CHAPTER 6

Land-Use/Land-Cover Change

CHAPTER CONTENTS

Land-use and land-cover are linked to climate and weather in complex ways. Key links between changes in land cover and climate include the exchange of greenhouse gases (such as water vapor, carbon dioxide, methane, and nitrous oxide) between the land surface and the atmosphere, the radiation (both solar and longwave) balance of the land surface, the exchange of sensible heat between the land surface and the atmosphere, and the roughness of the land surface and its uptake of momentum from the atmosphere. Because of these strong links between land cover and climate, changes in land use and land cover can be important contributors to climate change and variability. Moreover, reconstructions of past land-cover changes and projections of possible future land-cover changes are needed to understand past climate changes and to project possible future climate changes; land-cover characteristics are important inputs to climate models. In addition, changes in land use and land cover, especially when coupled with climate variability and change, are likely to affect ecosystems and the many important goods and services that they provide to society. The National Research Council recently identified land-use dynamics as one of the grand challenges for environmental research (NRC, 2001b).

Determining the effects of land-use and land-cover change on the Earth system depends on an understanding of past land-use practices, current land-use and land-cover patterns, and projections of future land use and cover, as affected by human institutions, population size and distribution, economic development, technology, and other factors. The combination of climate and land-use change may have profound effects on the habitability of Earth in more significant ways than either acting alone. While land-use change is often a driver of environmental and climatic changes, a changing climate can in turn affect land use and land cover. Climate variability alters land-use practices differently in different parts of the world, highlighting differences in regional and national vulnerability and resilience.

The interaction between land use and climate variability and change is poorly understood and will require the development of new models linking the geophysics of climate with the socioeconomic drivers of land use. Providing a scientific understanding of the process of land-use change, the impacts of different land-use decisions, and the ways that decisions are affected by a changing climate and increasing climate variability are priority areas for research.

In addition to being a driver of Earth system processes affecting the climate, carbon cycle, and ecosystems, land-use and land-cover change is a global change in its own right, requiring its own research

Figure 6-1: Land use: strip cropping and woodlots in Leelanau County, Michigan. Source: USDA NRCS (photo by Lynn Betts, 2001).

foundation. Key issues to be addressed by this research element include the spatial and temporal dynamics of land-use change, the role of fragmentation and degradation, the role of multiple drivers, the role of institutions, and the interactions among drivers and types of land-use change.

This research element provides the scientific underpinning for land-use decisionmaking and projections of future land use, and has substantial benefits beyond climate change assessment and mitigation by supporting a wide array of issues important to users of this information. To meet multiple objectives, the land-use and land-cover change research element will address two overarching questions:

- What processes determine the temporal and spatial distributions of land cover and land use at local, regional, and global scales, and how and how well can land use and land cover be projected over time scales of 5-50 years?
- How may changes in land use, management, and cover affect local, regional, and global environmental and socioeconomic conditions, including economic welfare and human health, taking into consideration socioeconomic factors and potential technological change?

To address these overarching questions, a focused, integrated research agenda is required that includes process studies, systematic observations, modeling and prediction, retrospective studies, research on impacts, and regional science networks and assessments. In addition, research collaboration with other program elements will be necessary to gain detailed understanding of the direct impacts of land-use and land-cover change on climate, as well as the combined effects of land use and climate change on ecosystems, water, and carbon cycles. Answers to the overarching questions will require research focused on the five specific questions posed in this chapter.

Question 6.1: What tools or methods are needed to better characterize historic and current land use and land cover attributes and dynamics?

State of Knowledge

During the previous decade, significant progress was made in planning and launching satellites with instruments suited for Earth observation. In addition, a number of national- to global-scale experimental land-cover databases were developed that led to increased use of land cover in climate and carbon cycle models. Methodological advancements were also made. As a result, there is an improved capability for and strong reliance on remote-sensing and land-cover databases for multi-scale environmental studies. The research and development associated with this question involves the continuation of, and improvements in, data collection systems and data products. This will provide new information leading to regular updates of land-cover databases at scales relevant for issues ranging from local resource management to global-scale analyses.

While remote sensing provides quick and comparatively inexpensive information about land-cover changes over large areas, land-cover database improvements will require integration of data from ground-based networks (see Figure 6-2). These networks offer a wealth of historical data (often with data records extending back 50-100 years), and can provide detailed site information (e.g., primary production, species composition, habitat quality, wildlife population statistics, soil type, tillage and crop rotation history, and land-use classifications). Integrating ground-based and remote-sensing data collection systems provides an opportunity to vastly improve the speed and quality of land-use and land-cover data for use in applied research. Much of our understanding of land-use and land-cover change has built up from individual case studies, using both remote sensing and ground-based data, and we will continue to rely on case studies as a means to gain required knowledge.

Illustrative Research Questions

- What improvements need to be made to current observing systems and what programs need to be put in place to provide the necessary long-term data and information to support the study of land-use and land-cover change at the global, regional, and national scales?
- What are the methodological advances needed to improve land-use and land-cover change analyses, including strategies for integrating ground-based data, socioeconomic statistics (e.g., census information), and remotely sensed measurements?
- What are the historical and current patterns and attributes of land use and land cover at national to global scales that affect the carbon cycle, atmospheric processes, and ecosystem structure and function?
- What are the national and global rates, patterns, and characteristics of contemporary land-use and land-cover change?
- Where are the current areas of rapid land-use and land-cover change at national and global scales?

Research Needs

Evolving public and private land management questions call for new data and information and improved scientific bases for decisionmaking. They also require long-term continuity in data collection, and the acquisition of data at the global scale. Coordination and prioritization of the specific land-use and land-cover change data requirements with the Observing and Monitoring research element is imperative. Methods and procedures now exist

to make routine global observations of land cover, but there is currently no operational program. With the current suite of satellite sensing systems and archived data sets available to the research community, studies at the large spatial scales needed to depict land-cover and management changes can begin.

While considerable progress has been made in mapping land-cover characteristics, the ability to accurately map the wide range of landscape attributes, including land use and biomass, will require a considerable research effort. Coordination of existing *in situ* data collection efforts, and the retrieval, analysis, and integration of historical data are needed to extend the usefulness of existing data and to enrich and standardize data attributes in future data collection and use. In addition, improvements in remotely sensed data quality and in automated algorithms for detection of local land-cover changes and their characteristics are needed. Data integration will be particularly important so that *in situ*, remotely sensed, and other forms of data can be merged and used to derive the needed land-use and land-cover information. As scientific demands and needs for land-use and land-cover information change, parallel innovation in the resulting data products will be essential.

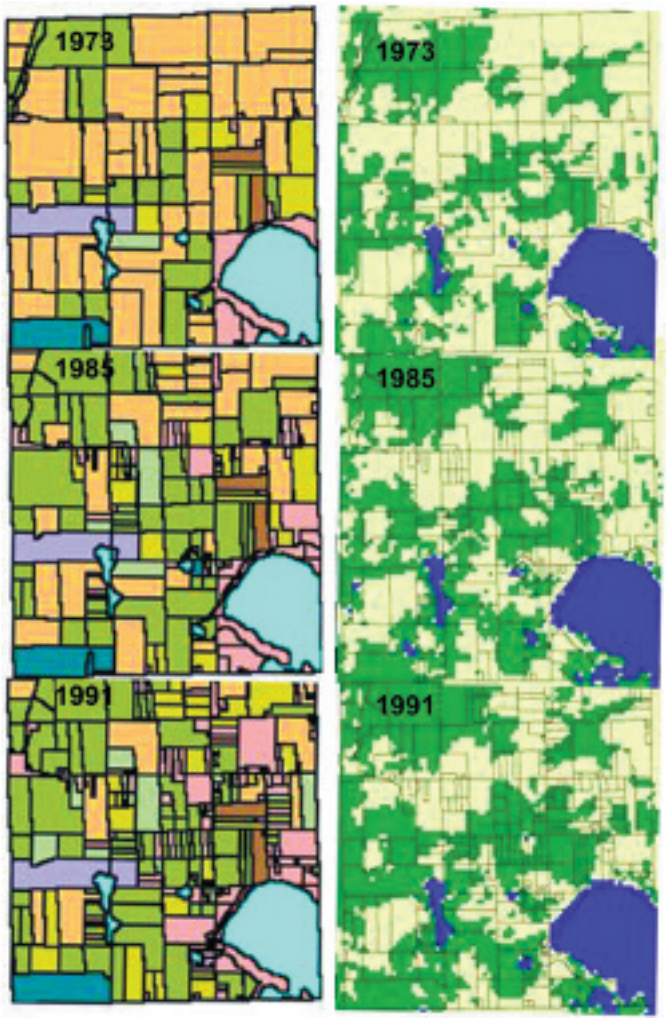

Figure 6-2: Forest cover increase and abandonment of marginal agricultural lands in Grand Traverse County, Michigan. The left image illustrates land-use change by parcel interpreted from aerial photographs. Green colors are forest, beige/yellow agriculture, and pink residential development. The right image is forest cover from Landsat satellite images. Green is forest and light yellow is not forest. Source: School of Natural Resources and Environment, University of Michigan. For more information, see Annex C.

Milestones, Products, and Payoffs

- National land-cover database for the United States that includes attributes of land cover and vegetation canopy characteristics [less than 2 years]. This product is a required model input needed by the Carbon Cycle, Water Cycle, and Ecosystems research elements.
- Continued acquisition of global calibrated coarse-, moderate-, and high-resolution remotely sensed data [ongoing].
- Global moderate-resolution land-cover database with attributes required for parameterization of climate, carbon cycle, and ecosystem models [less than 2 years]. Parameter specifications must be coordinated with the Climate Variability and Change research element.
- Global maps of areas of rapid land-use and land-cover change and location and extent of fires [less than 2 years].
- Quantification of rates of regional, national, and global land-use and land-cover change [regional, less than 2 years; national, 2-4 years; global, beyond 4 years]. This product is a required model input needed by the Carbon Cycle, Water Cycle, and Ecosystems research elements.
- Integrated land-use and land-cover change detection strategies and operational prototypes of detection systems that enable accurate and cost-effective detection of local to global changes [less than 2 years].
- Global high-resolution satellite remotely sensed data and land-cover databases with attributes required for national to global scale applications [beyond 4 years].
- Global and national land-use history maps spanning the period from the industrial revolution to the present (300 years). This product is required by the Carbon Cycle and Ecosystems research elements [beyond 4 years].
- Operational global monitoring of land-use and land-cover conditions [beyond 4 years]. This product will be used by several other research elements including Carbon Cycle, Ecosystems, and Climate Variability and Change.
- Analysis of the global occurrence, extent, and impact of major disturbances (e.g., fire, insects, drought, and flooding) on land use and land cover [beyond 4 years]. Input on the frequency of drought and flooding will be sought from the Climate Variability and Change research element.

Question 6.2: What are the primary drivers of land-use and land-cover change?

State of Knowledge

The ability to forecast land-use and land-cover change and, ultimately, to predict the consequences of change, will depend on our ability to understand the past, current, and future drivers of land-use and land-cover change. These factors as well as other emerging social and political factors may have significant effects on future land use and cover. Patterns of land use, land-cover change, and land management are shaped by the interaction of economic, environmental, social, political, and technological forces on local to global scales (see, for example, Figure 6-3).

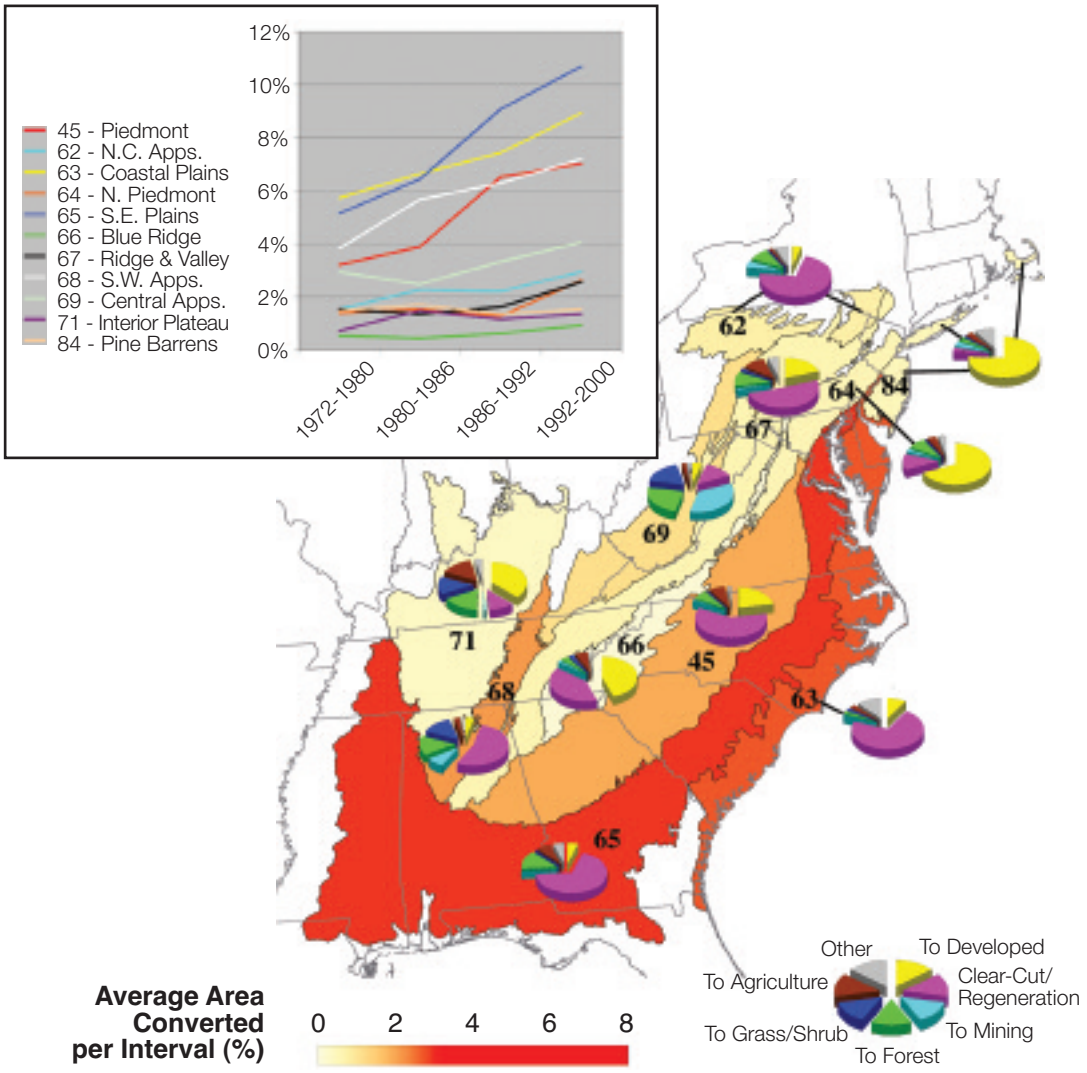

Figure 6-3: Land-cover change in eastern U.S. ecosystems, 1973-2000. An analysis of land-use and land-cover change in the eastern United States provides evidence of distinctive regional variation in the rates and characteristics of changes. The color of each ecoregion indicates the rate of change, while the pie charts indicate the type of change. In some areas, rapid, cyclic harvesting and replanting of forests was the main cause of change, while urbanization dominated in other areas. Source: USGS EROS Data Center. For more information, see Annex C.

An improved understanding of historical land-use and land-cover patterns provides a means to evaluate complex causes and responses in order to better project future trends of human activities and land-use and land-cover change. We must understand the primary modern and future drivers of land use and their interrelationship with land management decisions and resource policies to develop projections of future land-use and management decision outcomes under a range of economic, environmental, and social scenarios. This ability will allow better projections and hopefully minimize negative impacts, especially as related to climate change. This type of analysis will require the integration of various disciplines from the physical and social sciences.

Illustrative Research Questions

- What are the primary historic and contemporary natural and human drivers of land-use and land-cover change and what will they be in the future?
- What has been the historical relationship between land use and land management systems and how will the relationship change through the next few decades?
- What are the most significant drivers of land-use and land-cover change?
- How have and will the driving forces of change affect(ed) land use and cover at different scales (i.e., local, regional, and global) and where are there opportunities for managing land-use change to minimize negative impacts and maximize positive outcomes?
- How, and to what extent, do extreme events (e.g., natural disasters, public health emergencies, and war) affect land-use and land-cover change and vice versa?
- How will environmental, institutional, political, technological, demographic, and economic processes determine the temporal and spatial distribution of land use and land cover over the next few decades?

Research Needs

An innovative approach is needed to quantify, understand, model, and project natural and human drivers of land-use and land-cover change. Research is needed to understand and project the interactions of economic, social, and environmental choices on land use and management policies and decisions. New techniques and tools that integrate understanding of human behavior, opportunities, consequences, and alternatives are needed for improved decisionmaking and policymaking. There must be close collaboration with the Human Contributions and Responses research element to understand the social and economic drivers that affect human choices.

Improvements are needed in process models of land-use and land-cover change dynamics in space and time, combining field-level case

studies for analysis of processes and management systems, statistical studies for large regions, and empirical analyses using remote sensing at local scales. This process-level understanding of land-use and land-cover dynamics and interactions with socioeconomic and biophysical factors will aid the analysis of land-use and land-cover change across scales. Work is needed to understand the interactions between agents or causes of land-use change and climate change and variability.

Milestones, Products, and Payoffs

- Summary of the historical and contemporary regional driving forces of land-use and land-cover change [United States, less than 2 years; global, beyond 4 years]. This product is needed by the Ecosystems research element.
- Understand how primary drivers of land use and land management decisions are likely to change over the next few decades [United States, 2-4 years; global beyond 4 years].
- Quantify and project possible drivers of land-use change for a range of economic, environmental, and social values [beyond 4 years]. This product is needed by the Ecosystems and Carbon Cycle research elements.

Question 6.3: What will land-use and land-cover patterns and characteristics be 5 to 50 years into the future?

State of Knowledge

To understand the historical, contemporary, and future linkages between land-use and land-cover change and its resulting effects on biogeochemical cycles, climate, ecosystem health, and other systems, it will be necessary to make significant advances in documenting the rates and causes of land-use and land-cover change. Our current understanding of historic land-use and land-cover change is weak due to the anecdotal or very local nature of past research in this area. Future understanding of land-use and land-cover changes will be greatly improved through new systematic methods and study designs for land-use change research. To understand the forces of change that operate at different scales, it will be necessary to conduct studies that explicitly reveal the local and regional variations in land-use and land-cover changes. With this, the historical and contemporary data needed to develop models that project land use and land cover for specific intervals into the future will be produced.

Illustrative Research Questions

- What are the major feedbacks and interactions between climatic, socioeconomic, and ecological influences on changes in land use and land management?
- What spatial and temporal level of information and modeling are needed to project land use and land management and its impacts on the Earth system at regional, national, and global scales?
- Given specific climate, demographic, and socioeconomic projections, what is the current level of skill and what are the key sources of uncertainty and major sensitivities in projecting characteristics of land-use and land-cover change 5 to 50 years into the future?

Research Needs

A new suite of models that combine climatic, socioeconomic, and ecological data to model projected changes at scales that are relevant

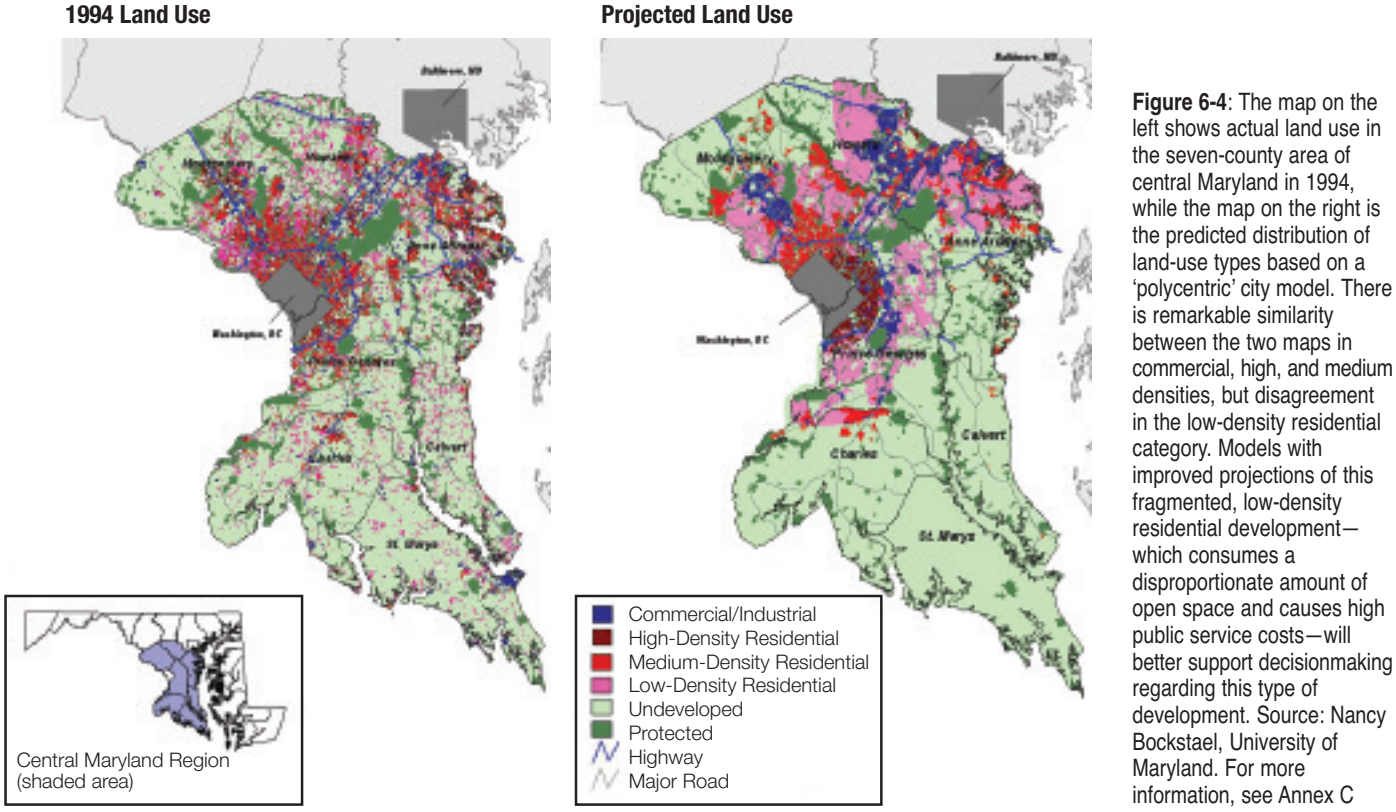

Figure 6-4: The map on the left shows actual land use in the seven-county area of central Maryland in 1994, while the map on the right is the predicted distribution of land-use types based on a 'polycentric' city model. There is remarkable similarity between the two maps in commercial, high, and medium densities, but disagreement in the low-density residential category. Models with improved projections of this fragmented, low-density residential development—which consumes a disproportionate amount of open space and causes high public service costs—will better support decisionmaking regarding this type of development. Source: Nancy Bockstael, University of Maryland. For more information, see Annex C

to resource management and to those relevant for global assessments is needed. This need for predictive models calls for a better understanding of the drivers of land-use change, characterization/parameterization of land-use elements, and credible predictions of land cover and land use at annual to decadal time scales. Partnerships are needed with state and regional assessment and research efforts, to ensure comparability between national/global and state/regional models. Integration among the Carbon Cycle, Ecosystems, and Human Contributions and Responses research elements will be needed to develop and test models for generating scenarios of land-use and land-cover change, and for making projections of change that take into account the various influences of ecosystem functioning, carbon, water, and energy cycling as well as human-managed systems. Model validation will be a particularly challenging element of this research area. Simulation of past conditions will be a necessary strategy for testing the performance of models, placing more significance on the need to understand land-use and land-cover change in both historical and contemporary contexts.

Milestones, Products, and Payoffs

- Single-sector (e.g., urban, suburban, agriculture, forest, etc.) change models [prototypes for selected sectors, less than 2 years; operational models for selected sectors, 2-4 years; operational models for all sectors, beyond 4 years].
- Identification and integration of components of land-use and land-cover change models [regional, less than 2 years; national, 2-4 years; global beyond 4 years].
- Development of regional, national, and global land-use and land-cover change projection models, incorporating advances in understanding of drivers [regional, less than 2 years; national, 2-4 years; global beyond 4 years]. This product will be used by the Climate Variability and Change, Water Cycle, Carbon Cycle, Ecosystems, and Human Contributions and Responses research elements.

Question 6.4: How do climate variability and change affect land use and land cover, and what are the potential feedbacks of changes in land use and land cover to climate?

State of Knowledge

Land-use and land-cover change is linked in complex and interactive ways to global climate change, and the feedback between the two exists at multiple spatial and temporal scales. Changes in greenhouse gas emissions, albedo, and surface roughness are the primary mechanisms by which land-use and land-cover change affect climate. Climate variability and change, in turn, can affect the land cover of a given area and the ways in which land is used. Some of the impacts of these feedbacks are local while others have global ramifications. For example, trace gas emissions and removals by sinks depend strongly on land cover and land-use practices (see, for example, Figure 6-5), while the deposition of atmospheric constituents affects the potential rate and magnitude of terrestrial sinks.

Illustrative Research Questions

- What are the critical land uses and landscape variables that affect climate?
- What can we learn about the relationship between climate and land cover from studies of the past?
- How do climate variability and extreme events affect land use and land cover?
- How will climate and land use/cover influence each other in the future?

Research Needs

Simulation of climate-land use/cover feedbacks will require advancement of current understanding of multiple stress processes

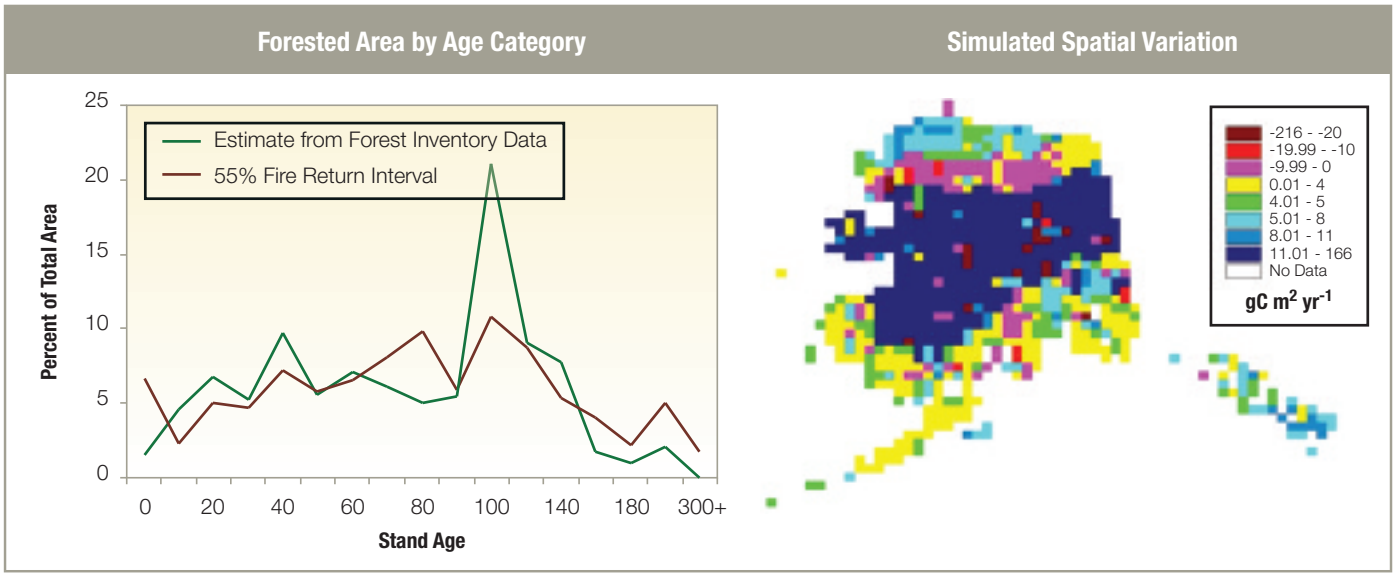

Figure 6-5: Increasing atmospheric carbon dioxide, climatic variation, and fire disturbance play substantial roles in the historical carbon dynamics of Alaska. Analyses of stand-age distribution in Alaska indicate that fire has likely become less frequent compared to the first half of the 20th century. Application of the Terrestrial Ecosystem Model indicates that regrowth under a less frequent fire regime leads to substantial carbon storage in the state between 1980 and 1989. Source: David McGuire and Dave Verbyla, University of Alaska, Fairbanks. For more information, see Annex C.

at local to global scales. We need to identify past changes in land use and land cover that are attributable to changes in climate, in order to project future changes in land use and land cover that could result from changes in climate. Validation of the interacting climate-land use effects for specific regions of the globe will be particularly challenging. Inputs will be needed from the Climate Variability and Change, Water Cycle, and Carbon Cycle research elements. International cooperation will be needed to optimize the currently existing and emerging observational networks.

Milestones, Products, and Payoffs

- Analysis of existing databases and theories about climate-related processes that affect land-use change, including uncertainty analysis [less than 2 years].
- Evaluation of how the type and distribution of land cover affects regional weather and climate patterns [less than 2 years]. Collaborative research with the Climate Variability and Change research element will be necessary.
- Sensitivity studies addressing how land-use and land-cover related changes in surface albedo, greenhouse gas fluxes, and particulates affect climate (such data will be given to the Climate Variability and Change research element) [2-4 years]. This investigation will involve collaboration with the Carbon Cycle and Climate Variability and Change research elements.
- Report on the effects of land-use and land-cover changes on local carbon dynamics. The report will discuss implications for sources and sinks of terrestrial carbon and the overall carbon budget and will be developed in collaboration with the Carbon Cycle and Climate Variability and Change research elements [2-4 years].
- Reports on the effects of land use and land cover on mitigation and management of greenhouse gases [beyond 4 years]. Data on greenhouse gas concentrations and history will be needed from the Carbon Cycle research element.
- Report on past trends in land cover or land use attributable to changes in climate (e.g., changes in forest type, changes in specific agricultural crops, or changes in the presence or absence of agriculture) [beyond 4 years]. Input will be needed from the Climate Variability and Change research element.
- Report on projected trends in land cover or land uses that are attributable to changes in climate (e.g., changes in forest type, changes in specific agricultural crops, or changes in the presence or absence of agriculture) [beyond 4 years].
- National and global models with a coupled climate-land use system [beyond 4 years]. This will be a collaborative task conducted with the Climate Variability and Change research element.

Question 6.5: What are the environmental, social, economic, and human health consequences of current and potential land-use and land-cover change over the next 5 to 50 years?

State of Knowledge

There is clear evidence that changing land use and land cover has significant impacts on local environmental conditions and economic and social welfare. For example, the water cycle depends heavily on vegetation, surface characteristics, soil properties, and water resources development by humans (e.g., dam construction, irrigation, channeling, and drainage of wetlands) which in turn affects water availability and quality. Land-use and land-cover change, climate variability and change, soil degradation, and other environmental changes all interact to affect natural resources through their effects on ecosystem structure and functioning. In turn, ecological systems may respond unexpectedly when exposed to two or more perturbations. The following research questions address the effects of changes in land use and land cover on other research elements (i.e., Ecosystems, Water Cycle, Carbon Cycle, Human Contributions and Responses).

Illustrative Research Questions

- How will different scenarios of land-use change stress or enhance the productivity of our natural resource base and the industries that depend on it, including agriculture and forestry?
- How will land-use and land-cover changes affect the form and functioning of ecosystems, including the ability to provide essential goods and services and levels of ecosystem biodiversity, and what are the ecological, economic, public health, and social benefits and costs of the changes?
- What are the impacts of future land-use and land-cover change on water quality and quantity (research will be undertaken with the Water Cycle research element)?
- Using focused case studies, how can landholders, land managers, and decisionmakers formulate land use and land management decisions and practices at various scales in order to mitigate negative impacts of, and take advantage of any new opportunities due to, climate change?

Research Needs

The other Climate Change Science Program research elements provide complementary information about the environmental and biophysical forces that influence potential land uses (e.g., atmospheric chemistry and processes, climate variability and change, water resources, nutrient flows, and ecological processes) and the anthropogenic pressures that will give rise to various land uses and processes (e.g., the Human Contributions and Responses research element). Development of coupled climate-land use/cover models that incorporate socioeconomic factors and ecosystem function should be accelerated. The challenge will be to use contemporary impacts of land-use and land-cover change to calibrate impacts on ecosystem goods and services; biogeochemical, water, and energy cycles; and climate processes. Research will require multidisciplinary cooperation to develop land-use and land-cover projections that address the necessary spatial and temporal scales, and include the necessary physical, biological, and social factors of interest, to ensure that projections of land use and land cover can be incorporated into models of impacts.

Milestones, Products, and Payoffs

- Report on the social, economic, and ecological impacts of urbanization on other land uses [less than 2 years]. This product will be used by the Ecosystems and Human Contributions and Responses research elements.
- Report on the social, economic, and ecological impacts of different scenarios of land-use change on agriculture, grazing, and

forestry [2-4 years]. This product will be used by the Ecosystems and Human Contributions and Responses research elements.
- Assessment of the impacts of different scenarios of urban and agricultural expansion on natural (terrestrial and aquatic) systems [2-4 years]. This product will be used by the Ecosystems research element.
- Reports on the relationship between land-use and land-cover change and human health [2-4 years]. This product will be used by the Human Contributions and Responses research element.
- Identification of the regions in the United States where land use and climate change may have the most significant implications for land management [2-4 years]. This product will be used by the Human Contributions and Responses research element.
- Report on the regional and national impacts of different scenarios of land use and land cover on water quality and quantity, conducted with the Water Cycle research element [regional, 2-4 years; national, beyond 4 years].
- Report on land management options associated with different climate change scenarios [beyond 4 years]. This product will be used by the Human Contributions and Responses research element.

National and International Partnerships

Nationally, several programs have identified land-use and land-cover change as part of their individual agency research agendas (e.g., the National Aeronautics and Space Administration, the U.S. Geological Survey, the National Science Foundation, the U.S. Environmental Protection Agency, and the U.S. Department of Agriculture) and have played an active role in developing this research element. It will be important as the program proceeds to engage multiple agencies and organizations working in this and related fields (e.g., the National Institutes of Health, the Department of Transportation, the Bureau of Land Management, and the U.S. Agency for International Development). In the next decade of global change research, it will be particularly important to include stakeholders (e.g., the National Governors Association, non-governmental organizations, and state and local land managers) in guiding this research element.

Global change research is strengthened through international partnerships. In the next 10 years, the establishment of international land-use and land-cover science programs will augment ongoing efforts such as the International Geosphere-Biosphere Programme to help bridge the gap between climate change researchers, land managers, and decisionmakers. For example, the Global Observation of Forest Cover and Global Observations of Land Cover Dynamics (GOFC-GOLD) is a new program and part of the Integrated Global Observing System (IGOS) for coordinating global land observations. GOFC-GOLD is implemented through regional networks of data providers and users to address a combination of global change and natural resource management questions, and engages local scientists with local and regional expertise and knowledge. Regional observational and monitoring networks and associated case studies are key to understanding phenomena at fine scales, and provide a test bed for models and a mechanism for comparative analysis.

Another example is the United Nations Land Cover Network—an emerging cooperative activity of the Food and Agriculture Organization (FAO) and the United Nations Environment Programme (UNEP) to develop monitoring and measurement of land-cover change in support of their global environmental outlooks and assessments (e.g., the Millennium Ecosystem Assessment). In addition to these activities, development agencies are attempting to address questions concerning the societal impacts of global change through new programs such as the U.S. Agency for International Development's Geographic Information and Sustainable Development program. Such programs can help in strengthening the scientific underpinning for the decisionmaking process.

To facilitate the U.S. science community achieving broad science and societal objectives in global land-use and land-cover research, international partnerships are being formed for regional studies of global importance. For example, during the last 10 years, studies of the Amazon have been conducted in the framework of the Large-Scale Biosphere-Atmosphere Experiment in Amazonia (LBA), a cooperative international project led by Brazil. Created through an international cooperative agreement, LBA has important institutional relations, including ties with over 40 Brazilian institutions, 25 institutions from various Amazonian countries, as well as institutions from the United States and eight European nations. The LBA project is expected to continue for at least 3 years.

During the next 3-5 years, the Northern Eurasia Earth Science Partnership Initiative (NEESPI) will produce a large-scale interdisciplinary program of research aimed at developing a better understanding of the interactions between ecosystems, the atmosphere, and human dynamics in northern Eurasia. This region, representing a quarter of the world's land masses, will be studied by U.S. scientists in partnership with scientists from northern Eurasia to enhance scientific knowledge and develop predictive capabilities to support informed decisionmaking with respect to land-use and land-cover changes.

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