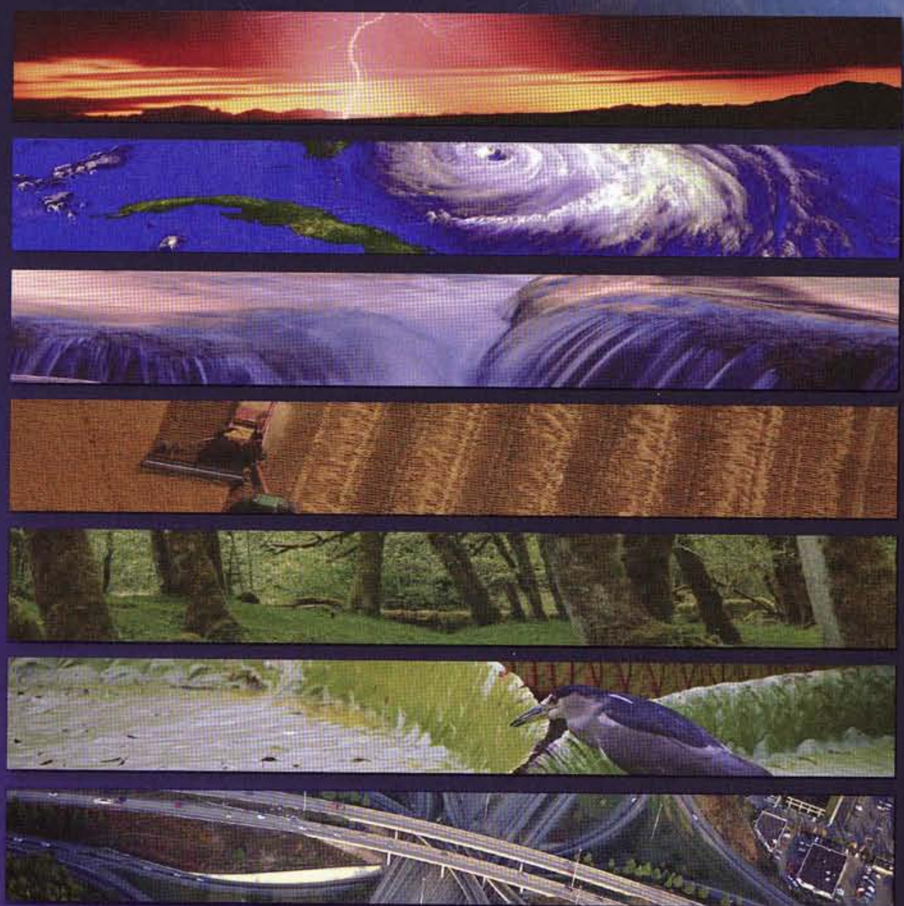
OUR CHANGING PLANET

The U.S. Climate Change Science Program for Fiscal Year 2006



A Report by the
Climate Change Science Program and
the Subcommittee on Global Change Research

A Supplement to the President's Budget for Fiscal Year 2006

Climate Change Science Program and Subcommittee on Global Change Research

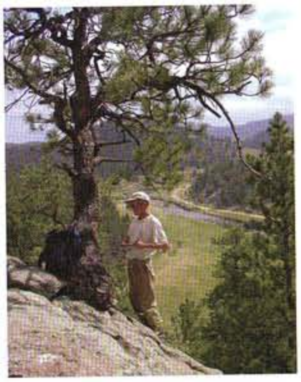
This document describes the U.S. Climate Change Science Program (CCSP) for FY 2006. It provides a summary of the achievements of the program, an analysis of the progress made, and budgetary information. It thereby responds to the annual reporting requirements of the U.S. Global Change Research Act of 1990 (section 107, P. L. 101-606). It does not express any regulatory policies of the United States or any of its agencies, or make any findings of fact that could serve as predicates for regulatory action. Agencies must comply with required statutory and regulatory processes before they could rely on any statements in this document or by the CCSP as a basis for regulatory action.

understanding a potential positive feedback on global warming caused by increased soil respiration in northern ecosystems (i.e., such a positive feedback might not occur in all ecosystems). In the warmed plots, tree growth began earlier in the spring and the growth of understory plants was greatly increased. Such changes in plant growth and its seasonal timing are important to the energy balance of northern ecosystems as the climate warms, and could result in a positive feedback to warming. Early results indicate greater carbon gains in the warmed plots relative to the ambient plots. For more information on this facility, see <per.ornl.gov/>.

Elevated Carbon Dioxide Effects on a Florida Ecosystem.[8] A study of a Florida scrub oak forest ecosystem suggested for the first time that the abundance of a trace element influenced the response of vegetation to elevated CO_2. The response of a nitrogen-fixing plant to elevated CO_2 declined over a 7-year period. The decline was strongly correlated to a decline in molybdenum, an element required for producing a key enzyme that affects nitrogen uptake by plants. The work illustrates that plant responses to elevated CO_2 may be highly species-specific. It also raises the possibility that the expected increase in plant growth due to elevated CO_2 could be limited by the availability of nitrogen.

Effects of Climate Change on Eastern U.S. Bird Species.[14] An atlas was produced that documents the current and potential future distribution of 150 common bird species in the eastern United States in relation to climate and vegetation distributions. Distribution data for individual species were derived from the Breeding Bird Survey from 1981 to 1990. Models were developed that related distributions of individual bird species to environmental variables (tree species abundance, climate variables, and elevation variables). Two scenarios of global climate change were then used to project potential changes in the distributions of the bird species. Depending on the global climate model used, as many as 78 bird species are projected to decrease by at least 25%, while as many as 33 species are projected to increase in abundance by at least 25% due to climate and habitat changes (see Figure 22 for an example).

Climatic Variability, Ecosystem Dynamics, and Disturbance in Mountain Protected Areas.[2,3,4,5,7,17,18] Northwestern mountain ecosystems play an important role in shaping the economies and landscape development of the region and provide services such as water purification and storage, and recreational opportunities. A project was initiated to quantify how the hydrological and ecological aspects of these ecosystems respond to climatic variability and large-scale landscape disturbance by examining past responses and projecting possible future outcomes of ongoing climatic change. The research project, Climate-Landscape Interactions on a Mountain Ecosystem Transect (CLIMET), was carried out across a transect of mountain systems along gradients of maritime to continental climate and decreasing landscape fragmentation (Olympic National Park, North Cascades National Park, and Glacier National Park) (Fagre and Peterson, 2002). The project has provided information on glacial decline, alpine forest changes, and ecological responses to climate variability (Fagre *et al.*, 2003). For example, an analysis of digital aerial photography and historical data documents that the number of glaciers in Glacier National Park has dropped from an estimated 150 in 1850 to 27 present today. The largest glaciers are, on average, only 28% of their previous size (see Figure 23). Future glacial recessions and vegetation distributions were projected using a geospatial modeling approach. Projections indicate that the largest glaciers will be gone in the northern Rocky Mountains by the year 2030 if current rates of warming continue (Hall and Fagre, 2003). The loss of glaciers in mountain watersheds will change the timing and amount of stream discharge and affect aquatic organisms dependent on cold waters.



Data are becoming available on the response of mountain ecosystems to climatic variability, particularly to multi-decadal trends in moisture. One such long-term pattern is the Pacific Decadal Oscillation (PDO), a period of above- or below-average sea surface temperatures in the Pacific Ocean that influences climate in the northwest part of North America. Mountain snowpacks in Glacier National Park track the PDO very closely and show regular 20- to 30-year periods of greater and lesser snow cover (Selkowitz *et al.*, 2002). These patterns explain glacier fluctuations and periods of increased tree growth in the northern Rocky Mountains (Pederson *et al.*, 2004). The frequency and size of forest fires in the Pacific Northwest also show a clear response to the PDO (Hessl *et al.*, 2003). Analysis of tree ring widths from drought-sensitive trees indicates that such multi-decadal oscillations have had an influence on these mountain environments for the past 500 years or more (Gedalof *et al.*, 2005). Such results suggest that it may be possible to forecast general mountain ecosystem responses to continuing climatic oscillations.

Sensitivity of Forests in Northern California to Climate and Fire Regime Variation.[19,21] Often, fire appears to serve as a catalyst for change during periods of rapid climate change. Time-series analyses show that vegetation associations with large, long-lived species (conifers) appear to lag in response to climate variations until major fires (as seen in charcoal influx to sediments) reset the stage and encourage major vegetation reorganization. This provides evidence of the potential influence of catastrophic fire on the reorganization of ecosystems under periods of rapid climate variation and could have major implications for habitat and forestry.

Leaf Pores: An Important Link among Increasing Greenhouse Gases, the Water Cycle, and Rising Temperatures.[13,15] Carbon dioxide and ozone (O_3), both greenhouse gases, directly affect plant physiological processes, including photosynthesis.

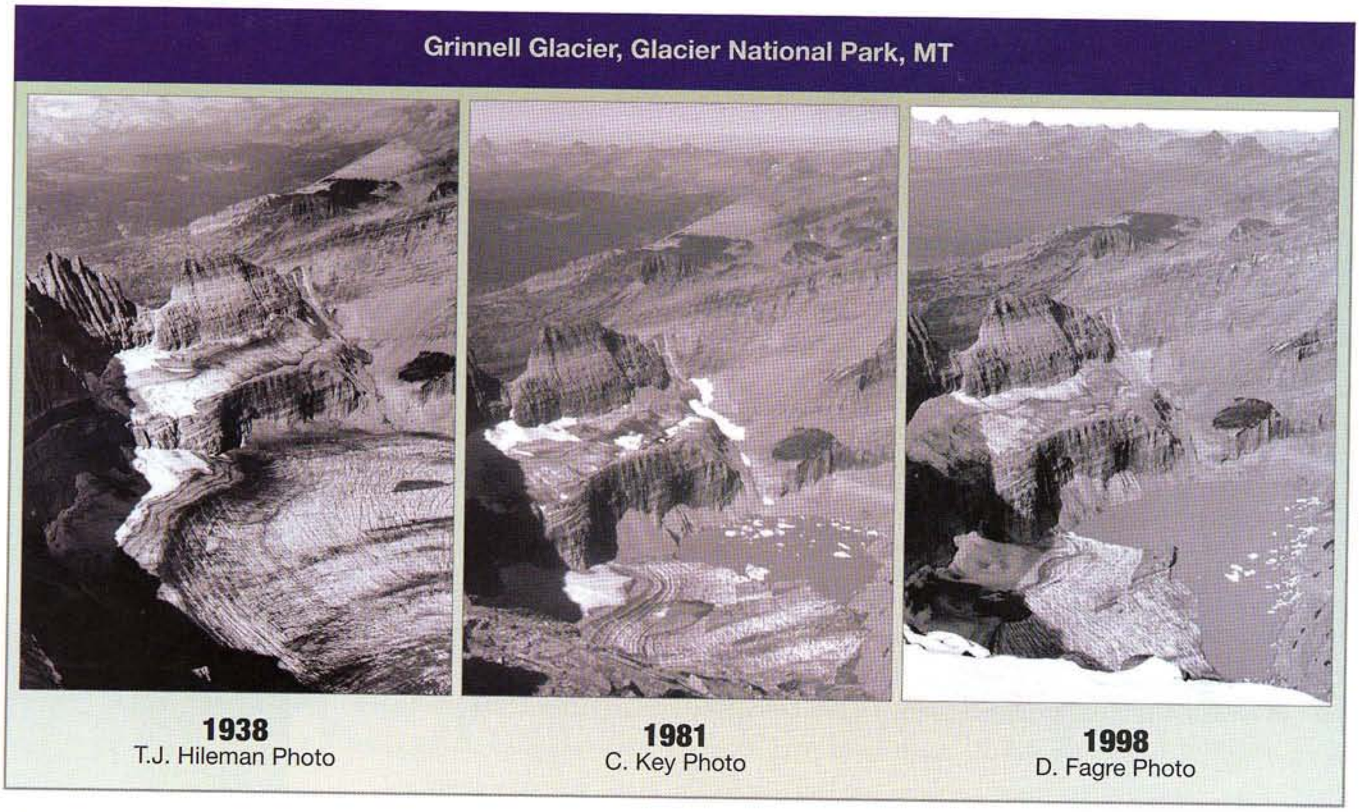


Figure 23: Glacier Retreat over the Past Century. Repeating photographs from the same location have provided visual documentation of the extent of glacier retreat over the past century. *Credit: USGS/Northern Rocky Mountain Science Center.*

These gases affect the opening and closing of microscopic pores (stomata) on plant leaves that regulate movement of water from the soil, through the plant, and into the atmosphere. Water vapor escaping through these pores cools the leaves and is important in the global water cycle. The number of stomata per unit of leaf area in grassland plant species in the southern United States was measured after the plants had been exposed for 4 years to a continuous CO_2 gradient spanning pre-industrial to near-double ambient concentrations. At higher CO_2 levels, stomatal density was greater for two species, decreased for one species, and unchanged for four species. In another field experiment using FACE technology, soybean plants were grown in the field at CO_2 and O_3 concentrations projected for the mid-21st century to explore how these changes in atmospheric composition might affect a nationally important agroecosystem. This work has provided the first field-scale evidence that rising CO_2 and O_3 concentrations decrease the loss of water vapor through the stomata and have the potential to substantially reduce summer moisture supply to the atmosphere (at the same time conserving soil moisture) and cause a warming of vegetated surfaces that will raise surface temperatures independently of greenhouse warming.

reference sites with non-reference sites to detect impairment. However, the combination of climate change and land-use change effects on biocriteria may cause baseline conditions at reference and non-reference sites to change, making impairment difficult to interpret. In FY 2006, case studies will be initiated in several States and for several aquatic ecosystems to identify those biocriteria metrics that are sensitive to climate and land-use changes, and those bioindicators that may be used to monitor shifting baselines between reference and non-reference sites. These studies will outline the general implications of climate change and land-use change for aquatic ecosystem health and for biocriteria programs.

These activities will address Question 8.3 of the CCSP Strategic Plan.

Effect of Agricultural Practices on Net Global Warming Potential. Research will provide new information about the effect of crop rotations, tillage, and nitrogen fertilization on the net global warming potential of agricultural systems – that is, the difference between total greenhouse gas emissions (carbon dioxide, methane, and nitrous oxide) and carbon sequestration. Collection of emissions and sequestration data along with soil environmental factors related to trace gas exchange will assist in verification of simulation models that can be used to estimate net global warming potential on larger spatial and temporal scales. In FY 2006, these analyses will lead to the development of methods by which global warming potential can be limited in irrigated and rain-fed cropping systems while sustaining agricultural yields.

These activities will address Question 8.3 of the CCSP Strategic Plan.

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