TESTIMONY OF
NEAL LANE
ASSISTANT TO THE PRESIDENT FOR SCIENCE AND TECHNOLOGY
BEFORE THE
COMMITTEE ON COMMERCE, SCIENCE AND TECHNOLOGY
UNITED STATES SENATE
MAY 17, 2000

Thank you for this opportunity to discuss with you the Administration's science and technology programs that are relevant to the understanding of climate change. I know the Members of this Committee share my strong belief that America's world-leading science and technology enterprise must be sustained and nurtured. While we sometimes differ on precisely how and where to invest our taxpayers' funds, we share a bipartisan understanding that the future prosperity of this country depends on continued strong federal support for all areas of scientific inquiry.

Today I come before you to suggest that we can bring that same common appreciation for science to an area of considerable policy disagreement -- the issue of climate change. Whatever your policy views may be on the wisdom of the Kyoto Protocol, I respectfully suggest that supporting scientific research on climate change and its potential impacts is in our national interest. The President's FY2001 budget requests substantial funding for the U.S. Global Change Research Program, as has every budget submitted by this Administration and those of President Reagan and President Bush. I hope that Congress sees fit to continue the bipartisan tradition of strong support for this scientific endeavor, which is providing the sound, objective information we need to support decision-making in the public and private sectors.

The Science of Climate Change

I would now like to summarize what we know about the Earth's climate and how it is changing. In 1995, the Second Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) reviewed all of the science then available. Through the IPCC process, leading scientists from more than 150 countries periodically review and assess scientific information about climate change and its environmental and economic effects. The report documented a series of changes that had already occurred, including increases in greenhouse gas concentrations, an unusually rapid increase in temperatures, and rising sea levels. It explained that the magnitude, timing, and geographic pattern of observed temperature changes closely matches the changes that models project from human activities, and does not match well with model simulations of natural change or changes seen in the natural record. The Report famously concluded: "The balance of evidence suggests that there is a discernible human influence on global climate."

The qualified nature of the IPCC attribution statement reflected the existence of alternative interpretations of parts of the data and known shortcomings in models of how the climate system

works.

Recently, however, important scientific evidence has emerged that has substantially undercut many of potential dissenting arguments, thereby fundamentally changing the debate over global warming. Basically, the debate has changed from "Are we warming the Earth?" to "How much are we warming the Earth?" To understand the current state of climate change science, let me first start with a series of statements that virtually all credible atmospheric scientists agree with.

1. The atmospheric concentration of CO2 has been significantly increased by human activities. In the past century or so the CO2 concentration has risen from less than 280 parts per million by volume (ppmv) to about 365 ppmv, an increase of about 30 percent. At 365 ppmv, CO2 is now higher than at any time over the past 420,000 years. It is universally recognized that human activity is responsible for this increase, mainly through fossil fuel combustion and deforestation. Our best estimates show that unless action is taken to reduce CO2 emissions, atmospheric carbon dioxide levels will likely reach about 700 ppmv by the end of the 21st century, about double current levels. Other greenhouse gases, such as nitrous oxide, methane, and halocarbons (CFCs and HFCs), have also increased due to human activities and further increases over the 21st century will add to the tendency for global warming.

2. The surface of the Earth is warming. There is now near unanimous agreement, including most of the climate skeptics, that the Earth's surface has warmed significantly over the last century.

A recent National Research Council report ("Reconciling Observations of Global Temperature Change") carefully examined direct measurements of surface temperature. The report concluded that "The warming trend in global-mean surface temperature observations during the past 20 years is undoubtedly real and is substantially greater than the average rate of warming during the twentieth century." These data show that the surface of the Earth has warmed by 0.4-0.7 degrees C (0.7- 1.4 degrees F) over the last 100 years, with 0.2-0.4 degrees C (0.4 –0.8 degrees F) of that coming in just the last 20 years.

Borehole measurements of temperature at various depths below the Earth's surface show that the average surface temperature of the late 20th century is without precedent in the last 500 years.

Using tree rings, lake sediment records, ice cores, and other paleoclimate indicators, a global temperature record extending back 1000 years has been constructed. This record is in broad agreement with the other data sets, and it shows that the 1990s were the Earth's warmest decade in the last 1000 years, and that 1998 was the warmest year in this entire period.

Measurements made over the last few decades have shown a precipitous decrease in both the areal extent and thickness of Arctic Sea ice. Model simulations of the data suggest that this decline is unlikely to be an entirely natural phenomenon. Mountain glaciers have retreated worldwide during the last century.

Over the last century, global mean sea level has risen 4 to 8 inches, and further rise is inevitable because of the thermal inertia of the ocean and melting glaciers.

During the past 45 years the upper 300 meters of world Ocean has warmed by approximately 0.56 degrees F. This warming is consistent with predictions from general circulation models that simulate the effect of greenhouse gas increases since the beginning of the industrial revolution.

3. The Earth's surface temperature will continue to rise during the next century. Elementary physics shows that increasing greenhouse gases in the atmosphere must exert a strong warming tendency on the surface temperature of the Earth. This is not a controversial concept. Indeed, the greenhouse effect is responsible for providing a hospitable climate on Earth. It is generally agreed that the Earth's surface temperature will rise over the next century as the atmospheric concentrations of CO2 and other greenhouse gases increase. The questions are: "How much and how fast will temperature increase, and with what regional impact?" The 1995 IPCC Second Assessment Report, representing the broad consensus of the scientific community, projected a temperature increase of 1.0 to 3.5 degrees C (2 to 6.5 degrees F) over the next 100 years. The more sophisticated analyses conducted since that time, which will form the basis of the IPCC Third Assessment Report, due out in early 2001, continue to show that such an increase is likely. This rate of warming would be greater than any seen during the past 10,000 years.

4. There is mounting scientific evidence that climate change is already affecting ecosystems. Data from many sites in Europe and North America show that the observed warming has been accompanied by earlier plant growth and flowering. For example, here in Washington D.C., cherry trees, along with 89 of 99 other plants examined, are blooming a week or more earlier than they did 30 years ago. Satellite data for high latitudes in the Northern Hemisphere show that plants are leafing eight days earlier in 1991 than in 1982. Observed changes are not confined to vegetation:

The ranges of some animals appear to be shifting. Birds are going further north to breed and the range of many European and North American butterflies are shifting north as well.

I. Some species are disappearing when a habitat changes. Warmer and drier conditions have caused the high elevation "cloud forest" of Costa Rica to rise and 20 frog species to disappear.
II. Observations in several sites along the Pacific coast of North America indicate that the distribution of fish and phytoplankton has changed as waters warm. There is also evidence that warming waters increase the amount of coral bleaching.

We have discovered much about the way the climate system works, and about how the climate system is likely to evolve in response to increases in greenhouse gases. As I noted above, the debate has changed from "Are we warming the Earth?" to "How much are we warming the Earth?" It leads directly to the question of "So what?" Right now, science only provides a partial answer. As temperatures rise evaporation will increase, leading to more moisture in the atmosphere. Hence, worldwide, an increase in total rainfall is likely, with much coming in heavier downpours. But increased evaporation will also lead to more drought in some regions. Rising temperatures will also bring sea-level rise. These changes in temperature, precipitation and sea level will likely change the ideal ranges for plant and animals, and will also affect human society. Our understanding of how the life support systems on Earth will respond to these changes remains quite uncertain. This uncertainty is no reason to be complacent about the future.Emerging Questions

Let me now move past points of agreement, and talk about the cutting edge of climate science.

To a large extent, the disagreements between future estimates of the climate are disagreements about effects of the "feedbacks" of the climate system. While increasing CO2 will, by itself, tend to increase the surface temperature of the Earth, it will also change other parameters, such as the amount of water vapor or the extent of clouds, which also affect the climate system. For example, if the climate warms due to increased CO2, then this will evaporate more water vapor into the atmosphere. Water vapor is a powerful greenhouse gas, so this will amplify the warming. This is an example of a positive feedback. On the other hand, the increase in CO2 might also increase low clouds. These clouds reflect sunlight, so if they increase it would cool the Earth, moderating somewhat the warming effects of the CO2 increase. These feedbacks are only roughly understood, and improving our understanding of them would significantly improve our ability to predict the future climate.

Changes in the amount of solar radiation would definitely affect the climate, and there are indications that changes in solar radiation may have been an important contributor to climate change over the past few centuries. However, changes in output of the sun cannot, by themselves, entirely explain the observed warming over the last century. Our best estimates are that changes in solar output could explain about 25 percent of the surface temperature increase observed in the last 100 years. The rapidly increasing concentrations of greenhouse gases also mean that solar variability will be an ever-smaller component of climate change in the future.

There are also important questions about the relationship of temperature change to other changes in the physical climate system. One of the expected consequences of warming is acceleration of the Earth's hydrological cycle. The increased evaporation of water described above will transfer water more rapidly from the land and oceans to the atmosphere, and could result in an increased incidence of both droughts and the extreme rainfall events that lead to flooding. There is already evidence that such change has begun in the US, where the incidence of heavy downpours (where more than 2 inches of rain falls in a 24-hour period) has increased by about 10% over the last century. We know that there will be significant regional variation in these changes, but our ability to project regional-scale precipitation change is very limited, and we do not have a good understanding of how precipitation change will interact with other stresses on managed and natural ecosystems.

We also need to quantify the relative contributions of the oceans and terrestrial plants to removing carbon from the atmosphere. Human activities add about 7 billion tons of carbon to the atmosphere every year. About 3 billion tons remain in the atmosphere, while 4 billion are absorbed by terrestrial and ocean "sinks." We know that land ecosystems play an important role in carbon sequestration, but important questions remain about the magnitude and geographic distribution of terrestrial sinks. For example, there is consensus that more carbon is being taken up than is released by land ecosystems in the Northern Hemisphere, but we don't know if the amount is on the order of tens of millions or hundreds of millions of tons. And where in the Northern Hemisphere is carbon is being sequestered? It could be mostly in North America, or it might be in Siberia.

More importantly, we don't know whether it is the above ground vegetation or the soils that are responsible for the apparent increase in sequestration. We also don't know what is causing this and whether it will persist. Is it from nitrogen fertilization, an effect that will disappear when soils become nitrogen-saturated, or as industrial and automobile pollution is decreased? Is it from carbon fertilization,

an effect that could slowly decline with increasing atmospheric concentrations? Is it from plants growing on abandoned farmland, or from increased use of "low-till" agricultural practices? Is it from growth of many young forests created recently under revised logging laws, an effect that will decline as the forests mature? Or is it simply from forest trees growing better in warmer, moister conditions, an effect that may continue indefinitely? Finally, we know that the amount of carbon the global biosphere stores and releases each year can vary widely. However, we don't know how much of that sequestered CO2 in the terrestrial biosphere is transitory, being returned to the atmosphere in a year or two to continue contributing to atmospheric CO2 increases. We also don't know how much carbon is retained in soils for the decades or centuries required to ameliorate atmospheric increases. Different answers to these questions will determine very different trajectories of future atmospheric CO2 change.

We also know that local plant and animal species are being mixed into ecosystems all over the world at increasing rates. Climate change may exacerbate this problem. We also know that when these exotic species spread aggressively, they can reduce and displace current species, disrupt ecosystem functioning, and do enormous economic damage. The National Academy of Sciences estimates that pubic and private-sector spending on Zebra Mussel control, a problem we did not even anticipate in the 1980s, will total $5 billion in 2000. Given that expected rates of change over the next century will alter the ideal ranges of plant and animal species faster than they can migrate, ecosystem disruption is likely.

New Directions in the US Global Change Research Program (USGCRP)

One of the consequences of increased understanding is the definition of new research questions. The process of revising and updating research strategies in response to new findings and new questions goes on every year. It is a regular part of managing large research programs, and the USGCRP is no exception. But periodically, it is also valuable to step back and take a longer-term view of what has been accomplished and what new research challenges are arising. One of the most important contributions of the National Research Council to the USGCRP is precisely this kind of taking stock. In 1996, the USGCRP requested the NRC to undertake a major study of emerging issues in global change science. The result was Global Environmental Change: Research Pathways for the Next Decade, which consists of a summary issued in mid 1998 and a full report published in 1999. The "Pathways" report identified a comprehensive set of science questions, and identified several cross-cutting areas of special concern, including carbon cycle science, water cycle science, and climate change research "on temporal and spatial scales relevant to human activities." These recommendations played an important part in the definition and initiation of a series of new activities in the USGCRP: the Carbon Cycle Science Initiative, an increased emphasis on water cycle research, and the initiation of the first National Assessment of the Potential Consequences of Climate Variability and Change for the US.

The USGCRP Carbon Cycle Science Initiative was established in the FY 2000 budget. The focus of this activity is on improving our understanding of how carbon moves through

the Earth's terrestrial ecosystems, soils, ocean, and atmosphere, with $229 million proposed in the FY2001 budget (a $25 million increase over FY2000). This on-going effort will provide critical scientific information on the fate of carbon in the environment, the sources and sinks of carbon on continental and regional scales, and how sinks might change naturally over time or be modified by agricultural or forestry practices. USDA, DOE, DOI/USGS, NASA, NSF, DOC/NOAA, and the Smithsonian Institution will all play important roles in this effort, guided by a science plan that has been drafted with participation by many of the leading scientists in this field.

The Carbon Cycle Science Initiative will employ a wide variety of research activities in a comprehensive examination of the carbon cycle as an integrated system, with an initial emphasis on North America. Comparison of North America to other regions will also be important for understanding the relative importance of our region in the global context. Atmospheric and oceanographic field sampling campaigns over the continent and adjacent ocean basins will be combined with atmospheric transport models to develop more robust estimates of the continental distribution and subcontinental-scale magnitude of North American carbon sinks. Local -scale experiments conducted in various regions will begin to identify the mechanisms involved in the operation of carbon sinks on land and in the ocean; the quantities of carbon assimilated by ecosystems, and how quantities might change to be enhanced in the future.

The initiative will also include evaluation of information from past and current land-use changes, both from remotely sensed and historical records, to assess how human activity has affected carbon storage on land. Potential management strategies for maximizing carbon storage will be studied, including evaluation of the variability, sustainability, lifetime, and related uncertainties of different managed sequestration approaches. Finally, enhanced long-term monitoring of the atmosphere, ocean, forests, agricultural lands, and range lands, using improved inventory techniques and new remote sensing, will be used to determine long-term changes in carbon stocks. Integration of new observations and understanding of carbon cycle processes in regional and global carbon system models will enable us to more accurately project future atmospheric concentrations of carbon dioxide and other greenhouse gases.

The highest priority for FY2001 will continue to be on understanding and quantifying North American carbon sources and sinks, and on filling critical gaps in our understanding of the causes of carbon sinks on land as well as processes controlling the uptake and storage of carbon in the ocean. Research advances on these questions will provide information needed as a basis for sound policymaking, as well as valuable information about potential management strategies to land and forest managers in both the public and private sectors.

Research on the Global Water Cycle is receiving increased attention in the USGCRP, with $308 million proposed in the FY2001 budget (a $35 million increase over FY2000). This has been an important research area since the inception of the USGCRP, but the increasing evidence that changes in the water cycle are already occurring, and that changes in the water cycle and climate are closely coupled, are leading to a new emphasis on water cycle science. The USGCRP has established a Water Cycle Study Panel that is focused on improving our understanding of how water moves through the land,

atmosphere, and ocean, and how global change may increase or decrease regional water availability. This group, which includes government and academic scientists, is developing comprehensive research and applications strategies that will take advantage of existing and future observing systems to address the major issues concerning the global water cycle and global and national water resources.

The primary goal is to achieve a greater understanding of the seasonal, annual, and interannual mean state and variability of water and energy cycles at continental-to-global scales, and thus a greater understanding of the hydrological interactions in the Earth's climate system. The study of the global water cycle is a unifying theme that bridges the gap between the spatial scales involved in global atmospheric (and atmosphere-ocean interaction) processes, and land surface hydrological processes, which determine the availability of water resources.

Finally, the U.S. National Assessment of the Potential Consequences of Climate Variability and Change is now nearing completion. The National Assessment effort, which began in 1997, is examining the degree to which particular regions and sectors of the US are vulnerable to climate variations and change. The National Assessment is examining the potential ecological and socioeconomic impacts of climate variations and change, and ways we might prepare for both the next few decades and the next century, including identification of possible adaptation measures. It is also identifying key information gaps and research needs (i.e., information that is still required to answer questions of interest to resource managers and decision-makers).

The assessment effort has included a series of regional workshops with participation from a broad range of public and private stakeholders in the identification of issues of interest and a series of regional and sectoral analyses, most of which are not yet complete. The major product of the assessment process is a National Assessment Synthesis Report that should be completed this year. The National Assessment Synthesis Report is undergoing a rigorous peer-review that includes several rounds of technical review, full agency review, and a 60-day public comment period before it is submitted to the President and the Congress. The US Global Change Research Act calls for this type of assessment of the potential consequences of global changes on a periodic basis.

The first National Assessment will soon be completed, but we expect many of the lessons learned during this process to play a significant role in the definition of future USGCRP research activities. There were important issues that it was not possible to fully address in this initial effort, such as the potential indirect effects on the US of changes in other parts of the world. Many additional questions of interest have been identified. Farmers and ranchers are curious about what might change for their competitors in other nations. People all around the country are interested in how climate change might alter the incidence of extreme climate conditions that affect the quality of life and livelihoods, such as drought, heat waves, and severe storms.

This first assessment is part of a larger evolution of the USGCRP. During much of the first decade of its existence, the program concentrated on observing and documenting change in the Earth's physical systems and understanding why these changes are occurring. It is now appropriately shifting from this predominant focus on physical systems to a much broader effort to understand how global change will affect the Earth's biological systems and the human societies that are dependent upon them, and make useful scientific data and information more broadly available for public and private planning and decision making.

To accomplish this, we must greatly improve our capabilities for conducting regional-scale assessment of global change and its potential consequences around the country. Our current level of understanding tells us that climate change and its effects will vary by region, but our ability to project specific regional effects remains limited. We also need to learn more about the interactions of natural and human-induced climate change and variability and other human-induced stresses on the environment, such as pollution, land-use change, resource extraction, and invasive species, many of which are regional in scale. Additionally, we need to achieve an integrated understanding not only of the nature and extent of physical and biological effects of climate change, but also of their ramifications for our social and economic systems.

The Organization of the U.S. Global Change Research Program

Our current understanding of climate change, as well as our understanding of many other important global change issues, is the result of the significant progress that has occurred over the last several decades through scientific research. U.S. climate change research is largely supported through the USGCRP. The Administration is committed to continued strong support for the research needed to improve our understanding of the mechanisms of the Earth's climate system, the likely future course of climate change, and the potential impacts of such change on the environment and human society.

The USGCRP, a program planned during the Reagan Administration and elevated to a Presidential Initiative under President Bush in 1989, was codified by the Global Change Research Act of 1990. The program has been strongly backed by every Administration and Congress since its inception. The FY 2001 Budget Request demonstrates President Clinton's ongoing commitment to the program, with an overall request for the USGCRP of approximately $1.74 billion dollars, about 2 percent (or $39 million) higher than last year's enacted level (tables showing the budget by agency and by program element area are attached).

Within the total, support for scientific research is up about $53 million (7%), including a $31 million increase for carbon cycle studies at USDA as part of the carbon cycle research initiative begun last year. Surface-based observations at NOAA are receiving a substantial increase ($26 million, or about 39%) that will help provide new information on changing patterns of temperature and rainfall in the US. The total increase for surface-based observations and science together is about $79 million, or 10%. The space-based observation component of the budget is reduced by about $40 million, to a total of $897 million. This decrease is mainly a consequence of decreases in NASA development costs as some of the first series of Earth Observing System (EOS) satellites are completed and launched.

The fact that the increase in science funding more than offsets the decrease in funding for space-based observations is important. Increasing the proportion of program funding for science has been one of the most consistent recommendations from the National Research Council and various agency advisory committees over the last few years. The National Research Council (NRC) report, Global Environmental Change: Research Pathways for the Next Decade, noted that 65 percent of the total USGCRP were devoted to space-based observations and data systems in the 1996 budget proposal. In this year's budget proposal, the equivalent number is about 52 percent, demonstrating the progress that has been made over the last 5 years in increasing the proportion of USGCRP funding for scientific research and analysis.

Since its inception, the USGCRP has been directed toward strengthening research on key scientific issues, and has fostered much improved insight into the processes and interactions of the Earth system. The results of research supported by the USGCRP play an important role in international scientific assessments, including assessments of climate change and stratospheric ozone depletion. The USGCRP research results provide the scientific information base that underpins consideration of possible response strategies. The USGCRP does not recommend specific government policies responsive to global change, nor does it include support for research and development of energy technologies or development of mitigation strategies.

Participants and Organization

The Subcommittee on Global Change Research (SGCR) of the Committee on Environment and Natural Resources (CENR), a component of the National Science and Technology Council (NSTC), provides overall direction and executive oversight of the USGCRP. In addition, the National Research Council within the National Academy of Sciences provides external oversight and review of USGCRP programs. Agencies manage and coordinate Federally supported scientific research on global change within this framework. In addition to USGCRP review of the overall set of agency research programs, each agency is responsible for the review of individual projects within its programs. These reviews are almost exclusively based on an external peer-review process, which is deemed an important means of ensuring continued program quality.

The agencies that actively participate in the USGCRP are USDA, DOC/NOAA, DOE, HHS/NIH, DOI/USGS, EPA, NASA, NSF, and the Smithsonian Institution. OMB and OSTP are the Executive Office of the President liaisons to the SGCR. The Department of State does not fund research but is part of the SGCR because of the extensive international cooperation necessary in all aspects of global change research. The Department of Defense does not fund research focused on global change, but participates in the SGCR because it performs related research, such as how changing ocean conditions may affect their ability to ensure the nation's security. Some of these agencies support research on a broad range of issues, while others have a more specialized focus. Programmatic contributions are closely matched to agency missions and areas of expertise. The crosscutting research that takes place in the USGCRP program element areas takes advantage of the unique capabilities of different agencies

and applies them to science problems that are beyond the scope of any single agency's mission or the ability of any one agency's programs to address.

The scientific community contributes to the planning, definition, and implementation of USGCRP research activities. An important aspect of this is scientific oversight and review of the USGCRP that is provided by the National Academy of Sciences. This function includes review of various program activities and examination of scientific issues in response to requests from the USGCRP and participating agencies. Over the past several years, the USGCRP has commissioned a series of reports, including "Pathways" and smaller reports on climate observations and climate modeling. These reports have provided important input to the ongoing planning and program implementation decisions of the USGCRP agencies, including the initiation of the carbon cycle and water cycle research efforts described above, and the current organization of the USGCRP as a series of other interrelated program elements.

Understanding the Earth's Climate System, with a focus on improving our understanding of the climate system as a whole, rather than its individual components, and thus improving our ability to predict climate change and variability. The FY2001 budget proposes $487 million for this program element (a decrease of $16 million), which is largely focused on the physical climate system. Improving our understanding of climate change, including its potential impacts on ecosystems and human society, requires support of research and integration of results across the entire USGCRP. Climate is a naturally varying and dynamic system with important implications for the social and economic well being of our societies. Understanding and predicting climate changes across multiple time scales (ranging from seasonal to interannual, to decadal and longer) offers valuable information for decision making in those sectors sensitive to rainfall and temperature fluctuations, including agriculture, water management, energy, transportation, and human health.

Biology and Biogeochemistry of Ecosystems, with a focus on improving understanding of the relationship between a changing biosphere and a changing climate and the impacts of global change on managed and natural ecosystems, including forests, coastal areas, and agriculture. The budget proposes $224 million in FY2001 (an increase of $19 million) for the study of changes in managed and unmanaged ecosystems. The biosphere consists of diverse ecosystems that vary widely in complexity and productivity, in the extent to which they are managed, and in their economic value to society. Better scientific understanding of the processes that regulate ecosystems and the capability to predict ecosystem changes and evaluate the potential consequences of management strategies will improve our ability to manage for sustainability.

Composition and Chemistry of the Atmosphere, with a focus on improving our understanding of the impacts of natural and human processes on the chemical composition of the atmosphere at global and regional scales, and determining the effect of such changes on air quality and human health. The budget proposes $368 million for programs studying the composition and chemistry of the atmosphere (a decrease of $21 million from FY2000). Changes in the global atmosphere can have important implications for life on Earth, including such factors as the exposure to biologically damaging ultraviolet (UV) radiation, the abundance of greenhouse gases and aerosols (which in turn affect climate), and

regional air pollution.

Paleoenvironment and Paleoclimate, with a focus on providing a quantitative understanding of the patterns of natural environmental variability, on timescales from centuries to millennia, upon which are superimposed the effects of human activities on the planet's biosphere, geosphere, and atmosphere. The budget proposes $27 million in FY2001 (a decrease of $2 million) for the study of the Earth's environmental past. Reconstructing the historical climate record offers an enhanced understanding of the mechanisms controlling the Earth's climate system and, together with insight obtained from numerical modeling exercises, provides a foundation for anticipating how the planet might respond to future environmental perturbations.
Human Dimensions of Global Change, with a focus on explaining how humans affect the Earth system and are affected by it, and on investigating how humans respond to global change. The budget proposes $93 million in FY2001 (level with FY2000) for the study of the human dimensions of global change. Scientific uncertainties about the role of human socioeconomic and institutional factors in global change are as significant as uncertainties about the physical, chemical, and biological aspects of the Earth system. Improving our scientific understanding of how humans cause changes in the Earth system, and how society, in turn, is affected by the interactions between natural and social processes, is an important priority for the USGCRP.

Conclusion:

This brief description of climate change science and US climate change research efforts should be seen as a summary rather than a comprehensive overview. Nevertheless, it highlights several very important points. The USGCRP is a broad and successful program of research on global change that is resulting in increases in our understanding of how the Earth system is changing, and of the human role in such change. In particular, it has made a major contribution to our understanding of climate change. USGCRP-supported research has played a key role in demonstrating that climate change is occurring, and that human activities are playing a role in causing such change. It has helped explain the relationships between climate change and other significant global-scale environmental changes, such as land cover change, ozone depletion, and loss of biodiversity.

We expect a much fuller understanding of the processes of change to emerge from this effort in the future. The sustained bipartisan support for global change research over the last decade has enabled steady scientific progress and resulted in the development of a new generation of tools that offer the promise of more rapid progress in the years ahead. We will benefit from unprecedented amounts of data about the Earth, and these data will be of higher quality than ever before. We will develop more complex and accurate models that permit more realistic simulation of the Earth system. Most importantly, we can expect to learn much more about the potential consequences of change for ecosystems and for human society. U.S. Global Change Research Program
By Agency/Appropriation Account

FY 2001 Budget
(Discretionary budget authority; in millions of dollars)

NEXTRECORD

FY 1999
Actual
FY 2000
Estimate
FY 2001
Proposed
Change
2000-2001ENDFIELD
ENDRECORD

Department of Health and Human Services
National Institutes of HealthENDFIELD

40ENDFIELD

46ENDFIELD

48ENDFIELD

+2ENDFIELD
ENDRECORD

National Aeronautics and Space Administration
Science, Aeronautics, and TechnologyENDFIELD

1,155ENDFIELD

1,173ENDFIELD

1,149ENDFIELD

- 24ENDFIELD
ENDRECORD

Department of Energy
Science (Biological & Environmental Research)ENDFIELD

114ENDFIELD

120ENDFIELD

123ENDFIELD

+3ENDFIELD
ENDRECORD

National Science Foundation
Research and Related ActivitiesENDFIELD

182ENDFIELD

187ENDFIELD

187ENDFIELD

0ENDFIELD
ENDRECORD

Department of Agriculture
Agricultural Research Service
Cooperative State Research, Education and
Extension Services
Research and Education
Economic Research Service
Natural Resources Conservation Service Conservation Operations
Forest Service
Forest and Rangeland Research ENDFIELD

26

7
1

1

17ENDFIELD

27

7
1

1

17ENDFIELD

36

14
2

14

20ENDFIELD

+9

+7
+1

+13

+3ENDFIELD
ENDRECORD

Subtotal -- USDAENDFIELD
52ENDFIELD
53ENDFIELD
85ENDFIELD
+32ENDFIELD
ENDRECORD

Department of Commerce
National Oceanic and Atmospheric Administration
Operations, Research, and FacilitiesENDFIELD

63
ENDFIELD

67ENDFIELD

93ENDFIELD

+26ENDFIELD
ENDRECORD

Department of the Interior
U.S. Geological Survey
Surveys, Investigations, and ResearchENDFIELD

27ENDFIELD

25ENDFIELD

25ENDFIELD

0ENDFIELD
ENDRECORD

Environmental Protection Agency
Science and TechnologyENDFIELD

17ENDFIELD

23ENDFIELD

23ENDFIELD

0ENDFIELD
ENDRECORD

Smithsonian Institution
Salaries and ExpensesENDFIELD

7ENDFIELD

7ENDFIELD

7ENDFIELD

0ENDFIELD
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TOTAL 1 TOTALENDFIELD
1,657ENDFIELD
1,701ENDFIELD
1,740ENDFIELD
+39ENDFIELD
ENDRECORD

Note:
Total may not add due to rounding.U.S. Global Change Research Program
Details by Program Element/By Agency
FY 2001 Budget
(Discretionary budget authority; in millions of dollars)

NEXTRECORD

FY 1999
Actual
FY 2000
Estimate
FY 2001
Proposed
Change
2000-2001ENDFIELD
ENDRECORD

Understanding the Earth’s Climate System
National Aeronautics and Space Administration
National Science Foundation
Department of Energy
Department of Commerce/NOAA
Department of the Interior
Smithsonian
Subtotal
ENDFIELD

324
82
64
38
7
*
515ENDFIELD

310
84
68
41
0
*
503ENDFIELD

271
84
73
59
0
*
487ENDFIELD

- 39
0
+5
+18
0
*
- 16ENDFIELD
ENDRECORD

Composition and Chemistry of the Atmosphere
National Aeronautics and Space Administration
National Science Foundation
Department of Energy
Department of Agriculture
Department of Commerce/NOAA
Smithsonian
Subtotal ENDFIELD

310
18
16
16
8
*
368ENDFIELD

330
19
16
15
9
*
389ENDFIELD

306
19
15
18
10
*
368ENDFIELD

- 24
0
- 1
+3
+1
*
- 21ENDFIELD
ENDRECORD

Global Water Cycle
    National Aeronautics and Space Administration
    National Science Foundation
    Department of Commerce/NOAA
    Department of Energy
Department of Agriculture
SubtotalENDFIELD

238
10
5
0
0
253ENDFIELD

255
10
5
4
*
274
ENDFIELD

288
10
7
3
*
308ENDFIELD

+33
0
+2
- 1
*
+34ENDFIELD
ENDRECORD

Carbon Cycle Science
National Aeronautics and Space Administration
National Science Foundation
Department of Energy
Department of Agriculture
Department of Commerce/NOAA
Department of the Interior
Smithsonian
SubtotalENDFIELD

154
13
14
7
4
3
*
195ENDFIELD

154
13
14
15
5
3
*
204ENDFIELD

150
13
15
37
10
4
*
229ENDFIELD

- 4
0
+1
+22
+5
+1

*
+25ENDFIELD
ENDRECORD

ENDFIELD
FY 1999
ActualENDFIELD
FY 2000
EstimateENDFIELD
FY 2001
ProposedENDFIELD
Change
2000-2001ENDFIELD
ENDRECORD

Biology and Biochemistry of Ecosystems
National Aeronautics and Space Administration
Department of Agriculture
National Science Foundation
Department of Energy
Department of the Interior
Smithsonian
Environmental Protection Agency
SubtotalENDFIELD

129
32
27
13
13
4
0
218ENDFIELD

124
22
29
11
13
4
2
205ENDFIELD

134
29
29
11
14
4
3
224ENDFIELD

+10
+7
0
0
+1
0
+1
+19
ENDFIELD

```
ENDRECORD
```

Human Dimensions of Climate Change
Health and Human Services
Environmental Protection Agency
National Science Foundation
Department of Energy
Department of Commerce/NOAA
Smithsonian
SubtotalENDFIELD

40
17
14
5
5
1
82ENDFIELD

46
19
14
8
5
1
93ENDFIELD

48
20
14
5
5
1
93ENDFIELD

+2
+1
0
- 3
0
0
0ENDFIELD
ENDRECORD

Paleoenvironment/Paleoclimate
National Science Foundation
Department of Commerce/NOAA
Smithsonian
Department of the Interior
SubtotalENDFIELD

18
2
2
0
22

ENDFIELD

19
2
2
6
29ENDFIELD

19
2
2
4
27ENDFIELD

0
0
0
- 2
- 2ENDFIELD
ENDRECORD

Total 12 3ENDFIELD
1,653ENDFIELD
1,697ENDFIELD
1,736ENDFIELD
+39ENDFIELD
ENDRECORD

Note:
* less than $500,000.
1 Total may not add due to rounding.
2 FY 1999 does not include $3 million in DOE Small Business Innovative Research funding.
3 FY 2000 and FY 2001 does not include $4 million in DOI Data Management funding.