

- Generating the first quantitative, geo-referenced, spatially comprehensive estimates of global terrestrial net primary productivity using data from the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on NASA's EOS-Terra satellite.
- Producing a quantitative assessment of which approaches for measuring carbon work best for a given scale. The USGCRP will acquire, compare, and integrate measurements at local, regional, and global scales, and reconcile differences among measurements and modeling approaches.
- Reducing the uncertainty of estimates of exchange of CO₂ between the ocean and the atmosphere in the North Atlantic and Pacific to less than a factor of two. This improved understanding of the role of the ocean in the carbon cycle will help to constrain estimates of the Northern Hemisphere terrestrial sink.

Understanding Changes in Ecosystems

The USGCRP budget includes \$224 million in FY 2001 for the study of changes in managed and unmanaged ecosystems (see Table 7). 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. Ecosystems directly provide forage, timber, fish, food, and fiber, as well as other services such as water cycling, climate regulation, recreational opportunities, and wildlife habitat. Ecosystems respond to and contribute to global change.

On one hand, changes in temperature and precipitation may alter the ranges of plant and animal species. The rates of change projected over the next century are faster than any that have occurred in the past 10,000 years; therefore, the character and diversity of ecosystems could undergo substantial change if their constituent species cannot adapt. Ecosystems also contribute to global change, however, by playing a role in modifying the atmosphere—and hence the climate system. Terrestrial and marine ecosystems play a role in carbon storage and the release of carbon to the atmosphere; they also are sources and sinks of other greenhouse gases, including methane and nitrous oxide. In addition, vegetation and soils influence climate by affecting the amount of radiation reflected or absorbed, the evapotranspiration of water, and other feedbacks to temperature, precipitation, and weather systems.

Management of ecosystems and natural resources will be an important aspect of society's response to global change. Ecosystems have the capacity to respond to stress; when that capacity is exceeded, however, natural resources and services are altered and begin to decline. Our ability to achieve a sustainable future depends on the protection of public lands and other lands, sustainable use of terrestrial and aquatic renewable resources, and more efficient use of nonrenewable resources. 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.

Recent Accomplishments

- Research has documented significant changes in the growth and development of Ponderosa and Jeffrey pine in response to elevated ozone exposure and elevated nitrogen deposition. Above-ground biomass increases, while root biomass decreases with exposure to ozone and nitrogen, raising important questions about predisposing trees to drought-induced mortality and other stressors. The interaction of ozone and nitrogen pollution has significant implications for the storage of carbon in soils, forest-floor litter, and woody biomass.
- A new assessment of fire risk from climate change uses results from Mapped Atmospheric-Plant-Soil System (MAPSS) vegetation distribution model simulations for seven future climate scenarios. The dynamic simulations indicate that climate change could lead to increased fire frequency over much of the western United States and, under scenarios that project the greatest warming, over many eastern U.S. forests.
- Research results suggest that increasing atmospheric CO₂ levels could stimulate the growth of rangeland plant species because of the direct CO₂ fertilization effect and indirectly by reducing water stress by virtue of increased water-use efficiency of plants at elevated CO₂ levels. In rangelands where undesirable species such as mesquite occur or are introduced, however, elevated CO₂ also could cause a deleterious effect on rangeland plant species composition by increasing the growth and establishment of such species.

Table 7 Understanding Changes in Ecosystems

FY 2001 Budget by Agency
(discretionary budget authority in \$millions)

USDA		29.2
DOE		10.8
DOI/USGS		13.9
EPA		3.0
NASA	Scientific Research	32.0
NASA	Space-Based Observations	101.9
NSF		29.0
Smithsonian Institution		3.8
TOTAL		223.6

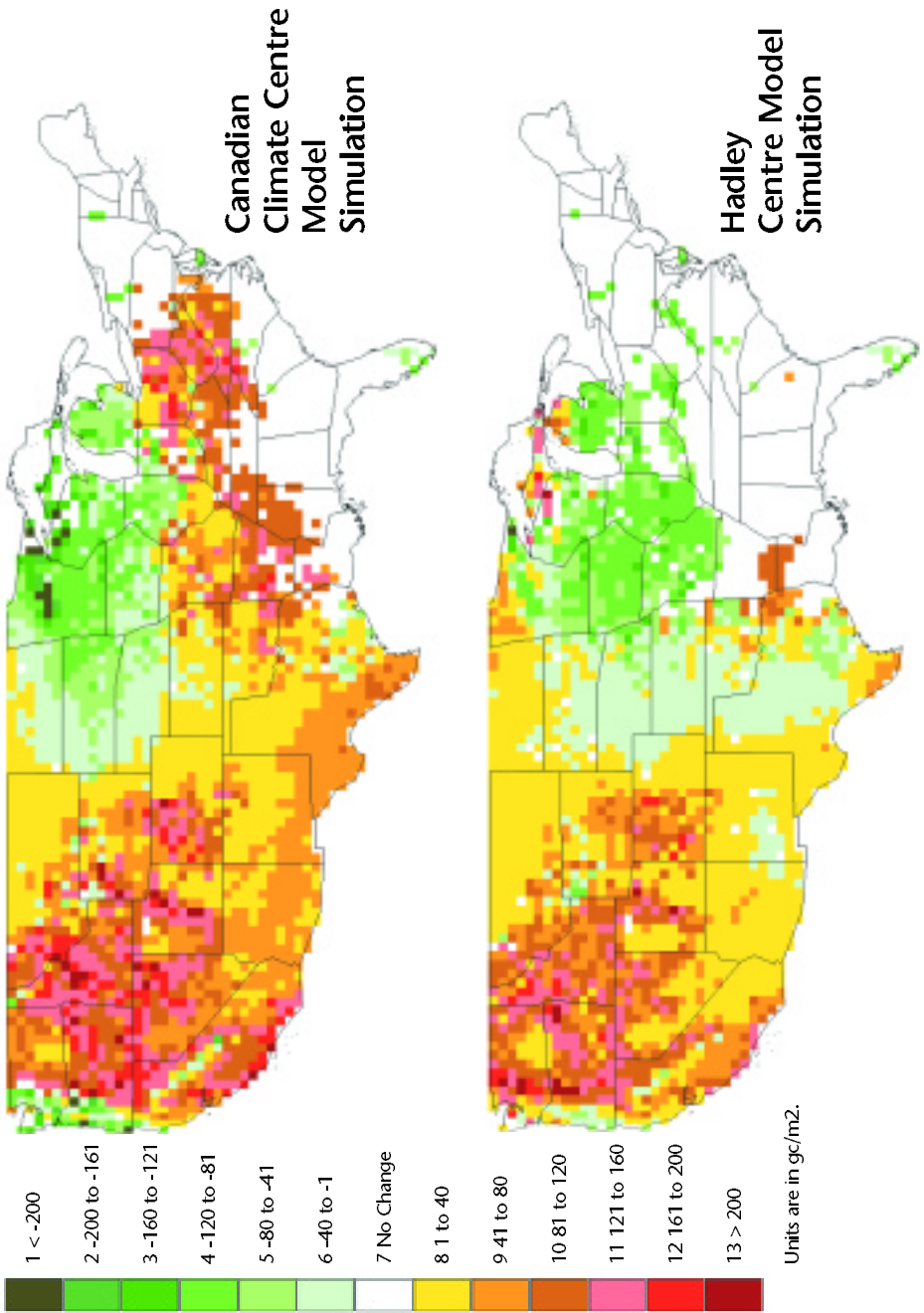


Figure 5. Potential Change in Wildfire Under Climate Change
 (See pages 41-42 for additional information)

FY 2001 Plans

The USGCRP will increase its emphasis on research to explain the relationships among land cover, land use, biodiversity, climate, and weather, and investigate ecosystem resilience to single and multiple stresses. Existing and new observational capabilities will be used to support increased understanding of ecosystems functioning and processes. Goals include:

- Producing quantitative estimates of the rates of land-use change and its effects on atmospheric chemistry and biodiversity in tropical areas such as Central Africa, Southeast Asia, and previously unmeasured areas of South America (non-Brazilian Amazon).
- Developing and publishing (electronically via the USGCRP Web site) of criteria and indicators of ecosystem sensitivity and sustainability to link landscape-scale changes and disturbance regimes with ecosystem carrying capacity.
- Producing an assessment of the state of understanding of advanced ecological and biogeochemical cycling models that blend processes occurring across time spans of days to centuries and seek to portray realistically the effects of disturbance and land-use history.
- Successful collection, processing, and analysis of global measurements of land and ocean surface temperatures, ocean color, ocean chlorophyll fluorescence, and terrestrial vegetation from the MODIS instrument on NASA's EOS-Terra satellite. Terra-MODIS, together with the SeaWiFS satellite, will provide significantly improved coverage of key elements of land and ocean ecosystems and thereby improve statistics on the variability of these systems.
- Creating and regularly updating the first high-resolution satellite data sets of tropical biodiversity hotspots using data from the Landsat 7 satellite, which includes a new 15 m resolution panachromatic band for the study of ecosystem disturbances. The USGCRP will continue the acquisition of Landsat-7 measurements and improve the land use/land cover data series provided by other Landsat missions for 26 years.

Understanding the Human Dimensions of Global Change

The USGCRP budget includes \$95 million in FY 2001 for the study of human dimensions of global change (see Table 8). About half of this amount is devoted to improving our understanding of the human health effects of stratospheric ozone depletion. Scientific uncertainties about the role of human socioeconomic and institutional factors in global change are as significant as uncertainties about 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. Key questions include the following: What are the major human drivers of changes and

how do they vary temporally, spatially, and across economic sectors and social groups? What are the human consequences of global environmental change? How might global change affect key life-support systems (water, health, agriculture), economies, and political systems?

Although systematic research on these questions is still at a relatively early stage of development, USGCRP human dimensions research efforts have resulted in insights that enhance our understanding of and ability to respond to the multiple stresses within our environment. Results from these efforts have begun to influence studies across the physical and biological sciences; as a result, such information and knowledge are becoming increasingly accessible to individuals and institutions who are responsible for action in areas that are sensitive to climate and environmental change.

The USGCRP will increase its research on the processes through which individuals and organizations perceive, identify, explore alternatives, and respond to a range of environmental hazards and risks—including sudden disasters such as earthquakes, severe storms, and floods and longer-term degradation of environmental quality. The USGCRP will communicate its research results to relevant decisionmakers in disaster management, engineering, and economic development.

Recent Accomplishments

- NOAA, NSF, EPA, NASA, and the Electric Power Research Institute initiated and produced the first joint research announcement on Climate Variability and Health. This announcement was released in November 1999, and proposals are now undergoing evaluation. NOAA made significant progress in overcoming legal hurdles to allow a high degree of interagency cooperation and private sector involvement.
- Interdisciplinary investigations of human responses to seasonal and yearly swings in climate are highlighting the effects of market forces, access to resources, institutional flexibility, transboundary context, and the role of indigenous knowledge on the likelihood that individuals and institutions will use improved scientific information.
- Integrated assessment studies are increasing our understanding of the relationship between climate change and human responses. Generally, scientists have found that people fear projected future changes in their environments—but that small events and slowly-changing environmental conditions rarely generate levels of concern that lead people to adopt new adaptation or mitigation strategies.
- EPA's Global Change Research Program issued its first Request for Assistance (RFA) related to human dimensions issues. This RFA, titled "Assessing the Consequences of Interactions between Human Activities and a Changing Climate," represents the first step in a multi-year plan to foster the development of models that capture the interaction of human behavior with natural (nonhuman) responses to climate change. Proposals are now undergoing peer review.
- The U.S. Department of Transportation recently established a virtual Center for Climate Change and Environmental Forecasting to identify effective ways to reduce transportation sector emissions and help prepare the Nation for the impacts of climate change. As part of its research efforts, the Center plans to investigate how climate change might affect transportation infrastructure.

Table 8 Understanding the Human Dimensions of Global Change

FY 2001 Budget by Agency
(discretionary budget authority in \$millions)

DOC/NOAA	Scientific Research	5.2
DOE		7.8
EPA		19.7
HHS/NIH		48.0
NSF		14.0
Smithsonian Institution		0.6
TOTAL		95.3

FY 2001 Plans

The USGCRP will continue to support fundamental research on and assessments of the effects of human activities on the environment and of the potential human consequences of global change. Goals include:

- Initiating new assessments of the effects of global change on weather-related morbidity, aquatic ecosystems, and the consequences of global change for tropospheric ozone.
- Completing and publishing eight regional assessments of the potential consequences of climate variability and change in the United States. These assessment activities were sponsored by the USGCRP as part of its National Assessment process. (Eight regional assessments and five sector assessments are expected to be completed by the end of FY 2000 and published as reports or in journals.)
- Examining the social and economic cost/benefit implications of long-term future greenhouse gas emission scenarios and consequent environmental change by conducting an intercomparison of more than 10 integrated assessment models.
- Assessing the health effects of combined exposures to climatic and environmental factors, with a focus on improving our understanding of the combined effects of higher temperatures and air pollutant concentrations.
- Continuing efforts to determine the effects of depletion of stratospheric ozone and providing this information to policymakers. This effort will include focused research on the mechanisms of skin cancers induced by UV-B radiation, the effects of UV-B radiation on the systemic and cutaneous immune systems, and the relationship of these effects to skin cancer.