Barbara.

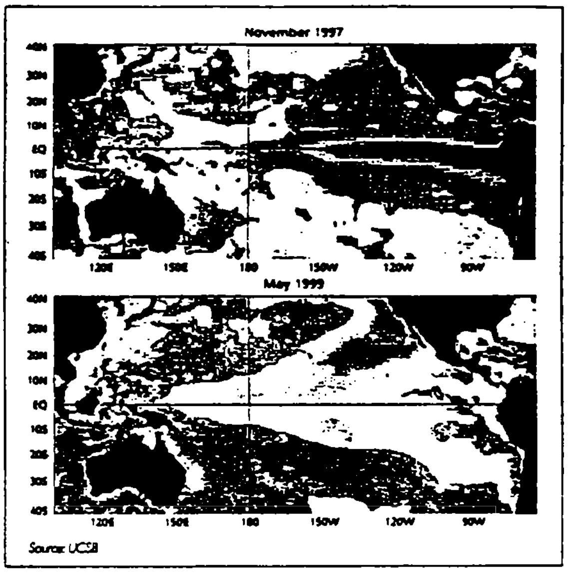
"It's not dire, but it's sobering," said Frank Davis, a UCSB geographer who worked on the two-year study, the most comprehensive to date on the possible impacts of global warming on California.

"I think we're all intuitively in tune with the idea that everything hinges on the weather; and this predicted warming is unprecedented within recent history. It could happen within the lifetimes of our children and grandchildren."

El Niño-spawned storms, like the ones that brought a record 47 inches of rain to Santa Barbara in the winter of 1997-98, could become even more intense or more common because of global warming, the report states. In agricultural areas, it says, warmer temperatures will increase the demand for water, even as less water is available from the Sierra snowpack. Water-intensive crops like alfalfa and grapes, two of California's key commodities, could become less profitable or go out of production altogether.

The average temperature in the state is predicted to rise 5 or 6

SEE CLIMATE ON A2



Dramatic weather patterns like those caused by the warm El Niño current, top, and cool La Niña, bottom could become more frequent and extreme, UCSB and other researchers say.

Warmer winters, drier summers predicted

CLIMATE

Continued from Page A1

degrees Fahrenheit in the winter and 1 or 2 degrees in the summer. That is a seemingly small change, but one that the study says could bring more thunderstorms to the southern deserts, pollute pristine mountain lakes with acid rain, trigger a proliferation of destructive beetles in the forests and push entire species of animals northward where it would be cooler.

"Relatively small changes in averages can have very complicated and far-reaching ramifications," said Steven Gaines, a UCSB marine biologist and a participant in the study. "Patterns in rainfall and distributions in timing play a huge role in the success of ecological systems and farming practices. There are cascading effects. We need to take these issues seriously."

The report, entitled "Confronting Climate Change in California: Ecological Impacts on the Golden State," was prepared by seven scientists, including John Melack, a UCSB biologist. It will be made public at news conferences today in Los Angeles and San Francisco.

The team did not gather original data for this study, but rather, used existing climate scenarios and ecological censuses to determine the possible consequences of global warming.

In California, a population of more than 30 million people has obliterated much of the natural landscape with urban sprawl and farmland. Californians make up 0.5 percent of the world population, yet they consume 2 percent of its fossil fuel, releasing, in the process, more than 400 million tons of carbon dioxide per year into the atmosphere, largely through their dependence on the automobile.

NEWS-PRESS FILE

Researchers predict drier conditions caused by global warming will contribute to an increase in destructive California wildfires, like the 1990 Painted Cave Fire.

Carbon dioxide is a greenhouse gas — that is, it traps solar energy within the atmosphere, heating up Earth's surface. Even if all production of carbon dioxide stopped today, the global warming trend would continue for many years, many scientists believe.

There are 10 distinct natural ecosystems, or communities of plants and animals, in California, ranging from the cool, wet redwood forests of the North Coast to the hot, dry Mojave and Colorado deserts of the southeast. Many of those ecosystems are highly sensitive to the availability of water. Thus, according to the report, the changes in the timing or amount of rain over the next century are likely to have a greater impact than changes in temperature.

Climate change also will shift the suitable range for each type of ecosystem and the plants and animals that live within it. Because the life span of marine organisms is short, Gaines said, scientists already have been able to observe some changes. In 1975, for example, he said, fully half of the species of fish off the coast of Southern California were cold-water species. Today, apparently reflecting the warming trend, only 30 percent are cold-water species.

"Things can happen much more quickly in the ocean," Gaines said. "It gives us a window on the types of change that are going to happen on land."

The report predicts the grasslands in California likely will expand into the foothill shrublands of the Sierra Nevada and the coastal ranges; and that at higher elevations, shrubs may proliferate at the expense of forests. "Museum" ecosystems — isolated remnants of animal and plant communities — could disappear altogether.

"They may well be hemmed in by development that makes it impossible for them to adjust to changes in climate," Davis said.

The scientists suggest a few steps that California's leaders can take now to protect and restore the natural environment. Development can be banned, they say, in vulnerable habitats such as wetlands, flood plains and woodlands, where the fire hazard is high. Nature preserves can be set aside on land and underwater to provide plants and animals some room to adapt to changing climactic conditions.

At the same time, Gaines said, the reserves must take into account the fact that the animals may travel north to survive. Perhaps entire networks of well-connected reserves should be set aside for species to move around in, he said.

"Understanding the potential complications here is really important," Gaines said. "We need to be thinking of these things not in terms of a static environment but in terms of climate changes."

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Collection/Record Group	Clinton Presidential Records
Series/Staff Name	Roger Ballentine
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Folder Title	Climate Change Other Science [1]
OA Number	19512
Box Number	
Description of Item(s)	Large map "Global Warning Early Warning Signs"

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