Interim Update of the 2000 Renewable Resources Planning Act Assessment

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Introduction

This report updates the 2000 Renewable Resources Planning Act (RPA) Assessment (USDA Forest Service 2001) that was prepared in response to the mandate in the Forest and Rangeland Renewable Resources Planning Act of 1974, P.L. 93-378, 88 Stat. 475, as amended. The RPA Assessment Update consists of this summary report and supporting documents. The U.S. Department of Agriculture (USDA) Forest Service has been carrying out resource analysis in the United States for more than a century. Congressional interest was first expressed in the Appropriations Act of August 15, 1876, which provided $2,000 for the employment of an expert to study and report on conditions. Between that time and 1974, Forest Service analysts prepared a number of assessments of the forest resource situation intermittently in response to emerging issues and perceived needs for up-to-date resource information. The 1974 RPA legislation established a periodic reporting requirement and broadened the resource coverage from timber alone to all renewable resources from U.S. forests and rangelands. Renewable resources in this RPA Assessment Update include outdoor recreation, fish and wildlife, wilderness, timber, water, range, and minerals.

Demands and supplies of renewable resources from the Nation's forest lands and rangelands are dynamic. Consumers of these resources accommodate the changing nature of resource supplies in various ways, including adoption of technologies that change the ways renewable resource outputs are used. Supplies of renewable resource outputs change in response to use, management, changing laws, and environmental conditions. Resource owners and managers respond to the changing demands by varying the amount and character of resource supplies. In the future, as in the past, accommodations will be made between demands and supplies through markets, policy actions, regulations, and management to influence the amount, quality, and value of renewable resource outputs and conditions. These accommodations influence the nature and extent of the forest land and rangeland estate.

In this review, the outcomes of these accommodations are presented within the context of the following criteria from the Montreal Process for conserving and managing U.S. forest lands and rangelands:

- Conservation of biological diversity.
- Maintenance of productive capacity of forest land and rangeland ecosystems.
- Maintenance of forest land and rangeland ecosystem health and vitality.
- Conservation and maintenance of soil and water resources.
- Maintenance of forest contribution to global carbon cycles.
- Maintenance and enhancement of long-term multiple socioeconomic benefits to meet the needs of society.
- Legal, institutional, and economic framework for forest land and rangeland conservation and sustainable management.

This context was used to organize the 2000 RPA Assessment and is used in this RPA Assessment Update to be consistent with the 2000 report.

Interest in sustainable management of the world's forest resources was heightened by the United Nations Conference on Environment and Development in Rio de Janeiro in 1992. Since that time, various countries have joined together to discuss and attempt to reach consensus on ways to evaluate the management of their forest resources. The United States is a participant in what has come to be known as the Montreal Process. The United States, together with Canada, Japan, Russia, New Zealand, Australia, Republic of Korea, Chile, Mexico, China, the Russian Federation, Uruguay, and Argentina, reached a nonbinding agreement on a set of criteria and indicators for the conservation and sustainable management of temperate and boreal forests. The criteria are intended to provide a common understanding of what is meant by sustainable forest management. The criteria provide a common framework for describing, assessing, and evaluating a country's progress toward sustainability at the national level.

Organization of the Document

The seven criteria resulting from the Montreal Process include 67 indicators of the conservation and sustainable management of forests. (See http:www.mpci.org/ for more information.) As reported in the *National Report on Sustainable Forests–2003* (USDA Forest Service 2004), data are available on a regular basis at a national scale for 8 of the 67 indicators, but some information is available for each indicator. The 67 indicators are a collection of agreed-upon measures that are indicators of resource condition. In this RPA Assessment Update, we report on those indicators from the Montreal Process where data are available at a national scale. In addition, we add to the Montreal Process by reporting on important drivers of change in resource condition and issues such as urbanization and globalization that cross-cut or affect many measures of U.S. renewable resource condition. For each of the renewable resources, we report on projections for selected measures of future resource use and condition. The capability to integrate across indicators, drivers, and issues to make a summary statement about the condition of U.S. renewable resources remains largely qualitative and subjective.

Overview

In this overview of the findings of the RPA Assessment Update, we present highlights of findings as answers to commonly asked questions about renewable resource conditions and policies in the United States.

What's Behind Expected Changes in Natural Resource Conditions?

Population growth—The U.S. population is projected to grow from 300 million in 2006 to 403 million by 2050.

Population distribution—Population growth continues on both coasts of the United States, but other fast-growing areas include the Southwestern United States.

Population composition—The average age is increasing, the population is more diverse racially and ethnically, and the population is becoming increasingly urban and suburban in location and occupation.

Economic growth—U.S. average per capita income will continue to outpace inflation in the future, increasing the overall purchasing power of the American public.

The result—The changing U.S. population will likely demand increased ecosystem services coming from forest land and rangeland resources, including fresh water, protection from drought and floods, carbon storage, recreation, and other cultural benefits.

What's Happening Across the Landscape?

Total forest land has remained relatively stable at about 750 million acres since 1900, but this stable trend masks dynamic shifts among forest types, forest age classes, and how forest cover is arranged on the landscape due to land use intensification. The area of rangeland has slowly declined from about 800 million acres in 1900 to approximately 580 million acres today. Since the middle of the 20th century, rangeland losses have averaged between 1 and 2 percent per decade.

Forest conversion—More than 50 million acres of non-Federal forests are projected to be converted to urban and developed uses in the next 50 years.

Net change in forest land—Conversion of pastureland to forest helps to offset future loss of forest land, but still an estimated net loss of 20 million acres of forest land, primarily to housing development, is expected over the next 50 years.

Rangeland loss—Rangeland area is projected to decline slowly over the next 50 years

Increasing urbanization—Urban land is projected to increase from 3.1 percent of the conterminous United States in 2000 to 8.1 percent in 2050—an increase in area the size of Vermont and New Hampshire combined.

Arrangement of forest lands and rangelands—Much of today's forests are subject to anthropogenic, or human-caused, "edge effects." Most large patches of forest are publicly owned, although urbanization and increasing intensity of land use on private lands are leading to further subdivision of these lands.

Parcelization—Nonindustrial private forest land is being held in increasingly smaller parcels by an increasing number of owners. Working ranches are also being subdivided into smaller parcels often called ranchettes.

The result—The interface between humans and natural land cover will increase as intensified land uses expand. Resulting edge effects will increase the risks of fire and invasive species, change the amount and pattern of wildlife habitat and alter the distribution of air pollution. Collectively, these changes will increase the challenges to management of forest lands and rangelands.

How Do Globalization Forces Affect Natural Resources?

Expansion of free trade policies has affected U.S. competitiveness in forest products and mineral and energy resources and accelerated restructuring and consolidation of the U.S. forest products industries. The United States is expected to continue to be a net importer of timber products, as well as numerous mineral and energy products.

Effects on domestic harvest—High levels of goods imports and continued high rates of paper recycling result in U.S. timber harvest increasing at a slower rate than in the last half of the 20th century.

Effects on measures of forest resource condition— Imports and loss of domestic processing capacity reduce domestic timber harvest, which affects the age-class distribution of domestic forests, which in turn affects habitat for plants and animals, biodiversity, and other measures of forest resource condition.

Effects on forest management—A slowing in the growth of stumpage prices caused by imports reduces expectations for long-term returns for forest management, raising questions about incentives for sustainable forest management.

Effects on domestic industrial capacity—Globalization has been associated with the loss of domestic capacity in forest industry and several mineral industries. The historical comparative advantage of some U.S. industries is now challenged by rising imports and structural changes in manufacturing. Related impacts are loss of related jobs and income, which is particularly problematic for natural-resource-dependent communities with few other economic development options.

Effects of imports on invasive species—Increasing forest product imports and global commerce in general increase the risk of invasive species entering the United States.

How Will Climate Change Affect Natural Resources?

Increasingly, the relationship between human-caused emissions and a warming climate is being documented. Although uncertainty exists in quantifying the impact of emissions on climate, a global warming of 1.4 to 5.8 degrees centigrade is projected by 2100. Melting of glaciers, reduction in arctic sea ice, and rising sea levels are expected to continue. Adapting to climate change and its potential impacts poses challenges and opportunities for managing resources, infrastructure, and the economy.

Ecosystem responses—The carbon dioxide fertilization effect on ecosystems is more complex than originally thought. Research is documenting changes in the breeding and migrating patterns of animals and flowering of plants, especially in northern latitudes.

Climate variability—Whether natural or human-induced, lack of understanding of climate variability limits natural resource managers' ability to plan mitigation for climatic extremes such as droughts, intense rainfall events, or extreme temperatures.

Effects on forest management toward the range of historical variation—Management to mimic the range of historical variation in resource conditions may no longer be plausible if climate change overwhelms the intent of the actions: management must adjust to dynamic conditions.

Other effects—Concurrent with climate change could be land cover and land use changes, increases in atmospheric pollutants such as ozone and nitrous oxides, and potential expansion of exotic plants and animals, some of which may be considered invasive.

What's the Role of the Nation's Forests and Rangelands in Carbon Management?

Forests and rangelands are seen as part of the solution to reducing atmospheric carbon dioxide and other greenhouse gases. Carbon management technology and trading are emerging. The magnitude of the opportunity for carbon storage and carbon trading is not well quantified.

Forests as carbon sinks—Although forests are expected to continue to be sinks for carbon, the size of the annual addition to the sink appears to be declining.

Forests reduce emissions—Trees and forests around buildings can reduce building energy use and consequently reduce carbon emissions from power plants.

Wood products as carbon reservoirs or fuel—
Accumulation of wood carbon in long-lived products holds down carbon dioxide release to the atmosphere; and use of wood for fuel, when combined with tree regrowth, can offset carbon dioxide emissions from fossil fuels.

What's Happening to the Nation's Biodiversity?

The largest reserves of intact forest are concentrated on public lands, with the largest share of public intact forest contained in the National Forest System (NFS). Since private lands can limit the degree of intactness on adjacent public lands, joint management may be needed to achieve a specified level of forest intactness.

Distribution of threatened and endangered species—
Geographic areas where threatened and endangered species are concentrated have remained unchanged for the past decade and include the southern Appalachians, coastal areas, and the arid Southwest. States that have recently lost the most species occur prominently in the South. More than 30 species have been lost from the biota of California, Texas, Tennessee, Alabama, and Florida.

Distribution of forest species richness—Data on the distribution of nearly 700 tree species and nearly 1,500 terrestrial animals show that biodiversity is concentrated in the Southeast and the arid Southwest. Future concentrations of biodiversity will be affected by global climate change.

Trends in bird biodiversity—Land use intensification and housing development is associated with reduced native diversity and increased exotic diversity. Potential impacts include an overall simplification of biological communities that may reduce the goods and services that humans derive from ecosystems.

Where Are All of These People Going To Recreate?
Recreation demand for forest lands and rangelands in the United States continues to grow. Population and income growth, coupled with technological advances in camping and off-highway transportation, are helping to expand use of our Nation's forests and rangelands.

Access to public lands—Primary and secondary home and resort development adjoining public lands will limit general public access and allow greater unmanaged recreational use of those public lands, including off-highway motorized use.

Access to private lands—Increasing closure of private lands to free public access and shortfalls in funds for public site and facility management will stress the U.S. public recreation supply system.

Effects on sensitive ecosystems—Wilderness areas and special attractions will experience greater congestion at peak times of the year. Unmanaged motorized uses and heavy uses in high-elevation alpine ecosystems (e.g., peaks over 14,000 feet) can be especially problematic.

What's the Role of the Growing Urban Forest?
Urban land is expected to grow from 3.1 percent of the total area in the conterminous States to 8.1 percent in 2050. Understanding how and where these urban areas and urban forests are changing is critical to helping develop policies and management plans to help sustain this growing resource and its numerous benefits, and to minimize negative urban effects on surrounding forests.

Carbon storage—Urban forests sequester an estimated 22.8 million metric tons annually, with total storage in urban forests estimated at 700 million metric tons.

Air quality—Urban forests can influence air quality by reducing temperature, removing air pollutants, and altering building energy use which affects pollutant emissions from utilities.

Water quality and runoff—Changes in tree canopy cover affect stream flows and water quality.

Wildlife habitat—Urban forests can provide important habitats for wildlife.

Quality of life—Besides the numerous environmental benefits associated with urban forests, these trees also provide significant social, psychological, and economic benefits that contribute to the quality of life in urban areas.

Outdoor recreation—Urban forests provide nearby outdoor recreation opportunities for residents. Some attractions may be so popular as to decrease pressure for recreation in the surrounding countryside.

Wildland-urban interface interactions—Urban land expansion increases the potential for human-caused pollution and enhances the risk of structural damage from wildfire. Increasing human population density that occurs with an expanding wildland-urban interface may also increase the risk of introducing exotic species into wildlands. Expansion of urban lands can also displace other land uses such as timber production.

Where Does Our Water Come From and Will We Have Enough?

Water supply—About 53 percent of the Nation's water supply originates on forest land, 26 percent on agricultural land, and 8 percent on rangeland. About 24 percent of the water supply in the contiguous 48 States originates on Federal lands and 18 percent on NFS lands alone, even though these lands occupy only about 11 percent of the surface area.

Water withdrawals—Water withdrawals in the United States are projected to increase less than 10 percent over the next 50 years, although population is expected to increase more than 40 percent. These increases in withdrawals, although relatively small, will further diminish instream flows in rivers and streams across the country. This trend will add pressure for amending laws and institutions to facilitate water transfers from low-value to higher-value water uses. Generally, the quality of water draining from forests is very good.

Where Do Our Timber Products Come From and Will We Have Enough?

Current timber supply—At the end of the 20th century, the United States imported the equivalent of 27 percent of the consumption of industrial wood used for products, up from 13 percent in 1965. Most of the imports originated in Canada, but Brazil, Chile, Finland, and other offshore countries are increasing in importance for some products. In 2002, private lands accounted for 92 percent of timber removals; national forests, 2.1 percent; and other public lands, the remaining 5.9 percent. In 2002, the South accounted for 58 percent of the domestic harvest; the North, 21 percent; the Rocky Mountain region, 4 percent; and the West Coast the remaining 17 percent.

Projected timber supply—Most of the projected increase in U.S. harvest through 2050 is in nonsawtimber (smaller) trees, and will come primarily from managed stands in the South. By 2050, 60 percent of projected softwood harvest is from managed plantations that occupy about 9 percent (46 million acres) of total U.S. timberland area. Projected product imports in roundwood terms will remain around 25 percent of domestic consumption. Aggregate U.S. forest inventory rises 31 percent for all owners as growth exceeds harvest over the next five decades. Supplies are generally adequate to moderate price increases for timber products. Solidwood product prices rise more slowly than historical rates and paper and paperboard prices are projected to decline in real terms. Consumption is expected to increase as population increases.

Concepts of Sustainable Development and Sustainable Forest Management

Although many ideas about sustainability have been put forward during the past two decades, most are consistent with the basic concept of sustainable development found in the 1987 Brundtland Commission Report (World Commission on Environment and Development 1987):

…development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

The concept of sustainable development links the environment, society, and the economy. These three basic components or spheres of sustainable development are often stated as three interdependent goals of environmental protection, social well-being, and economic prosperity. Environmental, social, and economic issues and values must be integrated into our decisionmaking and actions, while accounting for future, as well as present, needs.

Sustainable development involves all sectors of society and all resources. The capacity for sustainable forest management is often affected by events in other sectors, such as the demand for housing. The Society of American Foresters adopted the following statement defining the concept of sustainable forest management:

"*Sustainability as applied to forests is the enhancement of human well-being by using, developing, and protecting resources at a rate and in a manner that enables people to meet their current needs while also providing future generations with the means to meet their needs as well; it requires simultaneously meeting environmental, economic, and community aspirations.*"

The concept of sustainability implies that desired future conditions or societal goals are known and that society's relative values for desired future conditions are known. As pointed out in the National Report on Sustainable Forests—2003 (USDA Forest Service 2004), however, neither desired future conditions nor relative societal values are known for the U.S. forest situation. This RPA Assessment Update provides further information for readers to use in making judgments about the status and trends in the U.S. renewable resource situation.

Social and Economic Context for the Interim Update of the 2000 RPA Assessment

World Context

Worldwide growth in population and income has contributed to the evolution of issues related to the environment that are mirrored in domestic issues. The basic dynamics of population change contribute to social, economic, and technological change that can have profound effects on the ways that the renewable resources of the world are managed and used. After the Second World War, growth of the world's population and the economies of some countries forever altered ecosystems in many parts of the world. World population more than doubled from 2.5 billion people in 1950 to 6.4 billion in 2004 (U.S. Census Bureau 2005). Much of this growth was in the developing countries where population increased from 1.7 to 4.9 billion people during this time. One person in three now resides in India or China. Population in the developed countries increased from 800 million to 1.2 billion people.

Between 1950 and 2004, the population of the United States as a percent of the world population declined from 6 to 4.5 percent. Overall, the United States had about 78 people per square mile of land in 1999 (U.S. Census Bureau 2001). These figures compare with the world average of 119 people per square mile (Food and Agriculture Organization of the United Nations 2005a).

The Food and Agriculture Organization of the United Nations (2005a) projects world population to grow from 6.5 billion people today to 9.1 billion in 2050. Under the terms of the medium projection, the rate of growth in population will continue to decline in the future to 0.5 percent in 2045–50, down from a peak rate of growth of 1.2 percent in the period 2000–05. Although uncertainties are present with any projections, there is little doubt that there will be significant growth in world population with implications for resource use, carbon emissions, and other renewable resource issues that transcend national boundaries.

The population of more developed regions, currently at 1.2 billion, is anticipated to change little during the next 50 years with 30 countries actually projected to experience declining populations. The population of the less developed regions is projected to rise steadily from 4.9 billion in 2000 to 8.1 billion in 2050.

Through the 1970s, much of the income growth was in the developed countries. In the past two decades of the 20th century, liberalization of trade and many other factors contributed to income growth in some developing countries such as China and India. This growth in developing countries coincided with a general maturation of the economies of the developed countries. Thus, much of the change in the world economy originates in the developing countries.

Gross domestic product per capita in the United States was 5.5 times the world total in 1995 (World Resources Institute et al. 1998). Although per capita incomes in some developing countries such as China and India have increased in the past 20 years, others remain impoverished.

Population and income growth, changing societal values, and many other factors contributed to the development of various issues related to the environment during the last half of the 20th century. Growth in population often led to deforestation for agriculture in developing countries. Patterns in international trade often resulted in exports of forest products from developing to developed economies, leading to concerns over trade and the environment. Development of all types led to concern about diminishing biological diversity and increasing numbers of endangered species, and it is increasingly clear that the causes and outcomes of climate change transcend national boundaries. The United States' interests in these issues are reflected in the fact that we are signatories to the United Nations Convention to Combat Desertification, the Convention on International Trade in Endangered Species of Wild Fauna and Flora, and the International Tropical Timber Agreement. In addition, U.S. representatives have participated in the

Framework Convention on Climate Change and the Convention on Biological Diversity. Thus, the rest of the world is trying to deal with many of the same environmental issues that are being debated domestically in the United States.

The issues will likely change over time. For example, globalization has become an issue in the forest product and other manufacturing industries (see box 1). Biodiversity and other issues concerning plantations will likely grow as plantations increase in importance as a source of wood fiber (see box 2). Bilateral trade issues in forest products remain such as Canadian exports of softwood lumber and Chinese exports of furniture to the United States. We are connected to the rest of the world through trade. Imports of timber products can affect domestic forest resource conditions; imports of minerals can affect domestic mineral production, and international trade can affect domestic land use (see box 3).

Box 1

Globalization, consolidation, and structural change in the U.S. forest sector—A general definition of "globalization" is the ongoing expansion of global interconnectedness in society and culture, associated with reduced territoriality, higher speed of social activity, and long-term structural changes with multifaceted aspects (Stanford Encyclopedia of Philosophy [http://plato.stanford.edu]). Economic globalization is reflected in expansion of global interconnectedness in commerce, business, and capital investments. Structural change includes the competitive replacement of older and less efficient means of production by more efficient means of production, a process unlikely to be reversed. The U.S. forest products industries have a long history of structural change as timber harvesting moved around the country, and as technology and consumer demands evolved. At times, these market forces led to consolidation of capacity. Structural change is generally thought to result in economic gains over the long run, but possible negative consequences can include local job losses, economic instability, shifts in capital flows, or declines in local market demands for resources. Globalization can accelerate or alter the nature of structural change.

Globalization, consolidation, and structural change during the past decade contributed to a recent decline in domestic consumption of certain forest products (paperboard products and wood pallets used for packaging and shipping as well as paper used for print advertising), with corresponding loss of industrial capacity and related jobs, increased imports, and lower stumpage prices. According to Ince et al. (n.d.), globalization and structural change contributed to the following:

- Domestic consumption of paper and paperboard declined by 7 percent from a peak of 103 million tons in 1999 to 96 million tons in 2003, and then increased by 4 percent in 2004 (American Forest and Paper Association 2005).
- According to the Forest Resources Association (for more information, go to http://www.forestresources.org/), by 2002 annual volumes of pulpwood received at U.S. pulp mills declined by 16 percent since peaking in 1994 and volume rose by 4 percent from 2002 to 2004.
- Domestic hardwood lumber consumption in furniture declined from 3.3 billion board feet in 2000 to about 1.7 billion board feet in 2003; for pallets, the decline was from about 5 billion board feet to 3 billion board feet.
- Economic globalization contributed to significant abatement of growth in U.S. timber harvest because some processing capacity was lost to competitors in other countries.
- About one out of every six paper and paperboard mills has closed since the mid-1990s.
- One out of every three jobs at U.S. pulp and paper mills has been eliminated since the early 1990s due to consolidation, cost-cutting, and productivity improvements.
- Nearly 40 North Carolina furniture plants have closed since 2001.
- The number of major softwood sawmills in the United States declined from 850 in 1995 to 700 in 2004, with a 37-percent increase in average capacity as older mills were replaced with larger ones.
- In the 1990s, imports as a percent of U.S. sales of wood household furniture increased from 20 to more than 50 percent and continues to expand, primarily imports from China.

Box 1 (continued)

- Since 1990, imports of softwood lumber increased from 27.1 percent (12.1 billion board feet) of consumption to 38 percent (25 billion board feet).
- Imports of oriented strand board increased from 1.3 billion square feet (19 percent of consumption) in 1990 to 8.5 billion square feet (39 percent of consumption) in 2002.
- Southern pine pulpwood stumpage prices peaked about 1997, declined to half that level by 2002, and have not recovered to previous peak levels.

Globalization and structural change have contributed declines in exports of timber products from the United States. New suppliers have emerged in world markets and the nature of demand has changed for some countries. For example, softwood log export volume from the four West Coast States declined from 3.7 billion board feet in 1990 to less than 1 billion board feet in 2003. Much of the decline was due to reduced shipments to the People's Republic of China, Japan, and South Korea. Exports of softwood lumber, plywood, and wood chips from the United States have also declined.

Structural change and economic globalization have many implications for evaluation of the status and trends of renewable resources. For example, imports of timber products decrease domestic harvest and thereby affect commonly used measures of resource condition such as the growth removal ratio for roundwood. Structural change and globalization should also be key considerations in evaluation of future returns from forest management because they affect stumpage prices and costs of forest management.

Box 2

Plantations[1]**—**According to the Food and Agriculture Organization (FAO) of the United Nations (2005b), plantations account for 1.4 percent of global land area with tree cover, but only a fraction are industrial wood plantations. Most tree plantations serve other purposes such as soil conservation, or cultivation of crops such as nuts, or extractives, such as rubber plantations. An FAO analysis (2001) suggests that most countries will move away from the use of natural forest resources for wood and fiber production toward other land-based and non-land-based sources of supply, including the use of wood processing residues and recycled fibers.

Fast-growing industrial wood plantations occupy less than 2 percent of forested area worldwide, yet they supply one-quarter of all industrial roundwood. Furthermore, plantations are projected to supply half of global wood resource needs within two decades (Australian Bureau of Agricultural and Resource Economics and Jaako Poyry Consulting 1999).

Haynes (2003) projected that timber supply from fast-growing managed plantations in the United States (primarily southern pine plantations) will approach one-third of total U.S. timber supply and more than half of softwood timber supply, and will account for most projected increases in timber supply in the decades ahead. Yet managed plantations were projected to increase from only 6 percent of U.S. timberland area to about 9 percent by the year 2050. Since harvest is reduced on the remaining timber land, there are many implications for indicators of resource condition and trend on these lands.

The 2005 RPA timber assessment update (Haynes et al. 2006) projects a more modest but continued expansion in the area of southern pine plantations. Real hardwood pulpwood prices are projected by then to reach levels that will stimulate competitive expansion of hardwood short-rotation woody crops on agricultural land, and by 2050, the projected output is 100 million cubic feet per year.

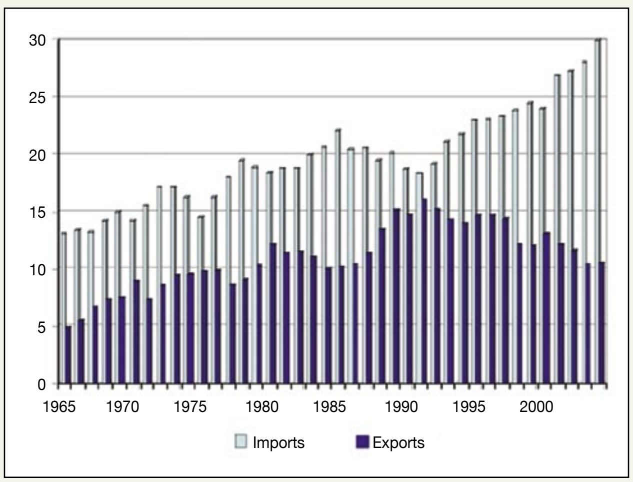
[1] Defined by Smith et al. (2001) as forest stands consisting almost exclusively as planted trees, of native or exotic species, and intensively managed to maintain this composition to maturity. Management practices may include extensive site preparation prior to planting and suppression of competing vegetation.

Box 3

Trade and the environment

Effects of imports of timber products on domestic forest resource conditions—From a small net export situation at the start of the 20th century, U.S. trade in timber products evolved into a deficit situation in volume terms (Hair and Ulrich 1964). Imports as a percent of consumption increased from 13.1 percent in 1965 to 27.2 percent in 2002 (fig. 1). Because imports have increased, U.S. harvest has been lower than it would have been without increasing imports. Imports also have the effect of dampening domestic prices for roundwood, thereby decreasing the incentive for forest management. Lower harvest could affect all indicators of renewable resource condition and trends. Exports as a percent of production have also decreased. In addition, increased U.S. imports of manufactured goods in general and broad displacement of U.S. manufacturing by imports, have directly affected U.S. demands for some forest products, such as demands in manufacturing for paper or paperboard packaging, wood product use in industry, and demands for paper in print advertising.

Figure 1.—*Imports as a percentage of consumption and exports as a percentage of production of industrial wood.*



Effects of imports of minerals—The United States is nearly 100 percent dependent on imports as a source of bauxite, chromium, cobalt, and the minerals in the platinum group (table 1).[1] Of the minerals in table 1, we are self-sufficient in copper and nearly self-sufficient in iron ore and lead. Japan is the most dependent on imports as a source of minerals although Russia is the most self-sufficient of the four industrialized areas. Many of the energy and mineral resources used by industrialized societies are imported from developing nations, some with fragile economies and unstable governments. The production of minerals is a driving force in many nations' economies. A low correlation exists, however, between the production and export of a mineral endowment and widespread economic prosperity in many developing countries. As with most commodities, imports of minerals dampen prices. This situation means that some deposits of minerals in the United States are not mined at current prices because of imports.

Effects of trade on land use—The quality of forest land conditions can be affected by trade. In our interdependent world economy, land-based sectors such as forestry and agriculture have significant trade components. Such trade affects product prices and land prices, thereby possibly influencing land allocation among sectors of the economy. For example, increased agricultural export demand can lead to reduced area in forest, given the fixed land base (Alig et al. 1998). In early decades, clearing of bottomland hardwood areas in the South was prompted by increased export demand for soybeans. Farm subsidies can compound the effects in land markets, in that they can affect the amount of agricultural trade, as well as the allocation of land between the forestry and agricultural sectors (Alig et al. 1998).

[1] Personal communication with Deborah Shields, Rocky Mountain Research Station, Fort Collins, CO.

Box 3 (continued)

Table 1.—*Mineral import reliance (net imports as a percent of consumption) of selected regions as of 1997. A value of 0 indicates that the region is a net exporter.*

	United States	Japan	Russia	European Union
Bauxite	99	100	21	80
Chromium	100	100	78	57
Copper	0	100	17	86
Cobalt	100	100	0	100
Iron ore	16	100	1	83
Lead	10	97	0	68
Platinum group	94	100	0	100

Source: British Geological Survey (2006).

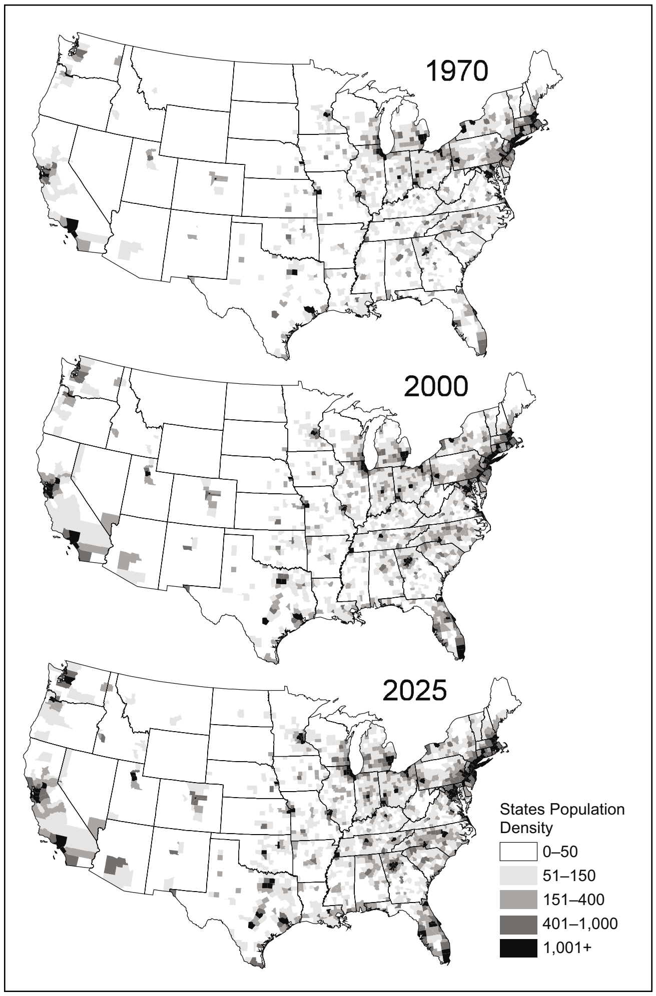
Commodity trade is now only one among a number of ways in which producers, consumers, resource managers, and policy makers must consider the international context of their decisions. Integration of national economies, and therefore natural resource conditions, also takes place through foreign investment and through multinational corporations. The interdependence of the U.S. forest sector with other countries—through trade, investment, and international agreements and policy processes—is likely to expand and become increasingly complex.

U.S. Context

The condition and trend in renewable resources are affected by changes in the Nation's population and the way in which people deploy themselves on the landscape. In 1900, most of the Nation's people lived in the East and were concentrated in the mid-Atlantic and Lake States regions. By 1999, the most heavily populated places were along the coasts (fig. 2) (Cordell and Overdevest 2001). Migration to be close to amenities such as recreational opportunities on national forests helps to explain some of the settlement pattern (see box 4).

Each year, hundreds of thousands of people move to or from the United States. By 2000, net migration into the United States was estimated to be 970,000 people. The legal immigrating population to this country is moving into all of its regions.

Figure 2.—*Population per square mile by county in the contiguous 48 States in 1970, 2000, and 2025.*



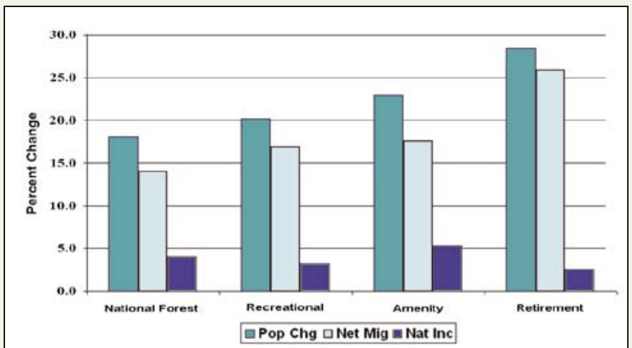
Box 4

Amenity migration—Increasingly, the U.S. population is choosing places to live on the basis of factors other than employment. The net increase or decrease in an area's population through migration is driven by many agents, including economic factors (job location, income differential), life courses changes (attending college, retirement), and noneconomic factors (physical attractiveness of the area, pace of life). People who choose their new area of residence based on its natural resources, recreation opportunities, and esthetic qualities are referred to as amenity migrants (Garber-Yonts 2004, Johnson and Stewart 2005). Since the 1970s, amenity migration has stimulated considerable population growth in rural areas rich in natural resources.

Measuring amenity migration is difficult because amenities are subjective and personal preference determines what resources are attractive. For this RPA Assessment Update, counties were classed according to their amenities, recreation opportunities, retirement allure, and whether or not national forests make up more than 10 percent of the county's land area. Counties with concentrations of national forests had demographic gains similar in size and structure to amenity, recreation, and retirement counties during the 1990s (fig. 3). In each county type, gains were fueled by net migration, and it is likely that amenities draw most of the migrants.

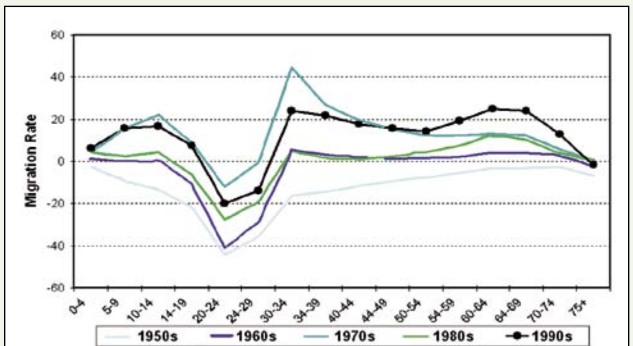
Amenity migration is bringing new people to rural areas, and with them, new demands for housing, infrastructure, government, and retail services, and a host of environmental services. Of particular interest to planners is the possibility that population growth is likely to increase the population density along the forest edge, putting additional pressure on riparian and environmentally sensitive areas, increasing the demand for recreational facilities, and complicating forest management and fire suppression. Retirees make up a large percentage of amenity migrants. If the "Baby Boom" generation makes retirement decisions similar to the decisions made by people in the 1990s, the likelihood of accelerating population growth in amenity rich areas is extremely high (fig. 4).

Figure 3.—*Demographic change from 1990 through 2000 by county type.*



Analysis: K.M. Johnson, Loyola University Chicago
Sources: U.S. Census Bureau; USDA Forest Service; USDA Economic Research Service; Johnson and Beale (2002)

Figure 4.—*Age-specific net migration: nonmetro national forest.*



Analysis: Johnson, Voss, Fuguitt, Hammer and McNiven (2003).
Data: U.S. Census Bureau

Almost 43 percent of foreign-born persons living in the North had moved into that region between 1990 and 2000; for the Rocky Mountain region, the similar percentage was 49 percent; for the South, 46 percent; and for the Pacific Coast, 38 percent.

The U.S. population continues to diversify. In 1900, 87.9 percent of the U.S. population was classified as non-Hispanic white, 11.6 percent was classified as non-Hispanic black, and the remainder was American Indian, Asian, or Pacific-Islander. By 1950, whites composed 89.5 percent of the population and blacks 10 percent. Change in U.S. immigration law and policies in the 1950s and 1960s led to a much-changed composition of the U.S. population. The Immigration Act amendments of 1965 (also known as the Hart-Celler Act) amended the Immigration and Nationality Act of 1952. The 1965 Act abolished the national origin quotas and established a policy that gave priority to family reunification and to bringing those who had certain "desirable or needed skills" regardless of nationality. By 2000, non-Hispanic whites were 69.1 percent of the population, Hispanics were 12.5 percent, blacks were 12.3 percent, Asians were 3.6 percent, and American Indians were 0.9 percent. Much of the growth in the minority (other than non-Hispanic white) population is expected to occur in the upper Midwest, the Pacific Coast, Florida, and parts of the West (fig. 5).

On average, people are living longer in the United States. In 1900, the average life span expected for persons born that year was 46.4 years for males and almost 49 years for females. By 1950, the corresponding data was 65.6 years for males and 71.1 years for females and, in 2000, 73.7 years for males and 79.4 years for females.

In 1900, less than 5 percent of the U.S. population was 65 or older. By 2000, more than 12 percent were in this age group. By contrast, in 1900, about 45 percent of the population was less than 20 years of age. By 2000, less than 30 percent of the population was under 20 years of age. The changing age composition of the population has many implications for entitlement programs such as social security, societal values, and demands for goods and services. For example, projected changes among counties with populations age 65 or older are mainly in the West and South (fig. 6).

Over time, the economic diversity of the Nation has changed, reflecting population movements, changes in technology, and a host of other factors. After the Second World War, growth in income and increases in leisure time led to increased demands for outputs of ecosystems as well as recreation and other values for these systems. For example, real gross domestic product increased by 50 percent between 1960 and 1970 (fig. 7). Changing societal values are reflected in Federal legislation that has been passed over the past several decades. Key legislation includes the Multiple Use-Sustained Yield Act of 1960, the Wilderness Act of 1964, the National Environmental Policy

Figure 5.—*Percent change in minority population by county from 2000 to 2025 in the contiguous 48 States.*

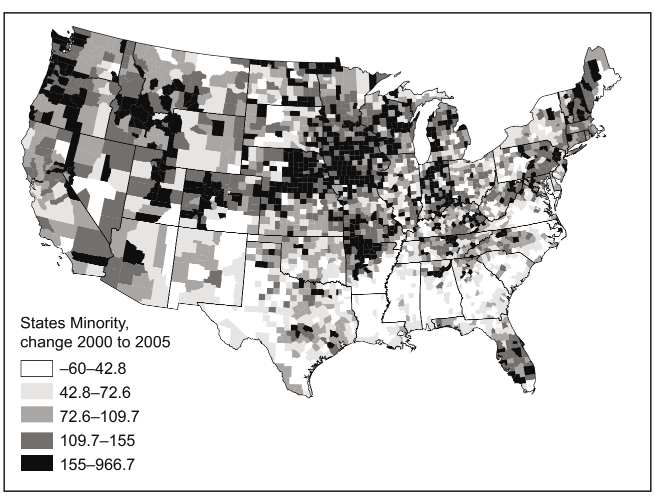


Figure 6.—*Projected percentage change among counties with populations age 65 and older in 2000 and 2025.*

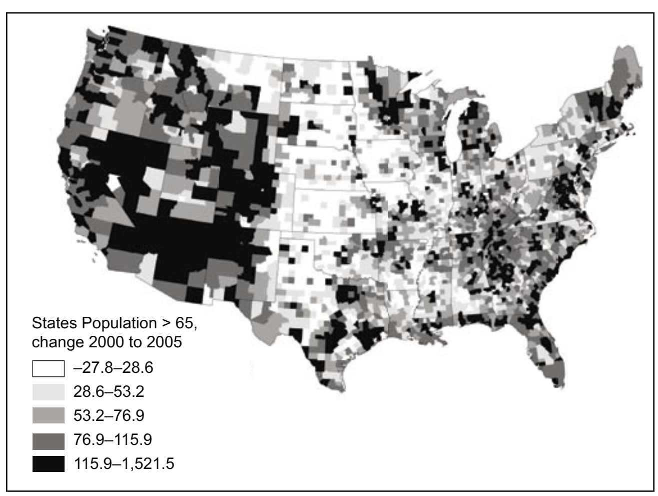
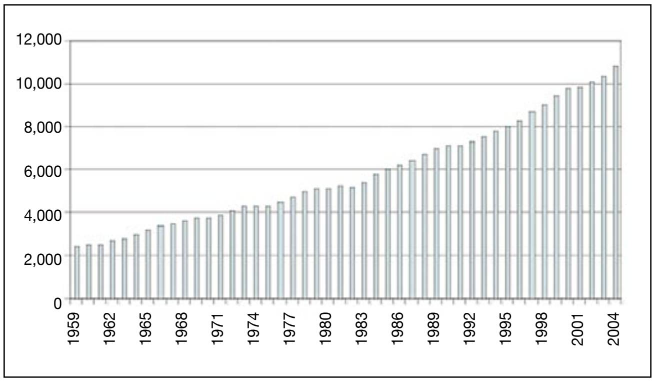


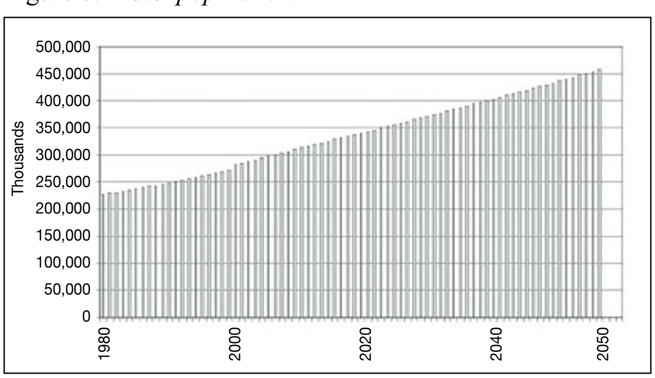
Figure 7.—*Real gross domestic product ($2,000).*



Act of 1970, the Endangered Species Act of 1973, the Forest and Rangeland RPA of 1974, the National Forest Management Act of 1976, and the Forest and Rangeland Renewable Resources Research Act of 1978. These and other legislated mandates provide direction to Federal agencies in management and protection of values associated with ecosystems found on Federal lands. Many of the environmental policy issues grow out of the public's perceptions of how these mandates are implemented and how values are protected. These values change over time (see box 5).

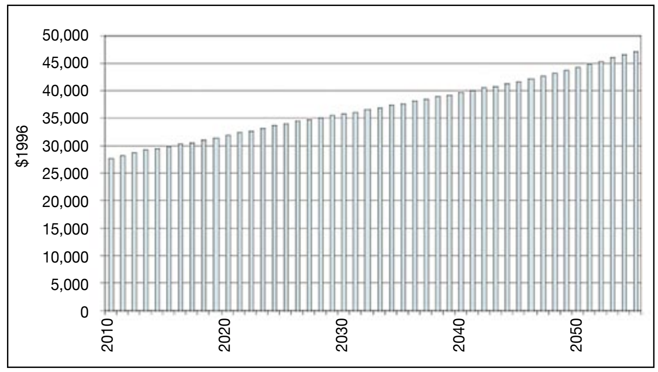
Demands on the Nation's forest land and rangeland ecosystems will continue to increase. By 2055, the population of the United States is projected to increase 45 percent, or by more than 129 million people (fig. 8) (U.S. Census Bureau 2004). During the past 50 years, the population increased by about 121 million. The population is projected to have more discretionary

Figure 8.—*U.S. population.*



income and thus more opportunity to enjoy the Nation's natural resources (fig. 9). This projection does not mean that population and income will increase uniformly across the country. For example, population growth in the Great Plains is likely to be small while growth in Florida, Texas, and California is likely to be relatively large. Any long-term economic projections are fraught with uncertainty, especially with consideration of globalization and implications for energy and other key essentials of modern living.

Figure 9.—*Projected per capita disposable personal income.*



Land Use and Cover in the United States[1]

Human land use is the primary force driving changes in ecosystem attributes. Through management and use of ecosystems, human land use affects all aspects of sustainable forest management. Thus, land use and cover are important aspects of the social and economic context for understanding the status and trends in U.S. renewable resources.

Changes in land use and cover can affect wildlife habitat, riparian and wetlands, risk of damage by insects and diseases, introduction of exotic species, and water quantity and quality, as well as the use of forests and rangelands for recreation. Data for changes in land use are based on the National Resources Inventory (NRI) conducted by the USDA Natural Resources Conservation Service (NRCS) (2000). The NRI is an inventory of land use on non-Federal lands. Much of the publicly owned forest land is stable in terms of land use.

[1] Data for U.S. forest land, rangeland, agricultural lands, and wetlands are maintained by the Natural Resources Conservation Service. At the time of publication of this report, the latest available data are for 1997.

Box 5

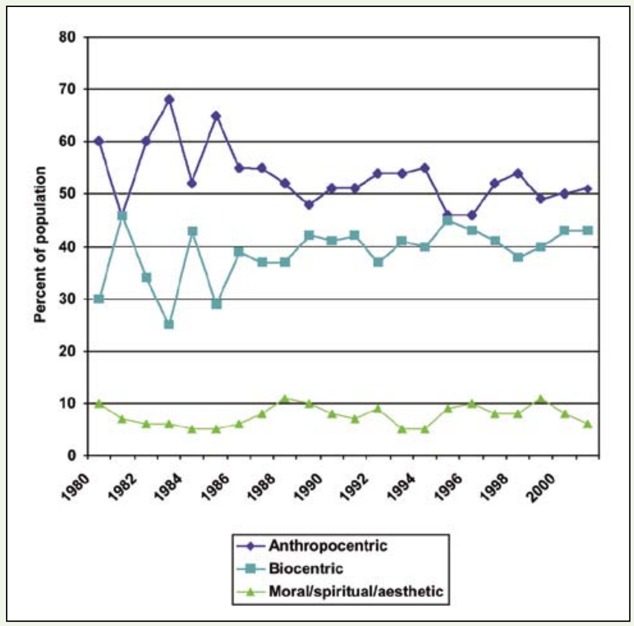
Values change over time—Bengston et al. (2004) characterized forest value orientations in three ways. An anthropocentric/utilitarian value orientation suggests that providing for human use and benefits is the primary aim of natural resource allocation and management. A biocentric value orientation emphasizes primary goals such as environmental protection, preservation, and ecosystem health and integrity. The moral/spiritual/aesthetic value orientation emphasizes the noninstrumental values of forests such as bequest values. Content analysis was used to review 8,379 stories about forest planning, management, and policy found in seven national newspapers, news magazines, and newswires over the period January 1, 1980 to May 1, 2002. Major national news sources such as these have been found to accurately reflect the national debate and public opinions about the environment and other policy issues. The analysis counted the number of expressions of each of the forest value orientations.

Figure 10 shows the share of each value orientation as a percent of total value expressions over time. The share of utilitarian value expressions declined significantly over time. Commodity production is still an important use of public lands, but other, nonconsumptive uses and related values have increased in relative importance. The share of biocentric value expressions increased and the share of moral/spiritual/aesthetic value orientation has remained constant over time.

Bengston et al. (2004) point out that drivers of changing forest values in the future will likely include continued declines in the economic importance of primary commodity industries, urbanization and the blurring of boundaries between urban and rural areas and values, and continued strong demand for environmental amenities and quality. Demographic changes such as rapid population growth and growing racial and ethnic diversity will also help shape our changing relationships with forests.

Cordell et al. (2004) found that utilitarian values such as production of wood products rank lower than biocentric and moral/spiritual/aesthetic value orientations in peoples' preferences for management of publicly owned forests.

Figure 10.—*Forest value orientations in the United States.*



Forest land—The area of the world's forests is estimated to be 9.6 billion acres as of 2005, or about 30 percent of the land area of the Earth (Food and Agriculture Organization of the United Nations 2005b). About 55 percent of the world's forests are located in developing countries and 45 percent in developed countries. The world's forests are almost equally divided between tropical/subtropical and temperate/boreal.

The U.S. forest land area of 749 million acres amounts to about 8 percent of the total world forest land area and 12 percent of the total area of temperate and boreal forests. The total area of forest land in the world has been decreasing at least since 1980 (Food and Agriculture Organization of the United Nations 2001). Most of the decrease has been in the developing tropical countries. Forest area in several developed countries such as Norway, France, and New Zealand has been increasing. The net area of forest land in the United States has been relatively stable since the 1920s, with decreases due to development and other land uses being offset by afforestation and natural reversion of abandoned crop and pastureland to forest land. We have 2 acres of forest land per person, which is more than the world average of 1.5 acres per person (Food and Agriculture Organization of the United Nations 2005b).

The United States is not alone in having a high proportion of forest land in private ownership (57 percent). Among other countries, Austria, Finland, France, and Japan have more than one-half of their forest and other wooded land in private ownership (United Nations Economic Commission for Europe and Food and Agriculture Organization of the United Nations 2002). By contrast, only 6.5 percent of Canada's forest and other wooded land is in private ownership.

According to NRCS (2000), forest land area had a net increase of about 3.6 million acres on non-Federal lands between 1982 and 1997 (table 2). This acreage amounts to less than 1 percent of the area that existed in 1982. Losses to other uses were more than offset by gains from other land cover categories. The largest loss of forest land was to development (10.3 million acres or 2.6 percent of the area in 1982). The largest gain in forest land was from pasture land (14.1 million acres or 3.5 percent of the area in 1982). In total, 23 million acres of forest land (5.7 percent of the area in 1982) was converted to other uses between 1982 and 1997 while 26.6 million acres (6.5 percent of the area in 1997) were added to the forest land classification, resulting in a net gain of 3.6 million acres of forest land.

Rangeland—Rangeland occupies nearly one-half of the Earth's land area or about 16.1 billion acres (Food and Agriculture Organization of the United Nations 1990). About one-half of this area is used for grazing livestock. Total world change in rangeland area amounts to less than 0.1 percent per year. This net change masks regional shifts: Niger, India, and Mongolia are losing pasture land at a much higher rate than South American countries, particularly Brazil, are gaining it. Much of the gain in rangeland area in the Tropics is attributable to conversion of rain forests. Although a consensus definition for rangeland area is elusive, the rangeland area of the United States amounts to about 5 percent of the total area of rangeland in the world (Mitchell 2000).

Between 1982 and 1997, non-Federal rangeland area nationwide had a 2.6 percent net loss (table 2). Of those acres

Table 2.—*Changes in land cover/use between 1982 and 1997.*

Land cover/use in 1982	Cropland	CRP land	Pastureland	Rangeland	Forest land	Other rural land	Developed land	Water areas & Federal land	1982 total
		1,000 acres							
Cropland	350,265.3	30,412.1	19,269.4	3,659.2	5,606.5	3,158.9	7,097.5	1,485.1	420,954.0
Pastureland	15,347.0	1,329.6	92,088.3	2,567.9	14,091.4	1,619.0	4,230.0	732.8	132,006.0
Rangeland	6,967.5	728.5	3,037.2	394,617.4	3,021.6	1,702.7	3,281.3	3,383.2	416,739.4
Forest land	2,037.1	128.8	4,168.2	2,098.8	380,343.3	1,754.8	10,279.2	2,528.0	403,338.2
Other rural land	1,386.8	93.1	1,013.6	719.1	2,767.7	42,713.3	726.9	227.8	49,648.3
Developed land	196.7	1.2	78.6	110.8	227.0	12.0	72,618.7	0.8	73,245.8
Water areas and Federal land	797.5	2.7	336.6	2,204.0	897.7	180.8	18.1	443,760.6	448,198.0
1997 total	376,997.9	32,696.0	119,991.9	405,977.2	406,955.2	51,141.5	98,251.7	452,118.3	1,944,134.7

Read this table horizontally to determine how a particular 1982 land use (row heading) was distributed in 1997 (column headings). Read this table vertically to determine where a particular 1997 land use (column heading) came from in terms of 1982 land uses (row headings).

CRP = Conservation Reserve Program.

that were rangeland in 1982, 5.3 percent were converted to another land use class in 1997. Of these converted acres, the largest proportion was converted to cropland (31.5 percent), just over 14.8 percent was converted to developed land, 13.7 percent was converted to pasture land, and 13.7 percent was converted to forest. It should be noted, however, that exurban developments on lot sizes exceeding 10 acres are not captured as a land use change by the NRI, although subdivision of ranches into ranchettes is common where population is growing in the West.

Rangeland supports habitat for some wildlife species and provides the settings for hunting and other recreation activities. In evaluating the state of rangeland habitats, it is important to recognize that present land use dynamics do not indicate the extent to which certain rangeland systems have been altered historically. Many rangeland ecosystems underwent extensive conversions long before land-based inventories were designed. Grazing, agricultural development, fire suppression, urban development, and exotic species invasions are primary agents of rangeland alteration. Tallgrass prairie habitats have been lost primarily to agriculture development. Eastern and northwestern grasslands and savannas have been lost to urban development, agriculture, and fire suppression.

Agricultural lands—Agricultural lands consist primarily of lands used to produce food, feed, fiber, and oilseed crops and are described as cropland and pasture land. Cropland is classed as cultivated and noncultivated. Cultivated cropland is annually planted for commodities including rowcrops such as corn, soybeans, and cotton or small grains such as wheat and oats. Noncultivated cropland consists of land planted to multiyear or perennial crops such as hay, horticultural plants, and orchards. Pasture land is used for livestock grazing and differs from rangeland in the level of management it receives. Pasture lands are planted with introduced or domesticated native forage species and receive periodic cultural treatments such as tillage, fertilization, mowing, weed control, or irrigation. Agricultural lands provide food and cover used by many species of wildlife and many agricultural cropping practices are used in managing habitats for wildlife. They also provide significant opportunities for outdoor recreation and are important for water quantity and quality.

From 1982 to 1997, cultivated cropland had a net decline of 10.4 percent (table 2). This net loss of 44 million acres resulted from 26.7 million new acres being converted to cultivated cropland while 70.7 million acres of cultivated cropland went to other uses. Of those 70.7 million acres of converted cropland, 43 percent was enrolled into the Conservation Reserve Program (CRP), 27.3 percent was converted to pasture land, and 10 percent went to developed land. The CRP removed highly erodible land out of crop production and established perennial vegetative cover for 10 to 15 years. The 1990 Farm Bill capped CRP acreage at 36 million and created an environmental benefits index that gives preference to lands being bid that will improve water quality and wildlife benefits.

Although pasture had only a net decline of 9.1 percent from 1982 to 1997, 30.2 percent of the 1982 pasture was converted to another use category. Some 38 percent of the pasture loss went to cropland and 35 percent reverted to forest land.

For the most part, farms have become larger and are now characterized by larger field sizes, reduced crop diversity, and a loss of wildlife habitats provided by fencerows and wetlands. These changes reduce the amount of vertical and horizontal wildlife habitat diversity.

The CRP has potential to directly improve wildlife habitat associated with agriculture. Enrollments in the CRP have shown local benefits to some nesting birds such as the ring-necked pheasant.

Wetlands—Wetlands are characterized by constant or recurrent shallow inundation, or saturation, at or near the surface. Wetland ecosystems are very productive and they are critical to flood and erosion control, aquifer recharge, and water purification. The inherent productivity of wetlands supports a diversity of wildlife and fish that are important to commercial fisheries, furbearer harvests, waterfowl hunting, recreational fishing, and nonconsumptive outdoor recreation and nature study.

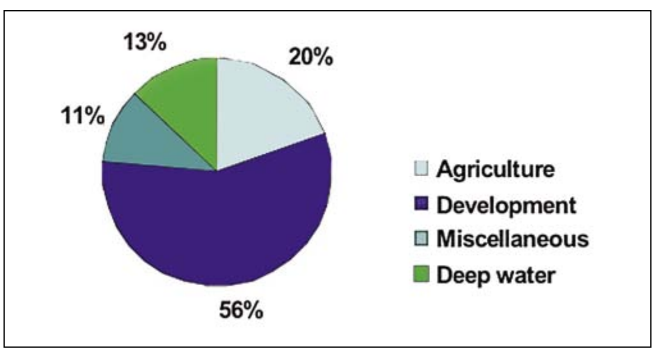
During the early settlement period of America, wetlands were perceived as an impediment to economic development and, up until the mid-1970s, wetland drainage and conversion was an accepted land use policy. Historically, agricultural development was the primary economic force in the conversion of wetlands. The loss of wetland area slowed from 460,000 acres per year in the 1950s to mid-1970s to 260,000 acres per year in the mid-1970s to mid-1980s and to 100,000 acres per year during the 1990s.

Causes of conversion of wetland habitats have now shifted away from agriculture to urban development (fig. 11). Urban and built-up land was responsible for 49 percent of the wetland acres that were converted during the 1992 to 1997 period, whereas agricultural development was responsible for 26 percent. Much of the pressure from conversion to urban and built-up land is likely due to continued development along coastal areas in the North and South.

Urban lands—Urban land[2] in the conterminous United States increased from 2.5 percent of the total land area in 1990 to 3.1 percent in 2000. This urban growth is equivalent to an area about the size of Vermont and New Hampshire combined. States with the greatest increase in the percent of urban land between 1990 and 2000 were Rhode Island (5.7 percent), New Jersey (5.1 percent), Connecticut (5.0 percent), and Massachusetts (5.0 percent) (Nowak et al. 2005). Much of the increase in the percent of urban land by county is clustered in specific areas of the Southeast, Midwest, Northwest, and California, but is particularly evident along the northeastern seaboard (fig.12).

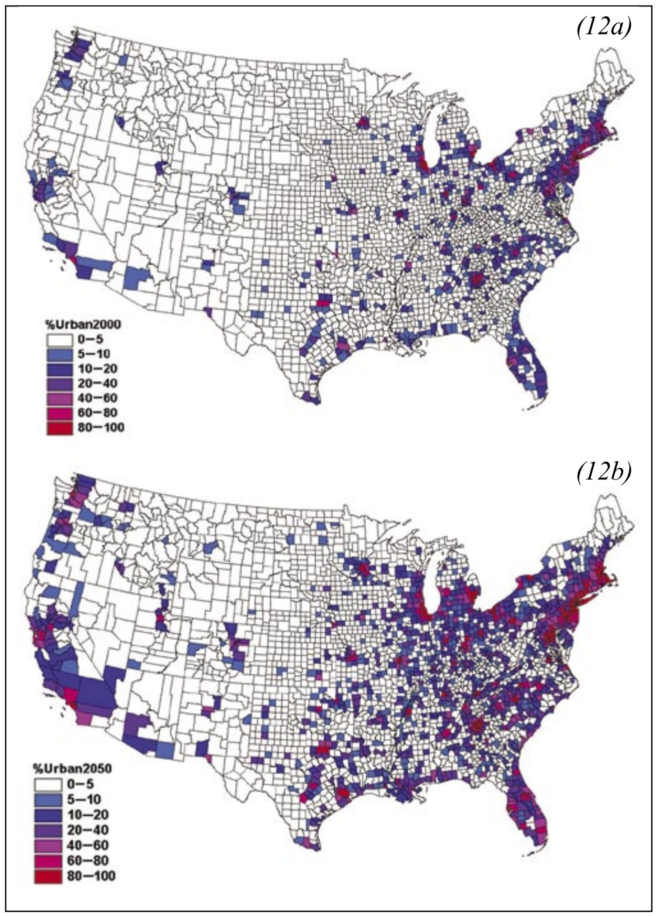
Basing information on the historical growth pattern between 1990 and 2000, urban land is projected to increase from 3.1 percent of the conterminous United States in 2000 to 8.1 percent in 2050 (Nowak and Walton 2005) (fig. 12). This projected urban growth is larger than the State of Montana. Urban expansion is projected to be greatest near the most urbanized regions.

Figure 11.—*Causes of conversion of wetland habitats.*



Urban areas are expanding at an increasing rate and will likely subsume significant amounts of exurban lands over the next 50 years, particularly in areas adjacent to existing urban lands. This urban shift will have significant impacts on natural resource management, and will increase the demands on urban forest management to help sustain environmental and human health in and around urban areas. The existing urban forests currently provide considerable benefits and the importance of this resource may increase in the future if these benefits can be

Figure 12.—*Projected percentage of land classified as urban in 2000 (12a) and 2050 (12b) by county.*



[2] Defined as all territory, population, and housing units located within either urbanized areas or urban clusters: a cluster of one or more block groups or census blocks with a population density of 500 people per square mile, surrounding block groups with a population density of 500 people per square mile, or less densely settled blocks that form enclaves or indentations or are used to connect discontinuous areas.

maintained. Understanding how and where these urban areas and urban forests are changing is critical to helping develop policies and management plans to help sustain this growing resource and its numerous benefits, and to minimize negative urban effects on surrounding forest areas.

When an area is converted to urban and built-up uses, it is likely to be a permanent conversion. Conversion of rural lands to urban and other built-up uses affects the mix of commodities and services produced from the U.S. land base. Between 1982 and 1997, the amount of U.S. land devoted to urban and built-up uses increased 34 percent, an amount that was larger than the percentage increase in population. Newly developed lands are coming predominantly from the conversion of croplands and forest land. The largest increases in U.S. developed areas between 1982 and 1997 were in the South, with major driving factors being growth in population and personal income (Alig and Plantinga 2004). Projected potential future urbanization and development indicate increases by about 80 percent by 2025, based on a projected 35-percent increase in the U.S. population and a projected significant future increase in real personal income. The magnitude of projected increase in developed uses varies by region. Developed area is projected to increase from 5.2 percent to 9.2 percent of the land base by 2025. More people on the forested landscape often means loss of open space and concern over the values generally associated with open space (see box 6). The growing concerns about the loss of forest land to development have also been reflected in public and private efforts to preserve forest land as open space (Kline et al. 2004). Because much of the growth is expected in areas relatively stressed with respect to human-environment interactions, such as some coastal counties, implications for landscape and urban planning include potential impacts on sensitive watersheds, riparian areas, wildlife habitat, open space, and water supplies (see box 7).

Box 6

More people on the forested landscape—Forest land development raises several issues for managers and policy makers associated with the manner in which development affects landscape patterns and conditions, and the goods and services provided by forests. More people on the forested landscape generally means increased parcelization (the breaking up of large parcels into smaller parcels for development) which can lead to conflicts with existing land uses. Forest land development can also have ecological effects in loss of habitat, landscape fragmentation, and changes in vegetation structure brought about by changing land uses. Socioeconomic effects can result from loss of access and the supply of open space for outdoor recreation and aesthetic enjoyment, just as demands for these services might be increasing. These changes can result in increasing political pressure for greater regulation of management practices. Other policies and programs intended to slow forest conversion include State use-value assessment programs that reduce property taxes on forest and farm lands, and programs that purchase development rights, conservation easements, or land in fee simple.

As the U.S. population grows, continued development of forest land seems inevitable. According to Stein et al. (2005), much of the privately owned eastern forest land will be under pressure from increased housing density. Nationwide, the trend of more people living on the forested landscape is projected to continue. The number of forested acres per capita in the United States has been declining and the number by 2050 is projected to be less than half the 1952 level (Alig and Butler 2005). Land managers and policy makers will increasingly need to become involved with issues regarding the interdependency of socioeconomic trends and changing landscapes.

Box 7

Measures of stress on ecosystems—Human use and natural processes combine to determine the condition of renewable resources. As more people demand products and services from forest lands and rangelands, they may stress ecosystem processes that produce environmental output from them. Hof et al. (2006) document the current and expected distribution of the following indicators of forest land and rangeland condition: Edge of natural land cover, average patch size of natural land cover, proportion of total exotic breeding birds, a measure of timber growth on timber land, a measure of timber mortality on timber land, a measure of streamflow variation, total nitrogen in surface waters, total phosphorus in surface waters, and acidity in precipitation. A specific example involves exotic birds. Commonly, as resource development intensifies, the abundance of exotic species that tolerate human activity increases. Figure 13 shows that compared with figure 14, the Midwest will continue to have the highest concentration of exotic breeding birds. Hotspots for each indicator are defined as the areas in the country with the highest 10 percent of the values for that indicator.

Figure 13.—*Current condition hotspots for exotic species.*

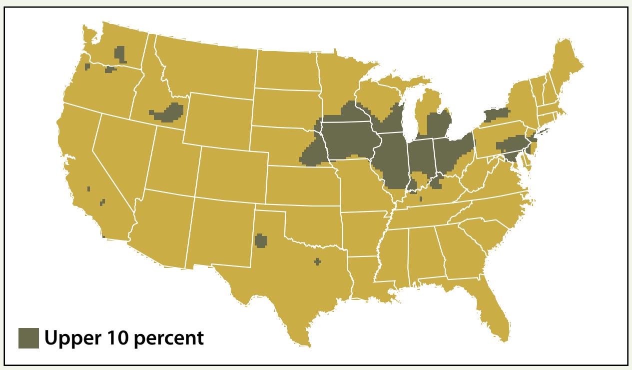
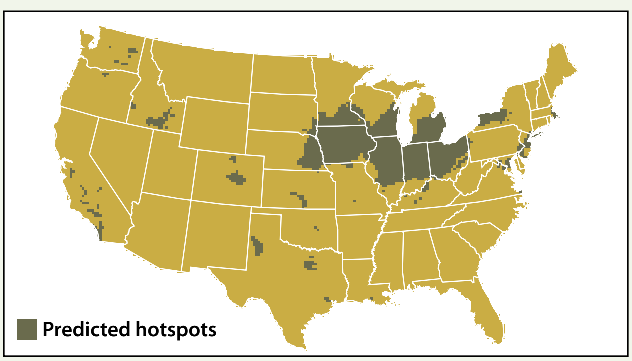
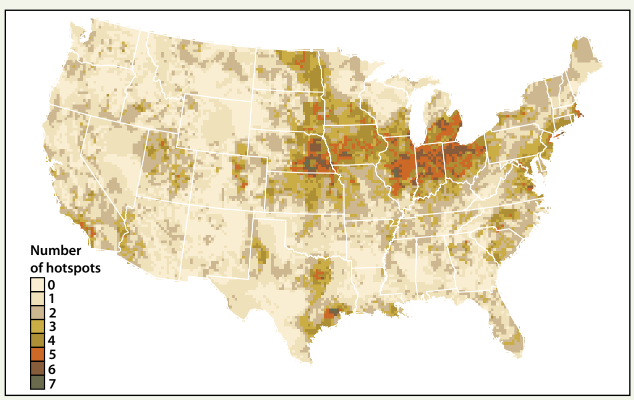


Figure 14.—*Predicted hotspots for exotic species in 2025.*



Interpreting the indicator maps must be done with caution. The methods used identify only patterns of association between the condition indicators and explanatory variables, not cause-effect relationships. Thus, the hotspots should be viewed only as candidates where ecosystem condition may erode in the future, suggesting areas for further investigation. Moving from east to west, the first noteworthy area of projected hotspot concentration is on the Atlantic seaboard, running from South Carolina through the North Carolina piedmont to Massachusetts (fig. 15). The most expansive concentration of projected hotspots includes a broad area through the Midwest extending from Ohio in the east, to the till plains of Iowa and western Nebraska in the west, south into Kansas, and north into Minnesota and South Dakota. Three much smaller concentrations appear in Texas, around the Houston area, the Dallas-Fort Worth area, and in west Texas around Lubbock and Amarillo. Additional areas with high concentrations of projected hotspots include the Front Range of Colorado, the Wasatch Range of Utah, the area around Las Vegas, and southern California. Additional areas with two or three projected hotspots are located throughout the West, the Northeast, Florida, and the large area south of the Great Lakes States.

Figure 15.—*Number of coincident predicted hotspots in 2025.*



Summary

The U.S. population continues to grow and diversify. Projected increases in population and income imply increased demands for all goods and services from U.S. forests and rangelands. Historical trends suggest that these increased demands will likely lead to land use changes that can affect the condition of renewable resources—sometimes permanently. There have been area changes back and forth between agriculture and forestry. But when areas become developed, they are unlikely to return to natural vegetation cover or agriculture, although urban forests can have associated environmental benefits. By 2050, about 1 acre in 12 may be classed as urban compared with 1 in 32 in 2000. The broader category of developed is projected to increase from 1 acre in 19 in 1997 to 1 acre in 10 by 2025. Urban and exurban development will affect watersheds, riparian areas, wildlife habitat, open space, water supplies, and goods and services desired from forests and rangelands.

The United States population and economy are increasingly linked to the world population and economy. Each year, the U.S. population increases by more than 1 million people, in large part because of immigration. Growth in demand for energy and raw materials in China and India now have effects felt around the world. Easing of trade restrictions since World War II has subjected some sectors of the U.S. economy to new sources of competition. Manufacturing industries such as steel, service industries such as data processing and fresh produce in the agricultural sector have all been affected by trade. These are examples of structural changes associated with globalization that influence needs for forest resources. In the forest products sector, the furniture industry has been reduced by competition from China, the pulp industry has been affected by decreased domestic demand and by competition from several sources, and softwood lumber and oriented strand board imports from Canada have captured increased market shares in the United States. Other sources of softwood lumber have also become more competitive in the U.S. market. Softwood log and chip exports have declined.

Trade in forest products affects timber harvest in the United States and thereby affects biodiversity, carbon storage, and other measures of renewable resource condition, as well as employment and other economic benefits of forest management.

Legal, Institutional, and Economic Framework for Forest and Rangeland Conservation and Sustainable Management

The legal, institutional, and economic framework for sustainable management of renewable resources is largely determined by ownership of these resources and laws that govern their use.

Ownership of Forest and Rangelands

In the United States, 57 percent of the forest land is privately owned (fig. 16). Some 15 percent of the forest land in private ownership is classed as forest industry and the remainder as nonindustrial private (Smith et al. 2004). Forest land[3] owned by Native Americans is included in the nonindustrial private category. The Forest Service is the largest public forest land management agency with responsibility for 47 percent of the total forest area in the public ownership category. State (20 percent), U.S. Department of the Interior (DOI) Bureau of Land Management (BLM) (14 percent), and County and Municipal (3 percent) are other ownership categories delineated by the data. The other public category includes 16 percent of the forest land in public ownership and includes lands managed by the DOI National Park Service (NPS), Department of Defense, Department of Energy, and all other Federal ownerships.

Forest land in the various ownership categories is not evenly distributed across the country. Some 54 percent of the forest land in the forest industry category is located in the South. About 73 percent of the forest land in the nonindustrial category is located in the East (fig. 17). About 44 percent of the forest land in the State category is located in Alaska and 32 percent is in the North. Nearly two-thirds of the county and municipal lands are in the North. About 86 percent of the forest land managed by Federal agencies is located in the West. About 79 percent of the publicly owned forest land is in the West and 74 percent of the privately owned forest land is in the East. The location and ownership of forest land tends to determine the focus of management issues, which differ by type of ownership.

Some 66 percent of the rangeland area is in non-Federal ownerships (table 3). About 61 percent of the rangeland in non-Federal ownership is in the Rocky Mountain region, 30 percent is in the South, about 9 percent is in the Pacific Coast region, and a small amount is in the North. Most of the rangeland within the NFS is in the West as is all of the rangeland managed by the BLM. The BLM manages 27 percent of the rangeland in the conterminous States and the Forest Service, 7 percent.

Figure 16.—*U.S. forest land by ownership.*

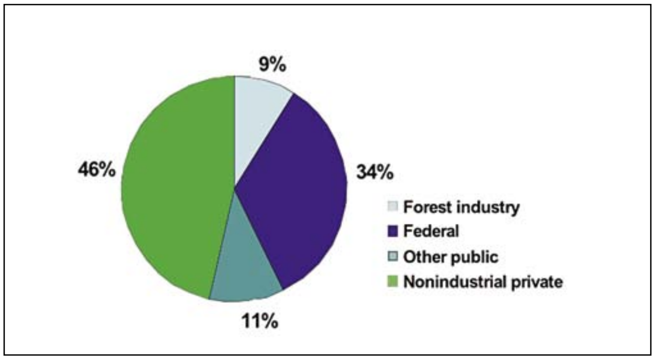
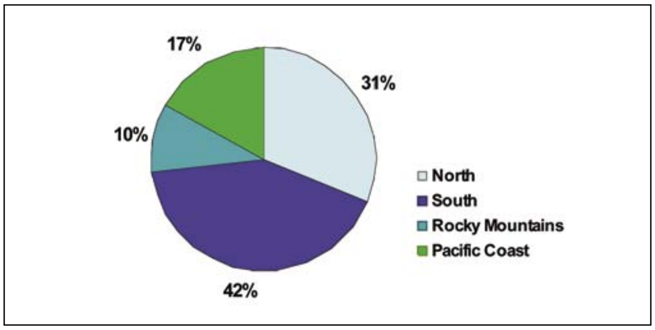


Figure 17.—*Distribution of forest land in the private nonindustrial ownership.*



[3] Lands held in trust by the United States or States for Indian tribes or individual Indians or lands owned in fee simple by Indian tribes whether subject to Federal or State restrictions against alienation or not.

Table 3.—*Rangeland area in the conterminous States by ownership and region in 1997 (1,000 acres).*

Region	Ownership			
	Non-Federal	National forests	BLM	Total
Pacific Coast	32,757	10,813	22,504	66,074
Rocky Mountain	229,117	29,785	132,903	391,805
South	112,770	0	0	112,770
North	98	65	0	163
Total	374,742	40,663	155,407	570,812

BLM = Bureau of Land Management

The Privately Owned Forest and Rangeland Estate

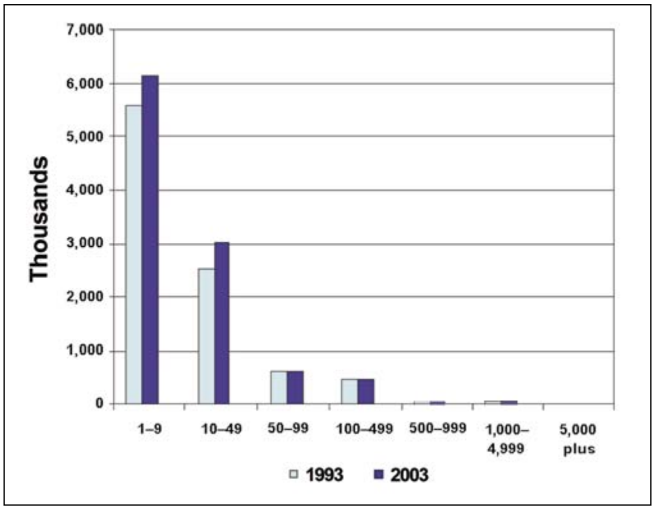
About 57 percent, or 430 million acres, of forest land in the 50 States is privately owned. Forest industry accounted for an estimated 66 million acres in 2002. The forest industry ownership units are associated with timber processing facilities; however, millions of acres in the forest industry ownership have been sold to timber investment management organizations, real estate investment trusts, or other entities that do not own processing facilities. We expect the number of acres in the forest industry category to decline as new forest inventories are reported.

Other private owners include other businesses or corporations, partnerships, tribes, families, and individuals. Family forests include lands that are at least 1 acre in size, 10 percent stocked, and owned by individuals, married couples, family estates and trusts, or other groups of individuals who are not incorporated or otherwise associated as a legal entity (Butler and Leatherberry 2004). An estimated 10.3 million family forest owners in the conterminous States control 262 million acres of forest land. An increasing number of family forest owners own smaller size tracts of forest land. The number of family forest owners in the conterminous United States increased by 11 percent between 1993 and 2003. Most of this increase occurred among owners with fewer than 50 acres of forest land (fig. 18). Private ownerships are managed with a variety of objectives. For family forest owners, the most common reasons cited as very important or important for ownership are to enjoy beauty/scenery, to protect nature and biological diversity, that the acreage is part of a farm or home site, for privacy, and to pass the land on to heirs.

Twenty percent of the forest land in family control is owned by people 75 years or older. Because of the advanced age of many owners and their stated intentions for their land, land transfers will be substantial during the next 10 to 20 years with implications for changes in management objectives as a new generation of forest landowners takes over.

Regulations affecting privately owned forest land vary by State and locality. Forty-four States have best management practice legislation that has the intent of promoting better management of lands, when timber production is involved, especially to protect water quality (Ellefson et al. 1995). Nine States have forest practice regulatory acts that have the intent of promoting good management practices and may require plans, reforestation, and other actions on the part of the landowner.

Figure 18.—*Number of owners by size of holdings (acres).*



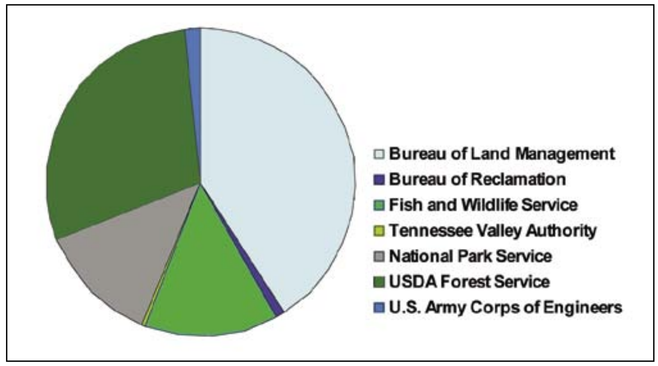
The Federal Government, as well as some State and local jurisdictions may offer incentives and/or technical assistance to private landowners to encourage better management of private lands. Such programs of the Forest Service include cost sharing for tree planting and other forest management activities and assistance in development of management plans. The USDA Cooperative State Research, Education, and Extension Service provides technical advice and assistance to private forest landowners. Some States provide assistance in management and may give forest land preferential tax treatment. Localities may offer tax incentives to keep land in forests. Income from forest land is subject to Federal taxes as well as State and local taxes as tax codes specify.

Private property rights have their origins in part with the Magna Carta (National Research Council 1997). Governments at all levels may take private property if in the public interest. The public interest is refined over time to reflect changing social values. For example, private property rights within the context of the Endangered Species Act of 1973 are currently being litigated in the courts.

The Publicly Owned Forest and Rangeland Estate

Management of Federal lands is influenced by Federal legislation as interpreted by the judiciary and as administered by the executive branch of government. The BLM manages the largest area of combined Federal land and water area (fig. 19). Changes in social values may lead to changes in management practices that are initiated by one or more branches of government. For example, the National Environmental Policy Act of 1969 requires that Federal agencies prepare an environmental impact statement for major actions affecting the quality of the human environment. This act facilitated public scrutiny of management of Federal forest land and associated resources. For the Forest Service, the Forest and Rangeland Renewable Resources Planning Act, as amended, further facilitated public involvement in management of renewable resources. Other Federal agencies have varying legislative mandates for management and public review of this management.

Figure 19.—*Distribution of land and water area among Federal land-managing agencies.*



State, county, and municipal governments own nearly 73 million acres of the Nation's forest land, with most of these lands in the Great Lake States (Minnesota, Wisconsin, and Michigan), Alaska, New York, Oregon, Pennsylvania, and New York. The largest single State ownership of 27 million acres is in Alaska.

State and county forests often have an economic development focus and thus have proven to be especially important to local and regional economies. Government programs that foster stability in community income and employment have proven to be especially important in accomplishing economic development (National Research Council 1997).

Management of and Access to Inland Water

About 7 percent, or 161 million acres, of the United States is covered by water. In the United States, the two water right doctrines are appropriation and riparian. The law of appropriation, developed by miners and farmers in the West to meet their needs, has two basic tenets: (1) a water right can be acquired by the party diverting the water from the water course and applying it to a beneficial use, and (2) the earliest water right will have priority over other, later-acquired rights.

Although most States in the West now recognize various instream-flow water rights (Gillian and Brown 1997), they often place many restrictions on who can hold them, the uses of the water, and the degree of proof to support them. Almost none allow the Forest Service to hold an instream flow right.

East of the 100th meridian, the doctrine of riparian rights entitles riparian landowners to reasonable use of streamflow as long as they obtain a permit from the State first. Over the past few decades, the riparian doctrine has been modified to more closely resemble the appropriation doctrine. The number of waterbodies with diminished streamflows is growing rapidly in the East.

Access rights for recreational use of water are also difficult to describe. In general, trespass laws apply to land adjoining water, and private owners can deny access. Once access has been achieved, however, water can generally be used for recreation despite the existence of adjacent, posted land.

The 191 million acres of NFS lands contain 128,000 miles of fishable streams and rivers, more than 2.2 million acres of lakes, ponds, and reservoirs, and 12,500 miles of coast and shoreline.

Management of and Access to Minerals

The Nation's forest lands and rangelands are underlain by extensive mineral resources. The greatest concentrations occur in the western mountain ranges, the Western Overthrust Belt, the Northern Great Plains, and the Appalachian region.

Ownership patterns for energy and mineral resources do not necessarily match surface ownership patterns because mineral rights may be severed from the surface. Privately held minerals underlie private, as well as public, lands. Similarly, publicly held mineral rights exist under both public and private lands. Significant undiscovered energy and mineral resources in the Western United States are publicly held. In the East, minerals are predominately privately held, although some areas with high mineral potential reside in the public estate.

The Mining Law of 1872 governs mineral locations on public domain lands (lands which have never left the Federal estate) for most nonenergy minerals. The law was framed to encourage mineral exploration and development by individuals or firms. If a deposit is discovered, it may be claimed and extracted to exhaustion by the finder. A deposit that can be shown to be economic may be patented, thus transferring the surface and mineral rights to private ownership. The rights to both claims and patented claims may be sold or transferred.

The Mineral Leasing Act of 1920 and its amendments govern the location and extraction of energy and some industrial minerals. Nonenergy minerals on acquired lands, which would otherwise be subject to the Mining Law of 1872, are covered by the Mineral Leasing Act. This law, too, was intended to encourage mining activities. Individuals and firms may explore the public lands; however, discovery does not lead to a transfer of ownership. Mineral locations are leased, with the lessor having an exclusive right to extract the deposit ore to exhaustion. Royalties are paid to the Government, based on the value of energy or mineral resource extracted.

Economic Institutions

Markets—Within U.S. economic institutions, the production and consumption of natural resources are governed by a number of factors, with competitive market forces being especially important for resources coming from private lands and from imported materials.

Markets for processed wood products are generally recognized as being competitive with producers and consumers responding to prices in expected ways. Markets for roundwood can be more or less competitive depending on the numbers of buyers and sellers in local situations. Depending on the product, local markets may be affected by international markets. Characteristics of markets for other renewable resources vary, depending on the resource and ownership. In some areas of the country, markets have developed for water rights, forage, various types of recreation including wildlife viewing, and mineral rights. For the most part, these markets have developed for renewable resources on private lands. Timber is also sold at fair market value on many public ownerships. The sale of the rights to use other renewable resources on public lands may involve a mixture of market information and legislative oversight or it may be provided free as is the case for recreation on many public ownerships.

Markets for minerals have much variation. Each mineral possesses characteristic physical properties that determine uses and, ultimately, markets for them. Metallic minerals typically occur in one of several types of mineralogical compounds. They are seldom traded at this raw stage, however. Instead, milling, smelting, and refining are used to separate the metal from other elements or compounds present in the ore. The metals are then sold in pure or near pure form, with any unit replaceable by and identical to any other, regardless of origin. Transportation costs aside, each unit sells for the same price. This degree of competition is not necessarily present in gaining access to minerals on public lands.

Water markets are emerging in many regions of the United States. Water prices are highly variable across regions and within local areas of the same region. Most activity in water markets has occurred in the Western United States, where the amount of water annually transferred through leases is more than 50 times greater than the amount transferred as water rights. On an annual basis, however, the price of water transferred as rights significantly exceeds the price of water transferred in leases. The median price of leases is greatest in Arizona, California, New Mexico, and Nevada. The median price of water rights is greatest in Colorado and Nevada. Combining across leases and annualized water rights, the highest medians for municipal purposes (above $85 per acre-foot per year) are found in California, Colorado, and Nevada and the lowest medians (below $30) are found in Texas and Utah; the highest median price for irrigation purposes (above $75) is found in Colorado and the lowest medians (below $10) are for Idaho, Oregon, Utah, and Wyoming; and the highest median for environmental purposes (above $60) is found in California and the lowest medians (below $25) are for Colorado and Idaho.

The use of market mechanisms is also evolving to maintain or enhance the production of ecosystem services from forest lands and rangelands. (See boxes 8 and 9 for defining ecosystem services and valuing them). Appropriate roles of markets and/or market-based approaches in influencing the supply of and demand for ecosystem services are still being defined. Market-based approaches, such as "cap and trade" systems and pollution taxes, have been used as an efficient way to implement environmental regulations. For example, the "cap and trade" system has been used in the United States to meet sulfur dioxide emission targets. Pollution taxes, which charge per ton of pollutant produced, create similar market incentives but are not necessarily linked to pollutant reduction targets.

Incentives—The United States has a long history of using incentive programs to accomplish environmental goals. For example, the Conservation Reserve Program provides incentives for farmers to take highly erodible cropland out of production, resulting in improvements in water quality as one of several benefits. Tree-planting subsidies for timber production in the South have a long and successful history. Market-based incentives are being considered to encourage the maintenance and enhancement of ecosystem services, in effect, encouraging the production of environmental "goods" rather than controlling environmental "bads." Programs specifically designed to enhance the production of services such as carbon sequestration, water and air quality, and biodiversity conservation are newer and their impacts uncertain.

Box 8

What are ecosystem services?—There is no commonly accepted or "correct" definition of ecosystem services. An often cited definition from Daily (1997) defines ecosystem services as the "conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life." The Millennium Ecosystem Assessment (World Resources Institute 2003) defined four categories of ecosystem services: provisioning services include all products from ecosystems, regulation services include benefits from ecosystem processes, cultural services include all nonmarket benefits obtained from ecosystems, and supporting services include ecosystem functions. Boyd and Bahnzaf (2005) defined ecosystem services as "end products of nature that yield human well-being." Although no one disputes that ecosystems provide a variety of services to society, understanding is limited about the processes that result in services and how humans value those services.

The Daily definition is broad and comprehensive, recognizing the interconnectedness of human and natural systems. The Millennium Ecosystem Assessment categories of services are also comprehensive, with some separation between ecosystem function and services across the four categories. The Boyd and Bahnzaf definition focuses on separating ecosystem services from ecosystem processes, functions, and benefits. For example, the Daily and Millennium Ecosystem Assessment definitions would include water purification, aesthetic beauty, and nutrient recycling as ecosystem services, although Boyd and Bahnzaf would categorize water purification as an ecosystem function (providing clean water as a service); and aesthetic beauty as an ecosystem benefit (based on an ecosystem service of landscape arrangement).

Separating processes from their services and benefits is particularly important for evaluating management and policy options. Biophysical scientists provide the understanding of how nature physically "produces" the services that are essential for society, and how human or natural disturbances alter service flows. Economists can then assess the value of changes in the service flows.

Box 9

What are ecosystem services worth?—It's a simple question with no simple answer. The National Research Council (2005) recently reviewed the state-of-the-art for valuing ecosystem services. The report recognized the importance of valuing ecosystem services for informing policy decisions, and also recognized the significant challenges:

> The fundamental challenge of valuing ecosystem services lies in providing an explicit description and adequate assessments of links between the structures and functions of natural systems and the benefits derived by humanity (National Research Council 2005: 29).

Urban forests have been recognized for providing a number of ecosystem services that improve environmental quality and human health. The Urban Forest Effects model (UFORE) was developed to model ecological processes and functions to estimate the effects of urban forests on services such as carbon sequestration and improved air quality (Nowak and Crane 2002). The UFORE model was used to estimate that urban forests nationally store between 335 and 980 million metric tons of carbon, sequester between 14.7 and 27.7 million metric tons per year (Nowak and Crane 2002), and remove 711,000 metric tons per year of air pollutants (Nowak et al. 2002). Valuing these services is more problematic since the appropriate value for an application is often both site and context specific. Nowak and Crane (2002) applied an estimate of the marginal social cost of carbon dioxide emissions of $20.30 per ton of carbon (Fankhauser 1994). Carbon markets in the United States

Box 9 (continued)

are developing, and may be a basis for estimating the total value of the storage and sequestration services in the future. The Chicago Climate Exchange has an increasing volume of trade, with prices per metric ton of CO2 reaching $2.75 per metric ton in March 2006 (Chicago Climate Exchange 2006). Prices on the European Carbon Exchange are considerably higher as a result of the Kyoto Protocol. European prices ranged between 25 and 30 euros through most of 2006, although prices dropped sharply at the end of April to about 17 euros (European Climate Exchange 2006)

The National Research Council report reviewed numerous ecosystem valuation case studies. Since most ecosystem services are public goods, nonmarket valuation methods are typically employed. Another approach that has been applied in a number of cases is the "replacement cost" or "avoided cost" approach, which can be an effective way to evaluate whether maintaining the service through resource management is more cost effective than some technological option (e.g., protecting watersheds for New York City rather than build new water treatment facilities), but this approach does not value the ecosystem service itself. Significant challenges remain, but progress has been made both in understanding the ecological processes and functions and in valuing the resulting services.

Research Institutions

Natural resources research in the United States is primarily supported by the Federal Government and, to a lesser extent, by State agencies, private foundations, and businesses. Research takes place in Federal institutions, State institutions such as universities, and private organizations such as research institutes and industry. Our ability to manage forest lands and rangelands depends largely on our understanding of forest land and rangeland dynamics and our ability to predict the consequences of management actions and natural and human disturbance. Our capacity to implement research depends on investments in research and fostering access to this research by stakeholders and policymakers.

Historically, research pertaining to rangelands has emphasized ecological and grazing-related problems. Within the socioeconomic research area, studies have primarily dealt with tradeoffs derived from different management practices. Little work has taken place that integrates ecosystem and economic processes to better understand the contribution of rangelands in providing ecosystem services and other measures of human well-being.

Availability and Extent of Data for Measuring Indicators of Sustainable Resource Management

Minerals—The Sustainable Minerals Roundtable developed 87 indicators of sustainability for energy and mineral systems. Thirty-eight of the indicators were given priority. The First Approximation Report of the Sustainable Minerals Roundtable lists the indicators, discusses the process used to develop criteria and indicators, and offers complete write-ups for a small number of indicators (Sustainable Minerals Roundtable 2003).

Water—A preliminary report by the Water Resources Roundtable discusses the roles of indicators, conceptual foundations for the work of the roundtable, and criteria and indicators on the sustainability of water resources (Water Resources Roundtable 2005). The report presents findings for 17 indicators selected from a candidate list of 386. Data availability and quality varied across the selected indicators.

Rangelands—The Sustainable Rangelands Roundtable (SRR) has developed 64 indicators of rangeland sustainable management at regional and national scales (Sustainable Rangelands Roundtable n.d.). A summary of data availability, as indexed using four categories based upon the existence of standardized measurement procedures and the accessibility of actual data sets, is presented for these indicators in table 4. Recognizing the technical, legal, and monetary hurdles to monitoring all 64 indicators, the SRR also reached a consensus on 27 core indicators that warrant more immediate attention by Federal agencies. These core indicators are underlined in table 4. Only 4 out of the 13 ecological indicators and 6 out of 14 socioeconomic indicators presently are populated with regional-level or national-level data sets based upon broadly accepted methodologies. Thus, serious challenges remain if a broad suite of indicators for monitoring the sustainable management of rangelands is to be widely accepted and used. One of the largest obstacles to monitoring biophysical indicators is the lack of consistent, comprehensive data sets on Federal rangelands.

Forests—Analysis of trends in resource condition as revealed by measurement of indicators requires the availability of data on a continuing basis. When the desire for scaling up and down from national to regional to local scales is considered, data must be available for the Nation as a whole through

Table 4.—*Categorized availability of data for 64 sustainable rangeland roundtable indicators.*

	Indicator	Availability of data sets[1]
Criterion 1: Conservation and maintenance of soil and water resources of rangelands		
1.	Area and percent of rangeland with significantly diminished soil organic matter and/or high carbon:nitrogen ratio	D
2.	Area and extent of rangelands with changes in soil aggregate stability	B
3.	Assessment of microbial activity in rangeland soils	D
4.	Area and percent of rangeland with a significant change in extent of bare ground	C
5.	Area and percent of rangeland with accelerated soil erosion by water and wind	B
6.	Percent of water bodies in rangeland areas with significant changes in natural biotic assemblage composition	A
7.	Percent of surface water on rangeland areas with significant deterioration of their chemical, physical, and biological properties from acceptable levels	A
8.	Changes in groundwater systems	A
9.	Changes in the frequency and duration of surface no-flow periods in rangeland streams	A
10.	Percent stream miles in rangeland catchments in which stream channel geometry significantly deviates from the natural channel geometry	B
Criterion 2: Conservation and maintenance of plant and animal resources on rangelands		
1.	Extent of land area in rangeland	B
2.	Rangeland area by vegetation community	C
3.	Number and extent of wetlands	A
4.	Fragmentation of rangeland and rangeland vegetation communities	C
5.	Density of roads and human structures	A
6.	Integrity of natural fire regimes on rangeland	C
7.	Extent and condition of riparian systems	C
8.	Area of infestation and presence/absence of invasive and nonnative plant species of concern	C
9.	Number and distribution of species and communities of concern	A
10.	Population status and geographic range of rangeland-dependent species	B
Criterion 3: Maintenance of productive capacity on rangeland ecosystems		
1.	Rangeland above ground phytomass	A
2.	Rangeland annual productivity	A
3.	Percent of available rangeland grazed by livestock	D
4.	Number of domestic livestock on rangeland	B
5.	Presence and density of wildlife functional groups on rangeland	C
6.	Annual removal of native hay and nonforage plant materials, landscaping materials, edible and medicinal plants, wood products, and native hay	D

Table 4.—*Categorized availability of data for 64 sustainable rangeland roundtable indicators (continued).*

Indicator		Availability of data sets[1]
Criterion 4: Maintenance and enhancement of multiple economic and social benefits to current and future generations		
1.	Value of forage harvested from rangeland by livestock	A
2.	Value of production of nonlivestock products produced from rangeland	D
3.	Number of visitor days by activity and recreational land class	C
4.	Reported threats to quality of recreation experiences	B
5.	Value of investments in rangeland, rangeland improvements, and recreation/tourism infrastructure	D
6.	Rate of return on investment for range livestock enterprises	B
7.	Area of rangelands under conservation ownership or control by conservation organizations	B
8.	Expenditures (monetary and in-kind) to restoration activities	D
9.	The threat or pressure on the integrity of cultural and spiritual resource values	D
10.	Poverty rate—general	A
11.	Poverty rate—children	A
12.	Income equality	A
13.	Index of social structure quality	C
14.	Community satisfaction	A
15.	Federal transfers by categories (individual, infrastructure, agriculture, etc.)	A
16.	Presence and tenure of natural resource nongovernmental organizations at the local level	D
17.	Sources of income and level of dependence on livestock production for household income	C
18.	Employment diversity	A
19.	Agriculture (farm/ranch) structure	A
20.	Years of education	A
21.	Value produced by agriculture and recreation industries as percent of total	A
22.	Employment, unemployment, underemployment, and discouraged workers by industrial sector	A
23.	Land tenure, land use, and ownership patterns by size classes	C
24.	Population pyramid and population change	A
25.	Income differentials from migration	A
26.	Length of residence (native, immigrant more than 5 yrs., less than 5 yrs.)	A
27.	Income by work location versus residence	A
28.	Public beliefs, attitudes, and behavioral intentions toward natural resources	C
Criterion 5: Legal, institutional, and economic framework for rangeland conservation and sustainable management		
1.	Land law and property rights	B
2.	Institutions and organizations	D
3.	Economic policies and practices	C
4.	Public information and public participation	C
5.	Professional education and technical assistance	C
6.	Land management	D
7.	Land planning, assessment, and policy review	C
8.	Protection of special values	C
9.	Measuring and monitoring	C
10.	Research and development	C

[1] Availability of data sets is categorized by: A—methods and procedures for data collecting and reporting, and data sets of useable quality exist at the regional-national level; B—standardized methods and procedures for data collecting and reporting exist at the regional-national level, but useable data set(s) do not exist at the regional-national level; C—some data set(s) exist at the regional-national level, but methods and procedures are not standardized at the regional-national level; D—conceptually feasible or initially promising, but no regional-national methods, procedures, or data sets currently exist.

comprehensive monitoring programs. Within the forestry sector, the comprehensive monitoring programs are the Forest Inventory and Analysis Program of the Forest Service and the Natural Resources Inventory of the NRCS. The Census Bureau provides locally, regionally, and nationally consistent data for some measures of the forest products industries. Trade associations such as the American Forest and Paper Association provide some data on capacity and production for some industries such as pulp and paper. Measures of participation and other attributes of recreation are provided on a continuing basis and are consistent locally, regionally, and nationally (Cordell et al. 2004).

The Forest Service (2004) reviewed the 67 indicators developed in the Montreal Process and found that data was generally complete nationally, current, and reliable for eight indicators—six based on the Forest Service Forest Inventory and Analysis Program and two based on Census Bureau data (fig. 20).

Localizing information from higher scale data—Local, regional, and national assessments are conducted at different scales but use the same basic measures of resource condition. In some cases, data sets can be aggregated from local to national scale. For example, the Forest Inventory and Analysis program conducts samples to gather detailed local timber

Figure 20.—*Capacity to measure and monitor changes in the 67 indicators from the Montreal Process.*

Criterion	Indicators	Data status		
		Coverage	Currency	Frequency
1 Conservation of biodiversity	1 Area of total land and forest land by type	green	green	green
	2 Area of forest by type and age	yellow	yellow	yellow
	3 Area of forest by type and IUCN category	green	yellow	red
	4 Area of forest by type, age, and IUCN	yellow	yellow	red
	5 Fragmentation by forest type	purple	yellow	red
	6 Number of forest-dependent species	yellow	yellow	red
	7 Status of forest-dependent species	yellow	yellow	red
	8 Number of forest-dependent species in restricted range	yellow	yellow	red
	9 Population levels of representative species	yellow	yellow	red
2 Maintenance of productive capacity of forest ecosystems	10 Area of forest land & timber land available for timber production	green	green	green
	11 All live and growing stock volume	green	green	green
	12 Area and growing stock in plantations	green	green	green
	13 Annual removals for products vs. sustainable volume	green	green	green
	14 Removals of nontimber products vs. sustainable levels	red	red	red
3 Maintenance of forest ecosystem health and vitality	15 Area and percent forest damaged by insect, disease, fire, flood, etc	yellow	yellow	yellow
	16 Area and percent forest affected by airbourne agents (nitrate, ozone, etc.)	purple	yellow	yellow
	17 Area and percent forest with diminished biological components	yellow	yellow	yellow
4 Conservation and maintenance of soil and water resources	18 Area and percent of forest with significant soil erosion	purple	yellow	yellow
	19 Area and percent of forest managed primarily for protective functions	red	red	red
	20 Percent of stream kilometers in forested catchments	yellow	yellow	yellow
	21 Area and percent of forest with significantly diminished soil organic matter	yellow	yellow	yellow
	22 Area and percent of forest with significant soil compaction	purple	yellow	yellow
	23 Percent of water bodies in forested areas with significant change in biodiversity	red	red	red
	24 Percent of water bodies in forested areas with significant change in hydro. character	red	red	red
	25 Area and percent of forest area experiencing significant accumulation of toxic substances	purple	yellow	red
5 Maintenance of forest contribution to global carbon cycles	26 Total forest biomass and carbon pool by type and age	purple	yellow	yellow
	27 Contribution of forest to total global carbon budget	purple	yellow	yellow
	28 Contribution of forest products to global carbon budget indicators	purple	yellow	yellow

Figure 20.—*Capacity to measure and monitor changes in the 67 indicators from the Montreal Process (continued).*

Criterion		Indicators	Data status: Coverage	Data status: Currency	Data status: Frequency
6 Maintenance and enhancement of long-term multiple socioeconomic benefits to meet the needs of societies	29	Value and volume of wood products (including value added)	Green	Yellow	Green
	30	Value and quantity of nonwood forest products	Red	Red	Red
	31	Supply and consumption of wood/wood products (including per capita)	Green	Yellow	Green
	32	Value of wood and nonwood forest products as percent of GDP	Yellow	Red	Yellow
	33	Degree of recycling of forest products	Yellow	Red	Red
	34	Supply and consumption/use of nonwood products	Red	Red	Yellow
	35	Area and percent forest land managed for recreation (rel. to total)	Purple	Red	Yellow
	36	Number and type of recreation facilities (rel. to forest area and population)	Yellow	Red	Yellow
	37	Number of recreation visitor days (rel. to forest area and population)	Yellow	Red	Yellow
	38	Value of investment in forest growth, health, management, recreation, etc.	Yellow	Red	Yellow
	39	Expenditures on research and education	Yellow	Red	Yellow
	40	Extension and use of new and improved technology	Red	Red	Yellow
	41	Rates of return on investment	Yellow	Red	Yellow
	42	Area and percent forest managed to protect cultural needs	Red	Red	Red
	43	Nonconsumptive forest use values	Red	Red	Red
	44	Direct and indirect employment in forest sector (rel. to total)	Yellow	Red	Yellow
	45	Average wage rates and injury rates in forest sector	Yellow	Red	Yellow
	46	Viability and adaptability to change of forest-dependent communities	Red	Red	Red
	47	Area and percent of forest land used for subsistence purposes	Red	Red	Red
7 Legal, institutional, and economic framework for forest conservation and sustainable management	48	Clarifies property rights	Yellow	Red	Red
	49	Provides for periodic forest-related planning, assessment, and policy review	Yellow	Red	Red
	50	Provides opportunities for public participation in public policy and decisionmaking	Yellow	Red	Red
	51	Encourages best practice codes for forest management	Yellow	Red	Red
	52	Provides for the management of forests to conserve special environmental values	Yellow	Red	Red
	53	Provide for public involvement activities and public education, etc.	Yellow	Red	Red
	54	Undertake and implement periodic forest-related planning, assessment, etc.	Yellow	Red	Red
	55	Develop and maintain human resource skills across relevant disciplines	Yellow	Red	Red
	56	Develop and maintain efficient physical infrastructure to facilitate the supply of forest products and services	Yellow	Red	Red
	57	Enforce laws, regulations, and guidelines	Yellow	Red	Red
	58	Investment and taxation policies and a regulatory environment which recognizes the long-term nature of investments	Yellow	Red	Red
	59	Nondiscriminatory trade policies for forest products	Yellow	Red	Red
	60	Availability and extent of up-to-date data, statistics, and other information	Yellow	Red	Red
	61	Scope, frequency, and statistical reliability of forest inventories, etc.	Yellow	Red	Red
	62	Compatibility with other countries in measuring, monitoring, and reporting	Yellow	Red	Red
	63	Development of scientific understanding of forest ecosystems	Yellow	Red	Red
	64	Development of methodologies to measure and integrate environmental and social costs and benefits into markets and public policies	Yellow	Red	Red
	65	New technologies and the capacity to assess socioeconomic consequences	Yellow	Red	Red
	66	Enhancement of ability to predict impacts of human intervention on forests	Yellow	Red	Red
	67	Ability to predict impacts on forests of possible climate change	Yellow	Red	Red

KEY

Notes on the rating system: This rating provides a general overview of the data supporting the indicators. Green means few gaps, yellow means several gaps, red means no data or numerous gaps, and purple indicates data that has been modelled.

		Data coverage	Data currency	Data frequency
Green	Data generally complete nationally, current, and reliable.	National	1997+	Annual to < 5-year periodic
Yellow	Data may not be consistent nationally, slightly dated, and not measured frequently enough.	Regional or some national	1980–96	5+ year periodic
Red	Data are from inconsistent sources or nonexistent, more than 15 years old or partial, and have no consistent plan for remeasurement.	Varies or incomplete	Incomplete	One-time or incomplete
Purple	Data are modelled (currency and frequency dots refer to model baseline data).	Modelled		

inventory data that can be statistically aggregated to larger geographic and thematic scales. Other types of measurements are not amenable to sampling, and must instead be made at regional scale, and then disaggregated for local assessments.

To illustrate one application of national assessment data at local scale, we used local scale land-cover maps to disaggregate national measures of forest fragmentation.

The national assessment protocols (Riitters et al. 2002) identified forest parcels as dominant (i.e., surrounded by 60 percent forest), interior (90 percent), and core (100 percent). The protocols for localizing the information (Riitters et al. 2003) disaggregate the national statistics according to forest type as identified by State-level maps from the GAP Analysis Program in Oregon and New York. The GAP maps were overlaid on the national fragmentation maps to assign a forest type to the fragmentation category measured in the national analysis.

Because fragmentation varies in meaningful ways with the size of the surrounding neighborhood, the results are shown for three neighborhood sizes of 2.25 hectares, 65.61 hectares, and 5314.41 hectares (5.56, 150, and 13,130 acres, respectively) (fig. 21). Typically, the proportions of core and interior forest decrease with increasing neighborhood size, indicating that most forests are fragmented to some degree. At the same time, the proportion of dominant forest decreases less rapidly with increasing neighborhood size, indicating that forest tends to be the dominant land cover type where it occurs. For a given combination of neighborhood size and fragmentation category, the differences among forest types (New York) or forest vegetation classes (Oregon) reflect local differences in overall forest fragmentation influencing locally defined forest types. Comparisons among neighborhood sizes or fragmentation categories can be interpreted with respect to spatial scales and intensities at which local fragmentation occurs (Riitters et al. 2003).

Figure 21.—*Localizing information from higher scale data. Forest land fragmentation statistics for selected forest types in Oregon (A) and New York (B). The proportions of total area of each type meeting national criteria for "core" (○), "interior" (△), and "dominant" (□) forest land are shown for landscape sizes of 2.25 hectares (ha), 65.61 ha, and 5,314.41 ha. The forest types have been sorted according to the proportion of "interior" for each landscape size. Adapted from Riitters et al. (2003).*

(A)

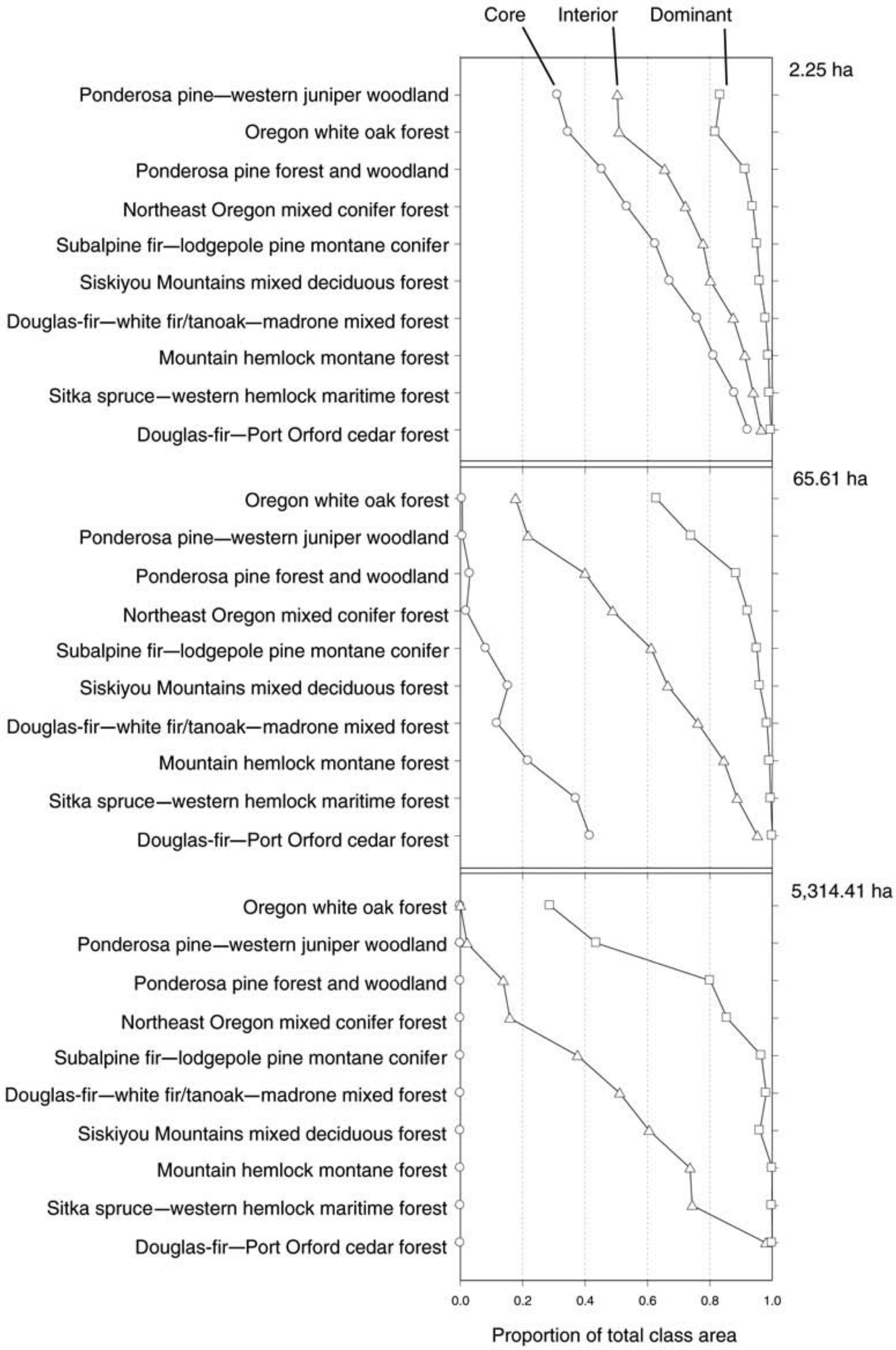
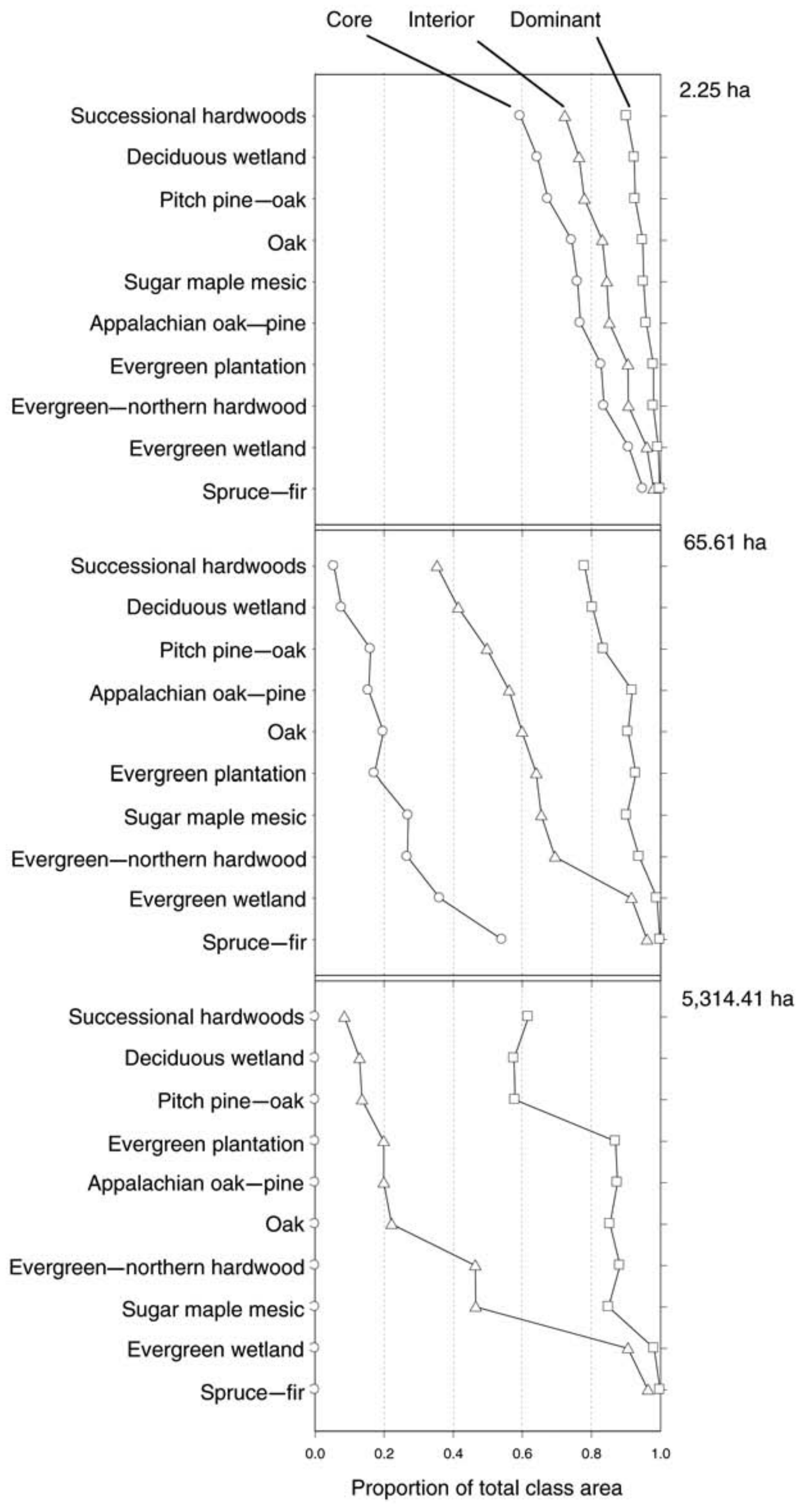


Figure 21.—*Localizing information from higher scale data. Forest land fragmentation statistics for selected forest types in Oregon (A) and New York (B). The proportions of total area of each type meeting national criteria for "core" (○), "interior" (△), and "dominant" (□) forest land are shown for landscape sizes of 2.25 hectares (ha), 65.61 ha, and 5,314.41 ha. The forest types have been sorted according to the proportion of "interior" for each landscape size. Adapted from Riitters et al. (2003) (continued).*

(B)



Summary

More than one-half (57 percent) of the forest land in the United States is privately owned and 85 percent of this land is in nonindustrial private ownership. Nonindustrial private forest land owners have a variety of ownership objectives. Because of the advancing age of people in this ownership category, a significant percentage of U.S. forest land will change ownership over the next 20 years with implications for possible changes in objectives. The number of forest owners continues to increase with consequent parcelization of the landscape. The decreasing average size of forest ownerships has implications for ownership objectives and delivery of services such as protection from wildfire.

The sale of millions of acres of forest land owned by forest industry to timber investment management organizations, real estate investment trusts, and other private ownership entities adds uncertainty to the future management and disposition of these lands. Available information suggests that, for now, some purchasers of forest industry lands may develop or sell lands with high residential value, but keep most of the ownership intact. The sale of forest industry lands is expected to continue (Clutter et al. 2005).

The publicly owned forest estate amounts to 43 percent of the total forest land area. Federal lands account for 77 percent of the publicly owned forest land. Changes in social values may lead to changes in management practices that are initiated by one or more branches of government. For example, timber harvest on national forests peaked at 12.7 billion board feet in 1987 and declined to 2 billion board feet in 2004, reflecting concern about threatened and endangered species and other values. State and county forests are managed with a variety of objectives.

Whether public or private, forest management with timber production as an objective is linked to global markets. The expected modest increases in stumpage prices in the next several decades weaken expected returns for implementing some management practices.

On all ownerships, ecosystem services have long been recognized as coproducts of forest land and rangeland ownership. If markets could be further developed for these products, forestry as a land use would become more competitive relative to other land uses. Markets for water are developing in the West and interest in markets for carbon storage is increasing. Some markets, such as leasing forest land for hunting, have been around for decades. Ecosystem services provided by urban forests for air pollution removal and carbon storage are valued in the billions of dollars per year.

Within the existing legal, institutional, and economic framework for forest land and rangeland conservation and management, lack of data for monitoring the condition of renewable resources at a national scale is apparent for minerals, water, range, and forests. This assessment of data availability was done within the context of the Montreal Process framework, but the issue is also more generally recognized (H. John Heinz III Center for Science, Economics, and the Environment 2002, 2006; United States Environmental Protection Agency 2003). We demonstrate one way to localize some information from higher scale data. The development of consistent local, regional, and national scale data for the indicators in the Montreal Process, however, is challenging in developing a statement about sustainable forest management in the United States.

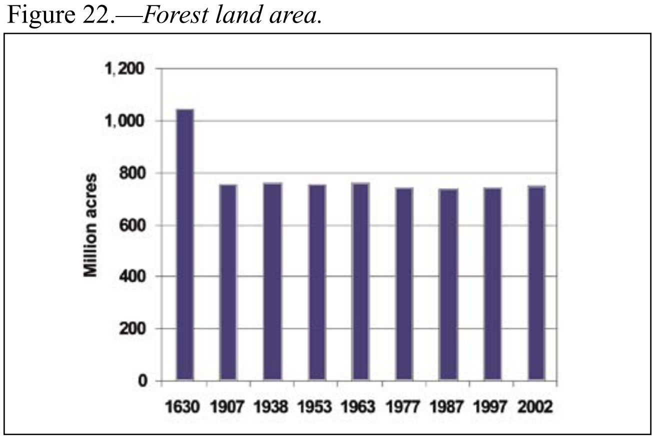
Conservation of Biological Diversity

Biodiversity enables the ecosystem to respond to external influences, to recover after disturbance, and to maintain the organisms essential for its ecological processes. Human activities can adversely impact biodiversity by altering habitats, introducing invasive species, or reducing the population or ranges of species. Conserving the diversity of organisms should support the ability of ecosystems to function, reproduce, and remain productive.

Historical Trends in Forest Land Cover

At the time of arrival of European immigrants around 1630, the total area of forest land in the United States is estimated to have been 1,045 million acres (fig. 22) (Smith et al. 2004). This acreage represented about 46 percent of the total land area. The area of forest land declined steadily as settlement proceeded, to an estimated 759 million acres in 1907 or 33 percent of the total land area. Forest area has been relatively stable since the 1920s, and in 2002, the area amounted to 749 million acres. Stability in total land area does not mean that no change in forest land area has occurred. There have been shifts from agriculture to forests and vice versa. Some forest land has been converted to more intensive uses such as urban land. Even on areas where the area of forest land has remained stable, changes occur as forests respond to human manipulation, aging of the forest, and other natural processes.

Figure 22.—*Forest land area.*



Area of Timber Land by Forest Type

Between 1977 and 2002 in the Eastern States, the area of spruce-fir, white-red-jack pine, oak-gum-cypress, oak-hickory, and maple-beech-birch increased (fig. 23). During this same time period in the Western States, the area of Douglas-fir, fir-spruce, other softwoods, and western hardwoods also increased (fig. 24).

Between 1977 and 2002, the area of longleaf-slash pine, oak-pine, elm-ash-cottonwood, and aspen-birch declined in the Eastern States. In the West, the area of ponderosa pine, western

Figure 23.—*Unreserved forest land in the East by forest type group: 1977 and 2002.*

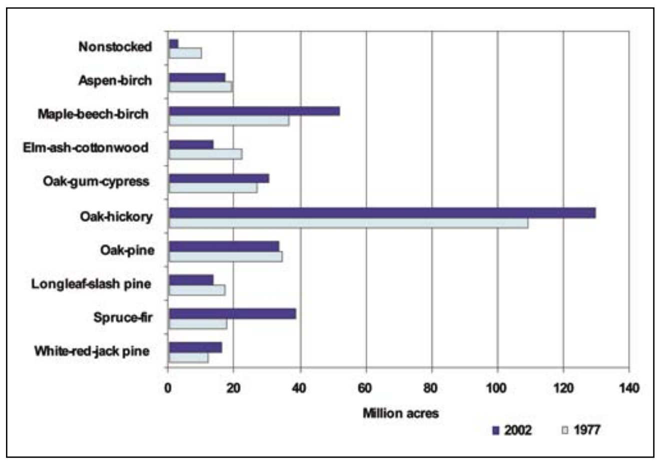
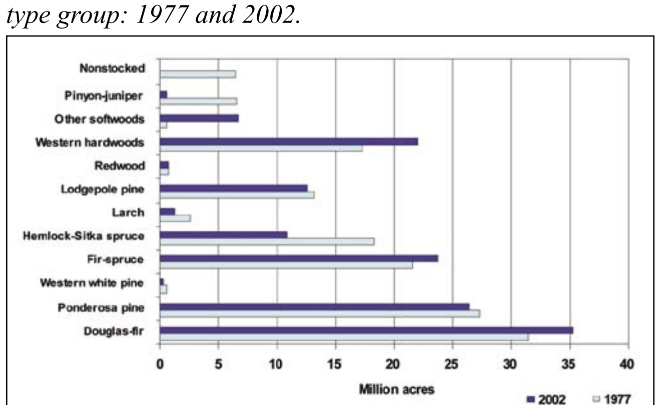


Figure 24.—*Unreserved forest land in the West by forest type group: 1977 and 2002.*



white pine, hemlock-Sitka spruce, larch, and lodgepole pine decreased during the same time period.

In the Eastern States, forests are getting older as represented by the increase in the area of forest types that are more representative of later stages of succession, and by the decrease in the area of forest types that are more representative of earlier successional stages. Increases in earlier successional forest types, such as cottonwood, birch, and poplar, reflect either new forest land or forest land that was harvested to the point where a completely new stand was established.

Natural processes will continue to result in changes in the area of forest types even if the total area of forest land remains constant. For example, without human intervention, the area of the aspen-birch forest type will continue to decline. Human intervention has caused the loss of area of forest types such as slash pine. Even as forests age, duplication of pre-European conditions are not possible. For example, the ravages of the exotic chestnut blight forever changed the nature of forest ecosystems in the East.

Forest cover projections differ markedly by region, owner, and forest cover type (Alig and Butler 2004a). Although some regions such as the North are projected to have relatively small percentage changes by 2050 in common types such as maple-beech-birch (less than 5 percent), others in the South have relatively large projected changes: Projected changes include reductions of 19 percent for upland hardwood on nonindustrial private forest timber lands and 58 percent on forest industry timber lands in the South Central region and increases in excess of 25 percent for planted pine for both private ownerships in the South. Although the area of softwoods is projected to increase across many regions of the country, especially on forest industry lands, hardwoods will remain the dominant forest type on private lands.

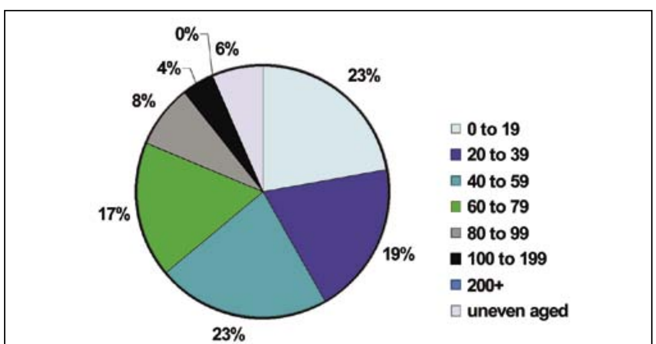
Projected changes in planted pine area in the South have important implications for future timber supplies, as a significant share of southern timber supplies are projected to come from planted stands (Haynes 2003). The area of planted pine in the South has increased more than tenfold since 1950, mostly on private lands (Haynes et al. 2006). Planted pine area on private lands increased by more than 25 million acres between 1952 and 1997. Management intensification on these industrial lands is one of the reasons some harvested natural pine, mixed oak-pine, and hardwood stands are being regenerated as pine plantations. Private landowners have responded to market incentives and government programs, including subsidized afforestation on marginal agricultural land. Timber harvest is a crucial disturbance affecting planted pine area, as other forest types may be converted to planted pine. The privately owned area in pine plantations is projected to increase by about 17 million acres by 2050, approximately a 53-percent increase largely owing to the addition of pine plantations on forest industry lands or lands owned by timberland investors (Alig and Butler 2004a). Conversely, many harvested pine plantations revert to other forest types, mainly because of passive regeneration behavior on nonindustrial private timber lands.

Extent of Area by Forest Type and Age Class or Successional Stage

Ecological processes and the species associated with those processes within any forest ecosystem are associated with vegetative structures (age of the vegetation, its diameter, and height) and successional stages (variable species of vegetation).

In the East, about 58 percent of all timber land is classed as having an average stand age of more than 40 years, 19 percent is between 20 and 40 years in average stand age, and 23 percent has an average stand age of less than 20 years (fig. 25). In the

Figure 25.—*Timberland area by stand-age class in the East.*



West, the average stand age is older (80 percent of the area has timber aged 40 years or more) than for the East, reflecting the fact that more areas in the West have never been harvested. About 6 percent of the timberland area in the East is classed as uneven aged compared with less than 1 percent in the West.

In 2002, about 65 percent of all timber lands were classified as sawtimber-sized in the Western United States.[4] Most of the remaining area was split between seedling-sapling (15 percent) and poletimber (17 percent). The area of nonstocked timber land amounted to 4 percent of total timberland area. In the East, 46 percent of timberland area was classed as sawtimber in 2002, 28 percent was poletimber, and 26 percent seedling/sapling. By comparison, in 1953, 29 percent of the timber land in the East was classed as sawtimber.

The Nation's forests are getting older in many areas of the country, but age is a relative term. Compared to the early 20th century, eastern forests are older, but they are only a fraction of the average age of forests at the time of pre-European settlement. From an ecosystem diversity perspective, this maturation will lead to increased diversity of forest structure but a decreased diversity of forest types because later successional stages will continue to increase at the expense of earlier successional stages.

Extent of Areas by Forest Type in Protected Area Categories as Defined by IUCN

There is worldwide interest in the extent of protection of representative ecosystems so as to maintain a pool of biodiversity for future generations, and various ways of classifying the degree of protection are given to an area. The classification scheme used by the International Union for the Conservation of Nature (IUCN) includes the following categories:

I. Strict nature reserve/wilderness area.
II. National park.
III. National monument.
IV. Habitat/species management area.
V. Protected landscape/seascape.
VI. Managed resource protection area.[5]

The IUCN classification scheme is based on the concept of protection by legal statute and thus does not apply well to private lands and some public lands in the United States. Individual landowners may have no intention to harvest timber, but subsequent owners may chose to harvest timber or otherwise develop the land. Some organizations such as the Nature Conservancy own land with the intention of preservation, but this protected status may change as organizational objectives change over time.

In 2002, about 77 million acres of forest land were classed as reserved and include wilderness areas on Federal and State lands and national parks. This estimate includes small areas of

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[4] To be classed as sawtimber, softwood trees must be at least 9.0 inches in diameter 4.5 feet above the ground and hardwood trees must be at least 11.0 inches. Seedlings are live trees less than 1.0 inch in diameter 4.5 feet above the ground and at least 1 foot in height, saplings are live trees 1.0 inch through 4.9 inches in diameter 4.5 feet above the ground, and poletimber trees are live trees at least 5.0 inches in diameter but smaller than sawtimber trees.

[5] Category I is defined as an area of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species, available primarily for scientific research and or environmental monitoring or a large area of unmodified or slightly modified land, and/or sea, retaining its natural character and influence, without permanent or significant habitation, which is protected and managed so as to preserve its natural condition. Category II land is a natural area of land and/or sea, designated to (a) protect the ecological integrity of one or more ecosystems for present and future generations; (b) exclude exploitation or occupation inimical to the purposes of designation of the area; and (c) provide a foundation for spiritual, educational, and recreational and visitor opportunities, all of which must be environmentally and culturally comparable. Category III land is an area containing one, or more, specific natural or natural/cultural feature that is of outstanding or unique value because of its inherent rarity, representative or aesthetic qualities, or cultural significance. Category IV is an area of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats and/or to meet the requirements of specific species. Category V is area of land with coast and sea as appropriate, where the interaction of people and nature over time has produced an area of distinct character with significant aesthetic, ecological, and/or cultural value, and often with high biological diversity. Safeguarding the integrity of this traditional interaction is vital to the protection, maintenance and evolution of such an area. Category VI is an area containing predominantly unmodified natural systems, managed to ensure long-term protection and maintenance of biological diversity, while providing at the same time a sustainable flow of natural products and services to meet community needs.

private lands. The reserved forest land area in 2002 amounted to 3 percent of the total forest land area in the East and 18 percent in the West (figs. 26 and 27). The area classed as reserved in 2002 was about triple the area classed as reserved in 1953. The remaining public forest land (242 million acres) is classed in categories III–VI. It is in national monuments or other custodial-managed areas, or it is in areas managed for the sustainable use of natural ecosystems. Currently, tens of millions of acres on Federal lands are classed in Category VI, even though they may never be available for harvest. They are protected by administrative action rather than legal statute.

A complete data set for the area of forest type in protected areas is not yet available by age class or successional stage. We expect that the area of reserved mid- to late-successional forest types, such as maple-beech-birch, will continue to increase. In the absence of disturbance, earlier successional forest type groups, such as aspen-birch, will convert to these later successional forest types. In the West, the area of larch and redwood, both on reserved forest land and in total, is limited.

Figure 26.—*Percent of forest land in reserved status by forest type in the East: 2002.*

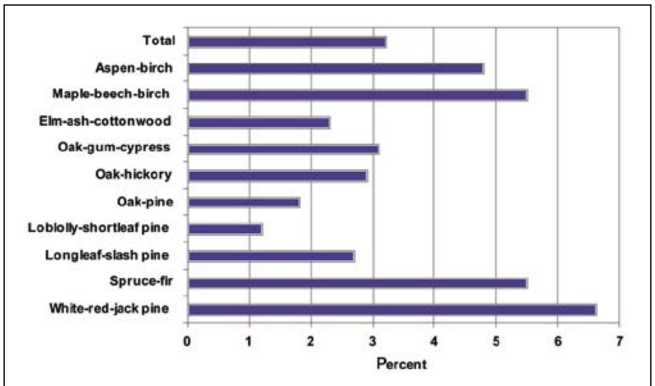
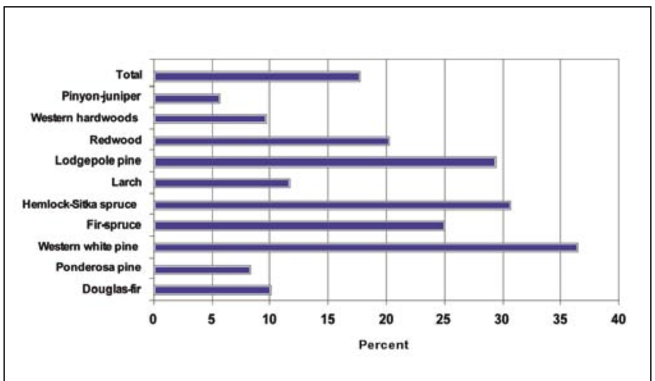


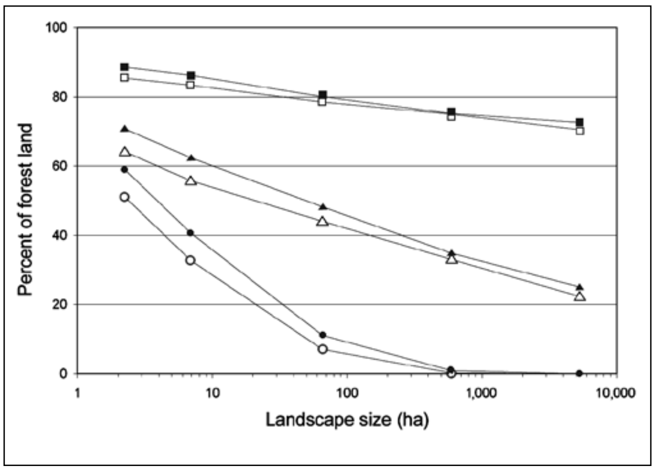
Figure 27.—*Percent of forest land in reserved status by forest type in the West: 2002.*



The Fragmentation of Forests

The fragmentation of forest area into small pieces affects habitat quality and thus biological diversity. A nationally consistent assessment of fragmentation was conducted by using maps of forest land derived from satellite imagery at 0.09 hectare (ha) resolution (Riitters et al. 2002). The results show that about three-fourths of all forest land is found in close proximity to large (greater than 5,000 hectares or 12,000 acres), yet heavily fragmented forest land patches, and the rest exists as smaller patches in mostly nonforested regions. The assessment protocols took into account the fact that fragmentation is a scale-dependent concept. Although 57 percent of all forest land is "core" in 2-ha neighborhoods, the proportion decreases rapidly with landscape size, and less than 1 percent of forest land is "core" in 590-ha or larger neighborhoods (fig. 28). Similarly, although 69 percent of all forest land is "interior" in 2-ha neighborhoods, less than

Figure 28.—*Forest land fragmentation from national land-cover maps. The chart shows percentage of forest land in the conterminous United States that is in landscapes of different sizes meeting the criteria for "core" (○, completely forested landscape), "interior" (△, more than 90 percent forested), and "dominant" (□, more than 60 percent forested). Open and closed symbols represent western and eastern RPA regions, respectively. Adapted from Riitters et al. (2002).*

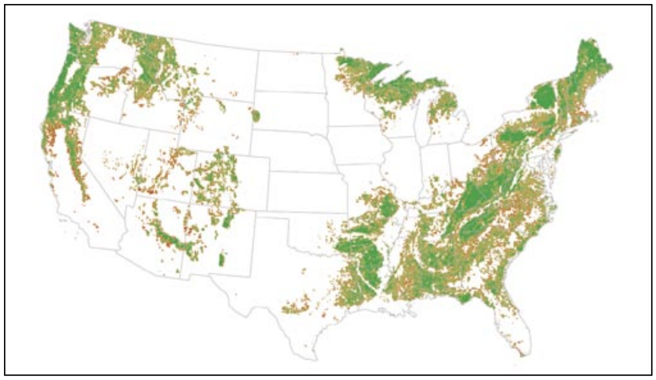


half is "interior" in neighborhoods larger than 66 hectares. A direct relationship exists between "core" status and distance to nearest forest edge (Riitters et al. 2002). Overall, 44 percent of forest land is within 90 meters of forest land edge, 62 percent is within 150 meters of forest land edge, and less than 1 percent is more than 1,230 meters from forest land edge. Although fragmentation is pervasive, forest land usually is "dominant" where it occurs; at least 72 percent of all forest land is in neighborhoods that are at least 60 percent forested for neighborhoods up to about 5,000 hectares in size (fig. 29).

Box 10

Impact of roads on fragmentation—The effects of roads on forest fragmentation were not specifically incorporated in earlier national assessments (Riitters et al. 2002, USDA Forest Service 2004) that were based on land-cover maps alone. Some roads are not large enough to be seen on satellite imagery, and as a result were not shown on the land-cover map. In a comparative analysis, Riitters et al. (2004) evaluated the degree and location of incremental changes in forest fragmentation resulting from superimposing detailed road maps upon the land-cover maps. There was more overall fragmentation when roads were included, but the land-cover maps alone detected greater than 80 percent of the forest edge and greater than 88 percent of the fragmentation of intact core forest that was detected by road and land-cover maps together. Important exceptions include many large regions of publicly owned forest land where small roads traverse relatively undeveloped forest landscapes. Nevertheless, the overall geographic patterns of core forest are very similar with and without roads. In both cases, the largest reserves of core forest are along the Oregon-Washington coast, northern Minnesota, New York, Maine, and in the northern Rocky, Ouachita, Ozark, and Appalachian Mountain ranges. Road maps should be used in future assessments if interest centers on road-caused fragmentation. Otherwise, land-cover maps alone may provide an adequate representation of the national geography of forest fragmentation.

Figure 29.—*Geographic distribution of relatively intact forests. The map shows the relative amount of "interior" forest at 7 ha scale shaded from low (red) to high (green) for areas containing more than 60 percent forest overall. The large green areas contain the major reserves of less fragmented forest land. Adapted from Riitters et al. (2002).*

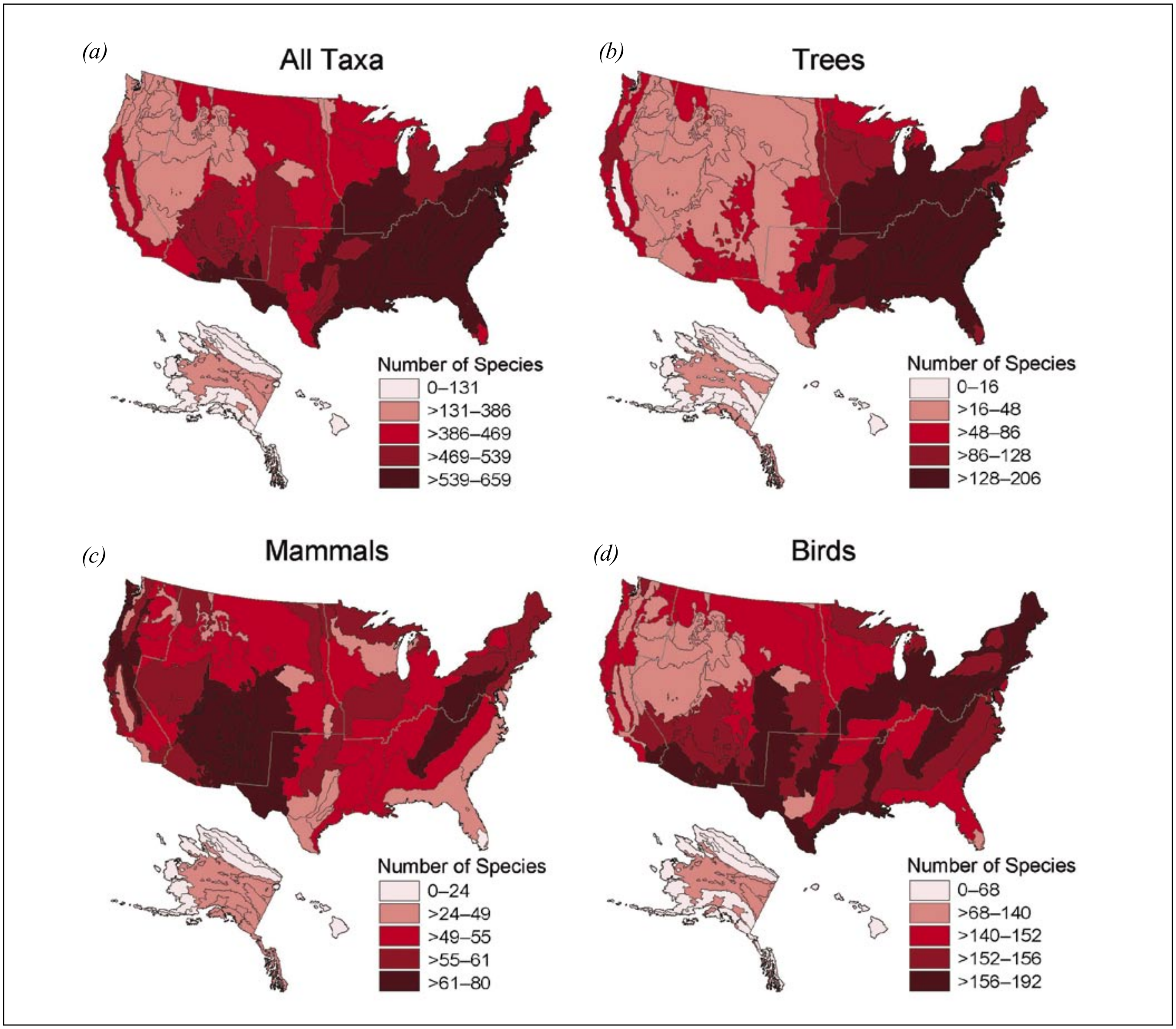


Number of Forest-Dependent Species

Flather et al. (2004a) analyzed data on the distribution of 689 tree and 1,486 terrestrial animal species associated with forest habitats (including 227 mammals, 417 birds, 176 amphibians, 191 reptiles, and 475 butterflies). For all taxa, the highest richness classes are concentrated in the Southeast and in the arid regions of the Southwest (fig. 30). Data on trends in the number of forest species was available only for birds (fig. 31). Areas with evidence of declining forest bird richness generally occur in the East, with notable areas of decline in the Mississippi lowland forests, southeastern coastal plain, northern New England, southern and eastern Great Lakes forests, and central Tallgrass prairie. Areas with evidence of increasing forest bird richness tend to occur in the West and include the great basin, northern Rocky Mountains, northern mixed grasslands, and southwestern deserts.

For the time period 1966 to 2000, 26 percent of native forest-dependent bird species increased in abundance, 27 percent decreased, and 47 percent showed no change (Sieg et al. 2004) (fig. 32). Even when the percentage of species with increasing and decreasing trends is compared early (1966–79) and late (1980–2000) in this period, we tend to see evidence for a balance in the number of species with increasing and decreasing populations (fig. 32).

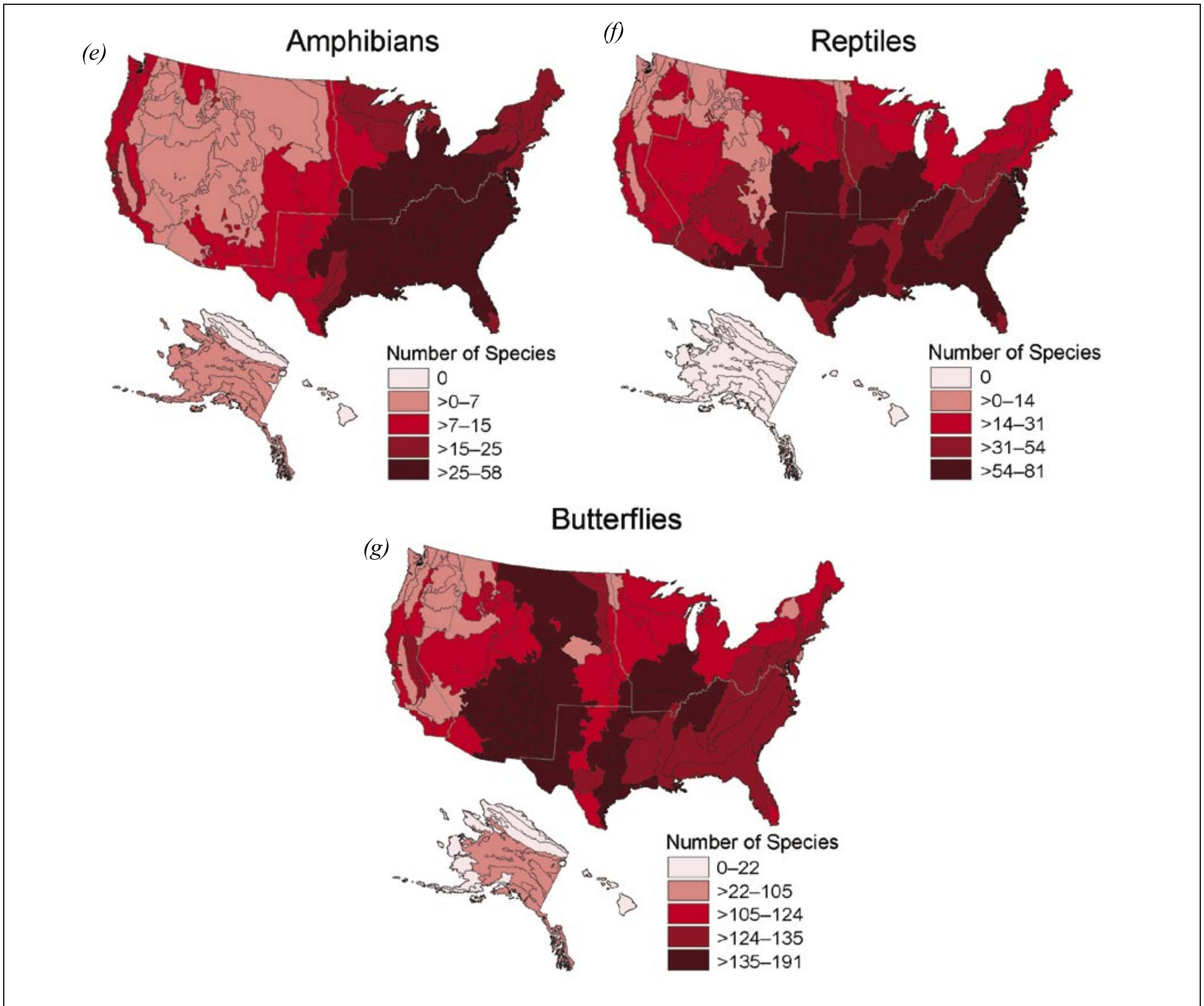
Figure 30.—*Geographic variation in the number of forest-associated species occurring within ecoregions for all taxa (a), trees (b), mammals (c), birds (d), amphibians (e), reptiles (f), and butterflies (g).*



Richness classes were based on percentiles defined to approximately reflect the upper 90th percentile (dark red), the 80th to 89th percentile, the 60th to 79th percentile, the 20th to 59th percentile, and the lower than 20th percentile (lightest red). The highest richness class represents the 10 percent of ecoregions with the greatest count of species. For details, see Flather et al. (2004b).

The interpretation of these forest bird population trends is complicated by the fact that not all native birds that breed in the forested habitats of the United States winter here (see Sieg et al. 2004). In fact, more than half of the landbirds that breed in temperate North America spend the winter months at the lower subtropical and tropical latitudes (Askins et al. 1990). Consequently, the factors causing increases or decreases in forest-breeding bird populations could be attributable to conditions either on the breeding grounds, along migration corridors, or in the wintering areas. Evidence suggests that human activities altering habitat in both the temperate and tropical regions affect migratory bird population trends

Figure 30.—*Geographic variation in the number of forest-associated species occurring within ecoregions for all taxa (a), trees (b), mammals (c), birds (d), amphibians (e), reptiles (f), and butterflies (g) (continued).*



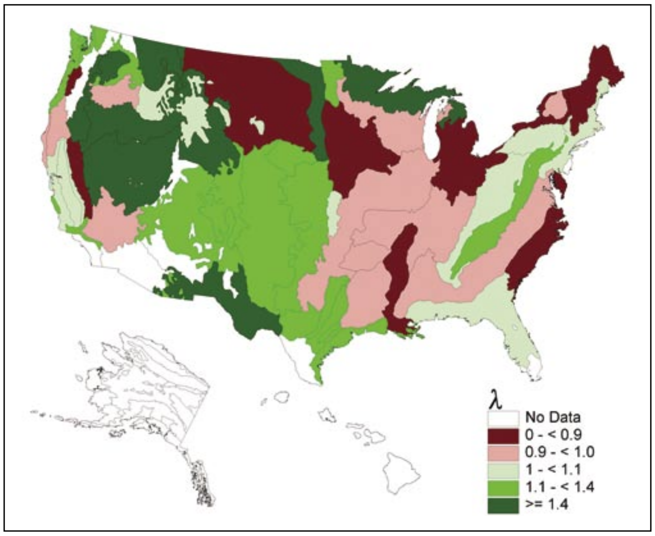
Richness classes were based on percentiles defined to approximately reflect the upper 90th percentile (dark red), the 80th to 89th percentile, the 60th to 79th percentile, the 20th to 59th percentile, and the lower than 20th percentile (lightest red). The highest richness class represents the 10 percent of ecoregions with the greatest count of species. For details, see Flather et al. (2004b).

(Robbins et al. 1989). A comparison of recent abundance trends (1980–2004) between permanent resident and neotropical migrant birds (Sauer et al. 2005) indicates that permanent residents have fared better (51 percent with positive trends) than long-distant migrants (40 percent with positive trends)—an indication that environmental factors off the breeding areas are playing a role in observed population dynamics.

The Status of Threatened and Endangered Species

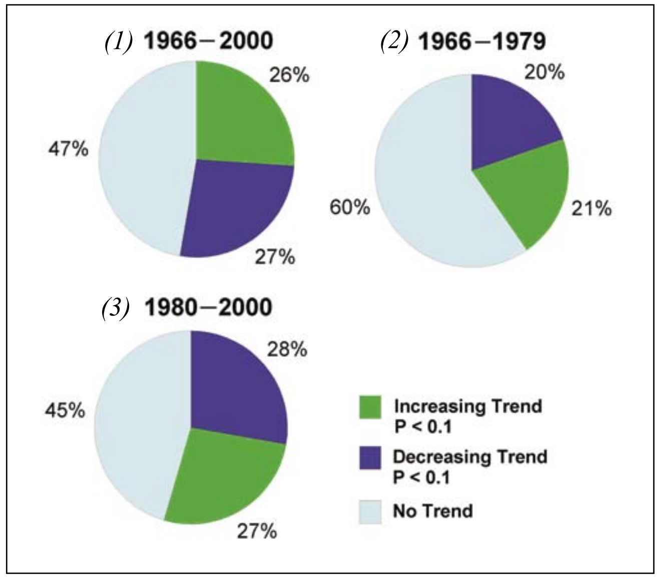
As of November 1, 2004, 1,264 species were formally listed as threatened or endangered within the United States. Of that, 746 were plants (59 percent) and 518 were animals (41 percent). Since the 2000 Renewable Resources Planning Act (RPA)

Figure 31.—*Trends in forest bird richness by ecoregion from 1975 to 1999.*



Change in richness is estimated by lambda, which is the ratio of estimated richness in 1999 to the estimated richness in 1975. Values of lambda greater than 1.0 indicate increasing richness (green shades); values of lambda less than 1.0 indicate declining richness (red shades). For details, see Flather et al. (2004b).

Figure 32.—*Percentage of breeding birds whose population trends have increased or decreased significantly (P<0.10) over three time periods: (1) 1966–2000, (2) 1966–1979, and (3) 1980–2000 (Sieg et al. 2004).*



Box 11

Housing change and relative species richness of forest birds—The amount of housing in the rural United States has been growing. This growth removes and alters wildlife habitat, potentially introduces exotic species, and increases human disturbance with potentially severe long-term effects on biodiversity. Two studies, one regional and one national, sought to better understand the influence of housing growth and land use intensification on breeding birds in the United States.

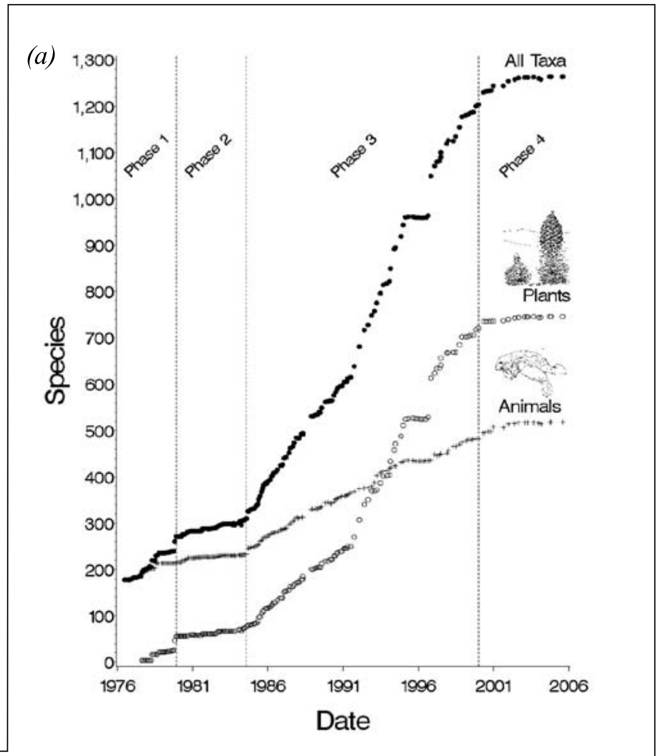
The regional study (Lepczyk et al. In review), conducted across the Midwestern United States, found that both total and native breeding bird richness were highest where human influence was lowest. Conversely, exotic bird species tended to increase with higher housing density and higher proportions of intensive human land uses. The fact that total richness declined with increasing human influences indicates that the observed gain in exotic richness was not sufficient to offset the loss of native species.

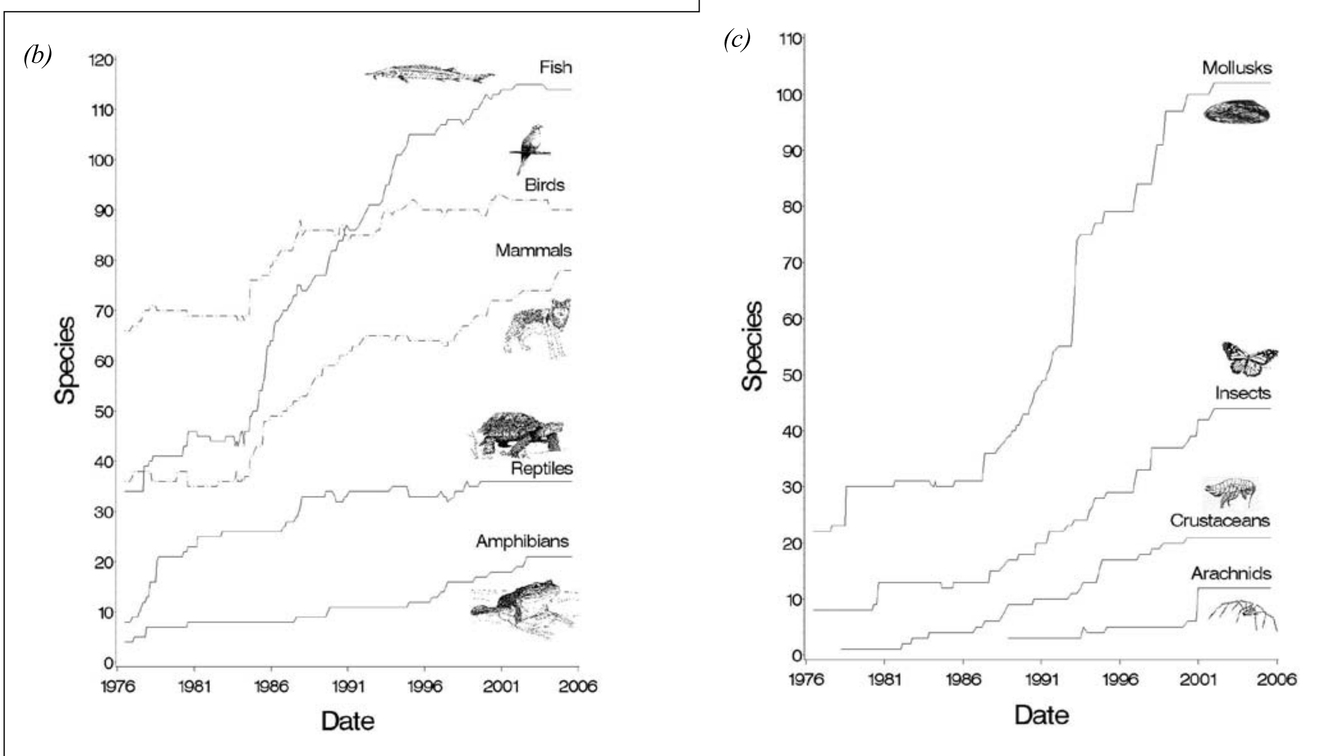
A study that focused on forest breeding birds across the conterminous United States found the observed relationship between housing density and land use intensification was more varied than the regional study indicated. Consequently, the relationship between bird diversity and the human footprint is more complex than originally thought and may depend on where a particular place falls along a gradient of pristine to highly altered landscapes. This variable response suggests that efforts to counteract the potentially negative influence of housing growth and human land use intensification through land management activities will be conditional on the peculiarities of the region under consideration.

Wildlife Assessment (Flather et al. 1999), 182 species have been added to the list. Since the mid-1970s, the number of species that has been added to the list has varied over time (fig. 33) (Flather et al. 2004b). As described in Flather et al. (1999), the Endangered Species Act listing history is characterized by three phases defined primarily by the rate at which species were listed. Early in the listing history, species were added at a relatively moderate rate and culminated in the mass listing of cactus species that were threatened by the plant trade. Phase 1 was followed by a period of relative inactivity. Phase 3 of species listing was characterized by a high rate of new species being classified as threatened and endangered.

Although phase 3 is bounded by the listing moratorium that occurred in April 1995, once the moratorium was lifted, the rate of listings appears to have resumed to premoratorium levels. The listing rate in phase 3 was caused primarily by new plant listings as animal listings have increased more slowly than plants. Since the 2000 RPA Assessment, however, the rate of species listed as threatened or endangered has declined five fold. This decline cannot be attributed to a reduced number of species that deserve protection for there are enough candidate

Figure 33.—*Cumulative number of species listed as threatened or endangered under the Endangered Species Act of 1973 from July 1, 1976, through November 1, 2004, for (a) plants and animals, (b) vertebrates, and (c) invertebrates (Flather et al. n.d. [b]) (continued).*



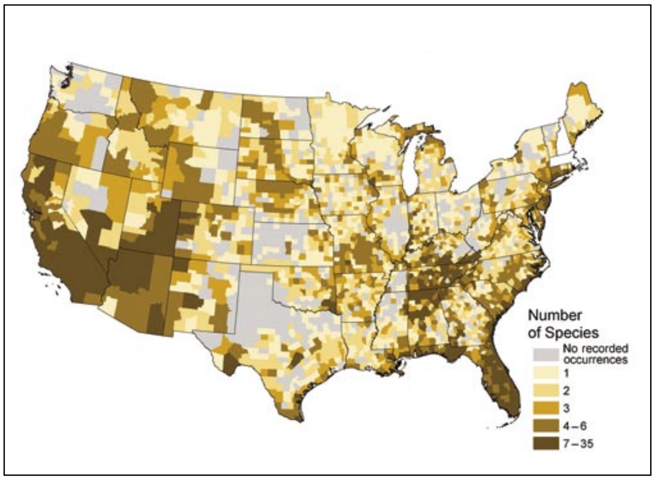


species to support a much higher listing rate for years to come. Rather, in 2003, the U.S. Fish and Wildlife Service estimated that processing the nearly 300 candidate species would require $153 million, an amount nearly 10 times its budget for all listing activities in fiscal year 2005 (Stokstad 2005).

Animal taxa that have contributed the greatest number of new species to the list include fish, mollusks, and insects. The number of counties having seven or more threatened and endangered species is concentrated in the southern Appalachians, Atlantic and Gulf coastal areas, and the arid Southwest (fig. 34).

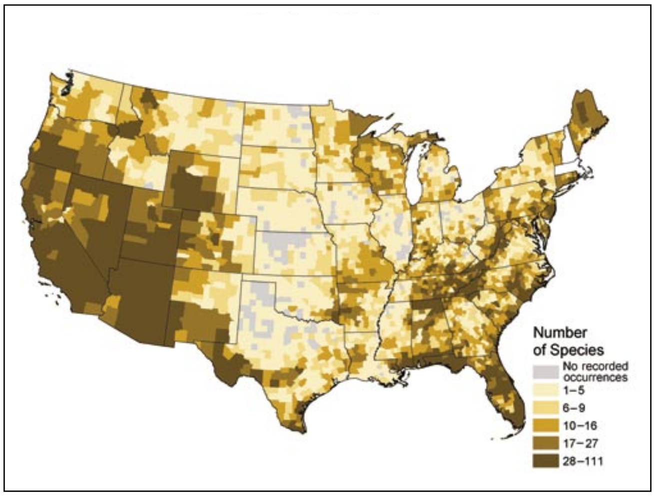
Data from NatureServe shows a somewhat similar pattern for at-risk species based on biological criteria (Flather et al., n.d. [a], n.d. [b]) (fig. 35). Ten percent of the counties having the highest count of at-risk species are again found in the southern Appalachians, peninsular Florida, Atlantic and Gulf coasts, and the arid Southwest. The count of at-risk species, however, indicates a potentially new area of conservation concern in the driftless area of southwestern Wisconsin and the northern mixed forests around Lake Superior.

Figure 34.—*The geographic distribution of county-level counts of species formally listed as threatened and endangered by the Endangered Species Act in the conterminous United States.*



The highest count class (7–35 species) represents 10 percent of counties with the highest occurrence of threatened or endangered species. County-level occurrence data were not available for New Hampshire and Massachusetts. For details, see Flather et al. (n.d. [b]).

Figure 35.—*The geographic distribution of county-level counts of species considered to be at risk of extirpation (conservation rank N1, N2, and N3) from the conterminous United States.*

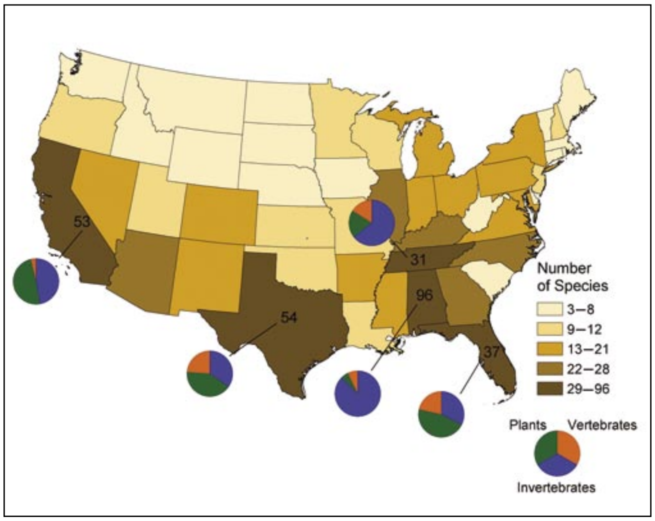


The highest count class (28–111 species) represents 10 percent of counties with the highest occurrence of at-risk species. County-level occurrence data were not available for New Hampshire and Massachusetts. For details, see Flather et al. (n.d. [a]).

Recent extirpation of species is most prominent in the southern third of the conterminous United States (fig. 36). More than 30 species of plants and animals have been lost in California, Texas, Tennessee, Alabama, and Florida. Invertebrates represent the majority of species lost in Alabama and Tennessee, whereas plants are a notable component of the extirpated biota in Florida and California.

The places that have gained threatened or endangered species have generally been in areas where other threatened or endangered species are already concentrated. States where species extirpations are most prominent coincide roughly with those areas supporting high concentrations of at-risk species. One of the arguments for focusing conservation efforts in those areas supporting high numbers of species thought to be at risk of extinction is that these areas represent places where species are likely to be lost from the species pool in the future. The results reported here support this argument. Land and resource management policies targeting those factors causing increased rarity in hotspots have the potential to avert future species losses.

Figure 36.—*The geographic distribution of State-level counts of species considered to be extirpated from a State (conservation rank SX and SH) for the conterminous United States.*

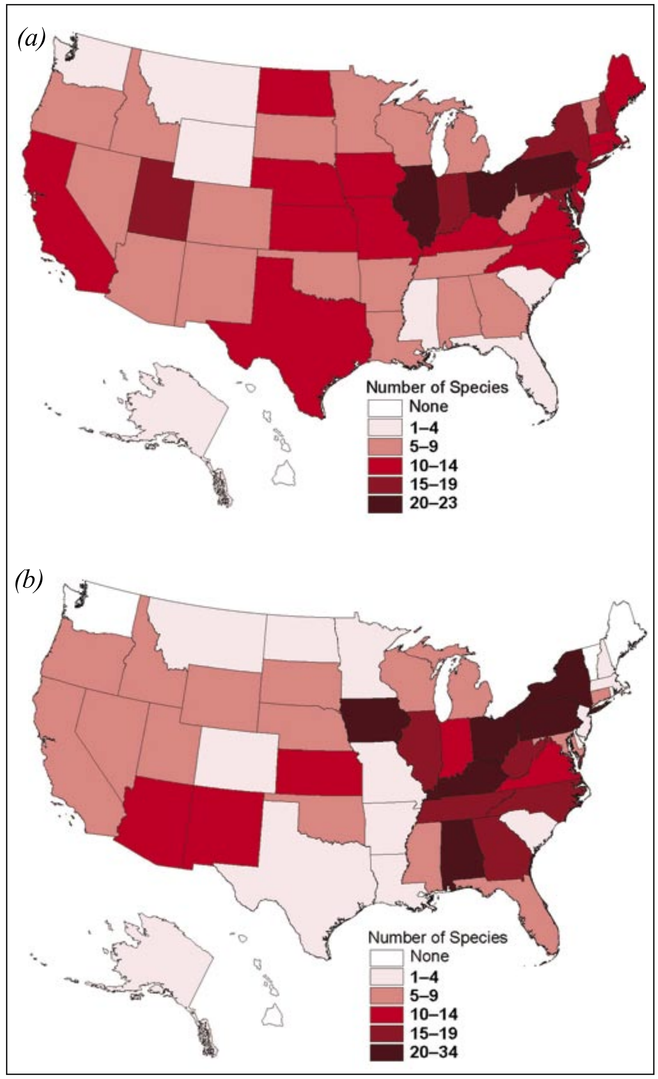


The highest count class (29–96 species) represents 10 percent of States with the highest count of extirpated species. Pie charts represent the proportional composition of extirpated species from each State that is vertebrate, invertebrate, and plant species. For details, see Flather et al. (n.d. [a]).

Number of Forest-Dependent Species That Occupy a Small Portion of Their Former Range

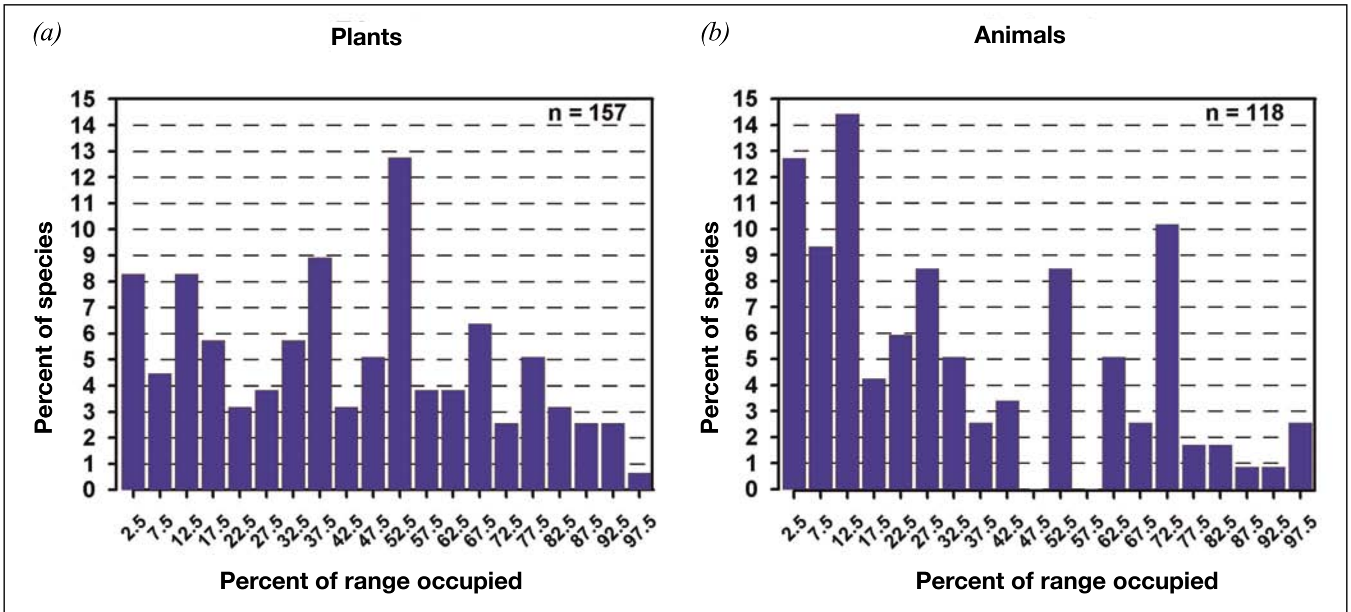
Geographic range data for 1,642 terrestrial animals associated with forests shows that 88 percent of species fully occupy their former range as estimated by State-level occurrence (Flather et al. 2004c). Of the 193 species that have been extirpated from at least one State, 72 percent still occupy at least 90 percent of their former range. The number of species that now occupy 80 percent or less of their range varies by taxonomic group (fig. 37). Range contraction of this magnitude is most commonly observed among mammals (5.7 percent), followed by amphibians (2.3 percent), and birds (1.4 percent). States that have lost the greatest number of terrestrial animal species associated with forest habitats are concentrated in the Northeast (fig. 38).

Figure 37.—*The number of terrestrial animal species (mammals, birds, amphibians, reptiles, and some insects [grasshopper and butterfly species only]) associated with (a) forest habitats and (b) the number of aquatic species (fish and mollusks) that have been extirpated within each State.*



Aquatic species were not assigned to broad habitat infinity classes and so the counts within each State reflect species associated with all habitats. Because range occupancy was estimated for only extant species, and because historical and current range size was measured at the State level, Hawaiian species are not reflected in these data. For details, see Flather et al. (2004c).

Figure 38.—*The percent of listed (a) plant and (b) animal species that now occupy varying amounts of their former geographic range.*



Percentage is based on only those species for which range reduction data were available. Values reported on the x-axis represent the mid-points of a 5-percent interval. For details, see Flather et al. (2004a).

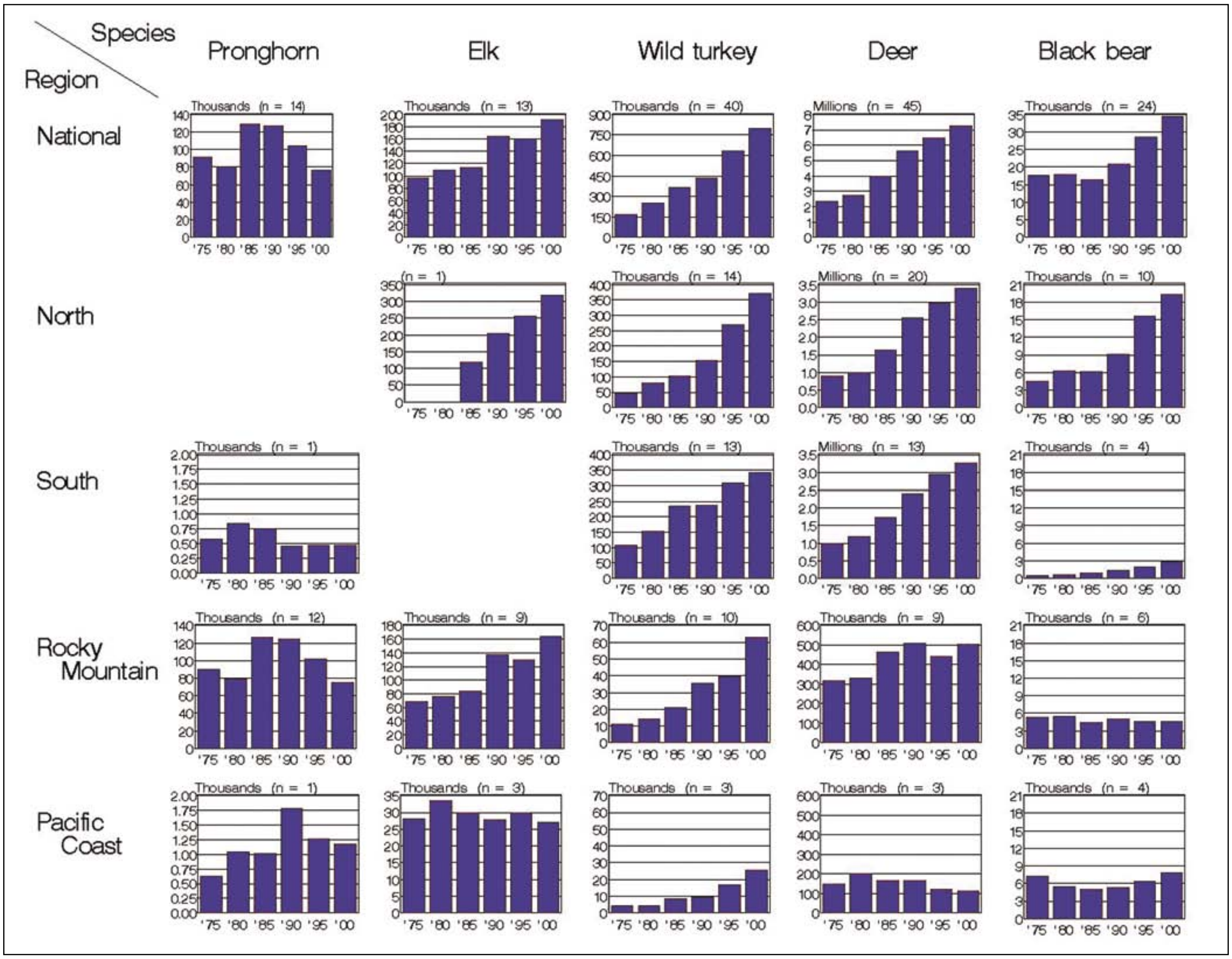
Population Trends in Recreationally Harvested Wildlife Species

Available data suggests that big game and small game populations and harvests differ in a very fundamental way. Big game populations and harvests have, with a few regional exceptions, increased consistently from 1975 to 2000 (fig. 39). For several species, such as for wild turkey and deer, the increases have been substantial. By contrast, available data suggests that small game populations and harvests have declined (Flather et al., n.d. [a]).

Because few States provided population data for small game species, the declines in population are suggested by the reported declines in small game harvests. On average, between 1975 and 2000, small game harvests declined by 49 percent. It is not possible to argue definitively that this decline is caused by population reductions because harvests can change for reasons other than population status. For example, declines in the accessibility of land for hunting, changes in species preferences that hunters pursue, and declines in the number of days devoted to hunting small game could all explain the observed reduction in small game harvest. Population trends derived from the North American Breeding Bird Survey (Sauer et al. 2005), however, suggest that small game harvest declines may be caused in part by population declines. Of the 13 small game bird species monitored by the Breeding Bird Survey, 10 showed evidence of declining trends (four of which were statistically significant declines).

Within species classified as small game, available data suggests that declines are prominent among those species associated with grassland, early successional, and farmland habitats. For example, three of the five small game species (northern bobwhite, cottontail, and prairie grouse) with the greatest percent decline in harvests are clearly associated with grassland and agricultural habitats. This pattern was reinforced by trends derived from the Breeding Bird Survey which show that populations of gray partridge, ring-necked pheasant, greater prairie chicken, and northern bobwhite have declined. These species are all associated with grassland/agricultural systems. There are regional exceptions to the national relationship between population and harvest. For examples, deer and elk harvests increased in all regions except the Pacific Coast and harvests of pronghorn and black bear in the Rocky Mountains region have declined despite population increases.

Figure 39.—*Harvest trends in selected species and species groups of big game for the Nation and RPA regions for 1975 through 2000 in 5-year increments.*



The number of States providing data is given by "n=". For details, see Flather et al. (n.d. [a]).

Box 12

Conservation easements on private lands—Land conservation in the United States has evolved since earlier eras which emphasized Federal Government acquisition and reservation such as establishment of the Forest Reserves in 1891 and the National Park Service in 1916. As the Federal estate moved toward maturation in the mid- to late 20th century, new methods of conserving natural lands for the public good have been emerging. Chief among these is the conservation easement.

Conservation easements became much more common after passage of the Uniform Conservation Easement Act in 1981. A conservation easement is a legal document that transfers some development and management options from the property owner to a nonprofit or government agency that holds those rights. Under a conservation easement, the property owner is selling or donating some of the property rights to the easement holder. In return, the owner continues to own the property and use the land subject to the restrictions imposed by the easement.

Box 12 (continued)

There are many types of conservation easements. Federal funding for conservation easements through the Land and Water Conservation Fund Act of 1965 has been declining, especially since the 1980s. In part, this decline, along with economic prosperity, increasing demand for open space, and other factors, enhanced the rise of non-Federal conservation easements. The widespread variability in the institutions, organizations, and properties involved make a national assessment of the role and extent of conservation easements in land conservation a very difficult task.

Federal agencies, including the Forest Service, and various State and local governments are active in conservation easement acquisition. Most Federal programs for conservation easements are agency sponsored grant-in aid or other incentive programs. The Conservation Reserve Program in the 1985 Farm Bill is an example of this type of conservation easement. Other examples include the Forest Service's Forest Legacy program and the National Fish and Wildlife Foundation.

State government involvement in conservation easements varies. For example, California has a wide array of State conservation programs under administration of the California Resources Agency. Florida's "Florida Forever" program receives $300 million in annual funding from the State to support a variety of environmental services and values.

Local government involvement in conservation easements varies around the country. No centralized database tracks these activities. An example is New York City's efforts to protect the watersheds that provide the city's drinking water through conservation easements and fee simple property. Also, Lancaster County, Pennsylvania, has an Agriculture Reserve Board to which landowners apply to sell development rights and agree to maintain the land in farming.

Nongovernmental organizations such as the Nature Conservancy and land trusts are placing additional areas under various types of protection. The area of water and land protected by the Nature Conservancy amounted to 7.6 million acres in 2004. The area of land trusts increased from 1.9 million acres in 1990 to 6.2 million in 2000.

Rangeland Area

The rangeland and grazed forest land base occupies about one-third of the Nation's land area (Vesterby and Krupa 2001). The national trend in the area of rangeland, however, has been slowly downward over the past century (Conner et al. 2001). Van Tassell et al. (2001) projected continued slow declines in the U.S. rangeland base, especially in the West and Northeast. In the South, the area of rangeland was expected to remain fairly constant. A recent, still unpublished analysis of Census Bureau data corroborates the above work (table 5). The three States losing the most privately owned rangeland and pasture between 1987 and 1997 were Arizona (6.2 million acres), Nevada (3.5 million acres), and Colorado (1.2 million acres).

Changes in the extent and distribution of rangeland vary widely by community type. An analysis of the National Resources Inventory land cover data in relation to Küchler potential natural vegetation classification data has shown that the largest rangeland losses have occurred in the northern Great Plains, the southern Rocky Mountains, and the semidesert and desert Southwest (fig. 40).

Table 5.—*Area and percentage of privately owned rangeland and pastureland lost between 1987 and 1997 by State (for those States having more than 1 million acres of rangeland and pastureland in 1997) and assessment region.*

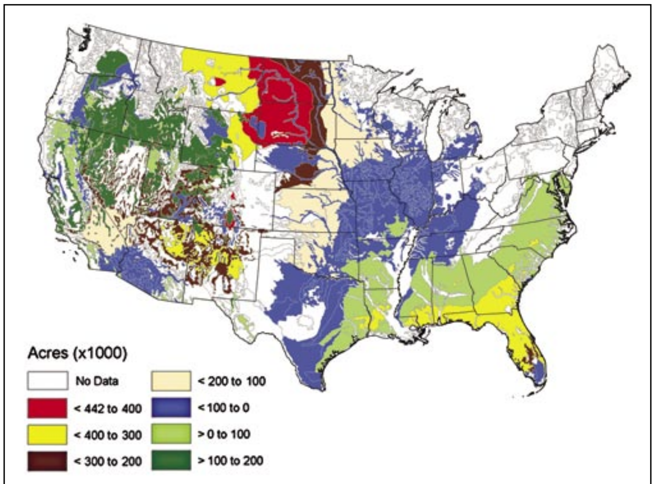
Assessment region or State	Land area (million ac.)[1]	Area of rangeland and pasture (ac.)[2, 3]		Loss or (gain)		Loss (gain) in relation to entire State (percent)
		1987	1997	Acres	Percent	
Iowa	35.76	1,452,248	1,440,627	11,621	0.8	< 0.1
Missouri	44.09	3,736,320	3,715,717	20,603	0.6	< 0.1
North	**413.45**	**11,258,408**	**10,295,362**	**963,046**	**8.6**	**0.2**
Alabama	32.48	1,234,245	1,062,424	171,821	13.9	0.5
Arkansas	33.33	1,483,476	1,466,303	17,173	1.2	< 0.1
Florida	34.52	4,495,653	4,069,927	425,726	9.5	1.2
Kentucky	25.43	1,232,448	1,127,746	104,702	8.5	0.4
Louisiana	27.88	1,011,276	1,006,084	5,192	0.5	< 0.1
Oklahoma	43.95	14,261,454	15,431,722	(1,170,268)	(8.2)	(2.7)
Texas	167.63	86,802,117	86,073,441	728,676	0.8	0.4
Virginia	25.34	1,180,356	1,074,183	106,173	9.0	0.4
South	**534.48**	**115,535,470**	**114,679,943**	**855,527**	**0.7**	**0.2**
Arizona	72.73	29,840,297	23,681,829	6,158,468	20.6	8.5
Colorado	66.39	21,173,673	19,943,701	1,229,972	5.8	1.9
Idaho	52.96	5,528,460	4,589,326	939,134	17.0	1.8
Kansas	52.37	13,254,094	14,062,576	(808,482)	(6.1)	(1.5)
Montana	93.16	39,459,291	37,974,463	1,484,828	3.8	1.6
Nebraska	49.20	20,443,481	21,876,974	(1,433,493)	(7.0)	(2.9)
Nevada	70.28	8,684,697	5,232,909	3,451,788	39.7	4.9
New Mexico	77.67	40,964,044	40,737,445	226,559	0.6	0.3
North Dakota	44.16	10,206,220	10,375,089	(168,869)	(1.7)	(0.4)
South Dakota	48.57	23,069,181	23,588,662	(519,481)	(2.3)	(1.1)
Utah	52.59	7,010,858	9,247,212	(2,236,354)	(31.9)	(4.3)
Wyoming	62.15	29,624,287	30,051,421	(427,134)	(1.4)	0.7
Rocky Mountain	**742.22**	**249,258,583**	**241,361,607**	**7,896,976**	**3.2**	**1.1**
California	99.82	17,111,110	14,384,908	2,726,202	15.9	2.7
Oregon	61.44	10,409,418	9,663,817	745,601	7.2	1.2
Washington	42.61	4,875,988	4,944,327	(68,339)	(1.4)	(0.2)
Pacific Coast	**573.03**	**34,276,665**	**30,547,641**	**3,729,024**	**10.9**	**0.7**
United States	**2,263.18**	**410,329,126**	**396,884,553**	**13,444,573**	**3.3**	**0.6**

[1] State land area is from 1998 USA counties, based on 1990 Census (http://censtats.census.gov/usa/usa.shtml).

[2] Rangeland/pasture area data from U.S. Census of Agriculture (http://www.nass.usda.gov/census).

[3] Rangeland/pasture area data include only private holdings.

Figure 40.—*National net change in Küchler types from 1987 to 1997.*



Net changes in non-Federal rangeland area by Küchler vegetation type between 1987 and 1997. The largest losses are ecosystems dominated by wheatgrasses and needlegrasses (red, yellow, and brown) in the northern Great Plains and Colorado, grama and galleta grasses (yellow) in Arizona and New Mexico, and pinyon-juniper (brown) in the Southwestern United States. To a lesser extent, creosote bush (tan) has also declined in the desert Southwest. The greatest increases are found in the sagebrush steppe (dark green) in the Great Basin and the California oak woodland (dark green). Data from National Resources Inventory.

Box 13

Decline in aspen and other early successional species in the West, Lake States, and Northeast—Even without human-caused disturbance, forests will change as a result of natural disturbances or natural succession. Since the 1980s, ecologists have concluded that aspen is in steady decline in many parts of the Intermountain West, particularly in Utah (Bartos 2001). The combination of modern fire suppression and a steady increase in elk herbivory has prevented aspen regeneration in some forests, with conifer understories now widely overtopping aspen stands in a slow successional process that takes more than a century to play out (Bartos et al. 1983). Aspen clones are able to persist in a suppressed state in the understories of conifers for many years, but without major fires, aspen stands may continue to decline. Evidence indicates, however, that aspen has not started to decline in abundance in all locations in the West (Manier and Laven 2002). For the Lake States of Minnesota, Wisconsin, and Michigan, the total area of the aspen-birch forest type group decreased by 7.8 million acres between 1953 and 1997.

Summary

The largest reserves of intact forest are concentrated on public lands and the largest share of intact forest is contained in the NFS. Indeed, for some types of ecosystems, only NFS lands contain significant amounts of intact forest. The status of adjacent private lands can determine the degree of intactness that can be achieved on public lands. For example, urbanization of private land next to public land increases the likelihood of invasive species on the public land. Even if public lands can be kept intact, changes in biological diversity will occur as forests and habitats evolve and as natural disturbances/succession lead to change such as the decline in aspen in parts of the West and North.

Those species that have been able to adapt to human activities did well in the 20th century, as have species such as elk that are highly valued and managed by humans. Species that need large undeveloped landscapes or specialized habitats vulnerable to development pressures did not do as well. Many species that are formally listed as threatened or endangered share some of these characteristics.

The rate of species listed as threatened or endangered has declined five fold since the 2000 RPA Assessment (USDA Forest Service 2001). This decline may not reflect so much on the condition of threatened and endangered species as on funding and other factors. Conservation efforts should continue to focus on those areas supporting higher numbers of species thought to be at risk of extinction. Most future forest loss will be to development/urbanization. We can expect more widespread occurrences of invasive species as this development progresses.

The area of private lands protected by conservation easements is growing. These easements offer various levels of protection, but most minimize the possibility for urbanization.

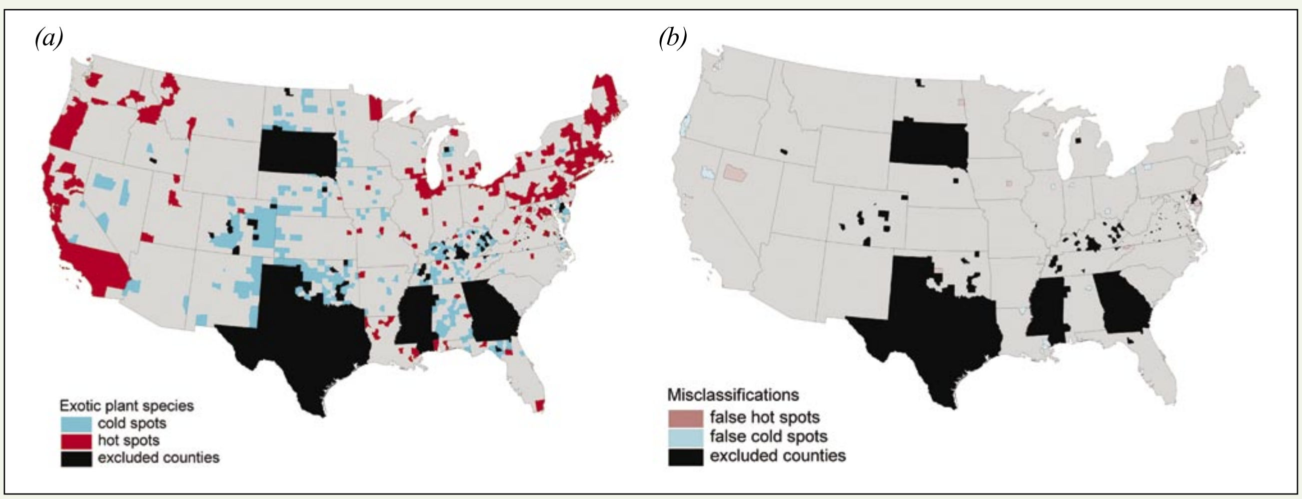
A development of the past 15 years has been forest industry's sale of large parcels of timber land, primarily to timber investment management organizations and real estate investment trusts. The objective of industry ownership was generally to protect a source of timber supply and reduce the risks of timber

Box 14

Exotic plant richness as an indicator of ecosystem health—The colonization of native plant communities by exotic species poses one of the greatest threats to natural ecosystems in the United States (Sieg et al. 2005). Invasions of plant species not native to the United States can alter the capacity of lands to support biodiversity and to provide services to humans. By displacing native species, invasive plants reduce biodiversity, threaten at-risk species, and can alter important ecological processes such as hydrologic and fire regimes in ways that reduce the capacity of ecosystems to provide services like water, forage, and recreation. The understanding of patterns of exotic species hotspots and environmental attributes that are related to these concentrations is a fundamental step in developing a national strategy for managing invasions.

Sieg et al. (2005) did a study that related county-level data on exotic plant species richness for the conterminous States to six variables: Population density; herbarium presence; average distance to the five closest counties with at least one herbarium; mean elevation; county area; and mean annual temperature. The positive relationship between human population density and exotic plant species richness is due in part to direct or indirect introductions by humans. There is the expectation that there would be increasing numbers of exotic plant species in counties with herbaria and decreasing numbers with increasing distances from counties with herbaria, suggesting that the better studied counties tend to be characterized by higher exotic plant species richness. Results indicate that hot spots of exotic species richness are associated with low mean elevation and low mean annual temperature. These results are consistent with the pattern of exotic species hot spots in low elevation coastal settings in the Southeastern United States as well as in the Northeastern United States that are characterized by generally lower mean annual temperatures. The positive relationship between area sampled and species richness is well accepted. The model used in the study correctly classified more than 93 percent of the county-level hot and cold spots of exotic species richness (fig. 41).

Figure 41.—*(a) Exotic plant species hotspots and coldspots. (b) Counties misclassified. False hotspots are those counties that were predicted to be hotspots but were actually coldspots, and false coldspots were counties predicted to be coldspots but were actually hotspots.*



price volatility. Because the industry managed its lands for timber production, this ownership generally assured maintenance of large landscapes. The sale of forest industry lands creates uncertainty about the long-term nature of these lands and the implications for associated biodiversity. Clutter et al. (2005) suggest that turnover in timberland ownership will continue to accelerate fragmentation issues on the urban-rural fringe. Hagan et al. (2005) found that in the northern forest, many of the new landowners do not have biodiversity practices and policies as strong as industry land owners.

Stability in the area of forest land does not mean no changes have occurred in forest area. Between 1982 and 1997, 23 million acres went out of forest land and 26.6 million acres went into forest land. Areas converted from forests went mainly to developed uses. Areas going into forest came primarily from pasture land. Acres that enter and exit the forest land base can be quite different; entering acres may be bare ground or have young trees, while exiting acres often contain older trees before conversion to developed uses. Forest land lost to development seldom changes back to a more natural land cover.

Forests in the United States are getting older. This aging will lead to increased diversity of forest structure, but to a decreased diversity of forest types because later successional stages will continue to increase at the expense of earlier successional stages. Although forests are getting older, duplication of pre-European conditions is not possible.

Expected increases in plantation areas in the South will be the source of much of the United States' increase in softwood timber supply. This increase will tend to decrease prices and reduce pressure for harvest on some private timber lands. Reduced harvest will change the dynamics of temporal changes in habitat and biodiversity.

Maintenance of Productive Capacity of Forest Ecosystems

If renewable resource inventories are stable or increasing on the land or if outputs are stable or increasing without diminishing the inventories, we can infer that productive capacity is being maintained. Inventories and outputs reflect the influences of harvesting, land use changes, natural disturbances, natural processes, management activities, and trade in renewable resources.

Forest Products

Area of forest land and net area of forest land available for timber production—About 504 million acres, or 67 percent of the total forest land area, is classed as timber land. These forest land areas are capable of producing more than 20 cubic feet per acre per year of industrial wood that is not withdrawn from timber utilization by statute or administrative regulation (Smith et al. 2004). Timber land is used here as a proxy for the net area of forest land available for timber production. Timberland area includes currently inaccessible and inoperable areas and thus overestimates the net area of forest land available for timber production. Also, no consideration is given to owner objectives regarding timber production when forest land is classed as timber land. Most of the timber harvested for roundwood products comes from this part of the forest resource base.

About 72 percent of the timber land is in the Eastern United States; in the Western United States, timber land is found primarily in Montana, Idaho, Colorado, and the Pacific Coast States. Timberland area has consistently amounted to about two-thirds of the forest land area since the 1950s.

Growing stock available for timber production—The volume of hardwood growing stock on timber land generally increased for the Nation as a whole and across ownerships during the period 1953–2002 (fig. 42). An exception was a downturn in hardwood inventories on forest industry lands, which may indicate conversion of hardwood stands to softwood.

The volume of softwood growing stock on timber land increased from 1953 through 2002. (fig. 43). Between 1987 and 2002, the volume increased on national forest and nonindustrial private timber land. Volume decreased on the forest industry ownership, in part because of decreased area in this ownership. Growing stock is defined as timber inventory that includes live trees of commercial species meeting specified standards of quality or vigor. Cull trees are excluded. Growing stock volume includes trees 5.0 inches diameter breast height and larger. As with the definition of “timber land,” no allowance is made for economic accessibility or operability and thus growing stock volume may overstate the volume actually available.

Figure 42.—*Hardwood growing stock inventory by ownership.*

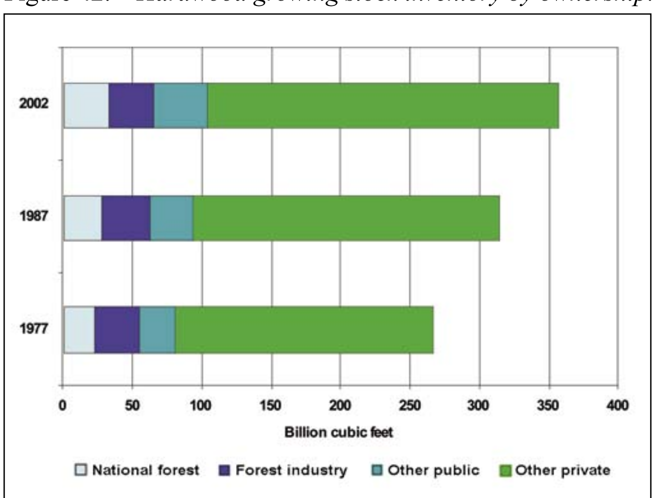
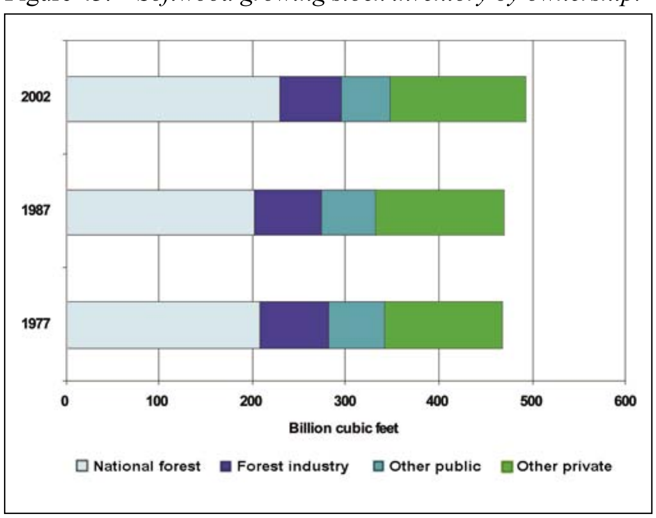


Figure 43.—*Softwood growing stock inventory by ownership.*



Area and growing stock of plantations—The area of plantations—mostly softwoods in the East—amounted to 41.9 million acres in 2002. The planted area amounts to 10.9 percent of all U.S. forest land in the East. Total growing stock volume in these planted areas amounts to about 7 percent of the total growing stock volume in the East. Southern pines are the dominant species on about three-fourths of the planted area in the East.

An estimated 13.6 million acres of planted forest are in the West; they primarily augment natural regeneration after harvest and ensure adequate stocking of desired species. Planted trees are often used to supplement natural regeneration and after 5 years or so, it can be difficult to differentiate planted and natural areas in the West.

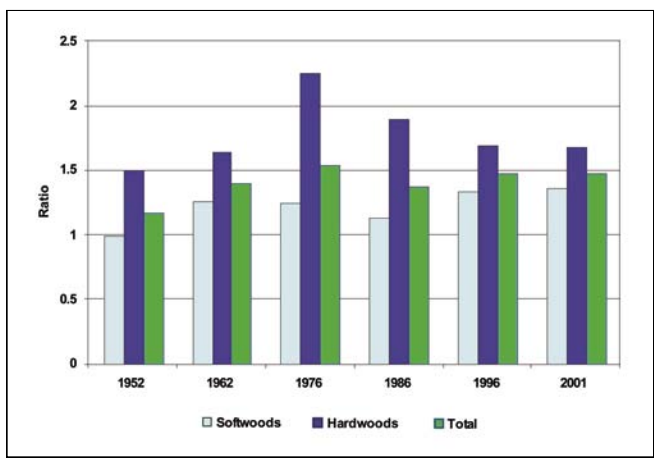
The Southern United States has witnessed a substantial decrease in the area of natural pine and a rapid increase in the area of planted pine over the past 50 years. The area of planted pine is now about equal to the area of natural pine. The loss of natural pine is largely due to land use conversions and transitions to planted pine and to upland hardwood following final harvest.

Annual removal of wood products compared to the volume determined to be sustainable—When Federal and some other public agencies produce wood products, production is generally planned within the frame of an overall plan that considers the management of all resources. These plans generally have in them some notion or intention to manage resources in a sustainable fashion. For timber, these plans would at a minimum include the objective that timber harvests should be at a level that can be maintained in the foreseeable future.

According to Butler and Leatherberry (2004), 3 percent of family forest land owners had prepared written management plans that covered 20 percent of the total private forest land area. Some plans on private lands may include consideration of sustainable outputs and some may be based solely on financial considerations. On private lands, the concept of sustainable outputs can be dependent on price and other workings of the market place. For example, higher prices may lead to more intensive management that could increase the level of sustainable output of wood products. In 2001, 8 percent of the timber output was produced on public lands and 92 percent on private lands.

From available data, the growth-removal ratio is a coarse-filter measure that approximates the notion of sustainable production: If the Nation is growing more wood than it is cutting, this ratio implies that current levels of wood production are sustainable. Growth is assumed to be a measure of sustainable output. The indicator, however, conveys no information about quality, forest types, size, and other attributes of growth and harvest. The indicator is affected by imports of timber products, forest management, and natural processes such as losses to mortality. Trends for the Nation as a whole indicate that growth exceeds removals for both softwoods and hardwoods (fig. 44). In total, the ratio of growth to removals was 1.49 in 2001. The growth-removal ratio for all species declined from 1976 to 1986. The increase from 1986 to 2001 reflects primarily the decrease of harvest on national forests. The growth-removal ratio for hardwoods was essentially unchanged from 1996 to 2001. A striking trend is an increase in the ratio for softwoods in the Pacific Coast region between 1991 and 1996. The rise reflects decreased harvesting on public lands and increased growth on timber stands that were regenerated after harvest during the 20th

Figure 44.—*Growth-removal ratios by softwoods and hardwoods.*



century (fig. 45). The growth-removal ratios for both softwoods and hardwoods in the South were relatively stable between 1996 and 2001after declining from 1976 to 1991. Current growth measures in the South do not reflect anticipated growth on millions of acres of plantations expected to reach maturity over the coming decades. The trees are not yet large enough to be classed as growing stock.

Removals continue to exceed growth on the forest industry ownership (fig. 46). The ratios on this ownership were little changed between 1996 and 2001. The growth-removal ratio on the nonindustrial private ownership was little changed between 1996 and 2001. The decrease in harvest on national forests is reflected in an increase in the growth-removal ratio between 1991 and 1996. The ratio for this ownership was more stable between 1996 and 2001.

Annual removal of nontimber forest products compared to the level determined to be sustainable—Annual or periodic harvest of nontimber forest products is largely undocumented in a systematic way, especially on private lands (Alexander 2004). Many case studies and examples from anecdotal information, however, document the widespread use and importance of nontimber forest products (Jones et al. 2002). Nontimber forest products include medicinal plants, food and forage species, floral and horticultural species, resins and oils, materials used for arts and crafts, and game animals and fur bearers. Some management issues regarding nontimber forest products are discussed by Kerns et al. (2002). For example, a major gap in current knowledge is how harvesting practices affect resource productivity, adversely or positively.

Certification of management of forest land adds a new dimension to making judgments about sustainable production of wood products (see box 15).

Figure 45.—*Ratio of net annual growth to removals by region.*

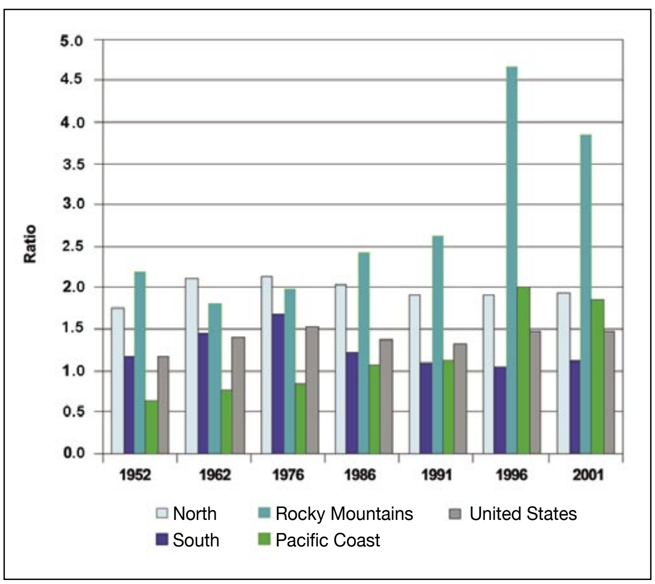
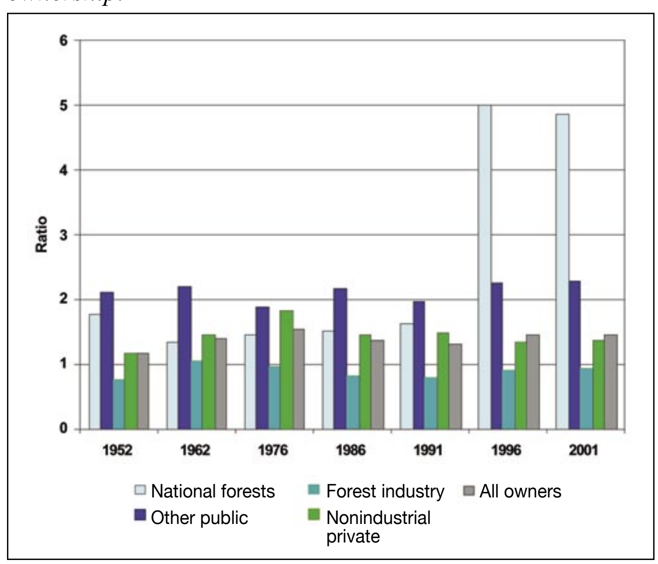


Figure 46.—*Ratio of net annual growth to removals by ownership.*



Box 15

Certification—Forest certification aims to identify forest land that is managed to meet agreed-upon standards and sometimes to label products originating from those forests (Hansen et al. 2006). Forest certification involves an independent verification that forests are being managed and that products are being produced that minimize or avoid harm to the natural forests and the human systems they support.

The ideas of certifying and publicly advertising a well-managed forest in the United States goes back to 1941 when the American Tree Farm System was created. This program is now sponsored by the American Forest Foundation. Other forest certification systems include: the Forest Stewardship Council spearheaded by the Worldwide Fund for Nature; the Sustainable Forestry Initiative initiated by the American Forest and Paper Association, and Green Tag developed by the National Forestry Association mainly for nonindustrial forest owners.

The above certification programs are performance based. The certifying organization sets most if not all performance criteria and oversees the assessment process to ensure conformance. Under systems-based certification such as International ISO 14001, the organization or individual seeking certification identifies its own environmental aspects and impacts, sets its own goals and targets, and devises an environmental management system to address them. The system does not demand that any particular performance level be attained.

Millions of acres of U.S. forest land have been certified by one system or another. To date, most of the acreage has been for private lands, but some State and county-owned forest land is also certified. Very little federally owned forest land has been certified. The Forest Service[1] and the Pinchot Institute have signed a joint venture agreement to evaluate the potential consistency of forest certification with the Forest Service's mission to conserve and sustainably manage Federal public land.

[1] For details, log on to http://www.fs.fed.us?news/2005/releases108/factsheets.pdf.

Box 16

Expectations for future timberland area, forest management types, and private inventories—Between 1953 and 2002, U.S. timberland area declined by 5 million acres, or about 1 percent, to 503.5 million acres. Haynes et al. (2006) project a further decline of about 3 percent by 2050. The major cause of loss in timberland area will be conversion to developed uses (e.g., residential and commercial building sites) rather than conversion to agriculture which was the dominant competing use in earlier decades.

Several significant recent trends in private timberland ownership are expected to continue. The result will be a smaller private timberland base and a more numerous and diverse set of owners with smaller parcels in closer proximity to urban areas. Land held by the forest industry group (firms integrated to processing) will continue to decline through sales to institutional and other financial investors (Timber Investment Management Organizations and Real Estate Investment Trusts). These groups manage for production of timber and for appreciation in the value of the forest land asset but do not operate timber processing facilities. The land base of nonindustrial ownerships is also projected to decline, by more than 12 million acres or about 4 percent by 2050, continuing the trend of the past 50 years. At the same time the number of nonindustrial land owners is expected to continue to grow and the average parcel size fall. Between 1997 and 2002, the forest area in major metropolitan areas increased by 5 percent (Smith et al. 2004). Future urban

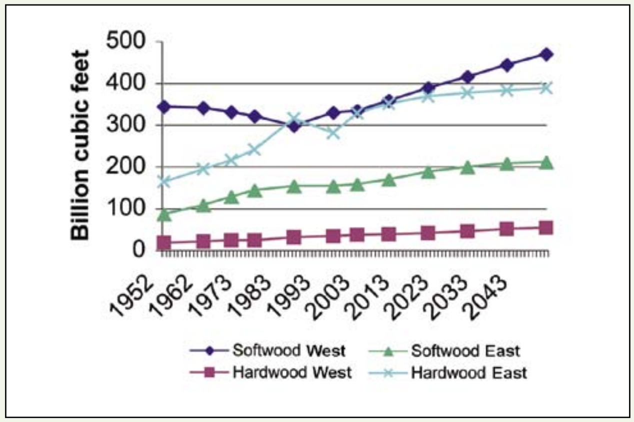
Box 16 (continued)

development will bring still more urban forests and more people living in closer proximity to the remaining forest lands (Alig and Plantinga 2005, Alig et al. 2004). The area of planted pine in the South will continue to expand as U.S. timber production is concentrated on fewer acres (Alig and Butler 2004b). Even so, hardwood types will continue to dominate the forest land base in the South and throughout the Eastern United States.

For the United States as a whole, and for virtually all regions and private owner groups, projected softwood inventory in 2050 is higher than estimated levels in 2000 (fig. 47). Growth exceeds harvest in all these cases despite rising removals over the projection. Aggregate U.S. private hardwood inventories also rise sharply by 2050, with continued expansion in the North offsetting modest reductions in the South.

One of the key determinants of long-term forest growth is private investment in silvicultural activities. For the South, the RPA Assessment Update base case projects continued shifts of private timber land in softwood types toward the more intensive forms of management for both industrial and nonindustrial ownerships. In western Washington and western Oregon, industrial ownerships will continue to shift lands toward more intensive silvicultural regimes until the decade 2010–19; by the end of the projection, the structure of management intensities will return to the mix observed in the 1990s.

Figure 47.—*U.S. private growing stock inventory by region and species group.*



Rangeland Products

Numbers of cattle and sheep—Cattle numbers have historically followed 10-year cycles since the mid-19th century. The national herd size increased until reaching a maximum of 132 million head in 1975. The latest cycle peaked in 1996 at 103.5 million head (fig. 48).

Per capita consumption of beef and veal has stabilized (fig. 49). Total demand for red meat in developed countries is projected to increase because of increased population. The annual increase through 2020 is expected to be less than 0.5 percent (Sere and Steinfeld 1996).

Grazing use of Federal rangelands—Livestock grazing on NFS lands has been relatively stable over the past 30 years (Mitchell 2000). On these lands, annual permitted cattle grazing has varied between 8 million and 9 million animal unit months, or AUMs, (the amount of forage needed to sustain a 1,000-pound cow for 1 month). Permitted sheep grazing during this time declined from 2 million to 1 million AUMs. Livestock grazing on BLM lands has been relatively stable at around 10 million AUMs.

Figure 48.—*Number of cattle and sheep.*

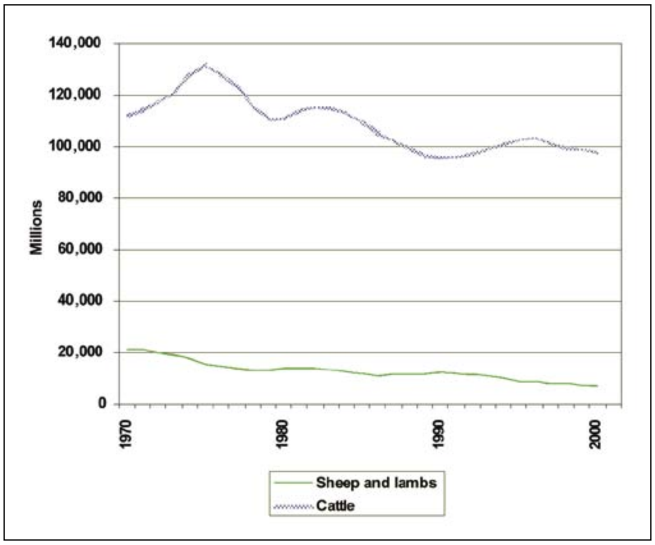
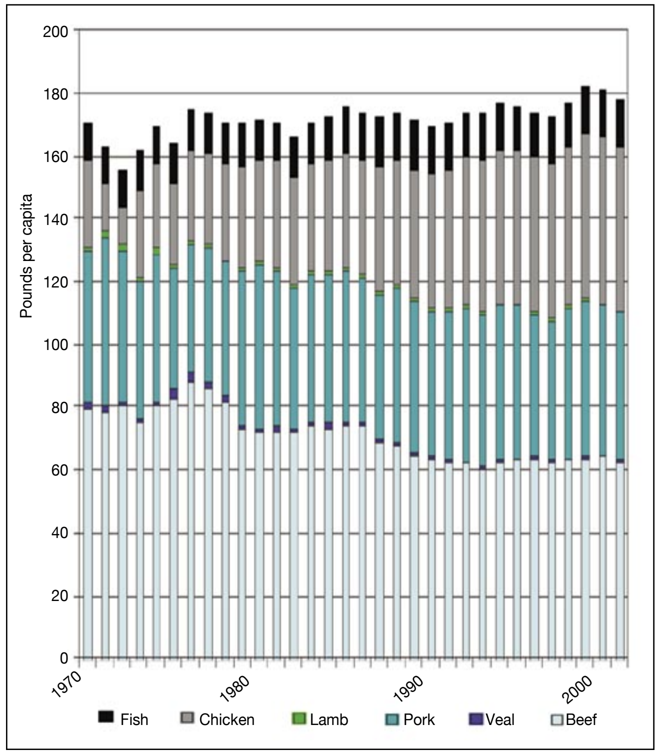


Figure 49.—*Per capita consumption of meat and fish.*



Box 17

Characteristics of private rangeland associated with public land grazing leases—The Western States have experienced tremendous population growth over the past 30 years, with many of these people moving into previously rural areas (Theobald 2001). This exurban development of former rangelands has the potential to significantly affect wildlife and ecosystem processes (Hanson et al. 2002). Any impacts of exurban development in the West tend to be aggravated by the relative positions of public and private lands; that is, private lands are generally at lower elevation and on more productive soils than public lands (Scott et al. 2001).

Little is known about the size, distribution, and types of rangeland occupied by private ranches having Federal grazing permits or leases, or about the beliefs and attitudes of public lands graziers. Some observers, however, have hypothesized that ranches, by their nature of requiring extensive acreages to produce an agricultural product, act as protected areas for open space and biodiversity (Maestas et al. 2003). Public rangelands contribute key parts of the annual forage requirements for ranches with public grazing leases. Although research has shown that ranchers would not want to sell their ranches if they lost their grazing privileges, such a loss would constitute a major variable in the complex of factors that influence the maintenance of livestock grazing in rural areas (Sulak and Huntsinger 2002). Unpublished results of a pilot study in the southern Rocky Mountains indicate that private ranches occupy areas that are proximate to public lands. Thus these lands may not only act to protect open space and biodiversity, but could also tend to mitigate ecological and social conflicts between public and private lands (Mitchell and Wallace 1998).

Summary

Available measures of productive capacity are very coarse. In this RPA Assessment Update, we project increasing volumes of growing stock inventory. The level of timber inventory depends in part on assumptions about future trade, management intensity, harvest, mortality and timberland area. The area of timber land is projected to remain relatively stable, but this outcome is dependent on assumptions about urbanization and rural land use changes including parcelization. The timber growth-removal ratio is projected to continue to be greater than one for the Nation as a whole for both hardwoods and softwoods. This outlook is dependent on assumptions about imports and exports, management intensity and harvest on timber land. Over the past decade, the sale of forest industry lands to timber investment management organizations and real estate investment trusts has increased uncertainties about the long-term management and disposition of these properties. Management of these lands has potential to affect the outlook for plantation area. There is little prospect for better data at a national scale for nontimber forest products such as wild mushrooms, berries, and so forth.

The grazing of cattle on Federal rangeland has been relatively stable during the past several decades, suggesting some measure of sustainability. Although at lower elevations, and generally more productive than Federal lands, privately owned rangeland is threatened by parcelization in some areas of the West.

Maintenance of Forest and Rangeland Ecosystem Health and Vitality

A basic need to know how and why our forest land and rangeland ecosystems are changing and to determine the importance of human influences on these changes will continue. Forest land and rangeland ecosystems are naturally dynamic, often changing species composition and abundance as the ecosystem evolves through succession or reacts to disturbances such as fire and insects. These dynamics are an essential ingredient of a healthy ecosystem. Human stresses on ecosystems include introduced insects, diseases, plants, and wildlife; altered fire patterns; air pollution; and land use practices such as timber harvesting and livestock grazing. Climate change can complicate all these stresses.

Climate Change

Climate change is one of many pressures on forest land and rangeland ecosystems in the United States encompassed under the term "global change." Ecosystems sustain human life by providing some of the goods and services on which life depends, including food, fiber, shelter, energy, and other amenities, such as biodiversity, clean air and water, recycling of elements, and cultural, spiritual, and aesthetic returns. Ecosystems also affect the climate system by exchanging large amounts of energy, water, and greenhouse gases with the atmosphere.

Climate variability and change can alter the structure and function of ecosystems. These variations and changes in turn can affect the availability of ecological resources and benefits, can change the magnitude of some feedbacks between ecosystems and the climate system, and can affect economic systems that depend on ecosystems.

Other pressures under the term 'global change' include the human stressors listed above. The deposition of atmospheric trace gases such as nitrogen oxides, sulfur dioxide, and ozone reduce vegetation growth. Introduced species, such as plants, insects, or animals, alter the native ecosystems. Land use changes such as the conversion of forests to agriculture or urban area reduce the land area in natural ecosystems as well as the dynamics of the remaining forest land. While some of these changes may occur at a faster rate than those resulting from climate change, particularly in the near term, climate change has the potential to fundamentally alter the large-scale distribution of U.S. forest land and rangeland ecosystems, their species diversity, their productivity, and their ability to supply ecosystem services.

The energy of the Earth's atmosphere and the dynamics of global and regional climates are strongly influenced by the chemistry of the atmosphere. Carbon dioxide, methane, nitrous oxides, chlorofluorocarbons, and water vapor are known collectively as greenhouse gases and have the potential to warm the atmosphere. The amount of warming is a function of the ability of these gases to absorb solar radiation (a physical constant) and the atmospheric concentrations of each gas. The 2003 concentrations of greenhouse gases are shown in table 6. For carbon dioxide, methane, nitrous oxides, and the chlorofluorocarbons, their concentrations since preindustrial times have increased from 13 percent (nitrogen oxides) to 145 percent (methane). Approximately three-quarters of the carbon dioxide emissions are from fossil-fuel combustion, the rest from land use change (Intergovernmental Panel on Climate Change 2001). Concentrations of carbon dioxide continue to increase in the atmosphere whereas methane concentrations at the global scale remained constant from 1999 to 2002.

Recent reports from the Intergovernmental Panel on Climate Change suggest that human-caused emissions of carbon dioxide and other greenhouse gases will alter climates and raise global average temperatures by 1.4 to 5.8 °C by the end of the 21st century. These emissions are likely to affect weather patterns, extreme climate events, and the seasonality of weather. And these changes in weather and climate will alter water resources, ecosystems, and the social and economic dynamics of communities. In the United States, average temperature is projected to rise from 2 to 5.5 ºC over the next 100 years. Projections of precipitation changes vary greatly across the United States and are more uncertain than the projected changes in temperature.

Table 6.—*Greenhouse gases in the atmosphere.*

	Atmospheric concentration[1] prior to 1750	Atmospheric concentration[2] 2003	Atmospheric lifetime (years)[3]	Increased radiative forcing (W/m^2)[4]
Carbon dioxide	280.0 ppm	374.9 ppm	Variable	1.46
Methane	730.0 ppb	1852.0 ppb	12	0.48
Nitrous oxide	270.0 ppb	319.0 ppb	114	0.15

[1] Following the convention of IPCC (2001), inferred global-scale trace-gas concentrations prior to 1750 are assumed to be practically uninfluenced by human activities such as increasingly specialized agriculture, land clearing, and combustion of fossil fuels.

[2] For most gases, concentrations for the year 2003 are given, as indicated more specifically in the footnotes below. Estimates for 1998, from IPCC (2001), are given for CHF3, C2F6, and SF5CF3. The current (2002) concentration of SF5CF3 is probably around 0.16 parts per trillion. Atmospheric concentrations of some of these gases are not constant throughout the year. Global annual arithmetic averages are given.

[3] The atmospheric lifetime is defined as "the burden (Tg) divided by the mean global sink (Tg/yr) for a gas in a steady state (i.e., with unchanging burden)" (IPCC 2001: 247).

[4] Increased radiative forcing is the change in the rate at which additional energy is made available to the Earth atmosphere system over an "average" square meter of the Earth's surface due to increased concentration of a "greenhouse" gas, or group of gases, since 1750. Energy is measured in joules; the rate at which it is made available is in joules/second, or watts; hence, radiative forcing is measured in watts per square meter (W/m^2).

Over the past 5 years, analysis of long-term trends in the natural systems has increasingly documented physical and biological changes. These changes include decreasing mass of glaciers and Artic sea ice, changes in seasonal dynamics of snowpack, rising sea levels, changes in temperature-sensitive events in the life cycle of plants and animals, and changes in ecosystem productivity.

Recent studies at the global and at the North American spatial scale have used large-scale patterns of surface temperature variation and climate models to investigate changes in climate over the 20th century. Increases in the North American temperatures observed from 1950 to 1999 were unlikely to be due only to natural climate variations. Observed trends were consistent with climate simulations that include increasing atmospheric greenhouse gases and sulfate aerosols, thus detecting a human influence on North American climate (Climate Change Science Program 2004).

Ecosystem impacts—The use of future climate scenarios and ecological models suggests that the impact of climate change on U.S. ecosystems could include increases in ecosystem productivity in the short term and shifts in the distribution of plants and animals in the long term (Joyce and Birdsey 2000). As climate changes advance, there are some indications that there will be increases in disturbances such as forest fires, drought, and insects (Dale et al. 2001)

Plants and animals have adapted to climate and have been known to respond to changes in climate on short-term as well as long-term time periods. Average body shape and size of animals reflect the adaptation to climate over evolutionary time periods. Changes in body shape, size and other physical traits may provide better adaptation to local climate (Parmesan and Galbraith 2004) and could occur in short time periods responding to changes in the local climate. The phenology of important events in a plant or animal's life cycle may be affected by climate. These events include the onset of spring growth, timing of migration, timing of breeding, and spring insect emergence, for example. Changes in the geographic distribution of plants and animals have been documented in paleoecological studies during and after the last glaciation in North America (Delacourt and Delacourt 1993). Recent efforts that have associated species diversity patterns with attributes of climate have confirmed what these paleoecological studies have suggested. Namely, that the diversity of trees, birds, mammals, amphibians, and reptiles may change dramatically under projected changes in climate (Hansen et al. 2001). At the ecosystem level, the relationship between ecological processes such as nutrient cycling and decomposition is known to be sensitive to moisture and temperature.

Box 18

Sea-level rise—Within the United States, 51 percent of the 2000 population lives within 80 km (50 miles) of an ocean or the Great Lakes coasts, whereas this area accounts for only 13 percent of the continental U.S. land area (Rappaport and Sach 2003). Increasingly, coastal areas are being developed, altering the natural systems along the coast lines. Ecological services provided by these coastal ecosystems include habitat for terrestrial and aquatic organisms, attenuation of waves and storm surge impacts, and the nutrient export to stimulate estuarine and near-shore productivity.

Sea-level rise globally over the past 100 years has been estimated to be between 10 and 25 cm (3 to 10 inches) (Shriner et al. 1998). Within the United States, sea-level rise has been 2.5 to 3.0 mm/year along parts of the U.S. Gulf coast and along the Atlantic coast south of Maine (Shriner et al. 1998). Along the Louisiana coastline, a combination of natural and human-induced processes (in addition to climate change) is resulting in land subsidence (Burkett et al. 2005). The Alaskan coast is experiencing a postglacial rebound and sea level appears stable.

A potentially warming climate will warm the oceans and will increase the melting of the glaciers. Sea-level rise occurs through the thermal expansion of the ocean, glacial melt, and ice-cap decline.

Given scenarios for climate change, global mean sea level is projected to rise by 50 cm (19.7 inches) above today's levels by 2100, with an uncertainty range of 20 to 86 cm (7.9 to 33.9 inches) (Shriner et al. 1998). For the North American Atlantic ocean coastlines, the sea-level rise may be higher than the global average, reflecting the higher historical rates of sea-level rise in this area. Similarly, the sea-level rise along the Pacific Coast of North America is likely to be lower than the global average, reflecting the lower historical rates there. Even if concentrations of greenhouse gases were stabilized at the 2000 levels, the atmosphere would continue to warm by another half degree C from the current levels of greenhouse gases in the atmosphere (Meehl et al. 2005). This further warming of the atmosphere would result in a sea-level rise of 10 to 18 cm (3.9 to 7.1 inches), from thermal expansion of the oceans only (Meehl et al. 2005).

Coastal ecosystems in the United States vary from coastal grasslands, salt marshes, mangrove forests, agricultural land and lowland forests. Sea-level rise influences these coastal ecosystems through increases in tidal flushing in estuaries and storm surges over low-lying coastal landforms, processes which alter the salinity levels, sediment transport and other coastal processes that maintain these ecosystems (Burkett et al. 2005). In addition, higher tides result in saline water moving farther inland in streams and rivers, increasing the salinity exposure to those riparian systems and salt water intrusion to water supplies.

Shriner et al. (1998) reported that a 50 cm (19.7 inches) rise in sea level would inundate approximately 50 percent of North American coastal wetlands in the 21st century. This 50 cm (19.7 inches) rise could also inundate 8,500 to 19,000 km^2 (3,282 to 7,336 square miles) of dry land (Shriner et al. 1998). This dry land includes forests and agricultural land, mainly in mid-Atlantic and Southeastern United States.

Coastal vegetation varies in its tolerance to saline conditions, resulting in a zonation of vegetation along the coastlines where plants with high tolerance experience the saline water and plants with lower tolerance are further from the coast and high tide marks. In the Big Bend region of Florida, forests are found on mounds above the mean higher high water (the higher of the two tides each day) (Burkett et al. 2005). When sea level rises, trees are unable to regenerate as the seedlings fail in high salinity conditions and under high water conditions (Williams et al. 1999). Burkett et al. (2005) noted that the loss of coastal systems may appear to be incremental however, some coastal systems may not show a response until an intrinsic threshold is reached, resulting in large-scale loss of the coastal system.

Understanding of recent changes in climate comes from the analysis of large spatial-scale patterns over long periods of time. Attribution of any biological response to climate change is complicated because short-term and local biological changes are strongly influenced by factors such as land use. As with the detection of the climate change signal, the underlying biological signal from climate change will be teased out only with analyses that seek systematic trends, over time, across large spatial regions, and across many diverse species (Parmesan and Galbraith 2004). Examples of existing studies include an analysis of the range and phenological patterns of 1600 species across the globe (Parmesan and Yobe 2003); the timing of initiation of breeding in tree swallows (Dunn and Winkler 1999), and the range of the Edith's checkerspot butterfly (Parmesan 1996).

Socioeconomic impacts—Climate variability and change can profoundly influence social and natural environments throughout the world, with consequent impacts on natural resources and industry that can be large and far-reaching. For example, seasonal to interannual climate fluctuations strongly affect agriculture, the abundance of water resources, and the demand for energy, while long-term climate change may alter agricultural productivity, land and marine ecosystems, and the goods and services that these ecosystems supply. At the national level, where climate change was projected to induce forest productivity increases, consumers were found to benefit but not producers. Projections of yield decreases had the opposite effect (Alig et al. 2004). Adaptation in the forest sector and in the agricultural sector could limit these effects. Options in forestry include land market adjustments, interregional migration of production (e.g., northerly migration of productive capacity), substitution in consumption between wood and nonwood products (reflected in overall growth in wood products use) and between sawtimber and pulpwood, and alteration of stand management (Alig et al. 2004).

Practices that increase carbon sequestration in ecosystems or reduce emissions are seen as ways to mitigate these potential impacts. The United States currently administers a variety of voluntary, regulatory, or incentive-based programs on energy efficiency, agricultural practices, and greenhouse gas reductions. The voluntary greenhouse gas reporting program allows for the reporting of practices that increase carbon sequestration or reduce emissions. Many western parks are implementing measures such as using alternative fuel vehicles, such as converting diesel fleets to 20 percent biodiesel or promoting bus shuttle systems, which helps address air quality concerns in pristine environments. The National Park Service Climate Friendly Parks Initiative reviews park activities to reduce emissions. In 2005, the Arapahoe Basin Ski Area in Colorado had a "Be Cool and Carpool" program that offered discounted lift tickets to those who arrived with four people or more in one vehicle.

Meanwhile, U.S. annual production of fuel ethanol (mostly from corn grain) climbed from 1.6 billion gallons in 2000 to 3.9 billion gallons in 2005 (Renewable Fuels Association 2006). At present, ethanol production consumes about 15 percent of U.S. corn grain harvest, and future increases in output of ethanol may begin to impact corn prices more significantly in the future. If so, alternative feedstocks for ethanol production, including lignocellulosic materials such as wood, may begin to be used on a large scale for ethanol production.

Forest Health and Vitality

Air pollution—Air pollution exposure has generally been highest in the East (Coulston 2004). Annual estimates of sulfate deposition for forested areas decreased across all regions from 1994 through 2000. In the East, about 50 percent of the forest was exposed to sulfate deposition of more than 13.4 pounds per acre per year for the period (fig. 50). Nitrate deposition rates were lowest in the Pacific Coast and Rocky Mountain regions. In those areas, approximately 84 percent of the forest received less than 4.2 pounds per acre per year from 1994 through 2000, as compared with the East where only 2 percent of the forest received this amount. Ozone exposure was highest across the South and in southern California; however, little or no ozone injury to plants was recorded on most ozone biomonitoring plots (fig. 51). In the North and South, about 77 percent of the biomonitoring plots received little or no injury. In the Pacific Coast and Rocky Mountain regions, 97 percent and 100 percent, respectively, of the biomonitoring plots had little or no injury from ambient levels of tropospheric ozone. Only a small portion

Figure 50.—*Cumulative distribution functions of forest subject to specific levels of wet sulfate deposition (1994 to 2000).*

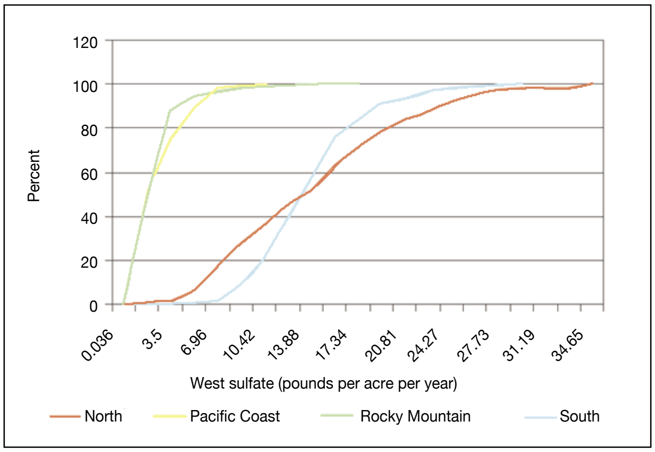
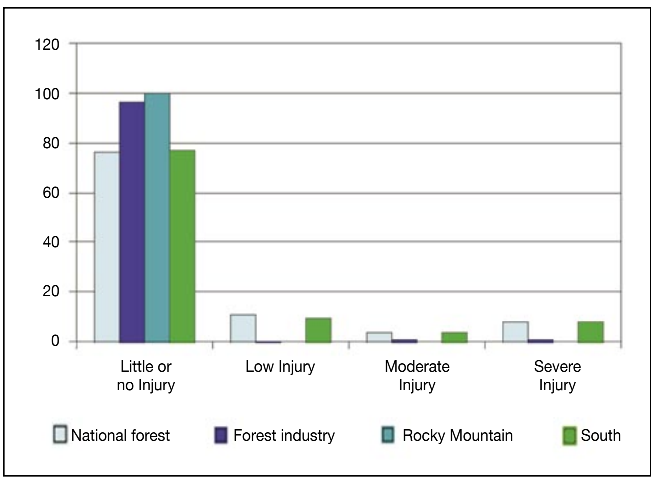


Figure 51.—*Percent of ozone biomonitoring plots with low, moderate, or severe foliar ozone injury.*



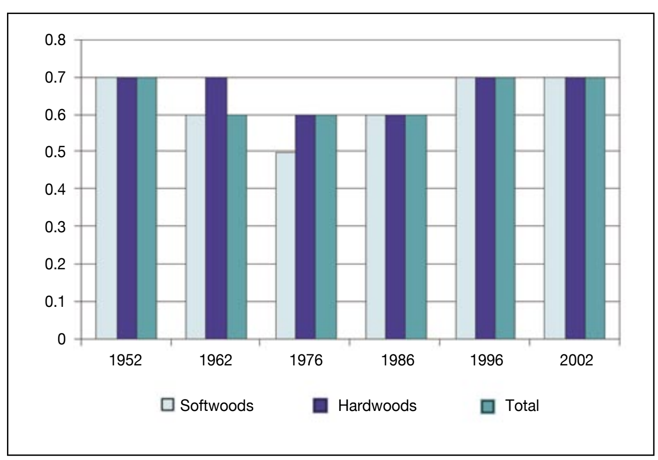
of plots, mostly in the North and South, had severe foliar injury. Results from multivariate analysis showed that oak-hickory and loblolly-shortleaf forest type groups were generally exposed to more air pollution than other forest types. Conversely, western white pine and larch forest type groups were exposed to less air pollution than all other forest types. Currently, it is not known if the specific levels of sulfate, nitrate, and ammonium deposition reported cause large-scale negative effects on forest ecosystems even though smaller scale effects have been observed, such as on high-elevation spruce-fir forests.

Mortality—Mortality is one indicator of health. Average annual mortality as a percent of timber inventory has generally been between 0.5 and 0.8 percent (fig. 52). Mortality is a coarse-filter measure of ecosystem condition. If dead and dying trees are salvaged and used between inventories, this volume is not reflected as mortality in timber inventories. Thus, relatively large losses of volume can occur due to disturbance agents that are not measured as mortality.

The Forest Service Forest Health Protection Program has developed estimates of the area of forests where increased mortality rates from insects and diseases are expected to occur (Lewis 2002). These rates were termed to be at risk because there was an expectation of at least 25 percent mortality over "normal" mortality rates from insects and pathogens over the next 15 years. Twenty-six insects and pathogens were evaluated using current survey data, models, and expert opinion to estimate forested areas at risk.

The Forest Service Forest Health Protection Program found an estimated 58 million acres or 8 percent of the forested area in the United States to be at risk. Gypsy moth in the East, root diseases in the West, southern pine beetles in the South, and bark beetles in the West were responsible for 66 percent of the total area at risk. In the North, 8.6 percent of the forested area was estimated to be at risk; 7 percent in the South; 13.6 percent in the Rocky Mountain region, and 5.8 percent in the Pacific Coast region.

Figure 52.—*Average annual mortality as a percent of growing stock inventory.*



Box 19

Bringing climate into natural resource management— Increasing concerns about climate have put the issue on the agenda of some natural resource managers in the Western United States and they are using institutional processes to develop management actions to address climate change. In listening to more than 70 natural resource managers and professionals in the Western United States, Joyce and Laskowski (2006) found that understanding the role that climate plays in the natural environment was an important step in developing management activities to address climate variability and change. In past natural resource management or planning, climate was often assumed to be static over the period of interest, so that the management focus was on managing the relationships between habitat changes or natural disturbances and the natural resource of interest. Today, consideration of climate, if any, is typically linked with a current resource management goal (e.g., improved grazing or hydropower capacity), concern about the sustainability of the natural resource, and recent climate variability.

Natural resource managers from Federal agencies, State agencies, and nongovernmental organizations are bringing the consideration of climate into the management arena through institutional processes such as assessment, monitoring, focused research, education, planning, field-based activities, and mitigation. A diverse array of assessments initiated by resource agencies or organizations have been aimed at describing and quantifying potential impacts such as the vulnerability of coastal ecosystems to sea level rise, the potential impact on resources and recreation within national parks, and the risk to economies in the Southwest. Long-term monitoring of climate change indicators to detect changes in the natural resources has been initiated by natural resource agencies, such as the NPS in the United States and Parks Canada in Canada. A variety of indicators are being considered such as weather, ice-free time in lakes, glacier photography, tree encroachment, and indicator species such as butterflies. Natural variability of climate such as drought (both the temperature and the moisture aspects) and intense rainfall events were phenomena that managers were addressing in their management plans.

Natural resource managers included the consideration of climate change only when scientifically accepted quantitative relationships between climate and a specific natural resource (e.g., water) were available and when applications were available that could easily be used within the manager's current planning or management framework. Managers benefiting from partnerships with climate-focused organizations, extension staff, and/or scientists within their geographic areas were able to incorporate consideration of climate variability and change into management planning processes.

Monitoring and recording of disturbances in our forests has taken place only over the past 100 to 150 years, depending on the disturbance agent. Observations are lacking for more distant timeframes, precluding us from knowing with certainty what the preceding historical conditions and trends may have been. Analyses of tree rings and other materials do provide clues to estimate some past conditions. Ciesla and Mason (2005) compared data for conditions for various disturbance agents in the period 1996–2000 with available data for the periods 1800–50 or 1979–95, depending on the disturbance agent. By definition, impacts from exotic insects, diseases, and plants are outside the natural range of variation of our forest ecosystems.

The following highlights the extent of disturbance by various agents. The range of variation for some disturbance agents in existing ecosystems is being established by the Forest Service Forest Health Monitoring (FHM) Program.

A potentially grave threat to coastal forests in California and Oregon, and possibly the rest of the country, has been the outbreak of an emerging generalist root rot pathogen, *Pytophthora,* first discovered in Europe as the cause of the Irish potato famine. *Pytophthora* has been causing significant mortality in various species of oaks, cedar, and redwood. (See http://nature.berkeley.edu.comtf/ for more information).

Various species of this exotic pathogen have also impacted southern oaks from South Carolina to Texas as well as trees in the Ohia forests in Hawaii.

Area of forest affected by insects and diseases—For the most part, outbreaks of native insects and diseases have been episodic with eventual collapse of populations/infestations by natural agents or fires. Ciesla and Mason (2005) suggest that acreage affected by the following indigenous insects may have exceeded their historical range of variation during the period 1973 through 1997, in the indicated year: southern pine beetle (1986 and 1995); mountain pine beetle (1981); spruce beetle in Alaska (1996); spruce budworm (1978); spruce budworm in Alaska (1997); western spruce budworm (1986), and Douglas-fir tussock moth (1973). Similarly for native diseases, Ciesla and Mason (2005) suggest that dwarf mistletoes, fusiform rust, root diseases in portions of northern Idaho and western Montana, oak decline in Arkansas, and oak wilt in Texas since the 1970s may have been at levels exceeding the historical range of variation. Data for annual forest and insect conditions are maintained by the Forest Service at http://www.fs.fed.us/foresthealth/pubsindex.shtml.

Invasive Plants and Animals

Forests can be adversely affected by invasive plants and animals. Throughout the landscape, plants and animals introduced from other countries can create problems and push out some native species. Some foreign plants and animals have no natural predators to stop them. Exotic weeds can take hold when new roads are installed as part of the expanded developed area in the United States (Alig et al. 2005) or when homes are built.

Human disturbances have also contributed to problems caused by native species such as raccoons, jays, and crows spreading into habitats where they normally do not occur in harmful numbers. One reason for that spread is human disturbance of natural systems. For example, raccoons in the developing lands of Shenandoah, Virginia, are now found in moderate to high densities (more than 10 per square mile) in 96 percent of counties, compared with only moderate densities in 43 percent of the counties in the 1970s. Raccoons not only are a predator of ground-nesting birds but also are vectors for rabies.

Protected open space lands give communities a better chance of keeping invaders under control. For example, where open spaces remain intact, controlling exotic weeds is a simpler task. Also, high-density developments sharing a common large tract of open space can result in a similar outcome—where weed control is part of the land covenant.

More than 4,500 exotic free-living species are in the United States—some 2 to 8 percent of plants, insects, and pathogens are introduced. Approximately 19 of the 70 major insect pests found in the United States are exotic.

High-profile exotics include Dutch elm disease, chestnut blight, white pine blister rust, Port-Orford-cedar root disease, European gypsy moth, hemlock woolly adelgid, and beech bark disease. These infestations can have effects extending well beyond the loss of timber volume. For example, loss of hemlock from eastern forests as a result of the hemlock woolly adelgid would impact riparian areas where hemlocks help regulate water temperature and wildlife species that depend on hemlock stands for shelter, nesting, and foraging habitat. Dutch elm disease had a large and adverse impact on urban forested ecosystems.

One 1994–95 study showed that a significant part of the total flora is composed of invasive plant species. The number of invasive plant species was highest (greater than 10 percent of the total flora) in areas of the North, and in areas of the Pacific Coast region. Invasive plant species accounted for 25 percent of the California cover (Stapanian et al. 1998).

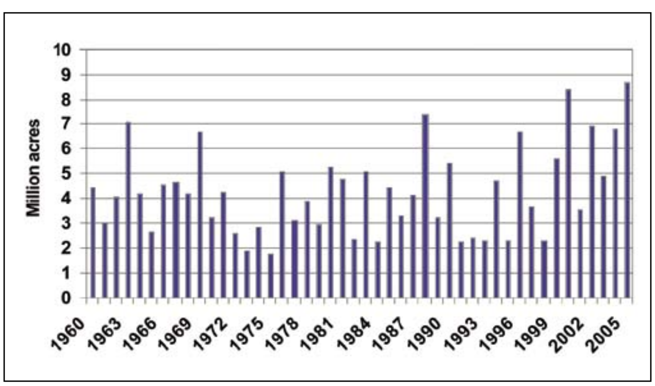
The scope, impact, and trends of invasive plants are outlined in a fact book by the Federal Interagency Committee for the Management of Noxious and Exotic weeds (Westbrooks 1998). Among the most worrisome exotic weeds found on U.S. forests and rangelands are leafy spurge, knapweeds, and star thistle, Canada and musk thistles, salt cedar, cheat grass, mile-a-minute, and purple loosestrife (Mitchell 2000).

Hypotheses on why invasive species expand so aggressively include the presence of fewer natural enemies (insects and disease), less competition from native species, and native species that are vulnerable to chemical attack by the invaders (called allelopathy). The knapweeds (*Centaurea* spp.) found on rangelands are exceedingly successful in completely dominating habitats because of allelopathy. Recent theoretical work by ecologists has concluded that invasive species tend to rely on two related mechanisms to occupy new sites—release from natural enemies and being adapted to make use of high levels of resources. Native species adapted to increased resource availability tend to be contained by natural enemies.

Wildfire—The frequency and scope of wildfire have changed dramatically over time (fig. 53). Fire suppression resulted in relatively stable areas burned from the 1950s through the 1970s. During the 1980s, the area burned by wildfires in the West began to increase again, due in part to unprecedented success of fire suppression and its effects on forest conditions. Fire suppression led to increased forest density and biomass, changes in forest composition and the resulting increases in insect and disease susceptibility and mortality, and the resulting buildup of fuels (Hill 1998).

Forest condition class—Historical (pre-European colonization) fire regimes were reconstructed from tree ring analyses and fire scars (USDA Forest Service Fire Sciences Laboratory 1999a, 1999b) to identify areas of relatively high change in forest condition. Current condition classes categorize departure from the historical fire regimes based on five ecosystem attributes: Disturbance regimes, disturbance agents, smoke production, hydrologic function, and vegetative attributes. Current condition class 1 represents a relatively small deviation from ecological conditions compatible with historical fire regimes. Condition class 2 is a deviation from

Figure 53.—*Area burned by wildfire.*



ecological conditions compatible with historical fire regimes that would require some silvicultural management to restore conditions compatible with historical fire regimes. Current condition class 3 represents a major deviation from the ecological conditions compatible with historical fire regimes that would require a major effort such as harvesting and replanting to restore.

Seventy-three percent of the forested area in the North was classified as condition class 2 or 3. Most of the forested area in the South (70 percent) has ecological conditions compatible with historical fire regimes and is classified as condition class 1. Eighty-six percent of the forested area in the Pacific Coast region was classified as condition class 2 or 3, as was 78 percent of the Rocky Mountain region.

Wildlife—Wildlife populations can increase to the point of becoming threats to the health and vitality of forest land and rangeland ecosystems. For example, in some portions of the East, white-tailed deer have reached numbers that are causing damage to plant community structure and forest regeneration (Ciesla and Mason 2005). Excessive deer browsing also has been shown to reduce nesting areas for songbirds, change the composition of small animals, reduce winter food for turkeys, and reduce cover for black bear and ruffed grouse.

Rangeland Health and Vitality

Traditional methods for monitoring rangeland condition have focused on vegetation and soil dynamics at the site level. Other indicators of rangeland health and vitality are more appropriate at regional and national scales. These include (1) area and percent of rangeland affected by processes like invasive weeds, fire, and grazing outside their range of natural vegetation, (2) deposition of air pollutants, and (3) area and percent of rangeland with diminished biological components indicative of changes in fundamental ecological processes. Currently, little is known about ranges of natural variation of disturbances at multiple scales, and no national inventory captures these metrics. Little theory or agreement exists on how indicators should be integrated for assessing changes in ecological processes at a broad scale.

Summary

The forest resources of the United States have always been affected by insects, diseases, fire, and other natural disturbances. European settlement brought land clearing, new domestic animals, new species of plants and animals, and other sources of disturbance beyond the range of historical variation for North American ecosystems. Human activities over the past three centuries have forever changed the nature of some forested ecosystems in the United States.

Pre-European conditions will never again exist for the bulk of U.S. forest land and rangeland ecosystems. Much of the forest in the North and West would require at least some silvicultural management to restore conditions compatible with historical fire regimes.

The range of natural variation in existing ecosystems has yet to be established in terms of disturbance, pollutants, and the functioning of fundamental processes. The FHM Program of the Forest Service is establishing a baseline to be used to evaluate changes in forest ecosystem health and vitality. As more States are included, results from this program will provide the basis for more wide-scale statements regarding ecosystem health and vitality. Until such a baseline exists, episodic outbreaks and damage from insects and disease, fuel buildups, and other disturbances will continue to be of concern and will be the source of speculation about their role in ecosystem health and vitality. Globalization of the world economy will mean more travel, trade, and opportunities for the spread of exotic insects and diseases. Fragmentation of landscapes and changes in land use will continue to stress forest health and increase the likelihood of invasion by exotics. Air pollution remains a threat to many forest and high-elevation alpine and subalpine ecosystems. Although sulfate levels are declining, regional haze, ozone, and nitrogen deposition have increased for some areas and pose increasing problems for sensitive forest, range, and aquatic ecosystems. In some areas, wildlife populations have increased to the point of being threats to forest land and rangeland ecosystem health and vitality.

The possibility of climate change adds new dimensions to the evaluation of forest land and rangeland health and vitality. Climate change may lead to land cover and land use changes, increases in atmospheric pollutants such as ozone and nitrous oxides, and potential expansion of invasive plants and animals.

Conservation and Maintenance of Soil and Water Resources

Condition of Forest Soil

There is little data but research-scale data regarding forest soil erosion, forest soil organic matter and other soil chemical properties, forest soil compaction or changes in soil physical properties, and the area of forest land experiencing an accumulation of persistent toxic substances (O'Neill and Amacher 2004a, 2004b, 2004c, 2004d). The following excerpts available information as reported in the four papers by O'Neill and Amacher.

Data from the Natural Resources Conservation Service State Soil Geographic (NRCS STATSGO) database and the Forest Inventory and Analysis (FIA)/FHM soil indicator program suggest that the potential for the most forest soil erosion is in the southern Appalachian Mountains of West Virginia, Kentucky, North Carolina, and Virginia—an area of erodible soil, high relief, and intense rainfall—and in mountainous areas in the northern Rocky Mountains and the Cascades Range (fig. 54).

Soil Organic Matter and Other Soil Chemical Properties

Analysis of the NRCS STATSGO data indicates a rough latitudinal gradient in soil organic matter contents, with low soil organic matter contents in the warmer southern portions of the country and higher soil organic matter contents becoming more prevalent toward the Northern United States. General patterns of carbon distribution based on FIA/FHM data are similar to those derived from the NRCS STATSGO data and indicate highest organic carbon concentration in upper mineral soils of New England, upper Minnesota, and the Pacific Northwest.

Soils in regions receiving higher precipitation, such as the Eastern United States, are more acidic than soils in arid regions (fig. 55). In these areas, high rainfall tends to leach base cations (e.g., calcium, magnesium, and potassium) from the surface of soil particles, resulting in increased acidity.

Figure 54.—*Modeled erosion limitation ratings derived from State Soil Geographic database of the Natural Resources Conservation Service.*

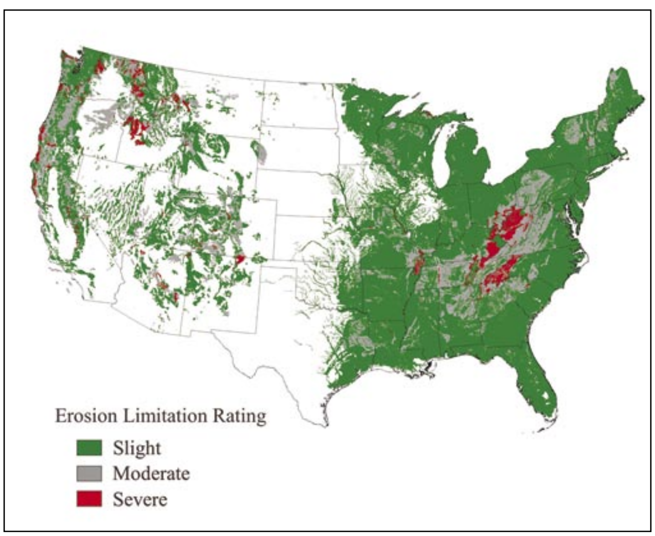
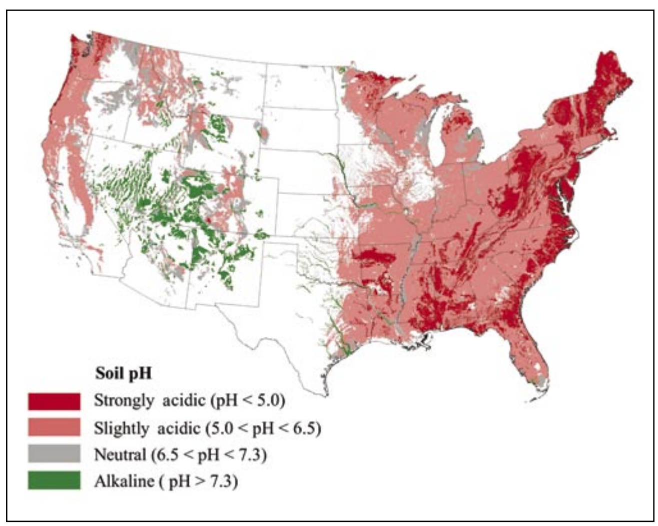


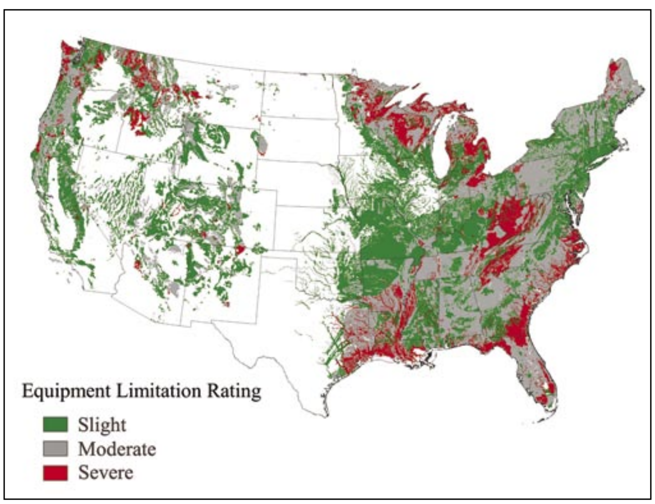
Figure 55.—*Modeled mean soil acidity in the upper mineral layer of woodland soils derived from the State Soil Geographic database of the Natural Resources Conservation Service.*



Data from the NRCS STATSGO database and the FIA/FHM soil indicator program can provide some general insights into the susceptibility of different regions to soil compaction or change in soil physical properties resulting from human activities. Although soils throughout much of the Eastern United States are rated as more susceptible to physical disturbance from management practices (fig. 56), evidence of surface soil compaction above trace levels was not found on 86 percent of FIA/FHM plots measured in 1999–2000.

The accumulation of persistent toxic substances in the soil depends upon a large number of site-specific factors, including proximity to the source, the composition and chemistry of the soil (e.g., acidity, organic matter content, clay content), drainage, and local climate. For this reason, pollutant accumulation can only be measured at the local level and cannot be inferred from deposition or soil properties alone. At present, no national-scale monitoring programs exist for accumulation of persistent toxic substances on forest land. O'Neill and Amacher (2004d) discuss an experimental approach to determination of the potential susceptibility of forest lands for accumulation of toxic substances.

Figure 56.—*Modeled equipment limitation ratings derived from the State Soil Geographic database of the Natural Resources Conservation Service.*



Condition of Water Flowing From Forest Land

No national-scale monitoring programs are in place to assess the various characteristics of water flowing from forest land. Water monitoring stations are generally placed at the bottom of watersheds that have a variety of land uses. For example, within a watershed may be forest cover, agricultural land uses, and urban settings. The water monitoring stations cannot differentiate the source of water in samples.

In an attempt to isolate samples of water draining from forested areas, the Heintz Center worked with the U.S. Geological Society and its National Water Quality Assessment program to determine nitrate loadings in streams coming from watersheds that are predominately forested (H. John Heinz III Center for Science, Economics, and the Environment 2002). The Federal standard for drinking water for the protection of human health is 10 parts per million of nitrate. Ninety-seven percent of forest stream sites had nitrate concentrations below 1 part per million, more than three-fourths had concentrations of less than 0.5 parts per million, and more than one-half had concentrations of less than 0.1 parts per million.

Brown and Binkley (1994) found that the quality of water draining forested watersheds is typically the best in the Nation, whether the forests are left untouched or managed. Water quality problems on forest land are highly variable over space and time. Relatively few forest areas of the country, if carefully managed, are prone to troublesome pollutant yields. Forest practices, however, are sometimes poorly implemented, leading to degradation of water quality. Sediment loads in streams are the most widespread water pollution problem in forests and are especially associated with poor road design and maintenance. Forest practices generally have little impact on oxygen levels or on dissolved solids. Nitrate generally is the only ion of critical interest in relation to forest practices. Harvesting markedly increases nitrate concentrations in the chapparal and northern hardwood areas. Application of nitrogen fertilizers may cause stream nitrate levels to peak at high concentrations. Buffer strips along streams can alleviate the effects of harvesting on water temperature.

Summary

Agencies such as the U.S. Geological Survey that monitor water quality tend to locate monitoring stations in areas with real or perceived water quality issues. The general lack of data for the characteristics of water draining from forested lands may suggest that, although there may be local problems, little basis exists for developing issues at a national scale. Regulations embodied in best management practices acts in 43 States generally have as one objective the protection of water quality (Ellefson et al. 2005).

Agencies charged with monitoring soil conditions also place added emphasis on land use types more at risk to disturbances. For example, the NRCS monitors erosion on agricultural lands, but not on forest lands. Soil erosion and compaction following forest management activities depend to a large degree on how the activity is implemented. Few data are available at a national scale for the condition of forest soils. The Forest Service FHM Program collects some data on forest soils. Initial data collected in 1999–2000 indicated that 86 percent of 2,006 plots had only trace levels of soil compaction. Soil compaction may be a serious problem on a local scale, however, as indicated by the high proportion of disturbance reported for some individual plots.

Until systematically collected data are available at a national scale, little basis exists for developing a national statement on management and policy implications for conservation and maintenance of forest land and rangeland soils and water draining from them.

Maintenance of Forest Contributions to Global Carbon Cycles

Forests contribute to global carbon cycles in at least two ways. First, carbon is retained in forests and in forest products as part of the larger cycle of carbon through the land, water, and atmosphere. Secondary emissions of carbon to the atmosphere are reduced to the extent that wood products production and use causes less fossil fuel carbon emissions than production and use of substitute products.

Carbon Retained in Forests and Forest Products

The accumulation of biomass as living vegetation, debris, peat, and soil carbon is an important forest process related to the health and vitality of the forest. Land management activities influence the uptake and release of the carbon stored in forests. Carbon is also stored in the atmosphere and the oceans as well as in vegetation. Because carbon dioxide is a greenhouse gas with the potential to warm the atmosphere, identifying the role of forests in storing and releasing carbon is important in determining changes in atmospheric carbon. Incorporation of carbon into vegetation is the fastest process whereas transfer to the soils and the ocean may operate on a time scale spanning centuries.

In the Intergovernmental Panel on Climate Change carbon budget for the globe, emissions from fossil fuel combustion and cement production are the larger of the carbon sources identified (table 7) (Intergovernmental Panel on Climate Change 2001). Land use change in the Tropics is a flux into the atmosphere and there is a residual terrestrial sink.

The carbon balances shown in figure 57 reflect an accounting for net annual growth and use of timber in the conterminous United States (Heath and Smith 2004). Forests in the United States have acted as carbon sinks at least since 1953 when data first became available. Thus, carbon has accumulated over time, mainly in aboveground live trees. Significant regional differences in past and projected carbon storage reflect

Figure 57.—*Carbon pools (Mt) on forest land in the conterminous States.*

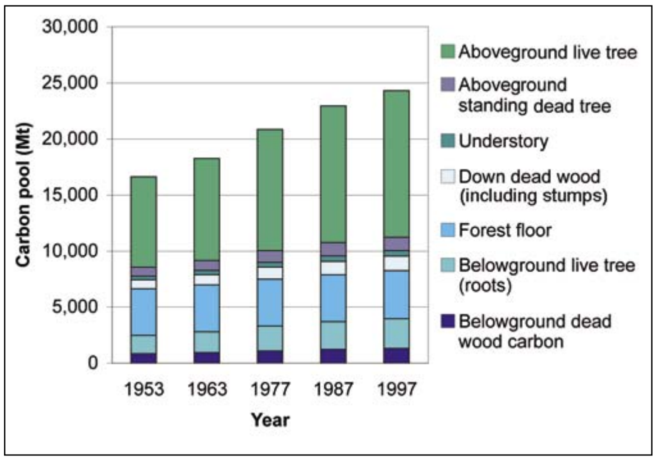


Table 7.—*Annual average anthropogenic carbon budget for 1980 to 1989. CO_2 sources, sinks, and storage in the atmosphere are expressed in GtC/yr.*

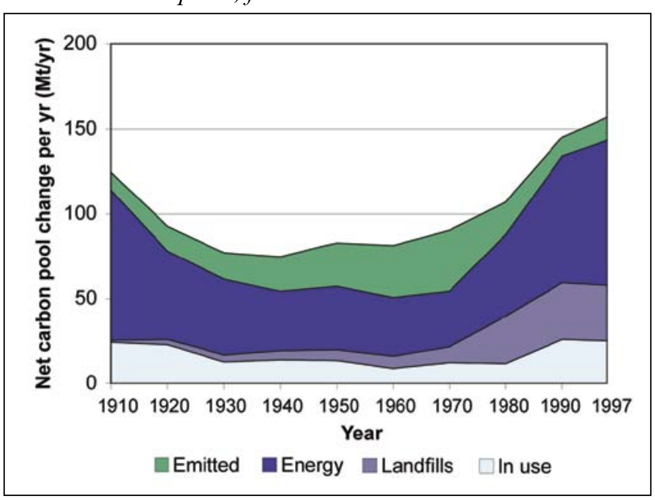
CO_2 sources	
(1) Emissions from fossil fuel combustion and cement production	5.5 + 0.5
(2) Net emissions from changes in tropical land use	1.6 + 1.0
(3) Total anthropogenic emissions = (1) + (2)	7.1 + 1.5
Partitioning among reservoirs	
(4) Storage in the atmosphere	3.3 + 0.2
(5) Ocean uptake	2.0 + 0.8
(6) Uptake by Northern Hemisphere forest regrowth	0.5 + 0.5
(7) Inferred sink: 3 – (4 + 5 + 6)	1.3 + 1.5

long-term changes in land use and harvesting. Millions of acres of forests in the Northeast have regrown on abandoned agricultural land, causing a steep historical increase in carbon, including a substantial buildup on carbon-depleted soils. As these forests mature, the rate of carbon buildup is expected to slow substantially.

The historical pattern is similar in the South Central States, but the more intensive utilization of southern forests for wood products has already leveled past gains as growth and removals have come close to balancing. In the Pacific Coast States, carbon stocks are expected to increase after a recent decline, mainly due to reduced harvest projections as more forest land has been reserved from timber production.

The half-life of carbon in products varies from 1 year for paper (except free-sheet used in books) to 100 years for wood used in new single-family homes. Carbon consumption in 1910 was not exceeded until 1990 (fig. 58). In 1990, some 18 percent of the carbon consumed was added to products in use and 23 percent was added to landfills. About one-half was burned for energy, presumably offsetting fossil fuel or other material that would have been burned.

Figure 58.—*Net changes in carbon in harvested wood products pools (Mt per year) for the United States, including carbon in net imports, from 1910 to 1997.*



Forests in the United States are a sink for carbon in that more carbon is sequestered than is emitted. In terms of annual flux, the change in carbon stored in forests amounted to 82 percent of the change in the stock of carbon in 1990.

Carbon Emissions Avoided With Production and Use of Wood Products

The production and use of wood products in end uses results in emissions of carbon to the atmosphere. To the extent that wood products are used in place of other products (e.g., steel and concrete, or plastics) that generate even larger carbon emissions, it is beneficial to use wood products rather than other products. One major end use that uses wood, steel, and concrete is residential housing. Wood (versus steel or concrete) is used to make 99 percent of roofs, 91 percent of walls, and 69 percent of floors (Wood Products Council 1999).

A life cycle analysis of the emissions associated with production and use of wood versus steel and concrete in housing has found that the global warming potential (for gases emitted) for typical houses is 25 percent to 30 percent greater when steel or concrete is used in place of wood in floors and walls (Lippke et al. 2004). The global warming impact associated with production and use of products for housing may be further reduced if wood is used for more components of walls and for exterior siding in place of alternate materials.

In the future, forests and tree plantations may contribute to global carbon cycles in a third significant way, if biomass fuels—such as cellulosic ethanol—displace significant volumes of fossil fuels. Cellulosic ethanol production is nearing commercial development and is favored by recent shifts in the global price of oil (from the $20 to $25 per barrel range of recent decades to a level above $60 per barrel) (U.S. Department of Energy Biomass Program, http://www/.eere.energy.gov/biomass). If the global oil price shift is, as some now suggest, a structural change due to long-run shifts in the global oil supply-demand balance, then large-scale cellulosic ethanol production may become a reality which could also offset fossil fuel carbon emissions.

Summary

Growth of forests in the United States has exceeded removals at least since 1952; earlier data are not available. Thus, U.S. forests have been a carbon sink—absorbing more carbon than they release. With the advent of sealed landfills in the 1980s, the amount of carbon stored in products increased, especially for paper and other fiber-based products. The annual rate of carbon accumulation in landfills and products in use is projected to increase from 65 million tons in 1990 to 83 million tons in 2040. This change is due entirely to the increasing rate of accumulation in landfills (table 8). Further guidance forthcoming on green house gas inventories and carbon reporting expected from the Intergovernmental Panel on Climate Change may lead to changes in carbon accounting because of reporting on all greenhouse gases, gross versus net changes in carbon, and representation of land area. Carbon management technology is emerging. Forests and rangelands can be part of the solution to reducing atmospheric carbon dioxide and other greenhouse gases. Production and use of wood products in place of alternate products can reduce carbon emissions and their associated contribution to global warming. In the future, biomass grown for cellulosic ethanol production, such as crops, may further offset carbon emissions from fossil fuels.

Table 8.—*United States net carbon accumulation, emission, net imports, and drain from the atmosphere by year.*[1]

	Net carbon flux (Tg)					
	1990	**2000**	**2010**	**2020**	**2030**	**2040**
Change in forests, CIC	274	189	192	176	166	161
Change in products in use, P	26.02	24.99	24.51	25.58	24.27	22.86
Change in landfills, L	33.38	32.48	39.37	42.53	46.89	50.74
Wood burning, WB	74.38	88.07	96.58	102.83	109.27	118.86
Emitted CO_2, ECO_2	11.43	14.02	14.83	15.77	16.49	16.98
Emitted CH_4 from landfills, ECH_4	0	0.23	0.5	0.61	0.62	0.55
Change in stock of carbon[2]	333.40	246.47	255.88	244.11	237.16	234.60
Net imports of wood products, paper, and paperboard (I-3)	2.23	3.26	3.67	3.87	2.84	1.50
Drain from atmosphere, S[3]	331.07	243.21	252.21	240.24	234.32	233.10
Drain from atmosphere in CO_2 equivalents, S_g[4]	331.07	238.61	242.21	228.04	221.92	222.10

[1] Base case projections.

[2] Change in stock of carbon = CIC + $P + L$.

[3] S = CIC + $P - (I - E) + L$. (Net carbon drain from atmosphere.)

[4] Sg = CIC + $P - (I - E) + L$ – 20(ECH_4). (Net carbon drain from atmosphere in CO_2 equivalents.)

Maintenance and Enhancement of Long-Term Multiple Socioeconomic Benefits To Meet the Needs of Societies

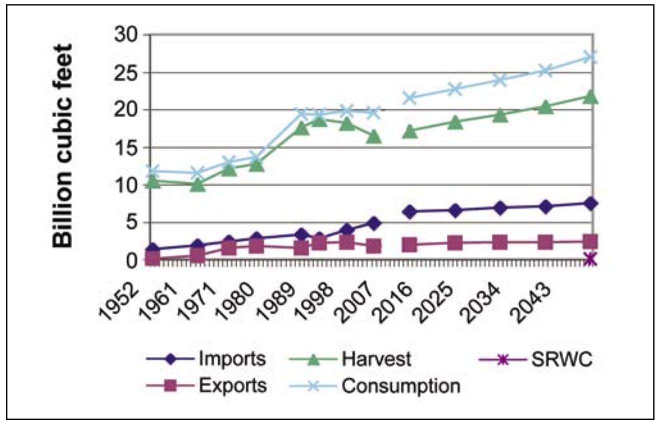
It is important to understand the values that people assign to the existence and use of renewable resources. Resources that have little or diminishing value will tend to be ignored in terms of investment in their maintenance and enhancement or will be converted to other uses. This part of the RPA Assessment Update presents available information for some indicators of socioeconomic values held by society.

Timber

Production and consumption—Haynes et al. (2006) project continued strong growth in total U.S. forest products requirements (domestic consumption plus exports) to 2050. Imports will continue to grow, but will supply a smaller portion of the growth in total wood requirements, and domestic sources a correspondingly larger share, over the next 45 years than was the case during the previous five decades. This reduced role for imports is based largely on the assumption that the allowable annual cut in Canada will be lowered in the future, especially after accelerated harvest in British Columbia in response to the wide-scale infestation of timber by bark beetles. Future harvests from domestic forests alone[6] are expected to grow each year by 0.11 billion cubic feet (Bcf), close to the trend over the past 50 years of 0.12 Bcf/year (fig. 59). At the same time, real product price growth will fall below long-term historical rates for all products.

Over the 50 years from 1952 to 2002, U.S. consumption plus exports of all forest products rose by some 9.5 billion cubic feet per year. U.S. harvest increased by 6.0 billion cubic feet and imports rose by 3.5 billion cubic feet over this same period (fig. 59). Real prices of softwood lumber, hardwood lumber and paper rose (compound rates of 0.8 percent, 0.4 percent and 0.3 percent, respectively), while prices of softwood plywood, oriented strand board (OSB) (since 1976), and paperboard fell. Projected U.S. consumption plus exports increases over the

Figure 59.—*Total U.S. roundwood consumption, harvest, and trade.*



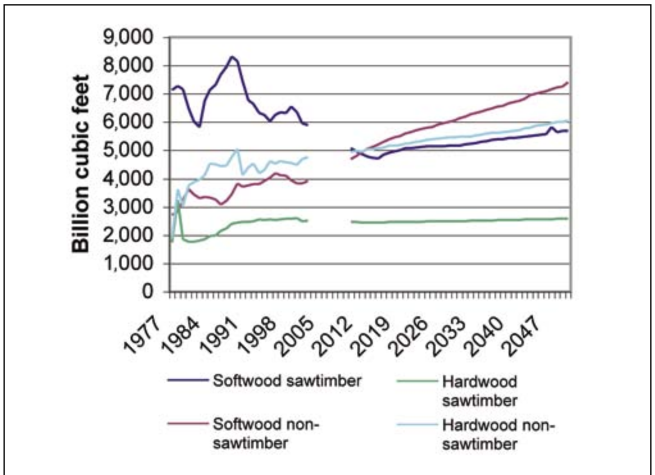
2002–50 period by 8.0 billion cubic feet. Imports grow by 2.6 billion cubic feet, while harvest from forests and short-rotation woody crop (SRWC) plantations rises by 5.4 billion cubic feet.[7] Prices of softwood lumber, hardwood lumber, and OSB rise slowly (0.2 percent, 0.3 percent and 0.1 percent, respectively), prices of softwood plywood, paper, and paperboard remain stable or fall.

Softwood harvest—U.S. softwood growing stock removals rise slowly over the projection at about 0.6 percent per year, driven entirely by expansion of pulpwood consumption (for OSB and wood pulp). Sawtimber cut for lumber, plywood, and other solid wood products declines slightly for the first decade of the projection (to 2015) then recovers to near current levels by 2050 (fig. 60). The decline to 2015 reflects a modest reduction in U.S. softwood lumber production and a steady fall in plywood output. Housing starts are projected to move back to levels of the late 1990s and the recent rapid growth in housing unit size will come to an end. This slowing in end-use activity is reflected in reduced softwood lumber consumption. At the same time, softwood lumber imports, both from Canada and off-shore sources, continue to out-compete domestic products.

[6] Excluding agricultural short-rotation woody crops.

[7] Domestic forest harvest rises by 5.3 Bcf and short-rotation woody crops by 0.1 Bcf.

Figure 60.— *U.S. sawtimber and nonsawtimber harvest by species group.*



The effects of a recently negotiated agreement with Canada regarding softwood lumber imports remain to be tested.[8] Thus, in the period to 2015, imports grow while U.S. output slowly declines. After 2015, driven by expansion in residential upkeep and alteration (and by a resurgence in new housing after 2030), growth in softwood lumber consumption and overall sawtimber harvest resumes. This growth in harvest is also based on the assumption that annual allowable harvest levels will be reduced in Canada. Softwood plywood consumption and output fall steadily through 2030, as substitution by OSB in all major markets continues.

In contrast, U.S. paper and paperboard output and OSB production continue to expand throughout the projection, driving up pulpwood consumption and total softwood nonsawtimber harvest (fig. 60). Between 2006 and 2050, total U.S. pulpwood consumption (at OSB and wood pulp mills) is projected to grow at an average annual rate of just over 0.8 percent, roundwood pulpwood consumption is projected to grow annually at about 1.1 percent, and wood residue pulpwood consumption is expected to decline by 0.7 percent per year. During this period, OSB production will expand at 1.3 percent per year and U.S. pulp production at 0.7 percent per year. OSB consumption will rise steadily, both because it continues to capture market share from softwood plywood and because it accounts for essentially all of the future growth in structural panel consumption.

U.S. paper and paperboard production and consumption both experienced a significant downturn after 1999, associated with economic globalization and a decline in overall U.S. industrial production. Downsizing and import competition have resulted in structural changes in U.S. manufacturing, and also in paper and paperboard production, with substantial labor productivity gains achieved by U.S. producers through consolidation and automation.

In 2004, U.S. output of paper and paperboard increased by more than 4 percent, as one element in a general recovery in U.S. industrial production. Although U.S. paper and paperboard production dipped again, by 1 percent in 2005, it is projected to increase in the period to 2050, in line with expected growth in consumption, population, and overall economic activity. Per capita consumption of paper and paperboard is projected to remain essentially flat at about 700 pounds in the decades ahead. The current growth outlook for U.S. production of paper, paperboard, and wood pulp contrasts sharply with the trends of the late 20th century (fig. 61). Whereas U.S. paper and paperboard output increased at an average annual rate of 2.3 percent from 1970 to 1999, the base projections from 2001 to 2050 yield an average annual rate of only 0.8 percent, with very modest expansion in production capacity.

U.S. wood pulp production is projected to increase at an average annual rate of 0.7 percent (2001 to 2050), less than half the historical growth rate from 1970 to 1999 (fig. 61). Wood pulp output growth stems in part from projected growth in paper and paperboard output and from limited projected growth in domestic recycled fiber use. Paper recovery for recycling in the United States is projected to climb above the current recovery rate of 50 percent, but growth in exports (mainly to China) accounts for the largest share of projected expansion in paper recovery.

[8] According to the framework of the agreement, no tax or quota is in place when the Random Lengths Framing Lumber Composite Price is higher than $355 per thousand board feet. If the Composite Price is $355 or less, the various producing regions in Canada can either pay an export tax of 5–15 percent (the lower the Composite Price, the higher the tax), or pay a lower tax and have a quota in place (Random Lengths 2006)

As U.S. municipalities shift toward single-stream recycling (commingled curbside collection) to reduce collection costs, downstream recycling industries incur higher expenses for sorting and separation. This approach favors shipment of recovered paper to countries such as China, where labor for hand sorting is cheap and paper-recycling capacity is rapidly expanding. U.S. recovered paper exports doubled in the past decade, with China the leading export destination, and are projected to increase from 16 million tons in 2005 to more than 26 million tons by 2050.

Hardwood harvest—Total hardwood harvest on forest land is projected to increase steadily over the projection. On average, hardwood harvest (excluding SRWCs) is projected to increase at 0.4 percent per year from 2005 to 2050. As in the case of softwoods, the increase is due to expansion of the pulpwood component of nonsawtimber harvest (fig. 60).

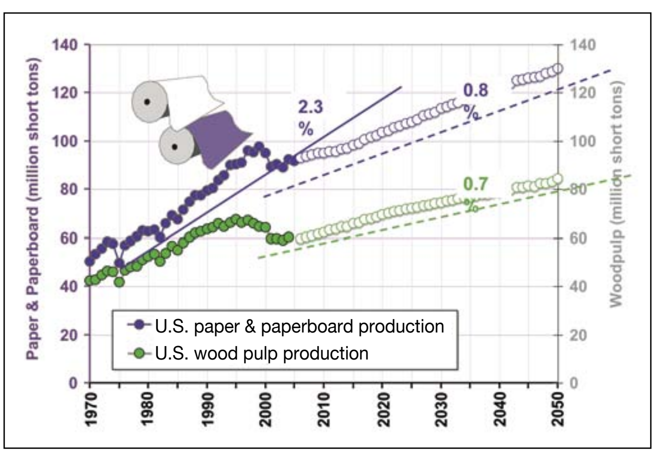
The net effect of the projected trends in fiber use and production is a relatively stable distribution of hardwood and softwood in projected U.S. pulpwood consumption. With increased wood pulp output, pulpwood consumption at pulp mills is projected to increase. The projected trend in hardwood pulpwood consumption is relatively flat as the hardwood share of total pulpwood consumption at wood pulp mills is projected to gradually decline. Historically, increased recycling had a more pronounced impact on growth in softwood pulpwood receipts at wood pulp mills (peaking in the late 1980s, see fig. 62), because recycled fiber use expanded more rapidly in paper and paperboard products that traditionally used large proportions of softwood fiber (newsprint and containerboard). Both softwood and hardwood pulpwood consumption were altered by economic globalization and the downturn in paper and paperboard output of the past decade. In the future, the projected leveling in printing and writing paper output affects hardwood receipts more than softwoods.

Projected growth in U.S. softwood pulpwood consumption (at about 0.9 percent per year between 2006 and 2050) is well below the 1960–2003 trend rate of 1.4 percent (fig. 62). Softwood, however, accounts for the largest share of projected gains in pulpwood consumption. The projected growth in U.S. softwood pulpwood consumption is supplied primarily by southern pine plantations.

In contrast, hardwood harvests for sawtimber products are relatively stable over the projection (fig. 60). This pattern is dictated by end-use consumption trends in hardwood lumber, where declining use for pallets and furniture offset growth in use for millwork and miscellaneous products.

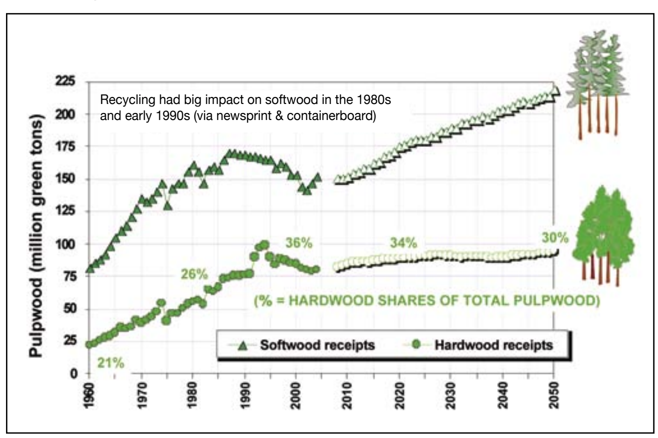
Prices—The 2005 RPA Assessment Update projects a very moderate future for growth in real forest products prices. Prices of some solid wood products are expected to rise (lumber and OSB), but at rates that are small in absolute terms (all 0.3 percent or less) and well below those of the past five decades.

Figure 61.— *U.S. paper, paperboard, and pulp production.*



Source: AF&PA (historical data): TNA (projections, May 2006).

Figure 62.— *U.S. receipts of pulpwood at pulpmills by species group.*



Source: FRA & Forest Service (historical data): TNA (projections, March 2006).

Prices for the large aggregates of paper and paperboard are expected to decline in real terms (fig. 63). Limited product price growth derives from continued improvements in input use efficiency in domestic production, competition from substitute products, and continued pressure from lower cost imports across the whole array of product classes.

Slow product price growth is reflected in many categories of timber prices (fig. 64). Sawtimber stumpage prices in the South and interior West decline slowly after 2010, while those in western Washington and western Oregon and the North rise at about 0.2 percent and 0.8 percent per year. Southern hardwood pulpwood prices rise in the projection as hardwood inventories contract. Southern softwood pulpwood prices oscillate in response to the changing fiber mix, ending the projection near recent levels.

Employment—Total employment in the forest sector is increasing and accounts for roughly 2 percent of all U.S. jobs (fig. 65). This percentage includes employment in wood and paper products firms, forest-based recreation, forest management, and forestry education (Skog et al. 2004). In 2000, jobs in logging, lumber and wood products, and paper and allied products were 1.1 percent of all U.S. jobs and 8.1 percent of manufacturing jobs (849,000 and 660,000 jobs, respectively). These percentages indicate a decline in share of jobs since 1950, from 2.5 percent of all jobs and 8.6 percent of manufacturing jobs. However, employment in logging, lumber, and wood products in 2000 was higher than in 1950 (849,000 and 824,000 jobs, respectively), as was the case for paper and allied products (660,000 and 485,000 jobs, respectively). Jobs in wood furniture industries were 182,000 in 1997.

Although the current number of direct jobs from forest-based recreation is uncertain, a rough estimate for the United States is 1.1 million or 0.8 percent of all U.S. jobs (table 9). An increase may be inferred by the increase in participation in U.S. forest recreation.

Jobs in forest management include those in the Forest Service, 29,400 in 2001, down from 37,236 in 1980; jobs on tribal lands in the DOI Bureau of Indian Affairs and tribal governments,

Figure 63.—*Real prices for forest products.*

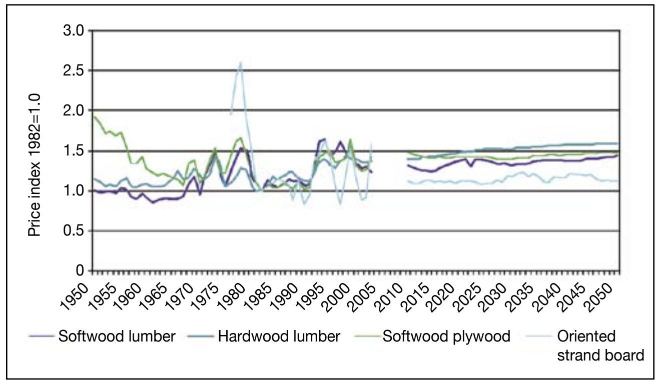


Figure 64.—*Real prices of softwood sawtimber stumpage by region and real pulpwood stumpage prices in the South (all in 1982 dollars).*

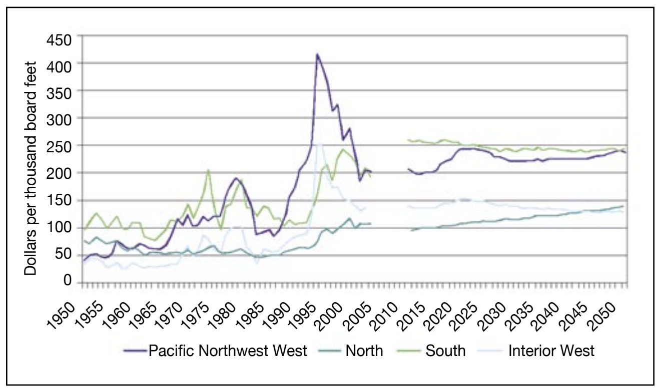


Figure 65.—*Employment in wood and paper products mills as a percentage of total employment and manufacturing employment from 1930 to 2000.*

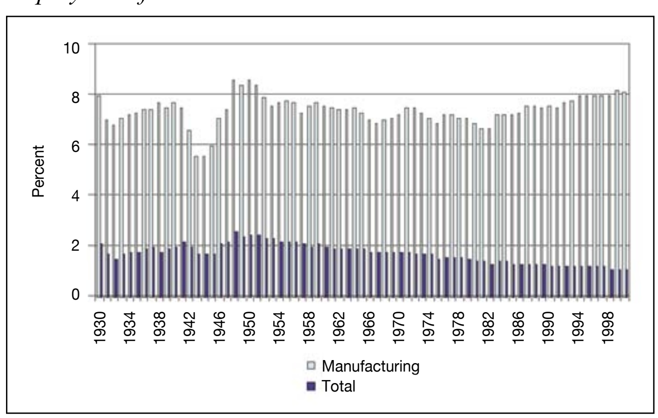


Table 9.—*Direct employment and indirect employment from indirect and induced effects of four forest-based sectors in 1999.*

Industry	Jobs per million dollars industry output				Industry output (million $)	Number of jobs[1]			
	Direct effect	Indirect effect	Induced effect	Total effect		Direct effect	Indirect effect	Induced effect	Total
Wood products	7.7	9.0	8.9	25.6	122,715	941,302	1,106,253	1,089,924	3,137,471
Wood furniture	8.2	8.3	9.2	25.8	70,963	584,973	588,602	655,881	1,829,448
Pulp and paper	4.0	7.8	8.2	20.1	167,293	669,733	1,310,387	1,375,560	3,355,671
All wood products	6.1	8.3	8.6	23.1	360,971	2,196,008	3,005,238	3,121,361	8,322,607
Recreation/tourism	16.1	5.8	8.1	30.3	67,726	1,091,576	389,568	549,569	2,030,713

[1] Number of jobs includes full-time, part-time, and self-employed jobs.
Source: Minnesota Implan Group, Inc. 1997, using 1999 data.

about 900 in the early 1990s; in State forestry agencies, 12,405 permanent and 5,648 seasonal in 1996; in the BLM, 9,728 in 1997; and an undetermined number in county and municipal governments, private land management organizations, private consultants, and private forest-resource-related organizations.

Firefighting and support jobs during fire season have recently numbered from 12,000 to 15,000 a year nationwide. Management of forests in parks includes forests in the National Park Service (18,361 total in 1997), and thousands of jobs in forests managed by State, county, tribal, and municipal governments.

Jobs in forest management education and research in 2001 include colleges and universities, 1,361; Forest Service research, 701 (included in the Forest Service total), and industry research, 124; and an undetermined number in providing forest resource education in high schools, and in education efforts of private associations and organizations.

Total forest-related jobs are estimated to be close to 3 million or a little more than 2 percent of all U.S. employment. This estimate does not include indirect jobs generated by expenditures of government agencies, businesses, or others.

Direct jobs in forest-based recreation and tourism employment is estimated to be highest in the North, followed by the South, Rocky Mountains, and Pacific Coast.

In 1997, forest products industry employment was highest in the North, at about 600,000, followed by the South (550,000), Pacific Coast (200,000), and Rocky Mountains (70,000). In 1996, employment in State forestry agencies was highest in the South (6,064 permanent and 1,508 temporary), followed by the North (3,399 permanent and 1,934 temporary), Pacific Coast (2,017 permanent and 1,714 temporary), and Rocky Mountains, (924 permanent and 492 temporary).

Indirect jobs (from indirect and induced effects) supported by expenditures of wood products firms, furniture firms, paper products firms and forest-recreation-related business, are estimated to be 2.2 million, 1.2 million, 2.7 million, and 0.9 million, respectively (table 9).

Alternative futures for timber and related markets— Haynes et al. (2006) projected various measures of timber inventory and timber markets in a "base case" (discussed previously). They then varied background assumptions one at a time and recast the projection to learn more about the sensitivity of outcomes to external conditions. Seven alternative projections are (1) increased timber harvest in British Columbia caused by an effort to salvage mortality due to an outbreak of mountain pine beetle, (2) a stronger U.S. dollar, (3) accelerated reduction in other private timberland area, (4) possible effects of climate change on timber growth rates, (5) increased public timber harvest in the West consistent with one possible restoration thinning program, (6) planting of additional plantations to sequester carbon, and (7) reduced rate of pine plantation establishment on other private lands in the south-central region. Rationales for selection of the alternatives are discussed in Haynes et al. (2006).

Each of the alternatives was modeled as a shift in timber supply. The availability of many types of substitute products and many sources of supply for any given forest product act to reduce the price impacts of supply shifts in forest product markets. For example, increased public harvest in the West under a restoration thinning program raises western softwood lumber output, but reduces production in the South and lowers the volume of softwood lumber imports. Of the western softwood lumber increment, 75 percent is offset by substitution across regional suppliers.

Substitution also regulates adjustment to supply shifts within a region. For example, fewer acres of planted pine on nonindustrial private forest lands in the south-central region cause stumpage prices to increase. Forest industry and institutional owners in the south-central region respond to the higher prices by increasing output and moderating the stumpage price increase.

Box 20

Timber processing capacity for various products in the West—A special concern related to timber supply is the availability of processing capacity. This issue was previously highlighted as a potential issue related to globalization and the continued loss of the timber industry. The lack of processing capacity is also an issue in the West in regards to markets for small-diameter timber. The need to clear more small-diameter timber in the West to restore forest health has been highlighted in the Healthy Forest Restoration Act of 2003 (HR 1904). Keegan et al. (2004) estimated timber processing capacity and capabilities in the Western United States for trees less than 7 inches diameter breast height (d.b.h.), trees 7 to 9.9 inches d.b.h., and trees equal to or greater than 10 inches d.b.h. Timber processing capacity is defined as the volume of timber that could be used by existing timber processors if demands for products were firm and sufficient raw materials were available. Timber processing capability is the volume of trees that could be processed efficiently at prices comparable to 1999–2001. The study area included the Pacific Coast and Rocky Mountains regions less the Great Plains States.

Calculations of timber processing capacity and timber use included facilities that primarily use timber to manufacture products. Sawmills, veneer/plywood plants, and producers of utility poles and pilings, posts, small poles, stakes, roundwood furniture, house logs and log homes, vigas and lattillas, cedar shakes, shingles, and split rail fencing were included. Timber use was estimated separately for manufacturers that primarily use industrial fuelwood or roundwood pulpwood, as well as log exporters.

In the study regions between 1986 and 2003, harvest on national forests declined from 9.9 billion board feet to 1.1 billion board feet. Associated with the decline in harvest was a 37-percent decline in capacity to process timber and a 32-percent decline in timber use. In the late 1980s, mills received 40 percent of their timber from national forests. By 2003, less than 10 percent of timber harvested in the study area came from national forests. Most of the capacity decline (from 5 to 3.18 billion cubic feet) occurred between 1986 and 1996. Capacity remained essentially unchanged from 1996 to 2003; however, timber use increased 6 percent between 1996 and 2003. Proportionately, capacity declines were greatest in the four corners area which was also the area with the greatest dependence/use of national forest timber.

Most of the timber processing capability (94.7 percent) and use (97.3 percent) is in the five States of California, Idaho, Montana, Oregon, and Washington (table 10). Use amounted to 77.6 percent of capability. Alaska has the lowest use versus capability (12.8 percent). Sawmilling capability to process timber less than 7 inches d.b.h. amounted to 2.4 percent of the total capability. About 59 percent of the capability to process timber less than 7 inches d.b.h. was located in Oregon and Washington. About 25 percent of the capability was used.

Box 20 (continued)

The capability to process timber 7 to 9.9 inches d.b.h. amounted to 17.7 percent of the total capability and 7.9 percent of use. Use as a percent of capability for timber 7 to 9.9 inches d.b.h. was 34.7 percent. Much of the capability (87 percent) to use timber in this size class was in California, Montana, Oregon, and Washington. Actual use of timber in this size class was mainly (73 percent) in Oregon and Washington.

Timber was also used for pulpwood and industrial fuelwood, or was exported as logs. Since 1986, use of timber for pulpwood and industrial fuelwood in the study area ranged from about 100 million cubic feet to 300 million cubic feet annually. In recent years, the total annual use of roundwood for pulp and industrial fuel has been near the low end of the range, with more than 50 percent of the volume from live trees greater than or equal to 10 inches d.b.h. Log exports during the 1986 to 2003 period ranged from more than 850 million cubic feet annually in the late 1980s to less than 200 million cubic feet in recent years. Virtually all exported timber was from trees greater than or equal to 10 inches d.b.h.

Table 10.—*Timber processing capability (million cubic feet) and percent used by State and tree diameter class.*

State	Tree d.b.h. (inches)					
	Less than 7.0		7.0 to 9.9		All sizes	
	Capability	% used	Capability	% used	Capability	% used
AK	< 0.05	NA	2.0	< 0.02	47.0	12.8
AZ	0.2	100.0	1.1	100.0	18.7	69.0
CA	9.4	0.5	60.0	22.2	558.7	65.0
CO	3.0	43.3	16.2	22.2	35.0	48.3
ID	3.9	76.9	34.5	33.0	264.9	83.8
MT	9.1	29.7	77.3	26.1	226.6	76.7
NM	0.4	25.0	1.4	12.3	7.3	59.3
OR	27.0	33.3	225.0	51.1	1,104.0	86.6
UT	1.2	41.7	48.0	20.8	12.7	48.8
WA	17.0	< 0.01	126.0	21.4	840.0	79.9
WY	3.7	29.7	12.8	7.8	41.9	41.1
Total	**74.9**	**24.6**	**561.1**	**34.7**	**3,161.8**	**77.6**

Water

About 70 percent of the Earth's surface is covered with water. Some 97.5 percent of the water on the planet is in oceans and is too salty to drink or grow crops. Most of the 2.5 percent that is not salt water is tied up in ice caps. Less than .00008 percent is annually renewable and available in rivers and lakes for human and wildlife use (Sedell et al. 2000).

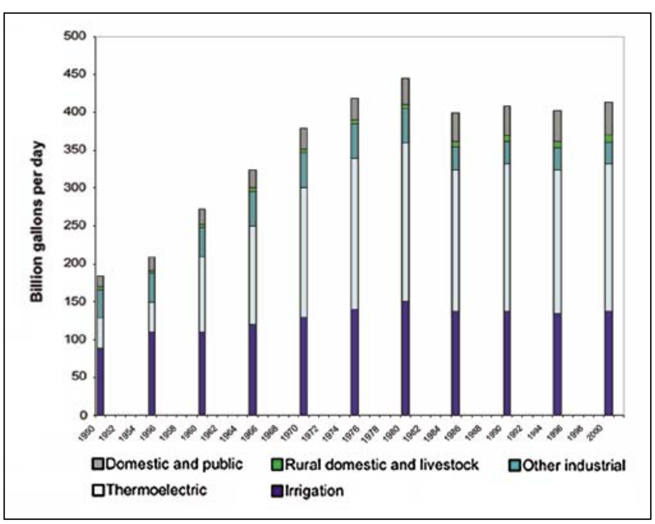
Supply—The supply of usable water is largely fixed. Most opportunities to develop water sources have been implemented. Some existing sources of water, such as dams, are losing their utility because of siltation. The demand for water continues to increase. Because of fixed supply and increasing demand, the value of the water resource is increasing.

About 53 percent of the Nation's water supply originates on forest land, 26 percent on agricultural land, and 8 percent on rangeland (Brown et al. 2005). Forested areas contributed 49 percent of the water supply in the conterminous States west of the Mississippi River and 56 percent in the East. Most of the rangeland is west of the Mississippi River, and thus rangeland is more important as a source of water in the West than in the East. Agriculture is relatively more important as a source of water east of the Mississippi River than for the West.

About 24 percent of the water supply in the contiguous 48 States originates on Federal land. Eighteen percent of the Nation's water supply originates on lands of the NFS alone even though these lands occupy only about 11 percent of the surface area. Land in State and private ownership supply the remaining 76 percent. Because Federal lands are concentrated in the western part of the country, the contributions of Federal lands to water supply are relatively more important west of the Mississippi River than for lands east of the Mississippi. West of the Mississippi River, 42 percent of the Nation's water supply originates on Federal land, with 32 percent on Forest Service land alone compared with 9 percent and 7 percent, respectively, east of the Mississippi.

Withdrawals—After continual increases in the Nation's total water withdrawals for offstream use for the period 1950–80, withdrawals declined from 1980 to 1985 and stabilized at about 400 billion gallons per day through 2000 (fig. 66) (Hutson et al. 2004).

Figure 66.—*Water withdrawals for off-stream use by type of use.*



Estimated withdrawals for public supply increased continuously since 1950, along with population served by public suppliers. The percentage of population served by public suppliers increased from 62 percent in 1950 to 85 percent in 2000.

Estimated withdrawals for self-supplied domestic use increased by 71 percent between 1950 and 2000. The self-supplied domestic population was 57.5 million people in 1950, or 38 percent of the total population. For 2000, 43.5 million people, or 15 percent of the total population, were self-supplied.

Data for withdrawals for livestock and aquaculture use includes fish farms from 1985 to 2000. Withdrawals increased from 1985 through 1995. Data for a total in 2000 is not available.

Withdrawals for irrigation increased through 1980 and then stabilized. Depending on the geographic area of the United States, the decrease since 1980 can be attributed to climate, crop type, advances in irrigation efficiency, and higher energy costs.

Thermoelectric power has been the category with the largest water withdrawals since 1965. Since 1980, withdrawals have been relatively stable. Withdrawals were affected primarily by Federal legislation that required stricter water quality standards for return flow and by limited water supplies in some areas of the United States. The average gallons of water to produce 1 kilowatt-hour decreased from 63 in 1950 to 21 in 2000.

The decline in other industrial use reflects stricter water quality standards for water discharges which encouraged conservation, greater efficiency, and lower water-using technologies. The decline in withdrawals is also attributable in part to a decline in manufacturing and reclassification of fish farms in 1985. Data for a total is not available for 2000.

Possible future trends—Brown (1999) projected total U.S. withdrawals to rise by 7 percent between 1995 and 2040 despite a projected 41-percent increase in population. This situation reflects the improving efficiencies projected for the municipal and industrial and thermoelectric sectors and the projected reductions in total irrigation withdrawals.

Minerals[9]

Production and consumption—In 2004, the U.S. economy used more than $200 billion of domestically produced nonfuel minerals plus more than $100 billion of domestically produced crude oil, natural gas, and coal. In addition, the U.S. economy also depended upon domestic reclaimed metals, mineral materials, and imports of energy and mineral raw materials.

A wide range exists in the extent of domestic production of minerals. The United States mining industry accounts for about one-quarter of the world's production of molybdenum and phosphate and about one-fifth of the natural gas and coal. It produces no chromium and very little of the metals in the platinum group. The United States is a net exporter of gold and molybdenum. About 40 percent of the unprocessed minerals and 12 percent of fertilizer and chemical minerals currently used in the United States are imported.

The Nation has extensive coal reserves and is a net exporter of coal. Coal production west of the Mississippi River exceeded production east of the Mississippi River for the first time in the late 1990s. More than 90 percent of the total U.S. energy needs are met by petroleum, natural gas, or coal. In contrast to coal, the United States relies on imports for 57 percent of petroleum consumption and 15 percent of natural gas consumption.

Investment—The contribution of energy and minerals industries to the U.S. gross domestic product declined from 2.66 percent in 1977 to 1.37 percent in 2001. Some of the decrease reflects lower prices and some decreased production, as well as increased growth in other sectors of the economy. Despite this decline in relative importance, the industry remains essential to the national economy and is especially important for the economies of some States. For example, in 2001, the nonrenewable resource sectors accounted for 22.2 percent of the gross State product in Wyoming, 16.7 percent in Alaska, 14.9 percent in Louisiana, and 9.1 percent in West Virginia.

Employment—Employment in all sectors of the industry peaked in the late 1970s or early 1980s. The decline reflects in part declines in production levels (oil and gas), increases in productivity (coal), and changes in extraction technology (metals). In 2001, the mineral industry employed about 558,000 people.

Real hourly wages ($1996) for all production workers increased slowly from $11.77 in 1977 to $13.34 in 2001. Compensation in the metals mining industry increased from $16.33 in 1977 to $19.05 in 2001 and for nonmetals, from $13.03 to $15.53. For all production workers and the metal and nonmetal sectors, most of the increase in wages occurred in the 1990s. Wages in the coal industry were $18.48 in 1977, peaked at $20.74 in 1984–85, and declined to a low of $17.80 in 2001. For oil and gas, wages were $14.29 in 1977, a peak of $15.40 in 1986, reaching a low of $14.51 in 1990, and increasing to $18.65 in 2001.

Outdoor Recreation

Availability of facilities for recreation and tourism found on forests and rangelands, and their use by people, are indicators of whether people enjoy the out-of-doors for these purposes, and that they are therefore likely to support management of the land on a sustainable basis. Research examining forest visitor perceptions about livestock grazing has shown that most forest visitors are conditionally supportive of management if the management objective provides for sustaining ecosystem health, protecting streams and lakes, and reducing conflicts among various user groups.

Available data are primarily for participation in recreational activities regardless of the type of land or its ownership. Thus, no direct measurements of recreation and tourism occur on forest land or rangeland.

For availability of forest land, we know that almost all publicly owned forest land (42.5 percent of the total forest land area) is available for recreational purposes. Lack of access or regulation

[9] The analysis in this section on minerals is from personal communication from Deborah Shields, Rocky Mountain Research Station, Fort Collins, CO.

of permitted activities such as in Wilderness areas may limit recreational use of these lands. Access to privately owned forest lands for recreational purposes can vary by ownership. From a survey of owners of private forest land, we do know that recreational use of their land is a primary objective for many owners (Butler and Leatherberry 2004). The proportion of privately owned forest land open to the public and free of charge declined steadily from 29 percent in 1979 to 23 percent in 1989, 15 percent in 1996, and 11 percent in 2001. Access to the remaining privately owned forest land is at the discretion of the owner and can vary from no access to free access. Recreational activities most likely to occur on private lands by the general public are hunting and other activities that require large open areas.

Participation—Congress created and funded the Outdoor Recreation Resources Review Commission (ORRRC) to study demand and supply of outdoor opportunities for Americans (Outdoor Recreation Resources Review Commission 1962). From that time, we have tracked outdoor recreation trends in this country using the National Recreation Survey Series that was begun by ORRRC. Here, we examine long- and short-term trends in Americans' participation in outdoor recreation activities. All data are from various applications of the National Recreation Survey, the most recent of which has been published as a book entitled Outdoor Recreation for 21st Century America (Cordell et al. 2004).

Trends since 1960—Since the first national recreation survey was conducted in 1960, the number of people legally living in this country has expanded to 300 million (U.S. Bureau of the Census 2006). That first survey was conducted in 1960 and reported in 1962. It is this survey and subsequent ones that we reference in examining briefly long-term participation trends. Subsequent national recreation surveys were repeated in 1965, 1972, 1977, 1982, 1995, 2000, and 2001.

Population growth has been highly correlated with changes in recreation participation seen in this country over the past 44 years. But population is not the only factor underlying growing outdoor recreation participation. Continuing growth in economic welfare, improved personal equipment technology, easier transportation, and better information are also contributors. Within the overall growth we have seen in outdoor recreation participation, some activities have grown faster, and some slower. This shifting in the hierarchy of popularity among activities clearly indicates that people's tastes, abilities, and the supply of opportunities has been changing.

Growing fastest between 1960 and 2000–01 are bicycling, camping, canoeing/kayaking, and swimming. Advancement of the technology of bicycles has transformed what was once a close-to-home, slow-paced activity into one involving many different types of biking with a wide variety of equipment and outdoor venues. The appearance of mountain bikes in the late 1970s and especially their more affordable availability beginning in the early 1980s was an especially significant development.

Technology and changing lifestyles also have impacted outdoor activity. Camping is a good example. Campgrounds now serve less the tent camper of the 1960s and more the contemporary travelers with large, high-technology motor homes and towed residences. Hookups for electricity, water, sewage, cable TV, phone, and high-speed cable for lap tops are no longer considered just nice-to-have amenities. Campers also demand hot showers, computer games, and other entertainment for children.

Participation in canoeing and kayaking grew from 2.6 million in 1960 to approximately 15 million in 1982–83, and then to 27.7 million in 2000–01. Today's kayaks include hole-riding boats, surfing boats, boofing boats, squirting boats, beginner boats, intermediate boats, advanced boats, and boats for all sizes of paddlers. Swimming, unlike other fast-growing activities, is not especially driven by technology. Its slower paced rise has been driven by persistent popularity and population growth. From 1995 to 2001, the proportion of people who said they went swimming outdoors in the past year held constant at about 55 percent. Due to population growth, however, this steady percentage participating has meant an increase of about 9 million swimmers to approximately 125 million.

Trends in the past 20+ years—Viewing or photographing birds was the activity growing fastest in this country from the early 1980s up to the early 2000s. There were more than 50 million additional birding participants in 2001 than in the early

1980s. Since the 1982–83 national survey, the growth rate in birding participation has exceeded 231 percent. Following birding has been day hiking and backpacking at 194 and 182 percent growth, respectively. Snowmobiling grew 125 percent in those almost 20 years between surveys. A second motorized activity within the list of fastest growing activities was driving motorized vehicles off road, including all-terrain and other four-wheel-drive vehicles.

Other activities growing fast, at between 50 and 100 percent since 1982, were attending outdoor concerts, plays and other events; walking for pleasure; camping in developed sites; canoeing or kayaking; running or jogging; downhill skiing and swimming in natural waters (i.e., streams, lakes, and oceans). Five of these seven activities are physically active. Growing at between 25 and 50 percent were the activities of ice skating, visiting nature centers/museums/etc., picnicking, horseback riding, sightseeing, and driving for pleasure. Most of these activities are relatively passive and are done within the confines of development or vehicles.

Because, generally, men participate in most activities at higher rates than women, the trends men set tend to have more influence on most population-wide activity trends (table 11). Trends in participation in walking for pleasure, running/jogging, driving motor vehicles off road, primitive camping, backpacking, fishing and snowmobiling have been greatly influenced by growth in participation by men. For most activities, however, participation by women has grown substantially and is becoming a larger overall share of the participant numbers. Regarding age-related trends, participation by the oldest age group, persons age 60 or older, was strongly up for a number of activities—putting older Americans among the outdoor trend setters. Regarding race (not shown in table 11), whites' trends in participation was a major driver of population-wide trends for most activities, especially for

Table 11.—*Estimated percentages of persons age 12 years or older who participated one or more times in the 12 months from 2000–01 and 1982–83[1] by activity, gender, and age.*

Activity	Population	Male	Female	Age 12–24	Age 25–39	Age 40–59	Age 60+
Land activities							
Walking for pleasure	83.1 (53)	79.8 (45)	86.0 (61)	84.7 (57)	83.8 (58)	84.6 (53)	78.8 (42)
Visiting nature centers, etc.	57.1 (50)	57.7 (50)	56.6 (51)	57.1 (65)	66.9 (62)	60.1 (41)	39.8 (26)
Picnicking	53.9 (48)	51.2 (45)	56.4 (51)	46.1 (52)	60.8 (59)	59.6 (46)	46.0 (29)
Sightseeing	51.4 (46)	49.7 (45)	53.0 (46)	45.4 (46)	53.9 (54)	56.7 (47)	46.7 (31)
Driving for pleasure	51.0 (48)	51.1 (47)	51.0 (49)	47.8 (48)	53.1 (59)	55.7 (46)	43.7 (35)
Attending outdoor sports events	50.7 (40)	56.0 (44)	46.1 (36)	62.7 (55)	53.6 (44)	49.1 (36)	35.9 (16)
Attending outdoor concerts, etc.	40.7 (25)	40.6 (25)	40.7 (26)	53.7 (34)	39.4 (29)	38.8 (22)	30.6 (12)
Bicycling	40.7 (32)	45.3 (33)	36.5 (32)	56.9 (55)	46.9 (37)	37.3 (22)	19.1 (7)
Running or jogging	37.3 (26)	44.7 (30)	30.6 (23)	73.9 (51)	38.1 (31)	23.4 (13)	12.3 (2)
Day hiking	33.3 (14)	37.0 (15)	29.9 (13)	33.8 (19)	40.3 (17)	35.5 (12)	19.2 (5)
Viewing/photographing birds	31.8 (12)	29.3 (11)	34.1 (12)	24.1 (10)	30.1 (12)	38.4 (12)	35.6 (13)
Camping (developed)	26.8 (17)	28.7 (18)	25.1 (16)	32.7 (24)	31.1 (22)	27.1 (15)	14.3 (5)

Table 11.—*Estimated percentages of persons age 12 years or older who participated one or more times in the 12 months from 2000–01 and 1982–83[1] by activity, gender, and age (continued).*

Activity	Population	Male	Female	Age 12–24	Age 25–39	Age 40–59	Age 60+
Playing outdoor team sports	24.5 (24)	33.0 (30)	17.0 (18)	49.8 (50)	27.0 (26)	15.4 (11)	4.7 (2)
Driving off road	18.3 (11)	23.2 (14)	13.8 (8)	28.9 (20)	20.9 (11)	15.1 (6)	6.3 (2)
Golfing	17.2 (13)	25.3 (20)	9.8 (7)	22.3 (16)	18.7 (13)	16.3 (13)	10.2 (7)
Camping (primitive)	16.6 (10)	22.0 (11)	11.7 (8)	24.2 (17)	18.6 (11)	15.1 (6)	6.0 (2)
Playing tennis outdoors	12.7 (17)	13.9 (18)	11.7 (16)	28.1 (32)	11.7 (20)	7.4 (10)	2.9 (1)
Hunting	11.6 (12)	20.3 (22)	3.7 (3)	15.3 (15)	12.3 (13)	11.3 (13)	6.8 (5)
Backpacking	11.1 (5)	14.6 (6)	7.9 (3)	16.4 (9)	13.8 (5)	9.7 (2)	2.5 NA
Horseback riding	10.2 (9)	10.6 (8)	9.8 (10)	16.3 (18)	11.6 (10)	9.1 (5)	2.7 (1)
Water activities							
Swimming in natural waters	42.8 (32)	45.5 (34)	40.5 (30)	56.4 (49)	50.1 (40)	41.7 (21)	17.8 (7)
Swimming in outdoor pool	42.6 (43)	41.0 (43)	44.0 (42)	63.5 (67)	48.5 (49)	37.0 (33)	18.0 (11)
Fishing	34.7 (34)	45.1 (47)	25.4 (23)	42.4 (43)	37.6 (40)	34.9 (31)	22.1 (17)
Motorboating	24.8 (19)	29.4 (22)	20.7 (16)	29.6 (25)	27.8 (23)	24.9 (17)	14.5 (7)
Canoeing or kayaking	12.1 (8)	14.6 (10)	9.9 (7)	19.2 (14)	12.9 (9)	11.2 (6)	3.8 (1)
Waterskiing	8.8 (9)	11.1 (11)	6.8 (7)	17.7 (17)	10.1 (12)	5.6 (4)	0.8 NA
Sailing	5.3 (6)	5.5 (7)	5.2 (5)	7.6 (9)	5.3 (7)	5.2 (5)	2.8 (2)
Snow and ice activities							
Sledding	15.7 (10)	16.6 (12)	14.8 (9)	30.5 (22)	19.7 (11)	10.9 (5)	2.3 NA
Skiing downhill	9.1 (6)	11.1 (8)	7.3 (5)	16.1 (12)	10.6 (8)	7.0 (3)	1.3 (1)
Ice skating	7.7 (6)	7.6 (6)	7.7 (6)	18.2 (15)	8.2 (6)	4.4 (3)	0.6 NA
Snowmobiling	5.9 (3)	7.6 (4)	4.5 (2)	10.5 (6)	6.8 (3)	4.3 (2)	1.3 NA
Skiing cross country	3.9 (3)	4.3 (4)	3.6 (3)	5.3 (5)	3.9 (4)	4.7 (3)	1.4 NA

[1] 1982–83 information in parentheses.

NA = Not available.

Sources: 1982–1983 National Recreation Survey; National Survey on Recreation and the Environment, 2000-2001.

outdoor sporting events, day hiking, viewing/photographing birds, golfing, primitive camping, swimming, motor boating, canoeing/kayaking, and snowmobiling.

Trends since 1995—The most popular activities in 2000–01 (those having the most participants), included walking for pleasure, outdoor family gatherings, and visiting a beach. These are the same activities that were at the top in 1994–95. Examining percentage growth by activity, however, shows that the hierarchy of popularity among activities is changing over time. Of the 62 activities examined through the National Survey on Recreation and the Environment, many at the top of the list, when ranked by percentage growth from 1994–95 to 2000–01, are physically demanding (table 12). Highly physical and challenging sports, such as kayaking, snowboarding, backpacking, and mountain climbing, typically require specialized equipment and skills not possessed by everyone. Together with larger numbers of people participating in outdoor activities in 2001, a changing mix of activities means very noticeable differences between what one would have witnessed at a typical outdoor area in earlier times, and now. Many of the activities at or near the top of this list in terms of percentage growth do not represent large numbers of added people (for example, participants in kayaking) while others further down the list with lower percentage growth have increased substantially in total numbers. Numbers reporting viewing and photographing wildlife, for example, have risen by more than 34 million and viewing or photographing fish have risen by more than 26 million.

Table 12.—*Participation percentages and number of participants in the United States by the 20 fastest growing activities from 1994–95 to 2000–01.*

Activity	Percent participating 1994–95	Millions of participants 1994–95	Percent participating 2000–01	Millions of participants 2000–01	Percent increase 1994–2001
Kayaking	1.3	2.6	3.5	7.4	185.7
Snowboarding	2.3	4.4	4.9	10.4	134.8
Jet skiing	4.7	9.3	9.5	20.3	119.3
Viewing or photographing fish	13.7	26.8	24.8	52.8	96.8
Playing soccer outdoors	4.7	9.3	8.1	17.3	87.2
Snowmobiling	3.6	7.0	5.6	11.8	70.2
Ice fishing	2.0	3.9	2.9	6.2	59.5
Sledding	10.2	20.0	14.7	31.2	56.2
Viewing wildlife	31.2	61.1	44.7	95.2	55.8
Backpacking	7.6	14.8	10.7	22.8	53.8
Day hiking	23.8	46.7	33.3	70.9	51.8
Canoeing	7.0	13.8	9.7	20.7	50.7
Bicycling	28.7	56.1	39.5	84.2	50.0
Horseback riding	7.1	13.9	9.7	20.6	48.0
Mountain climbing	4.5	8.8	6.0	12.9	46.5
Running or jogging	26.2	51.3	34.5	73.6	43.5
Coldwater fishing	10.4	20.3	13.6	28.9	42.8
Ice skating outdoors	5.2	10.3	6.9	14.6	42.7
Surfing	1.3	2.6	1.7	3.6	40.4
Camping developed	20.7	40.5	26.4	56.2	38.7

Sources: NSRE 1994–95 data (1995 number of participants based on estimate of 195.8 million, civilian, noninstitutionalized population 16 years and older); NSRE 2000–2001, Versions 1-9 (2000–01 number based on estimate of 213.1 million, civilian, noninstitutionalized people 16 years and older).

National forests in many areas serve a unique role in providing recreational opportunities. For example, roaded areas in natural settings increasingly are to be found only on public lands.

Participation in recreation and tourism is a function of the availability and supply of recreation opportunities as well as the demand for recreation. Demand for outdoor recreation and tourism is driven in part by population, disposable income, and people's tastes and preferences. For many outdoor recreation and tourism activities, the availability of facilities determines whether the activity is possible or not.

Implications of participation rates—A fixed land base with a growing population and increasing demands for recreation has many management implications, including a smaller and more fragmented rural land base and less "connectiveness" between people and the land. Perhaps the most important implication is greater conflicts and competition for access to land. For example, the public puts clean water, protection for future generations, wildlife habitat, and naturalness at the top of their list of most highly valued purposes for public forests (Tarrent et al. 2003). These uses are often at odds with motorized and resource extraction uses.

Possible future trends—Cordell (1999) presents projections of participation by selected recreation activities. In part due to projected rising incomes, the number of participants in most recreation activities is projected to increase faster than the rates of growth in population. Increased rates of participation are expected in most activities. The expected increasing number and diversity of the U.S. population will affect future recreation patterns. The population is also aging and fewer people come from a rural background.

Wilderness

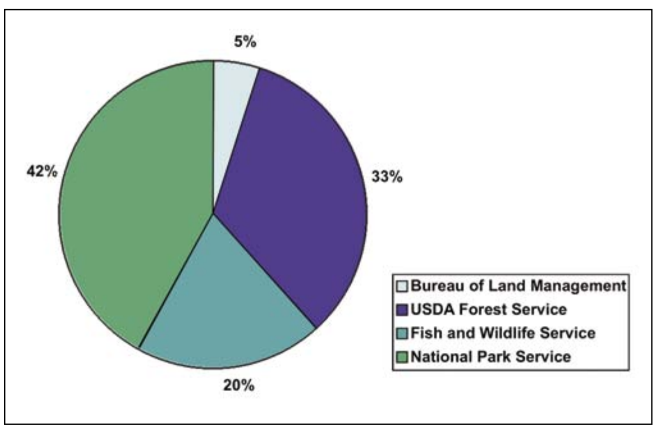
Status of the system—The National Wilderness Preservation System (System) was started in 1964 with 54 areas that totaled 11.4 million acres. Over the past decades, the System has grown to 662 units that, as of January 2004, totaled about 106 million acres. The System is expected to continue to grow. The System is managed by the BLM, Forest Service, U.S. Fish and Wildlife Service, and National Park Service. The Forest Service manages 33 percent of the total area in the System (fig. 67). The NPS has the largest area to manage—41 percent of the total.

Alaska has 55 percent of the designated area where it accounts for 15.9 percent of the total land area. Wilderness areas comprised 5.8 percent of the total land area in the rest of the West, 0.5 percent in the South, and less than 0.3 percent in the North. Most of the growth in the number of areas and total area in the System has been in the West where the majority of the federally owned land is located.

The entire population of the United States lives within 400 miles of one or more wilderness areas. Nearly 17 percent live within 25 miles, and more than two-thirds of the population live within 100 miles of one or more wilderness areas.

Some characteristics of the system—In general, the more diverse the elevation and other natural characteristics of the wilderness system, the greater are their contributions toward sustaining a variety of natural species. Not surprisingly, most of the wilderness area at high elevation is in the West. Nationally, about 2 percent of the total area in wilderness is above 10,000 feet and more than 40 percent is at elevations between 5,000 and 10,000 feet.

Figure 67.—*Area of the National Wilderness Preservation System by managing agency, 2002*



Box 21

Off-highway vehicle participation—Since 1982, driving motor vehicles off highways became one of the fastest growing activities in the country: The number of participants over 12 years of age increased by more than 100 percent (Cordell et al. 2004). From the sample period fall 1999 to summer 2000, to the sample period fall 2003 to fall 2004, the number of people age 16 and over and participating at least once in the past 12 months in off-highway motorized driving or riding increased from 36 million to 51 million people (table 13). In 2003–04, the number of participants amounted to 23.2 percent of the population.

Available data indicates that most off-highway-vehicle participants are younger than 50 years of age, male, white, and urban. Across all demographics in table 13, the number of people participating were increasing, except for American Indian and Asian Pacific Islander.

Off-highway vehicle impacts—Available information regarding the effects of off-highway vehicles is anecdotal or based on case studies. The following impacts are from studies on national forest lands. Noise has a negative effect on breeding birds within about 100 meters. Off-highway vehicles and mountain bike activities substantially increase movement rates of elk, cause elk avoidance of use areas, and reduce foraging time by elk. Off-highway vehicles emit particulates and ozone precursors. Issues identified with off-highway vehicle management on the national forests of California were mainly related to natural resources (soil erosion and trampling) and social institutions (violations of regulations, such as off-highway vehicles going too fast).

Table 13.—*Millions of people in the United States age 16 years or older participating at least once in the last 12 months from 1999–2000 to 2003–2004 in off-road vehicle use.*

Demographic	Fall 1999–summer 2000	Fall 2003–fall 2004
Total participating	36.0	51.0
Age—under 30	14.5	18.7
Age—30–50	15.5	23.4
Age—51 and older	5.8	9.2
Male	22.1	31.2
Female	14.1	20.1
White	29.3	39.7
Black	2.7	4.0
American Indian	0.4	0.3
Asian/Pacific Islander	1.3	0.8
Hispanic	2.8	5.7
Nonmetropolitan	10.0	13.6
Metropolitan	27.3	34.2

As well as elevation, precipitation contributes to determining the plant and animal species in wilderness ecosystems. Arid areas receiving less than or equal to 15 inches of annual precipitation are found in the West and comprise about one-quarter of the total area (table 14). The West also contains wilderness areas receiving a variety of amounts of precipitation. Much of the wilderness area in the East receives 16 to 60 inches of precipitation.

Every acre designated as wilderness protects a number of aspects of national systems. As a growing population distributes itself farther and farther into the rural landscape and as the mileage and distribution of roads rises, designated wilderness areas will become of greater uniqueness.

Table 14.—*Number of areas, acres, and percentage of acres of wilderness by precipitation amounts per year for the conterminous United States.*

Precipitation (inches)	Areas	Acres (million)	Percent
0–15	146	12.9	27.6
16–30	138	9.5	20.3
31–40	101	8.8	18.7
41–60	185	9.8	20.9
61–90	63	3.5	7.5
100 +	20	2.3	5.0

Source: Daly and Taylor (2000).

Rangeland

Production and consumption—Beef cattle and sheep consume some 431 million animal unit months of grazed forages each year. Of this total, 86 percent comes from deeded nonirrigated lands, 7 percent comes from public grazing lands, 2 percent from irrigated grazing, and 5 percent from crop residue. In addition to domestic livestock, wild herbivores depend on range forage for a portion of their dietary needs. Big game populations have been stable to increasing, suggesting that range forages are adequate for the needs of these populations.

Since much of the forage consumed by livestock is produced from nonirrigated pasture owned by the livestock enterprises, it is not priced in a forage market. Thus, decisions to change forage production will be based on the likely economic return associated with the final output such as livestock or wildlife. The amount of forage produced on public lands that is available for livestock consumption is set at different scales, respectively, by allotment management plans, management-unit-level plans, and agency strategic plans, all of which are directed by public policy.

Forage production is not inventoried in a manner that can be aggregated and reported upon at regional or national levels. Use, not production, is quantified when forage consumption estimates are derived from livestock inventories. Forage consumption estimates derived from livestock inventories do not include estimates of forage consumed by wild herbivores.

The demand for livestock is a function of society's demand for red meat. Other market commodities such as hides, wool, tallow, and secondary products such as pharmaceuticals can have a minor effect on demand. These demands in turn are based largely on human population and income. In the time since the 2000 Renewable Resources Planning Act Assessment, per capita beef and lamb consumption in the United States has remained constant at approximately 67 pounds and 1 pound, respectively. Consumption of pork and turkey has also remained fairly constant. Per capita consumption of broilers (chickens), however, steadily increased from 76.9 pounds in 2000 to 84.3 pounds in 2004.

Rangelands provide many values in addition to forage. They contribute to meeting people's needs for recreation, conserve biodiversity, are sources of clean water, and provide vistas and other amenities that many people enjoy.

Valuing grazing use of rangelands—The value of rangeland forage is an important component of any assessment of trends in the supply and demand for natural resources. In the United States, numerous studies have evaluated the value of forage in terms of private lease rates, particularly for public lands (Bartlett et al. 2002). Private lease rates, however, do not always represent the sum of all benefits received from the use of forage on Federal rangelands. A rancher's total willingness to pay for public lands grazing extends beyond its forage value for livestock production to include other attributes associated with grazing permits like access rights and maintaining a ranching lifestyle (Liffman et al. 2000). Researchers have also observed large variations in observed grazing costs, both within and across regions of the United States, making it difficult to ascertain the true value of forage use (Van Tassell et al. 1997).

Possible future trends—According to Mitchell (2000), the supply of forage in the United States is not likely to change significantly over the next few decades. The country's productive capacity should remain adequate to promote sustainable management of U.S. rangelands, however.

Summary

Americans enjoy many values from their forest lands and rangelands. This enjoyment is evident from timber harvest that meets 73 percent of domestic needs for wood and wood fiber, the provision of range forage and minerals, clean water, the hundreds of millions of visits for recreation on forest lands and rangelands each year, and use of these lands to satisfy cultural, social, and spiritual needs and values. In addition, forest lands and rangelands are used for subsistence purposes by many people, and interest in nonwood and nonforage goods and ecosystem services is increasing. Forest lands and rangelands are the basis for employment for millions of people. The availability, nature, and relative importance of these values to society will evolve over time as the needs of society and the character of the resources change over time. For example, the changing cultural backgrounds and demographics of the U.S. population will likely alter the hierarchy of values the public holds toward public and private forest lands and rangelands.

With expectations of rising income and increased population, there is little doubt that demands for goods and services from our forest lands and rangelands will continue to increase. We have every reason to believe that U.S. forest lands and rangelands will continue to provide at least some level of goods and services that society desires. Globalization also facilitates worldwide movement of goods that are easily traded, such as mineral and wood products.

Provision of other renewable resources such as water and recreation will be more dependent on management of domestic forest lands and rangelands. Increasing demands for goods and services from a fixed land base set the stage for continuation of conflicts in the use and management of renewable resources. Resource owners and managers and consumers will continue to respond through reliance on markets and public processes to help guide adaptive management as new resource conditions and public opinions evolve. Increasing the area in conservation easements and further developing markets for ecosystem services may become more common as ways to resolve conflicts in resource use and management. Societal values, management of private forest lands and rangelands, technological change in the growing, processing, and use of timber products, recycling, public land management policies, trade in timber and mineral products and, more recently, globalization have all contributed to the current renewable resource situation in the United States and will likely continue to do so in the future. Developing phenomena such as climate change and invasive species may change the goods and services provided by U.S. forest lands and rangelands. Rising energy prices may stimulate interest in ethanol production from wood fiber.

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