CHAPTER 10

ECOSYSTEMS

from the

Strategic Plan
for the
Climate Change Science Program

By the agencies and staff of the
US Climate Change Science Program

Review draft dated 11 November 2002

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US Climate Change Science Program
1717 Pennsylvania Ave., NW
Suite 250
Washington, DC 20006
Tel: +1 202 223 6262
Fax: +1 202 223 3065

11 November 2002

Dear Colleague,

The Climate Change Science Program will hold the U.S. Climate Change Science Program Planning Workshop for Scientists and Stakeholders at the Marriott Wardman Park Hotel in Washington, D.C., from 3-5 December 2002. The purpose of the Workshop is to provide a comprehensive review of the discussion draft of the Strategic Plan for U.S. climate change and global change research. This Workshop will offer extensive opportunities for the scientific and stakeholder communities to provide comment and input to the Climate Change Science Program Strategic Plan. When finalized by April 2003, the Strategic Plan will provide the principal guidance for U.S. climate change and global change research during the next several years, subject to revisions as appropriate to respond to newly developed information and decision support tools.

We are writing to request your comments on the discussion draft of the Climate Change Science Program Strategic Plan. Comments on all elements of the plan from all communities are essential in order to improve the plan and identify gaps. In your review, we ask you to provide a perspective on the content, implications, and challenges outlined in the plan as well as suggestions for any alternate approaches you wish to have considered, and the types of climate and global change information required by policy makers and resource managers. We also ask that you comment on any inconsistencies within or across chapters, and omissions of important topics. For any shortcomings that you note in the draft, please propose specific remedies. To participate in the review it is not necessary that you review the entire plan.

We ask that comments be submitted by E-mail to <comments@climatescience.gov>. All comments submitted by 13 January 2003 will be posted on the <http://www.climatescience.gov> website for public review. While we are unable to promised detailed responses to individual comments, we confirm that all submitted comments will be given consideration during the development of the final version of the Strategic Plan.

Attached to this letter are instructions and format guidelines for submitting review comments. Following the instructions will ensure that your comments are properly processed and given appropriate consideration. If you wish to distribute copies of the plan to colleagues to participate in the review, please provide them with a copy of this letter as well as the attached instructions and format guidelines. We have posted the plan on the workshop website at <http://www.climatescience.gov>. PDF files for individual chapters of the plan can be downloaded from this site. If you have any questions, please contact: Sandy MacCracken at 1-202-419-3483 (voice), 1-202-223-3065 (fax), or via the address in the footer below.

We appreciate your contribution of time and expertise to this review, and look forward to your response.

Sincerely,

James R. Mahoney, Ph.D.
Assistant Secretary of Commerce for Oceans and Atmosphere, and
Director, U.S. Climate Change Science Program

Instructions For Submission of Strategic Plan Review Comments

Thank you for participating in the review process. Please follow the instructions for preparing and submitting your review. Using the format guidance described below will facilitate our processing of reviewer comments and assure that your comments are given appropriate consideration. An example of the format is also provided. Comments are due by **13 January, 2003**.

- Select the chapter(s) or sections of chapters which you wish to review. It is not necessary that you review the entire plan. In your comments, please consider the following issues:
  - **Overview**: overview on the content, implications, and challenges outlined in the plan;
  - **Agreement/Disagreement**: areas of agreement and disagreement, as appropriate;
  - **Suggestions**: suggestions for alternative approaches, if appropriate;
  - **Inconsistencies**: inconsistencies within or across chapters;
  - **Omissions**: omissions of important topics;
  - **Remedies**: specific remedies for identified shortcomings of the draft plan;
  - **Stakeholder climate information**: type of climate and global change information required by representative groups;
  - **Other:** other comments not covered above.
- Please do not comment on grammar, spelling, or punctuation. Professional copy editing will correct deficiencies in these areas for the final draft.
- Use the format guidance that follows for organizing your comments.
- Submit your comments by email to <comments@climatescience.gov> by 13 January, 2003.

Format Guidance for Comments

Please provide background information about yourself on the first page of your comments: your name(s), organization(s), area of expertise(s), mailing address(es), telephone and fax numbers, and email address(es).

- Overview comments on the chapter should follow your background information and should be numbered.
- Comments that are specific to particular pages, paragraphs or lines of the chapter should follow your overview comments and should <u>identify the page and line numbers</u> to which they apply.
- Comments that refer to a table or figure should identify the table or figure number. In the case of tables, please also identify the row and column to which the comment refers.
- Order your comments sequentially by page and line number.
- At the end of each comment, please insert your name and affiliation.

Format Example for Comments

I. Background Information

Name(s): John Doe
Organization(s): University College
Mailing Address(es): 101 1st Street, New York, New York, 10001
Phone (s): 800-555-5555
Fax(es): 800-555-6666
E-mail(s): John.Doe@univ.edu
Area of Expertise: Atmospheric Composition

II. Overview Comments on Chapter 5: Atmospheric Composition

First Overview Comment: (Comment)
Reviewer's name, affiliation: John Doe, University College

Second Overview Comment: (Comment)
Reviewer's name, affiliation: John Doe, University College

III. Specific Comments on Chapter 5: Atmospheric Composition

Page 57, Line 5: (Comment)
John Doe, University College

Page 58, Line 32 - Page 59, Line 5: (Comment)
John Doe, University College

Table 1-4, Row 3, Column 6: (Comment)
John Doe, University College

Please send comments by email to <comments@climatescience.gov>

Foreword

In February 2002 President George W. Bush announced the formation of a new management structure, the Climate Change Science Program (CCSP), to coordinate and direct the US research efforts in the areas of climate and global change. These research efforts include the US Global Change Research Program (USGCRP) authorized by the Global Change Research Act of 1990, and the Climate Change Research Initiative (CCRI) launched by the President in June 2001 to reduce significant uncertainties in climate science, improve global climate observing systems, and develop resources to support policymaking and resource management.

The President's Climate Change Research Initiative was launched to provide a distinct focus to the 13-year old Global Change Research Program. The CCRI focus is defined by a group of uncertainties about the global climate system that have been identified by policymakers and analyzed by the National Research Council in a 2001 report requested by the Administration.

The Climate Change Science Program aims to balance the near-term (2- to 4-year) focus of the CCRI with the breadth of the USGCRP, pursuing accelerated development of answers to the scientific aspects of key climate policy issues while continuing to seek advances in the knowledge of the physical, biological and chemical processes that influence the Earth system.

This *discussion draft* strategic plan has been prepared by the thirteen federal agencies participating in the CCSP, with input from a large number of scientific steering groups and coordination by the CCSP staff under the leadership of Dr. Richard H. Moss, to provide a vehicle to facilitate comments and suggestions by the scientific and stakeholder communities interested in climate and global change issues.

We welcome comments on this draft plan by all interested persons. Comments may be provided during the US Climate Change Science Program Planning Workshop for Scientists and Stakeholders being held in Washington, DC on December 3 – 5, 2002, and during a subsequent public comment period extending to January 13, 2003. Information about the Workshop and the written comment opportunities is available on the web site www.climatescience.gov. A specially formed committee of the National Research Council is also reviewing this draft plan, and will provide its analysis of the plan, the workshop and the written comments received after the workshop. A final version of the strategic plan, setting a path for the next few years of research under the CCSP, will be published by April 2003. We appreciate your assistance with this important process.

James R. Mahoney, Ph.D.
Assistant Secretary of Commerce for Oceans and Atmosphere, and
Director, Climate Change Science Program

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of the
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CHAPTER 10

ECOSYSTEMS

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Question 1: What are the most important linkages and feedbacks between ecosystems and global change (especially climate), and what are their quantitative relationships?

Question 2: What are the potential consequences of global change for ecosystems and the delivery of their goods and services?

Question 3: What are the options for sustaining and improving ecosystem goods and services valued by societies, given projected global changes?

Key Linkages

Ecosystems sustain life on Earth by providing a wide variety of goods and services, including food, fiber, shelter, energy, clean air and water, and recycling of elements. From a human perspective, ecosystems provide renewable resources, together with cultural, spiritual, and recreational benefits. During the next 10 years, research on ecosystems will focus on two overarching questions:

- **How do natural and human-induced changes in the environment interact to affect the structure and functioning of ecosystems at a range of spatial and temporal scales, including those functions that can in turn influence regional and global climate?**
- **What options does society have to ensure that desirable ecosystem goods and services will be sustained or enhanced in the face of potential regional and global environmental changes?**

Global environmental changes are altering the structure and functioning of ecosystems, affecting in turn the flow of ecosystem goods and services. Research during the last decade focused on the vulnerability of ecosystems to global change and contributed to assessments of the potential impacts of global change on ecosystems at multiple scales. We now know that impacts of environmental changes and variability may be manifested in complex, indirect, and conflicting ways. For example, warming may enhance tree growth by extending growing season length, but pathogens able to survive the winter because of higher temperatures may decrease forest productivity and further increase vulnerability to disturbances such as fire. Subtle changes in the salinity or temperature of ocean currents may alter the ranges and population sizes of fish species and increase or decrease fish catches. Whether environmental changes are anthropogenic or natural in origin, human societies face substantial challenges in ensuring that ecosystems sustain the goods and services on which we depend for our quality of life and, in some cases, for survival itself.

Ensuring the provision of ecosystem goods and services needed and valued by a growing human population requires understanding the interactions among basic ecosystem processes and developing approaches to reduce the vulnerabilities or take advantage of opportunities that arise within ecosystems as a result of global change. Scientific research can contribute to this societal goal by addressing three questions that will provide information to determine linkages and feedbacks between ecosystems and drivers of global change, identify important consequences for ecosystems on which societies depend for crucial goods and services, and identify options for how society might respond to sustain and enhance ecosystem goods and services as environmental conditions change.

Question 1: What are the most important linkages and feedbacks between ecosystems and global change (especially climate), and what are their quantitative relationships?

STATE OF KNOWLEDGE

Biological, chemical, and physical processes occurring in ecosystems affect and are affected by weather and climate in many ways. For example, ecosystems exchange large amounts of greenhouse gases with the atmosphere, including water vapor, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Moreover, the reflection (or absorption) of solar radiation by ecosystems is important to the temperature of Earth's surface, and several ecosystem processes affect this reflection. Linkages among the physical, chemical, and biological components of ecosystems are important on short time scales (minutes to days) as well as over the long term (years to millennia). Global change has the potential to alter ecosystem structure (e.g., amount of leaf area, plant height, or species composition) and ecosystem functioning (e.g., rate of evapotranspiration, carbon assimilation, or nitrogen cycling), and those potential ecosystem changes might themselves alter linkages between ecosystems and the global chemical and physical environments and therefore contribute to global change through numerous feedback mechanisms.

The most important feedbacks (either positive or negative) are likely to involve:

- Altered ecosystems exchanges of greenhouse gases (e.g., water vapor, CO_2, CH_4, N_2O);
- Altered ecosystem exchanges of aerosols (such as black carbon and sulfur resulting from controlled and uncontrolled ecosystem burning);
- Altered releases of volatile organic compounds;
- Changes in ecosystem/surface albedo; and/or

- Changes in the fraction of absorbed solar radiation that is "used" to evaporate water compared to directly heating the plants and soils in ecosystems.

Better understanding of ecosystem feedbacks on climate and atmospheric chemistry is needed to predict future climate and to inform policy decisions. Achieving this understanding will require collaboration with the Carbon Cycle (Chapter 9), Water Cycle (Chapter 7), and Land Use/Land Use Change (Chapter 8) research elements.

Feedbacks

A feedback from ecosystems to global change occurs when a change in the environment causes a change in the ecosystem (either its structure or functioning) that in turn alters the rate of the environmental change. A *positive feedback* intensifies the environmental change whereas a *negative feedback* slows the change. Both positive and negative feedbacks could be brought about in many ways. A positive feedback could occur, for example, if warming and drying (caused by rising atmospheric CO_2) of high latitude ecosystems containing large amounts of carbon in plants and soils (e.g., tundra and peatland) resulted in greater ecosystem respiration. That increase in respiration would accelerate the atmospheric CO_2 increase, which could accelerate the warming and drying. A negative feedback might occur if, for example, rising atmospheric CO_2 increased the geographic expansion of ecosystems into presently unfavorable environments and the increased areal extent of those ecosystems resulted in greater transfer of CO_2 from the atmosphere into the expanded ecosystems where it was stored in plants or soils. Complex feedbacks could occur if climatic change (perhaps accompanied by modified human activities in response to such changes) leads to land cover changes (e.g., ice/snow cover; balance between greenness, desertification, and urbanization; plant community changes) that alter the Earth's albedo, which itself could further modify climate.

ILLUSTRATIVE RESEARCH QUESTIONS

- How might various global and regional environmental changes (e.g., temperature and precipitation) affect net ecosystem exchanges (or timing or geographic distribution of those exchanges) of greenhouse gases?
- How might changes in climate and greenhouse gas concentrations, in combination with other factors such as land use/cover changes, affect nutrient cycling, ecosystem albedo, and energy exchange?
- How might changes in regional air quality, including chemicals and aerosols released from disturbances such as wildfires and crop residue burning, in combination with other global changes, affect ecosystem albedo and exchange of greenhouse gases?
- How might changes in ecosystems (particularly in the Arctic) alter ocean circulation, and could this contribute to abrupt changes in regional climates?
- How might various human activities, including redistribution of nutrients and water, affect the release or uptake of greenhouse gases by various ecosystems (e.g., wetlands, croplands, deserts, tundra, pastures and rangeland, coastal/estuarine systems, forests, lakes and rivers, and urban areas)?

RESEARCH NEEDS

Ecosystems research needs include ecological experimental facilities, improved ecosystem models, and enhanced ecosystem monitoring capabilities and programs (at different scales) to link point observations with remote sensing data to scale up. New research and monitoring programs may be too expensive, so the major efforts might be directed at enhancing existing capabilities. Specific research needs include:

- Large-scale field experiments and long-term ecological monitoring facilities required to understand ecosystem-environment interactions (focusing on ecosystem greenhouse gas and energy exchanges) to develop data needed to parameterize, calibrate, and evaluate models of ecosystem-climate-atmospheric chemistry feedbacks;
- Models that link remote sensing of land surface albedo to changes in the spatial distribution of ecosystems and exchanges of mass, energy, and momentum for implementation in general circulation models; and
- Spatially explicit ecosystem models capable of representing complex interactions between diverse ecosystems and the physical/chemical environment.

PRODUCTS AND PAYOFFS

- Reports presenting a synthesis of current knowledge of observed and potential (modeled) feedbacks between ecosystems and global/climate change, to aid understanding of such feedbacks and identify knowledge gaps for research planning (2 years).
- Identification of indicators of ecosystem change that are most important to feedbacks to climate and atmospheric chemistry, to help identify early responses and focus on important potential consequences (3 years).
- Definition of the initial requirements for monitoring of ecosystems to quantify feedbacks to climate and atmospheric chemistry, to guide enhancement of existing environmental monitoring programs, and possibly create new ones (4 years).
- Quantification of important long-term relationships between potential global change (especially multiple factors), linkages between ecosystems and climate, and resulting feedbacks to the atmosphere and ocean, to improve the accuracy of climate projections (> 4 years).

Question 2: What are the potential consequences of global change for ecosystems and the delivery of their goods and services?

STATE OF KNOWLEDGE

There is considerable evidence that ecosystems are already responding to global change, including climate change and variability and changes in atmospheric chemistry. For example, responses to changes in a single property (e.g., rising or extreme temperatures) have been linked to longer growing seasons (period of leaf display), grass species decline, changes in lake acidity, and coral bleaching. Climate change variables also interact. For example, increased temperatures in the tropics may increase coral bleaching and expand the range of corals poleward. These and other observations have come from long-term ecological research and monitoring, as well as from shorter-term, individual investigations. The few programs that support long-term observations (e.g., forest productivity, ultraviolet (UV) radiation fluxes, nitrogen deposition, and the spread of invasive species) have unambiguously established that large-scale ecological changes are occurring.

Most ecosystems are subject to multiple changes at any given time. Recent reviews have summarized the range of observed and potential undesirable consequences of combinations of climate and other local and shorter-term drivers (e.g., invasive species, nutrient pollution, and physical habitat modification) on coastal and marine ecosystems. In terrestrial systems, increased primary productivity driven by increased CO_2 depends in part on soil fertility, and warming has the potential to alter the effects of rising CO_2 on primary production processes. Interactions among temperature change, precipitation, and fire regimes can influence ecosystem vulnerability to invasive species. Survival and spread of pathogens and their vectors (carriers) are highly dependent on climate and weather, thus, climate change and increased weather variability can be expected to affect disease-causing organisms that can alter population sizes and genetic diversity of humans, animals, and plant hosts.

ILLUSTRATIVE RESEARCH QUESTIONS

- What are the effects of multiple environmental changes on the structure, functioning, and biodiversity of terrestrial and aquatic ecosystems, particularly changes in CO_2, ozone, temperature, nitrogen cycling, UV radiation, sea level rise, precipitation patterns, and regional and global ocean circulation?
- How do changes in climate, climate variability, or weather variability intensify or mitigate the effects of other ecosystem stresses (e.g., pollution, invasive species, and changes in land and resource use)?
- What impacts will global environmental change have on the delivery of ecosystem goods and services such as forest and agricultural productivity, groundwater recharge, flood protection, fisheries, and recreation, and which will have the greatest socioeconomic impacts on humans?
- How do changes in climate and weather (both variability and extremes) affect the ecology and epidemiology of infectious pathogens, dissemination by their vectors, and the susceptibility of the humans, animals, and plants that are their hosts?

RESEARCH NEEDS

Identifying and quantifying the consequences of global change for ecosystems is essential for accurately assessing options for responding to ecosystem changes. Determining the most important and societally relevant ecosystem responses to global change will require collaboration among the physical, biological, and social science communities and an improved understanding of complex interactions between natural and human disturbances and climate variability. Some specific research needs to support this effort include:

- Investigations of the link between biodiversity and ecosystem functions and flows of services;
- Experiments on intact natural ecosystems to study the interactive effects of climate change, elevated CO_2, nutrient/pollution deposition, and other factors on key species and ecosystems;
- Remote sensing data to quantify key characteristics (e.g., vegetation composition and structure, biomass amount, and disturbance patterns) of present ecosystems, monitor trends in ecosystem changes, and link these observations to known processes;
- Studies to connect contemporary and historical changes in ecosystem structure and functioning; and
- Maintenance and enhancement of basic remotely sensed terrestrial, atmospheric, and ocean monitoring systems and networks to monitor trends and provide necessary data to observe changes, parameterize models, and verify model projections.

PRODUCTS AND PAYOFFS

- Reports describing the potential consequences of global and climate change on a range of terrestrial, freshwater, and marine ecosystems (e.g., Arctic and estuarine ecosystems; fire-susceptible ecosystems; Great Lakes) based on available research findings, to alert decisionmakers to the most likely consequences to ecosystems (2 years).
- Summaries of information to identify indicators of ecosystem change most important to the delivery of goods and services, and summaries of requirements for monitoring and modeling those ecosystems to enable tracking and forecasting changes to societally-relevant aspects of ecosystems (4 years).
- Spatially explicit ecosystem models at regional to global scales, based on data from experimental manipulations focused on the effect of interactions among global change variables, to improve our capacity to observe contemporary, historical, and long-term changes in ecosystem structure and functioning (> 4 years).

Question 3: What are the options for sustaining and improving ecosystem goods and services valued by societies, given projected global changes?

STATE OF KNOWLEDGE

As described previously, experiments and observations have demonstrated linkages between climate and ecological processes that indicate that possible future changes in climate could alter ecosystems in ways that might disrupt the flow of ecosystem services. Research has identified and evaluated some specific adaptation measures, including integrated land and water management; selection of plants and livestock for many intensive systems; multiple cropping systems; multiple-use systems for freshwater and land systems; protection programs for key habitats, landscapes, and/or species; intervention programs (e.g., captive breeding and/or introduction programs); efficient use of natural resources; and institution and infrastructure mechanisms (e.g., market responses, crop insurance, and water flow and supply management).

Research has investigated how management practices may affect climate-related ecosystem services. For example, ecosystems emit greenhouse gases such as CH_4, N_2O, CO_2, water vapor, and aerosols; they store carbon, nitrogen, phosphorus, and other elements in soils, plants, wetlands, and oceans; and they reflect solar radiation. Management practices may result in positive or negative feedbacks to the climate system by altering emissions, carbon and nutrient storage, or reflectivity of the Earth's surface. However, while specific management strategies have been investigated, society's knowledge and ability to manage the broad array of ecosystem services in the context of increasing and potentially conflicting demands is extremely limited.

ILLUSTRATIVE RESEARCH QUESTIONS

- How could aquatic ecosystems (e.g., rivers and coral reefs) be managed to balance the production and sustenance of ecosystem services across multiple demands (e.g., management of rivers to supply freshwater for drinking, irrigation, recreation, and aquatic species; and management of coral reefs for tourism, erosion protection, refugia for commercially and recreationally important species, recreational and cultural activities, and biodiversity), considering the future effects of interacting global changes?
- How might terrestrial ecosystems such as rangelands, forests, woodlands, and agricultural lands be managed to balance the production and sustenance of ecosystem services across multiple demands (e.g., food, fiber, fuel, fodder, recreation, non-wood forest products, biodiversity, biogeochemical cycles, tourism, and flood and storm control), considering the future effects of interacting global changes?
- What options exist for society to preserve genetic diversity, respond to species migrations or declines, and manage changing disease incidence and severity in the face of environmental change?
- What are the effects of management techniques on global or regional environments (e.g., atmospheric chemistry; water supply quantity and quality), nitrogen cycling, and the maintenance of health, productivity, and resilience of ecosystems?
- What dependency, use and value do societies have for non-market services provided by terrestrial and aquatic ecosystems?

RESEARCH NEEDS

There is a need for evaluations of the influences of societal needs and demands on ecosystems and the values that societies place on ecosystem goods and services. Precise understanding of effective options to maintain and enhance the supply of critical goods and services will require substantial improvements in modeling capabilities to project impacts of interacting environmental changes on ecosystem services and to evaluate the effectiveness of alternative management responses. Specific research needs include:

- Exploring the causal mechanisms that create the complex changes in ecosystem services across multiple scales, including development of genetic and molecular tools to better understand, manage, and predict ecosystem/environment interactions;

- Integrated analyses of how ecological information, technology, forecasts, and scientific uncertainties may affect human behavior and be incorporated into environmental decisionmaking;
- Development of local to regional decision support tools linked to fully interactive ecosystem-climate models capable of simulations to evaluate climate change scenarios; and
- Development of methods, tools, and management approaches to sustain ecosystem services, coupled with an assessment of the direct and indirect effects of these approaches.

PRODUCTS AND PAYOFFS

- Data for preliminary comparisons of the effectiveness of selected forestry and agricultural management practices (e.g., fuel management, silviculture, timber harvesting, crop and tree genetics, nutrient management, tillage systems, irrigation, and crop rotations) in selected regions focusing on N_2O emissions, trace gas fluxes, and health and productivity of the targeted ecosystems and their services under changing environmental conditions (2 years).
- Data for preliminary comparisons of the effectiveness of selected management practices in other types of ecosystems (e.g., wetlands, fisheries, boreal forests, tundra, and coral reefs) in selected regions focusing on N_2O emissions, trace gas fluxes, and health and productivity of the targeted ecosystems and their services under changing environmental conditions (4 years).
- Data and spatially explicit models for examining the impact of management and policy decisions on a wide range of ecosystems, to predict the efficacy and tradeoffs of management strategies at varying scales relevant to the decisions at hand (> 4 years).

Key Linkages

Given the nature of the drivers of ecosystem change, research must span spatial scales (from small experimental plots to global satellite image mosaics), time scales (taking data from ice cores, tree rings, and fossil pollen to near-real-time forecast models), and the scientific elements of this plan. Monitoring systems at multiple spatial scales are needed to develop a consistent record of environmental change over time. Data from such observation systems would provide inputs to models and also allow evaluation and improvement of model performance. The resulting large collections of environmental data will necessitate large databases. Interagency facilities and mechanisms must be in place to process, archive, and distribute the data collected and generate relevant products.

Future observation systems may rely on networks of terrestrial and aquatic ecosystem observatories within particular biomes or larger ecoregions. They should link together and build on existing networks of field stations, experimental forests and ranges, environmental and resource monitoring programs, and long-term ecological research sites sponsored by many different government and academic organizations, many of which have lengthy records of environmental and ecological data.

For the ecosystems research community to make significant contributions to our understanding and management of global change, explicit scenarios and information to drive ecosystem models must be obtained from other research elements under this plan, including Scenario Development and Applied Climate Modeling (Chapter 4), Atmospheric Composition (Chapter 5), Climate Variability and Change (Chapter 6), Carbon Cycle (Chapter 9), Water Cycle (Chapter 7), Land Use/Land Cover Change (Chapter 8), and Human Contributions and Responses (Chapter 11). In turn, products from studies of the linkages between global change and ecosystems can be expected to improve the scientific products of these other plan elements. Collaboration with appropriate international efforts will involve programs and organizations such as several sponsored wholly or in part by the International Geosphere-Biosphere Programme (IGBP), including the Global Climate and Terrestrial Ecosystems (GCTE) project, the Global Environmental Change and Food Systems (GECaFS) project, or the Biospheric Aspects of the Hydrological Cycle (BAHC) project. Scientists conducting research under the Ecosystems element of this plan will participate in the planning of international collaboration activities.

Authors and Contributors

PART II. THE U.S. GLOBAL CHANGE RESEARCH PROGRAM (USGCRP)

Chapter 10. Ecosystems

Lead Authors

Susan Herrod Julius (Co-Chair), EPA
Steve Shafer (Co-Chair), USDA
Jeff Amthor, DOE and CCSP
John Calder, NOAA
Susan Conard, USDA
Knute Nadelhoffer, NSF
Don Scavia, NOAA
Woody Turner, NASA

Contributors

Larry Adams, USDA
Nancy Cavallaro, USDA
Pat Megonigal, Smithsonian Institute
Jessica Orrego, CCSP
Catriona Rogers, EPA
Chuck Trees, NASA