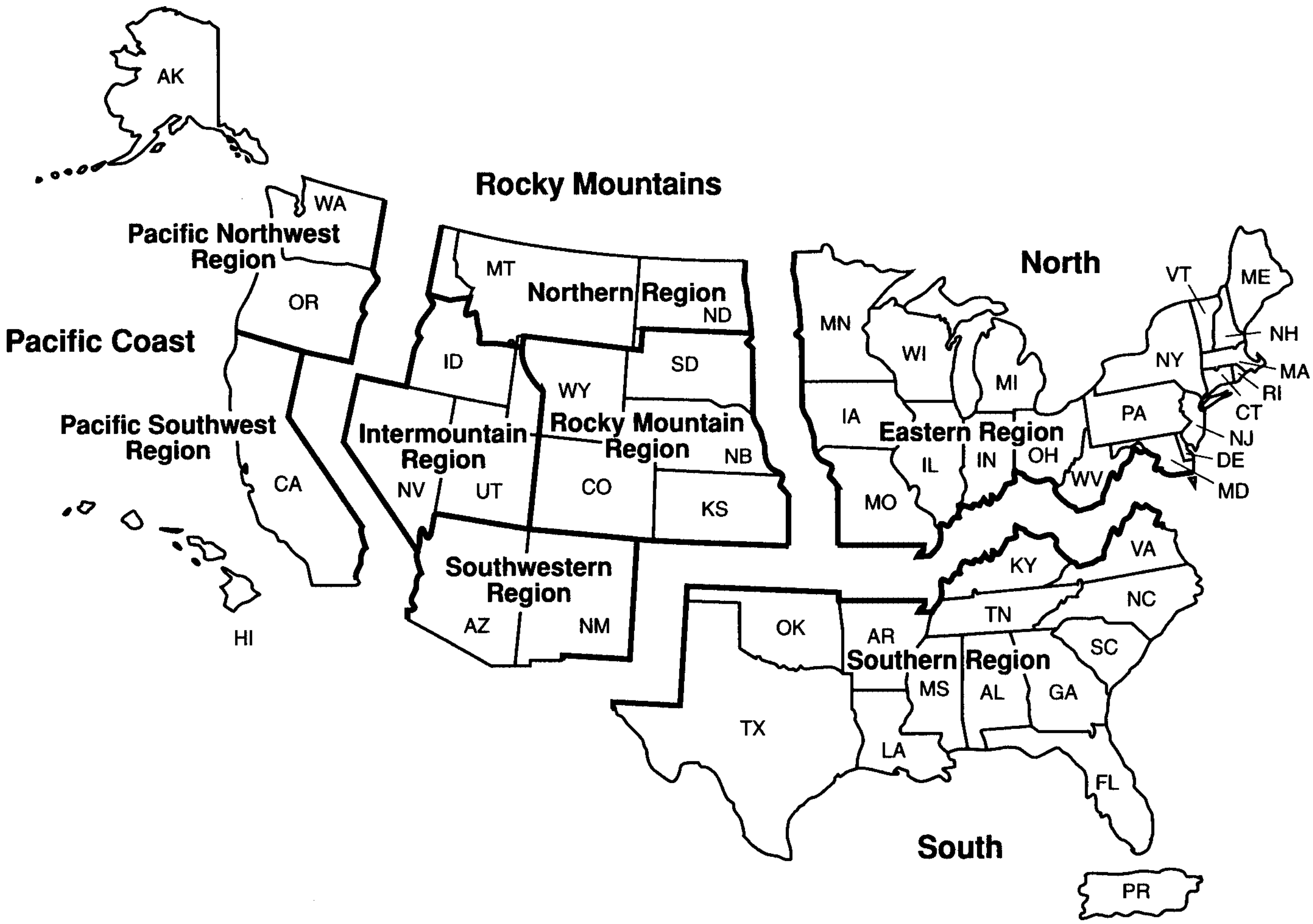
2000 RPA Assessment of Forest and Range Lands

U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE

Forest Service Regions and Assessment Regions



Contents

Introduction

This 2000 Renewable Resources Planning Act (RPA) Assessment is the fourth 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 (RPA). The 2000 RPA Assessment consists of this summary report and supporting documents.[1] The United States Department of Agriculture (USDA) Forest Service has been carrying out resource analysis in the United States for over 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 forest 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 assessment include outdoor recreation, fish and wildlife, wilderness, timber, water, range, and minerals.

The renewable resource assessments required by the 1974 legislation have been concerned largely with indicators of resource condition and trend. The renewable resource assessments are to include "an analysis of present and anticipated uses, demand for, and supply of the renewable resources, with consideration of the international resource situation, and an emphasis of pertinent supply, demand, and price relationship trends" (sec. 3 (a)(1)).

Demands for and supplies of renewable resources from the Nation's forests and rangelands are dynamic. Consumers of these resources have accommodated the changing nature of resource supplies in various ways, including adoption of technologies that change the ways renewable resource outputs are used. Supplies and the quality of renewable resources change in response to use, management, changing laws, environmental conditions, and other factors. 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 policy actions, regulations, and management to influence the amount, quality, and value of renewable resource outputs, conditions, and opportunities. These accommodations will determine the nature and extent of the future forest and rangeland estate.

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 progress toward 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, 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 provide a common framework for describing, assessing, and evaluating a country's progress toward sustainability at the national level.

In this assessment, the outcomes of accommodations between demands and supplies are described within the context of the following five criteria for conservation and management of U.S. forests and rangelands:

- Conservation of biological diversity
- Maintenance of productive capacity of forest and range ecosystems
- Maintenance of forest ecosystem health and vitality
- Maintenance of forest contribution to global carbon cycles
- Maintenance and enhancement of long-term multiple socioeconomic benefits to meet the needs of societies

In addition, the following criterion is discussed to convey the overall U.S. legal, agency, and private framework that is foundational to the conservation and sustainable management of forests and rangelands:

- Legal, institutional, and economic framework for forest conservation and sustainable management

[1] Supporting technical documents can be found at http://www.fs.fed.us/pl/rpa/publications_in_support_of_the_2.htm

Highlights

Conservation of Biological Diversity

- Since 1920, forest land area has remained relatively stable at approximately one-third of the total U.S. land area.
- In the East, there has been an increase in the area of forest types that are representative of later stages of succession.
- Older forests will lead to more diversity in forest structure, but decreased area of some forest types.
- In 1997, reserved forest land amounted to 3 percent of the forest land in the East and 11.1 percent in the West.
- Threatened and endangered species occur in the highest concentrations in 12 hotspots across the United States, located along the coastline, the arid Southwest, and the southern Appalachians.
- Mammals have the greatest proportion of species with reduced ranges.
- Parcelization of private ownerships will continue to be a management challenge with landscape-level planning becoming more difficult and habitat associated with edge effects becoming more plentiful because of increased fragmentation of forest cover.
- Most harvested wildlife populations are doing well, with the exception of upland game species. A high number of grassland ecosystems have lost at least 85 percent of their historical extent. As a result, a relatively large number of grassland bird species show declining trends.

Maintenance of Productive Capacity of Forest and Rangeland Ecosystems

- More outputs must be produced from a slowly declining land base.
- Timberland area amounts to about two-thirds of forest land area.
- The area of privately owned forest land is projected to decline 2 percent over the next 50 years. The volume of growing stock per person is expected to remain relatively stable during this time.
- The growth-removal ratio for timber is expected to continue to exceed 1.0 for both hardwoods and softwoods.
- 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 over 40 percent. These increases in withdrawals, while small, will place additional pressures on already diminished instream flows for rivers and streams across the United States. They will likely be issues in economic expansion in many parts of the country.
- The productive capacity of rangelands is likely to be adequate to meet national demands for forage.
- Demand for grazed forage is expected to slowly decline in the Western and Southern United States, while remaining the same to slowly increasing in the Northern States.

Maintenance of Forest Ecosystem Health and Vitality

- Pre-European-settlement conditions will never again exist for U.S. forest and rangeland ecosystems.
- Future climate scenarios and ecological models suggest that there could be increased forest productivity as a response to climate change.
- Fire suppression has caused a build-up in fuels, especially in some parts of the West.
- Over the next 15 years, the risk of tree mortality from insects and pathogens for about 8 percent of forest land is projected to be at least 25 percent above normal mortality rates.
- Of the 70 major insect pests in the United States, 19 are exotics.
- In 1998, over 54 million acres of forested land were affected by various insects and diseases.
- Mortality as a percent of timber inventory has generally been between 0.5 and 0.8 percent per year.
- Generally, the quality of water draining from forests and rangelands is very good.
- 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.

- Geographic areas that are likely to be subject to high levels of land use stress are focused in seven areas of the United States including the west slope of the Cascade Mountains in the Pacific Northwest, portions of California, the desertic basin regions of west Texas and southern Nevada, the central till prairie, peninsular Florida, and the southern Appalachians (figure 1). These areas have the greatest potential for negative changes in indicators of forest and rangeland conditions.

Maintenance of Forest Contribution to Global Carbon Cycles

- Net annual additions of carbon stored in forests and products are estimated to have increased in the last several decades and currently amount to about 24 percent of annual U.S. emissions of carbon dioxide.
- Forests are expected to continue to be sinks for carbon.
- Changes in carbon accounting systems can have large effects on the perceived roles of forests and forest products in matters of carbon sequestration.

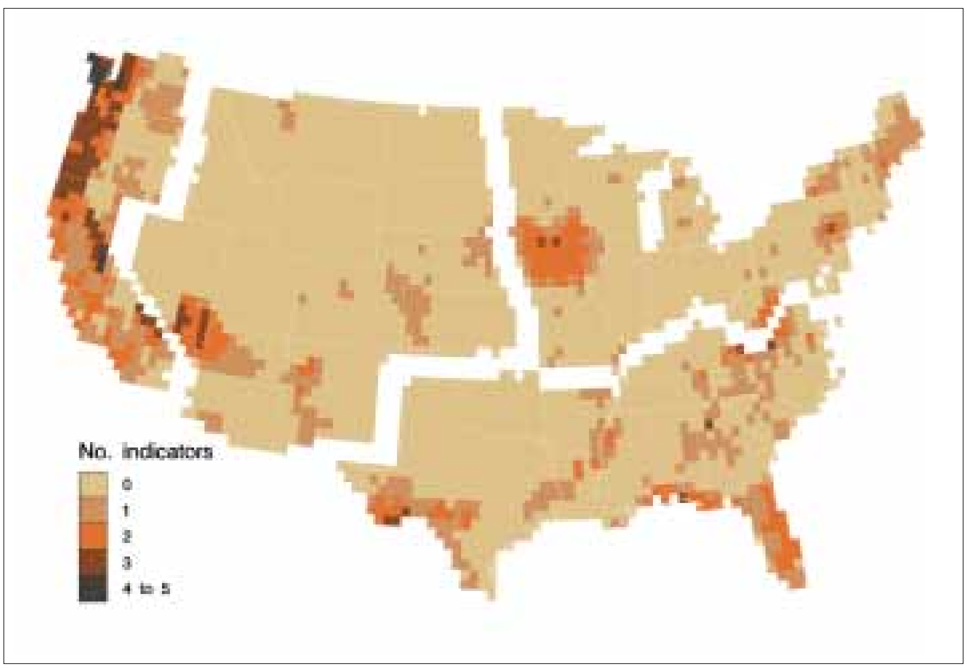


Figure 1 — Coincidence of hotspot condition indicators

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

- Wood production and consumption are expected to increase substantially, and consumer preferences and fiber-use technology will likely continue to modify the mix of resources needed in response to changing resource availability.
- In volume terms, the United States has long been a net importer of timber products and this is expected to continue.
- Canada is expected to continue to be the primary source of imports of wood products, but other sources are emerging.
- By 2050, about two-thirds of the softwood timber harvest is projected to come from plantations.
- Over time, the wood products processing industries have become more efficient in the use of wood.
- National forests account for about 14 percent of the total water runoff in the conterminous States.
- Improvements in the efficiency of water use in the industrial and energy sectors have done much to contain withdrawal increases and will likely continue to do so.
- Extractive industries' contributions to gross domestic product (GDP) have declined, but these industries are still important in certain States and local communities.
- Production of many mineral and energy commodities is decreasing in the United States, but certain commodities from National Forest System lands represent a major portion of U.S. supply (for example, lead).
- The percent of private land available for public recreation continues to decrease.
- Area continues to be added to the National Wilderness Preservation System.

- Markets for outdoor recreation activities are likely to change as new forms of participation are discovered; as the backgrounds, perspectives, and tastes of recreationists change; and as constraints and opportunities shift.
- Consumption and provision of outdoor recreation opportunities continue to grow in the United States at all levels of government and in the private sector.
- The more popular beaches, forest sites, parks, and special attractions will experience greater congestion at peak times of the year.
- There is a continued trend toward multiple activity, but shorter length recreation trips. This is probably due in part to the stress of coordinating family schedules.
- About 7 percent of grazed forages come from public grazing lands.
- Total beef and lamb consumption in developed countries is expected to increase by less than 0.5 percent annually over the next quarter-century. Per capita red meat consumption continues to decline.

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

- In the United States, population and income continue to increase; the resource base has remained resilient in the face of these changes.
- The urban forest is a large and important resource that is growing in area and diversity.
- Land area in the United States affected by extreme weather events is increasing. Improved management techniques are needed to minimize the effects on natural resources, social, and economic systems.
- Changing U.S. demographic composition will likely impact demands for forest and range resources and how resources are managed.
- Markets and private sector ownership of forest land are institutions that have affected management of these lands, as well as the extent of parcelization.
- The condition of U.S. renewable resources and their contribution to domestic economic, ecological, and social well-being will increasingly be linked to international processes and decisions.
- Energy and mineral production development is increasingly controversial, especially in rural areas experiencing industrial and population growth.

Social and Economic Context for the Assessment

World Context

Within a worldwide context, growth in population, income, and education has contributed to the evolution of global issues related to the environment that are mirrored in domestic issues. The dynamics of population change create 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 accelerated alteration of ecosystems in many parts of the world. World population more than doubled from 2.5 billion people in 1950 to 5.9 billion in 1998 (U.S. Bureau of the Census, 2000). During this time, much of this growth was in developing countries where population increased from 1.7 to 4.1 billion people. Growth in developed countries was from 800 million to 1.2 billion people.

World real per-capita income more than doubled between 1950 and 1995 (Brown et al., 1995). During this time, liberalization of trade contributed to economic growth in both developed and developing countries. The oil price shocks of the 1970's and a general deflation in commodity prices in the 1980's contributed to the pattern of economic growth during this time. During the 1990's, the industrial structure of many countries, including the United States, shifted in emphasis to service sectors as compared with industrial sectors. In many cases, industrial sectors continued to grow, but service sectors grew even faster, leading to declines in the relative importance of the industrial sectors.

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 in general led to concern over biological diversity and endangered species, and it is increasingly clear that the causes and outcomes of climate change could transcend national boundaries. The U.S. interest in these issues is 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 increasingly trying to deal with many of the same environmental issues that are being debated domestically in the United States.

The issues will likely evolve over time. For example, concerns are increasingly being raised about the possible environmental effects of accelerated tariff liberalization (Office of the United States Trade Representative and the White House Council on Environmental Quality, 1999). These concerns are being raised after decades of negotiations to liberalize tariffs on forest products under the terms of the Kennedy, Tokyo, and Uruguay Rounds of the General Agreement on Tariffs and Trade.

The world population will continue to grow, with implications for resource use, carbon emissions, and other renewable resource issues that transcend national boundaries. The U.S. Bureau of the Census (2000) projects world population will grow from 5.9 billion people in mid-1998 to about 9 billion in 2050. Although there are uncertainties with any projections, there is little doubt that there will be significant growth in world population.

An analysis by the United Nations Food and Agriculture Organization (1999) suggests that, in most countries, there will be a move away from the use of natural forest resources for wood and fiber production towards other land-based and nonland-based sources of supply, including the use of wood processing residues and recycled fibers. This analysis also suggests that plantations will provide the greatest share of the expanded industrial wood production potential in the future.

U.S. Context

Indicators of condition and trend in renewable resources are affected by the development of 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 (figure 2).

Population shifts have not been evenly spread out over this century. Between 1910 and 1920, the Homestead Act lured many people to farm the West and Midwest (Case and Alward 1997). From 1920 to 1930, many of these areas depopulated, reflecting many failures at trying to earn a living farming or ranching land that could not sustain these activities. During the 1930's, there was mass movement of people to California.

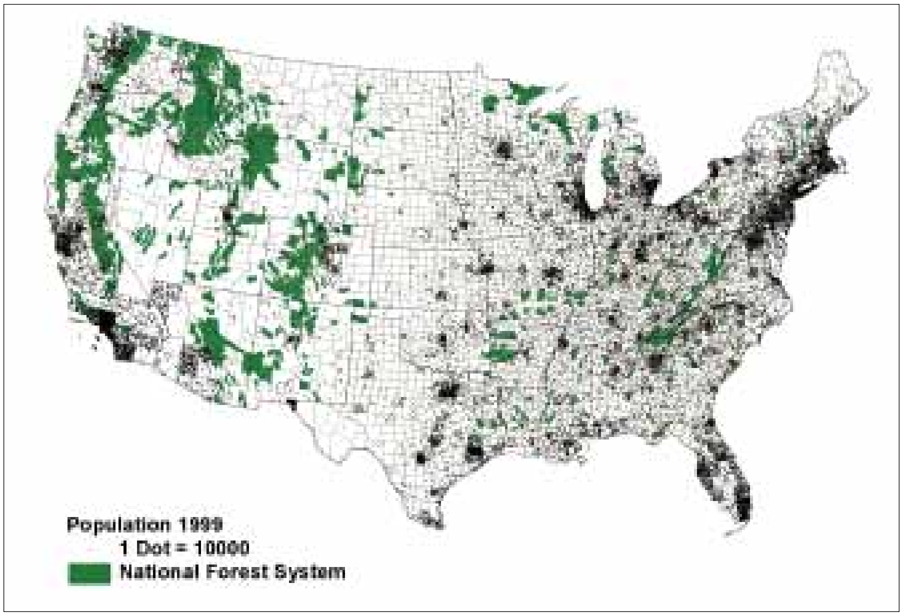


Figure 2 — Map of population density in 1999 in relation to National Forest System lands

Over time, the economic diversity of the Nation has changed, reflecting population movements, better access to markets, changes in technology, and a host of other factors (Case and Alward, 1997).

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 environmental values for these systems. For example, real per capita disposable personal income increased by 39 percent between 1960 and 1970 (figure 3). 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 Act of 1970, the Endangered Species Act of 1973, the Forest and Rangeland Renewable Resources Planning Act of 1974, the National Forest Management Act of 1976, and the Federal Land Policy and Management Act of 1976. These and other legislated mandates provide direction to Federal agencies in the 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.

Since the change in U.S. immigration laws in 1965, immigration patterns have shifted from being mainly European in origin to predominantly Asian and Hispanic. This first generation of non-European immigrants has many values that differ from some values associated with U.S. citizens who have been here for several generations. It is unknown at this time to what extent recent immigrants' cultural values will change as subsequent generations become more exposed to other - lifestyles.

Immigrants have chosen to settle largely along the coastal areas of the United States. There are large concentrations of immigrant populations in the northeast Atlantic States, in Florida, in a broad swath running the length of the Pacific coast, and all along the Mexican border to include Texas. Some 18.5 percent of the population in the Pacific Coast region is foreign born (Cordell and Overdevest, 2000).

Emigration within the United States in the last 50 years has shifted the geographic focus of many resource issues relating to how people use and value renewable resources. For example, amenity migration is driven by people's desires to live in areas where they value the natural or other settings found there. Thus, many people are retiring to counties near national forests and other public lands (figure 4). Retirement to seasonal homes is also likely to increase (Stynes et al., 1997). Amenity migration is thus based largely on a sense of place that may create a constituency for the status quo in terms of management of particular areas. The values of this constituency may conflict with the values held by longer term residents of the area.

There will continue to be increasing demands on the Nation's forest and rangeland ecosystems. The human population of the United States is projected to increase 49 percent by 2050 (figure 5). In the past 50 years, the population increased by some 125 million people or 78 percent. The U.S. population is projected to have more discretionary income and thus more opportunity to enjoy the Nation's natural resources (figure 6). This 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. The U.S. population is also aging. By 2050, the average age will be 41 years as compared with 36 in 1999 (U.S. Bureau of the Census, 1999). An aging population will affect demands for renewable resources, especially areas used for recreation.

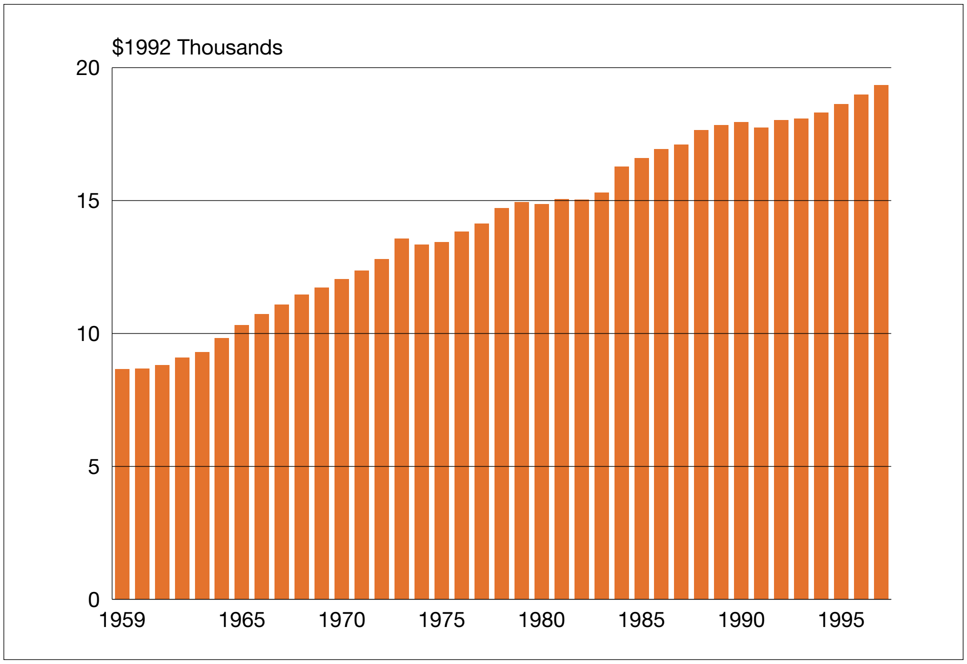


Figure 3 — U.S. per capita disposable personal income

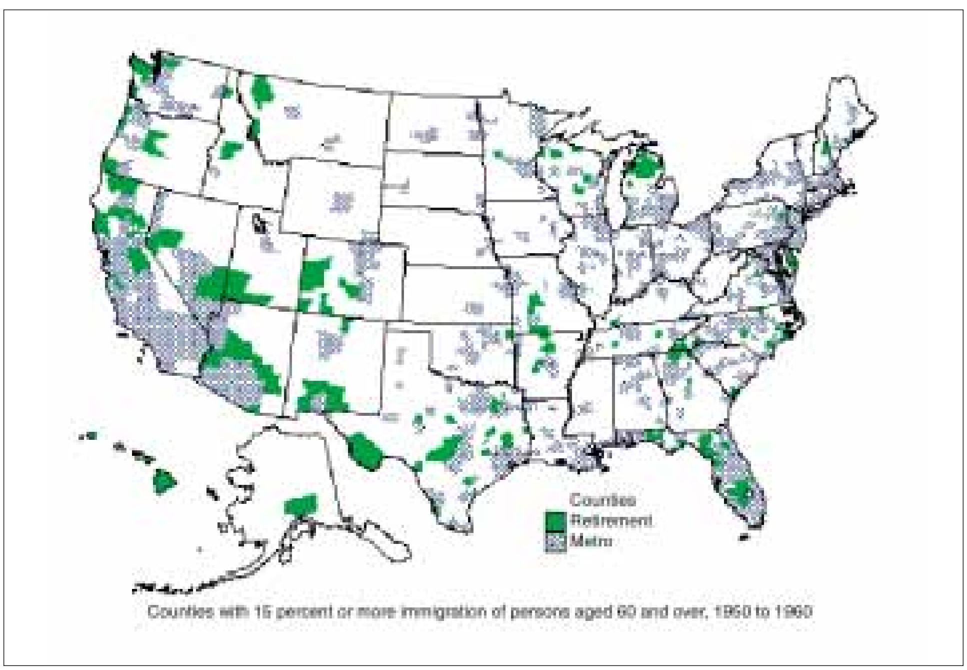


Figure 4 — Nonmetro retirement destination counties, 1990

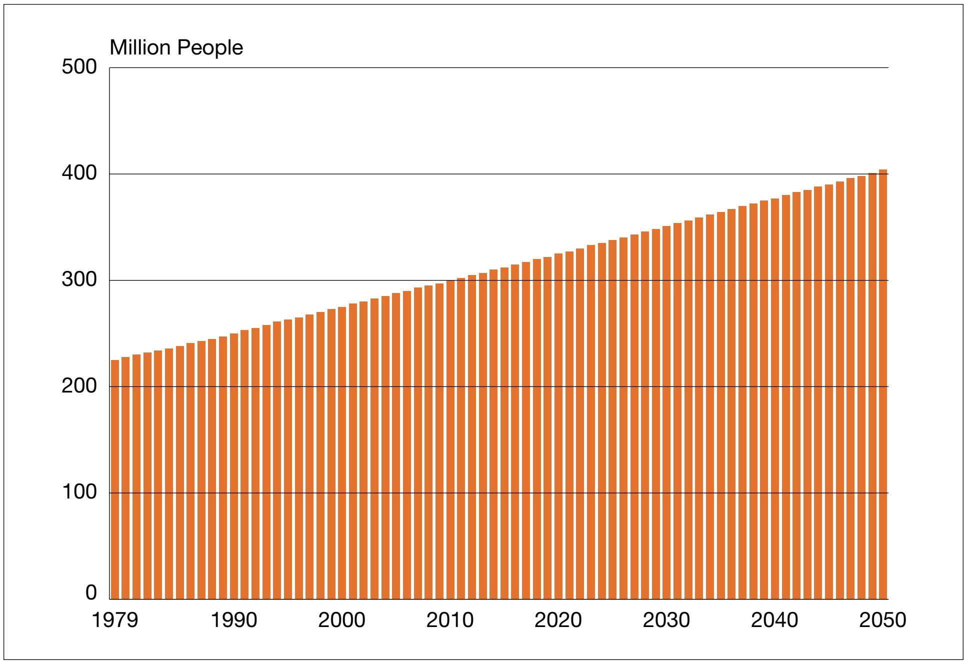


Figure 5 — U.S. population

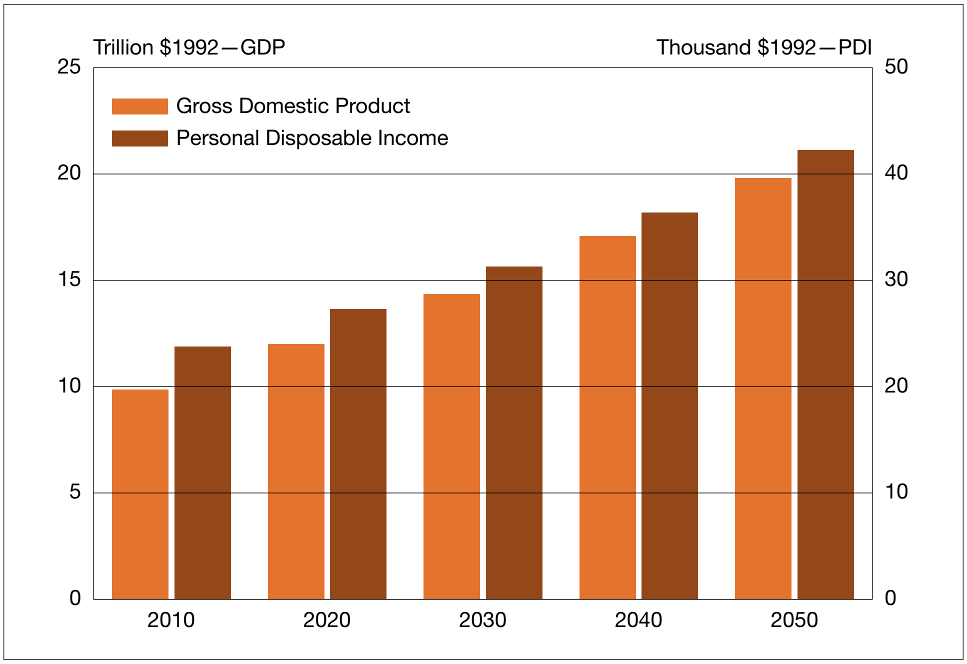


Figure 6 — Projected gross domestic product and per capita disposable income

United States In a World Context

Forests

The area of the world's forests was estimated to be 8.5 billion acres as of 1995, or about one-fourth of the land area of the Earth (United Nations Food and Agriculture Organization, 1999). About 55 percent of the world's forests are located in developing countries, 45 percent are located in developed countries. The world's forests are almost equally divided between tropical/subtropical and temperate/boreal. About 3 percent of the world's forests are plantations, the remainder are natural or seminatural forests. In the United States, about 8 percent of forests are classified as planted (Smith et al., 2001).

The U.S. forest land area of 747 million acres amounts to about 7 percent of the total world forest land area and 12 percent of the total area of temperate and boreal forests. Since at least 1950, the total area of forest land in the world has been decreasing (United Nations Food and Agriculture Organization, 1999). Most of the decrease has been in the developing tropical countries. Forest area in much of the developed world, 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 1920's, with decreases due to development and other land uses being offset by afforestation and natural reversion of abandoned crop and pasture land to forest land. In the United States, there are 2 acres of forest land per person, which is equal to the world average (United Nations Food and Agriculture Organization, 1999).

The United States is not alone in having a high proportion of forest land in private ownership (63 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, 2000). By contrast, only 6.5 percent of Canada's forest and other wooded land is in private ownership. All of the forest and other wooded lands in the member states of the former Union of Soviet Socialist Republics are considered to be in public ownership.

Rangelands

Rangelands occupy nearly one-half of the Earth's land area or about 16.1 billion acres (United Nations Food and Agriculture Organization, 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 while some 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).

Population and Income

The population of the United States, as a percent of the world average, declined from 6 percent in 1950 to 4.6 percent in 1998. Growth in population has occurred in the developing countries. One person in three now resides in India or China. Total world population increased from 2.5 billion in 1950 to 5.9 billion in 1998.

Gross domestic product per capita in the United States was 5.5 times the world per-capita average in 1995 (World Resources Institute et al., 1998). Although per capita incomes in some developing countries have increased in the last 20 years, others remain impoverished.

Production, Consumption, and Trade in Timber Products

The United States is the largest producer and consumer of sawnwood, wood-based panels, wood pulp for paper, and paper and paperboard. (figure 7). Compared to the rest of the world, the United States is a major importer of softwood lumber (almost all from Canada) (figure 8). At the same time, the United States is a significant exporter of logs, sawnwood, and wood pulp for paper.

In part because of custom and in part because of the availability of inexpensive wood, only Japan, Canada, the United States, and the Scandinavian countries have a history of widespread use of wood frame housing. In tropical countries, termites and other pests make extensive use of wood in housing impractical. This history of wood use and relatively high per capita income have led to relatively high per capita consumption of wood products in the United States. Per capita consumption of industrial roundwood and the roundwood equivalent of net trade in the United States of 62.5 cubic feet per year is about six times the world average.

International Tourism

Between 1987 and 1997, international tourism to the United States grew about 66 percent, going from 27.8 million visitors to 46.2 million (Cordell, 1999). Receipts from travel grew even more, going from $30.5 billion in 1987 to some $88.9 billion in 1997. Canada accounted for about one-third of international arrivals.

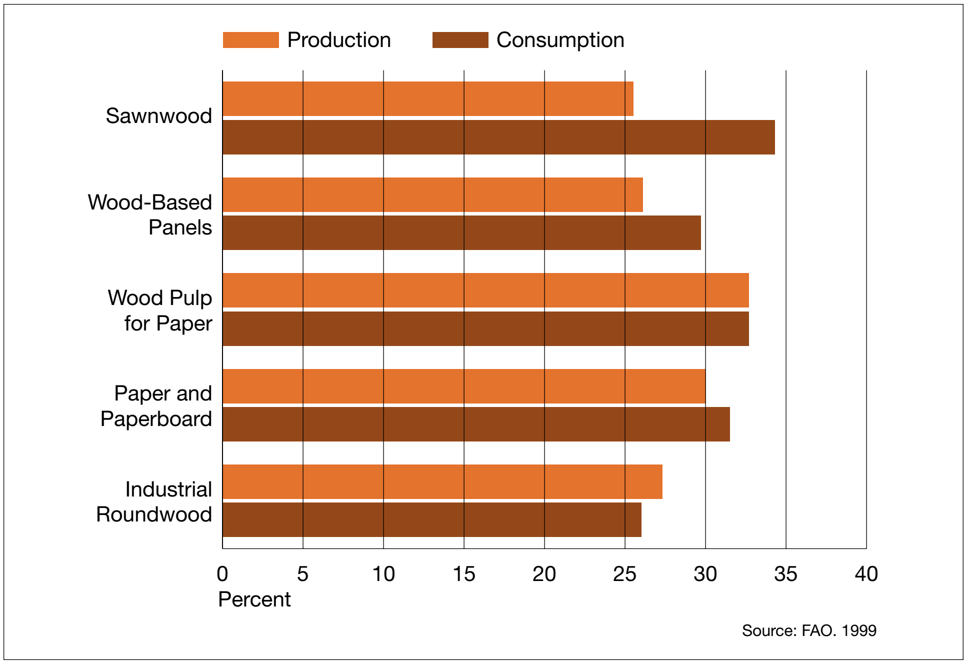


Figure 7 — U.S. production and consumption as a percent of world totals by selected product grouping, 1996

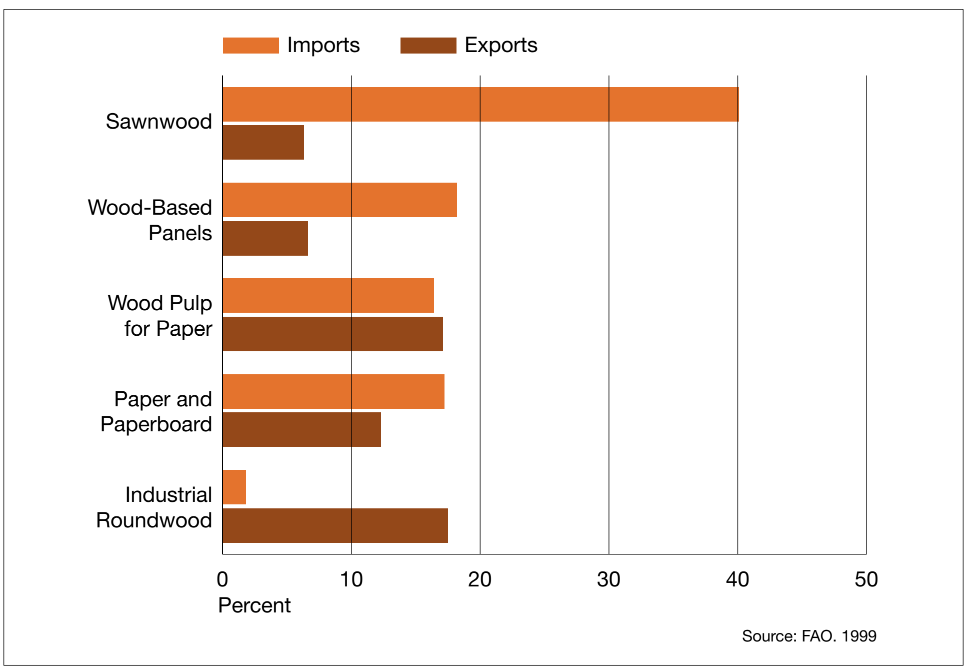


Figure 8 — U.S. imports and exports as a percent of world totals by selected product grouping, 1996

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

This framework largely cuts across other criteria for 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 Range Lands

In the United States, 63.3 percent of the forest land is privately owned (figure 9). Some 14.4 percent of the forest land in private ownership is classed as forest industry and the remainder as nonindustrial private (Smith et al., 2001). Forest land owned by Native Americans[2] is included in the latter category. Of the remaining 36.7 percent of total forest land, the USDA Forest Service is the largest public forest land management agency, with responsibility for 53.5 percent of the total forest area in this ownership category. Other ownership categories delineated by the data are State (22.1 percent), Bureau of Land Management (12.4 percent), and county and municipal (3.4 percent). The remaining 8.6 percent of the forest land in public ownership includes lands managed by the National Park Service, Department of Defense, Department of Energy, and all other Federal ownerships.

Forest lands in the various ownership categories are not evenly distributed across the country. Some 54.7 percent of the forest land in the forest industry category is located in the South (figure 10). Nearly three-fourths of the forest land in the nonindustrial category is located in the East. Some 40 percent of the forest land in the State category is located in Alaska; 36 percent is in the North. Nearly two-thirds of the county and municipal lands are in the North. Approximately 84 percent of the publicly owned forest land is in the West, and 67 percent of the privately owned forest land is in the East. Approximately 72 percent of the hardwood growing stock volume is in nonindustrial private ownership, and another 10 percent is in forest industry ownership. Most of this hardwood volume is in the East (Smith et al., 2001). By contrast, 46 percent of the softwood growing stock volume is in national forests, and 11 percent is classed as other public. Forest industry has 14 percent of the softwood growing stock volume and nonindustrial private has the remaining 29 percent. The location and ownership of forest land tend to have strong influences on the focus of management issues.

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

Of the rangeland area, 66 percent is in non-Federal ownerships (table 1). 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 National Forest System is in the West, as is all of the rangeland managed by the Bureau of Land Management. The Bureau of Land Management manages 27 percent of the rangeland in the coterminous States. The USDA Forest Service manages 7 percent.

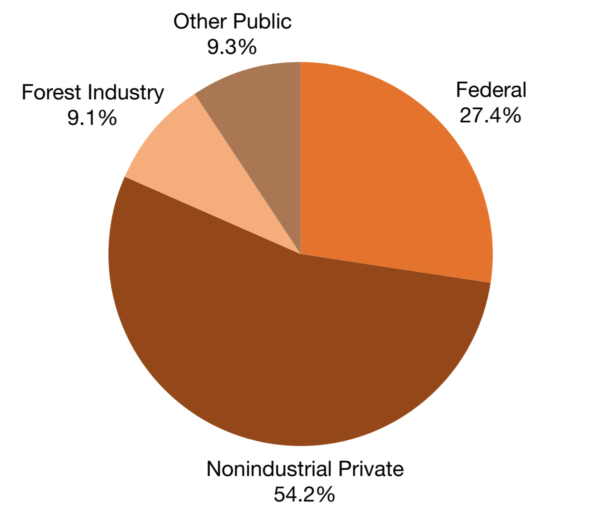


Figure 9 — U.S. forest land by ownership — 1997

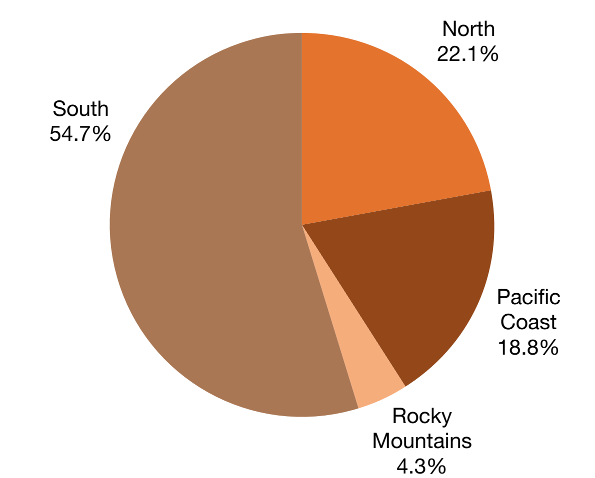


Figure 10 — Regional distribution of forest land in forest industry ownership

The Privately Owned Forest and Range Land Estate

There were 9.9 million private forest land ownership units[3] in the United States in 1994, up from 7.8 million in 1978 (Birch 1996). Coincident with the increase in the number of ownership units, there has been an increase in the proportion of the forest area in smaller ownerships (figure 11). These lands are managed with a variety of objectives. Over 25 percent of privately owned forest land is managed with timber production as the primary reason for ownership (table 2). Land investment and recreation were among other reasons for ownership of forest land. Hunting, fishing, and camping are among the most popular recreational activities on private land (Cordell, 1999).

Regulations affecting privately owned forest land vary by State and locality. Some 44 States have best management practice legislation intended to promote better management of lands, especially when timber production is involved and particularly to protect water quality (Ellefson et al., 1995). Nine States have a version of a forest practice regulatory act intended to promote good management practices and may require management plans, reforestation, or other actions on the part of the landowner.

The Federal Government, as well as 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 USDA 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 also provides technical advice and assistance to private forest landowners. Some States provide technical and financial 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 specified by tax codes. Nongovernmental organizations can buy conservation easements and otherwise provide incentives to influence management of private lands.

Private property rights have their origins in part with the Magna Charta (National Research Council, 1997). However, there are limits to the institution of private ownership. Governments at all levels may take private property when it is in the public interest to do so. The public interest has been 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 over the takings issue.

The Publicly Owned Forest and Range Land 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 Bureau of Land Management manages the largest area of Federal land (figure 12). 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 Federal actions significantly affecting the

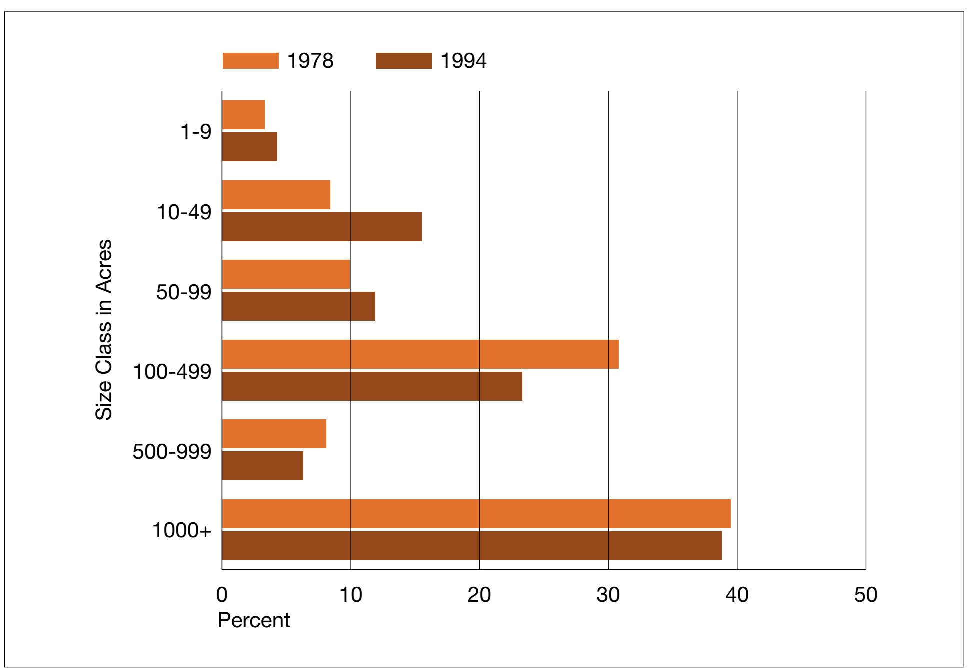


Figure 11 — Percentage distribution of privately owned forest land by size class of ownership, 1978 and 1994

[3] Ownership units include all types of legal entities having ownership interest in land, regardless of the number of people involved.

Table 1 — Rangeland area in the conterminous United States by ownership and region

Region	Ownership: Non-Federal	National Forests	Bureau of Land Management	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

Table 2 — Estimated number of ownership units and acres of forest land, by primary and secondary reason for owning forest land

Reason	Primary reason: Number	Primary reason: Percent	Secondary reason: Number	Secondary reason: Percent
	(In owners)		(In owners)	
Land investment	920,000	9	496,000	5
Recreation	874,500	9	667,900	7
Timber production	272,200	3	258,700	3
Farm and domestic use	816,400	8	749,200	8
Esthetic enjoyment	1,392,400	14	1,467,500	15
Part of farm	1,189,800	12	464,800	5
Part of residence	2,641,500	27	1,060,500	11
Estate	992,000	10	1,143,800	12
Other	448,900	5	106,800	1
No secondary reason given	—	—	3,132,500	32
No answer	354,100	3	354,100	4
Total	9,901,700	100	9,901,700	100
	(In thousands of acres)		(In thousands of acres)	
Land investment	39,253	10	37,193	9
Recreation	37,868	10	40,949	10
Timber production	113,220	29	34,764	9
Farm and domestic use	35,778	9	27,565	7
Esthetic enjoyment	28,699	7	31,685	8
Part of farm	38,637	10	15,359	4
Part of residence	32,620	8	19,387	5
Estate	26,407	7	35,066	9
Other	34,572	9	11,932	3
No secondary reason given	—	—	132,975	34
No answer	6,334	2	6,334	2
Total	393,389	100	393,389	100

quality of the human environment. This act provided the first statutory mandate for public scrutiny of management of Federal forest land and associated resources. For the USDA Forest Service, the Forest and Rangeland Renewable Resources Planning Act, as amended by the National Forest Management Act of 1976, further facilitated public involvement in management of renewable resources. Other Federal agencies have varying legislative mandates for resource management and public review of this management. Federal lands are managed for a variety of objectives related to management of renewable resources.

As of January 1, 1997, State and county governments owned nearly 64 million acres of the Nation's forest land, most of which is in the Great Lakes States (Minnesota, Wisconsin, Michigan, Pennsylvania, and New York), Alaska, Washington, and Oregon (Smith et al., 2001). The largest single State ownership of 22 million acres is in Alaska. According to the National Research Council (1997), State and county forest-resource programs have been strengthened markedly over the past 25 to 30 years. Federal technical and financial assistance has assisted in this process.

Management of State and county forests often has an economic development focus and, thus, has proven to be especially important to local and regional economies. To accomplish economic development, government programs that foster stability in community income and employment have proven to be especially important (National Research Council, 1997).

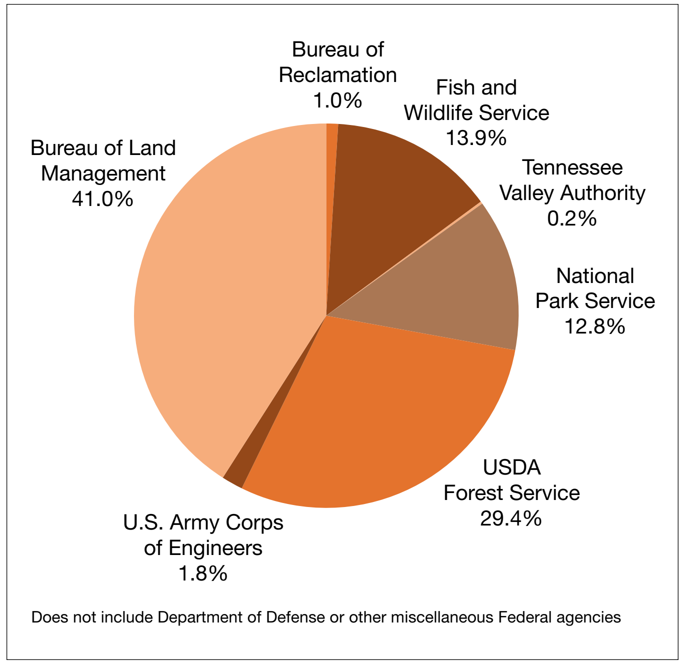


Figure 12 — Distribution of land and water area among Federal land-managing agencies, 1995

Management and Access to Inland Water

About 7 percent, or 161 million acres, of the United States is covered by water. In the United States, there are two water right doctrines: Appropriation and riparian. The law of appropriation, developed by miners and ranchers 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 water rights.

While 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 USDA 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 National Forest System lands contain 128,000 miles of fishable streams and rivers, over 2.2 million acres of lakes, ponds, and reservoirs, and 12,500 miles of coast and shoreline.

Management and Access to Minerals

The Nation's forests 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 ownership. 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 likely exist in the Western United States and some 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 subject to disposal under mineral leasing procedures. This mineral leasing 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 commodity 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.

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, recreation (including hunting, fishing, and wildlife viewing), and mineral rights. For the most part, these markets have developed for renewable resources on private lands. Timber is 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 many recreation opportunities on many public ownerships.

U.S. trade policies for forest products are generally nondiscriminatory except in cases where bilateral trade disputes may be at issue. For minerals, the other renewable resource most directly affected by current trade policies, national security, and other concerns may lead to a variety of policies that depend on the commodity in question.

The Economy and the Environment

It has long been recognized that gross domestic product is a measure of market output, not of national welfare. By design, traditional changes in gross domestic product primarily reflect the value of goods and services as measured in the marketplace, excluding changes in leisure time, public health, environmental quality, and other aspects of social well-being. One of the indicators of sustainable forest management from the Montreal Process expresses interest in signatory countries' capability to include—in the system of national income accounts—measures of environmental quality and the stock of natural resources. Development of this capability has proven to be very difficult. There is little agreement about how to value many aspects of environmental quality or even on how to establish methods for such values. Many of the technical issues to be overcome are illustrated in a prototype analysis of mineral resources done by the U.S. Department of Commerce Bureau of Economic Analysis (1994). This type of environmental accounting is beyond the scope of this assessment.

A panel convened by the National Research Council (1999) concluded that the development of environmental and natural resource accounts is an essential investment for the Nation. The panel also recommended that environmental accounts must not come at the expense of maintaining and improving the current core national accounts.

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 and range lands depends largely on our understanding of forest and rangeland dynamics and our ability to predict the consequences of management actions and the consequences of natural and human disturbance. Our capacity to implement research depends on investments in research and fostering access to this research by stakeholders and policymakers.

Land Use and Cover

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.

The following highlights changes in land use and cover before discussing trends in ecosystem attributes. Changes in land use and cover affect a number of elements of ecosystems such as wildlife habitat, riparian and wetlands, opportunities for increased insects and diseases, introduction of exotic species, and water quantity and quality, as well as the use of forests for recreation. Data for changes in land use are based primarily on the National Resources Inventory (NRI) conducted by the USDA Natural Resources Conservation Service (1999). 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.

Forest Land

According to the USDA Natural Resources Conservation Service (1999), there was a net increase in forest land area of about 800,000 acres on non-Federal lands between 1982 and 1997 (table 3). This 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 sources. The largest loss of forest land was to development (11.7 million acres or 2.9 percent of the area in 1982). The largest gain in forest land was from pasture land (13.8 million acres or 3.5 percent of the area in 1997). In total, 25.1 million acres of forest land (6.3 percent of the area in 1982) was converted to other uses between 1982 and 1997 and 25.9 million acres (6.5 percent of the area in 1997) was added to the forest land classification.

The current situation for forest lands is a far cry from conditions that existed around 1900 (MacCleery, 1992). At that time, there were about 80 million acres of "cutovers" that continued to be either idle or lacking merchantable trees. The volume of timber cut nationally exceeded that of forest growth and there was no provision for reforestation. Aside from a few experimental programs, long-term forest management was not practiced at the turn of the century.

Rangeland

Between 1982 and 1997, there was a 3-percent net loss of non-Federal rangeland area nationwide (Table 3). Of those acres that were rangeland in 1982, 5.6 percent were converted to another land use class in 1997. Of these converted acres, the largest proportion was converted to cropland (29.5 percent), just over 16.6 percent was converted to developed land, 12.9 percent was converted to pasture land, and 12.2 percent was converted to forest.

Table 3 — Changes in land cover/use between 1982 and 1997

	Land cover/use in 1997								
Land cover/use in 1982	*Cropland*	*CRP land*	*Pasture land*	*Rangeland*	*Forest land*	*Other rural land*	*Developed land*	*Water areas and Federal land*	*1982 total*
	(1,000 acres)								
Cropland	348,766.7	30,514.4	19,109.9	3,492.7	5,401.0	3,279.6	8,812.7	1,598.6	420,975.6
Pasture Land	15,618.2	1,308.9	92,183.9	2,596.0	13,812.2	1,892.5	5,335.5	812.2	133,559.4
Rangeland	6,911.9	695.9	3,037.1	392,041.3	2,871.4	1,760.9	3,898.7	4,287.6	415,504.8
Forest Land	1,927.2	117.0	3,918.5	2,021.7	373,140.7	1,767.0	11,718.6	3,609.3	398,220.0
Other Rural Land	975.8	55.8	1,017.0	750.2	2,872.5	47,278.3	738.3	506.1	54,194.0
Developed Land	242.8	2.4	78.9	112.2	219.9	32.5	74,827.4	2.9	75,519.0
Water Areas and Federal Land	601.4	2.6	227.6	2,099.7	713.1	241.8	37.9	442,237.6	446,161.7
1997 Total	375,044.0	32,697.0	119,572.9	403,113.8	399,030.8	56,252.6	105,369.1	453,054.3	1,944,134.5

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).

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.

During the period from 1982 to 1997, there was a net decline in cultivated cropland of 10.9 percent (table 3). This net loss of 45.9 million acres resulted from 26.3 million new acres being converted to cultivated cropland while 72.2 million acres of cultivated cropland went to other uses. Of those 72.2 million acres of converted cropland, 42 percent was enrolled into the Conservation Reserve Program (CRP), 26 percent was converted to pasture land, and 12 percent went to developed land. The CRP removed highly erodable 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 there was a net decline in pasture of only 10.4 percent from 1982 to 1997, 31 percent of the 1982 pasture was converted to another use category. Some 38 percent of the pasture loss went to cropland and 33 percent of it 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-1970's, 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 has slowed—from 460,000 acres per year in the decades of the 1950's to mid-1970's, to 260,000 acres per year in the mid-1970's to mid-1980's, and 79,000 acres per year in the late 1980's to early 1990's.

Causes of conversion of wetland habitats have now shifted away from agriculture to urban development (figure 13). Urban and built-up land was responsible for 57 percent of the wetland acres that were converted during the 1982 to 1992 period, whereas agricultural development was responsible for 20 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.

One outcome of land use change in the United States has been a growing urban forest resource.

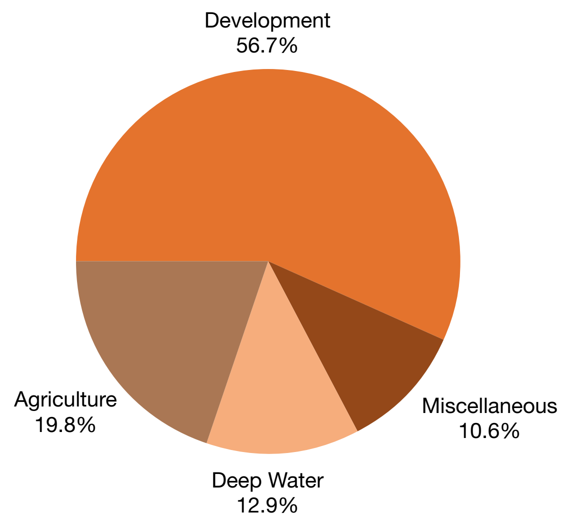


Figure 13 — Causes of conversion of wetland habitats

Urban Lands[4]

Metropolitan areas (a county or group of counties that contain a large population nucleus as its core and can include adjacent counties that have a high degree of economic and social integration with the core) contain 80 percent of the total U.S. population and average 33.4 percent tree cover (figure 14). Metropolitan areas include most of the country's urban and urbanizing areas. Metropolitan areas contain a total of 255,826 square miles of tree canopy cover—the equivalent of an unbroken forest area nearly the size of Texas.

Metropolitan areas grew from 8.5 percent to 23.8 percent of the land area in the United States between 1950 and 1990 (figure 15). This expansion represents an area about 4 times the size of Arizona. Metropolitan areas contained 61.5 percent of the total population in 1950 and 80 percent in 1996.

Urban forests are ecosystems characterized by the presence of trees and other vegetation in association with people and their developments. Vegetation varies widely across the urban area and occurs along streets in parks and preserves, around homes, in parking lots, in corridors, along streams and rights-of-way, and, in other places.

[4] Information on urban lands is based on Dwyer et al., 2000.

Tree and ground cover, buildings, infrastructure, wildlife, and human populations all contribute to the diversity of urban forests and interact to create relationships among the components of the system. Various vegetation configurations on land uses interact with each other, humans, and the physical environment to create a complex, connected system that affects societal well-being and functioning. The connections among vegetation configurations on different land uses at the local level, and between urban and rural vegetation configurations at the regional scale, can affect the movement of wildlife, people, insects, and diseases, as well as the distribution of social and physical benefits provided by various vegetation structures.

National forests throughout the United States are being increasingly affected by urban expansion and increased levels of use by urban populations. Some national forests are partially located within metropolitan areas and have relatively high population densities nearby. Seasonal home developments, especially in the Upper Great Lakes region and the West, are also frequently concentrated in areas adjacent to national forests (figure 16).

Urban areas are the most urbanized portions of metropolitan areas. Urban areas also include unincorporated or incorporated places with at least 2,500 people. These areas support the system of forest resources that has traditionally been viewed by many as the urban forest. Urban areas occupy 3.5 percent of the United States and have an average tree cover of 27.1 percent. They contain 75 percent of the total population.

The extent and character of forests across the urban landscape are shaped by the surrounding natural environment, land use patterns, intensity of urban development, age of land use type, and vegetation management.

An urban area's natural capacity to sustain vegetation is a major factor determining the extent of forest cover. Cities in forest ecotypes have more tree cover (34 percent) than cities in grasslands (18 percent) or deserts (9 percent).

Land use inherently defines a number of site characteristics that influence tree canopy cover and other components of urban forest structure (for example, ground cover, available growing space, wildlife, environmental conditions, buildings, infrastructure, and population density). Hence, land use is an important determinant of the extent, composition, and condition of urban forest resources.

Figure 14 — Places included in the Renewable Resources Planning Act urban forest cover analysis

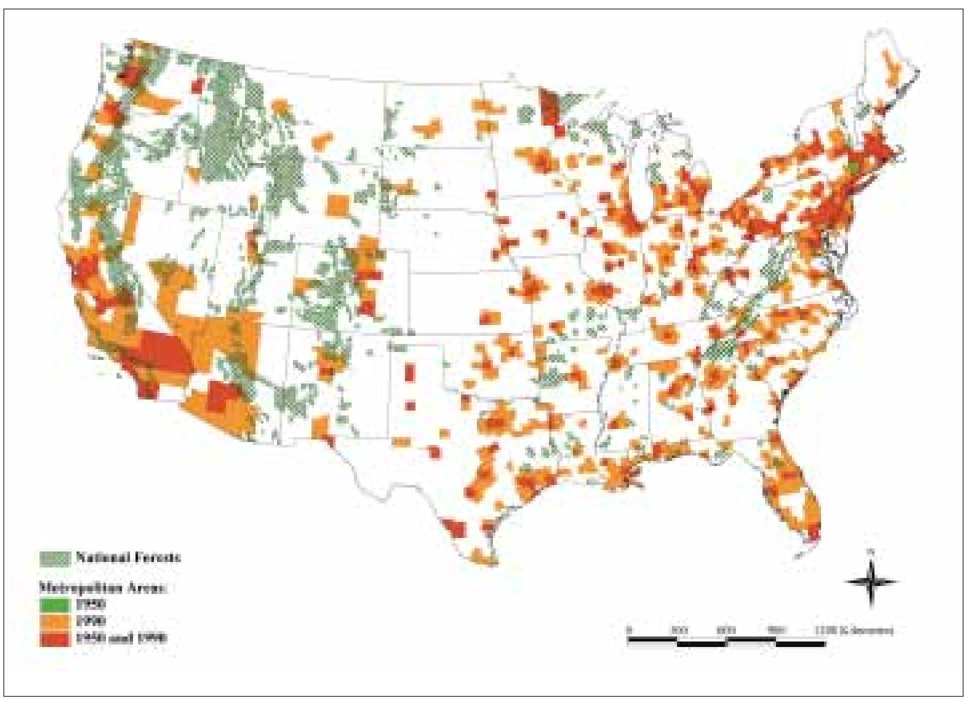


Figure 15 — National forests and metropolitan areas: 1950 and 1990

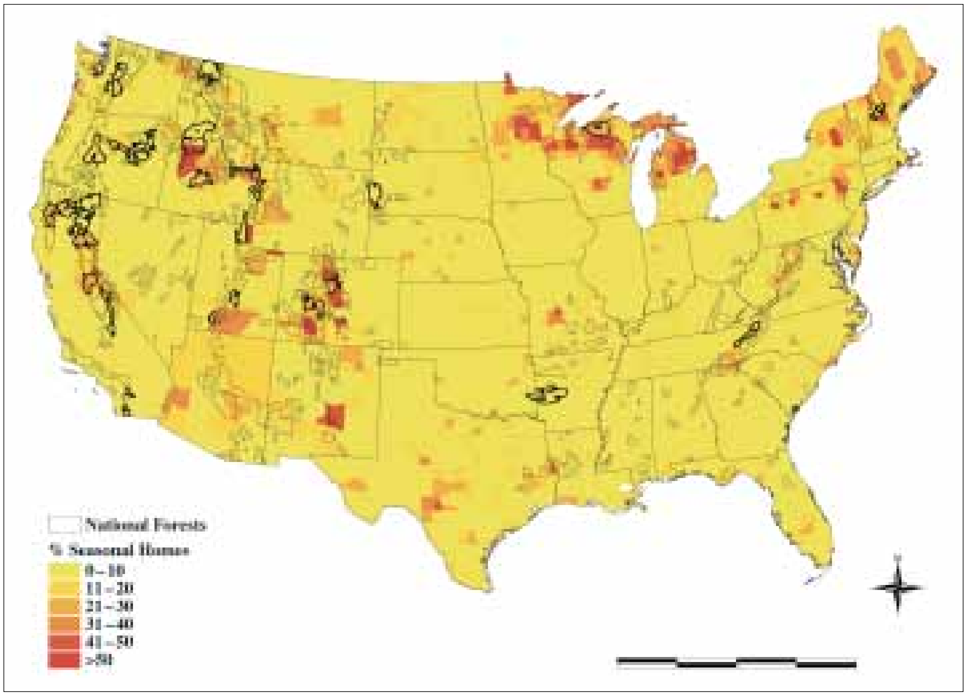


Figure 16 — Percent seasonal homes by county

Forest structure may differ across an urban area depending on the intensity of urbanization. As an urban area becomes more intensely developed, the amount of growing space decreases, residential lot size is reduced, and the amount of impervious ground cover increases. With reduced growing space and potential increases in environmental stresses, the extent of tree canopy tends to decrease.

The duration of land use type tends to determine the structure of urban vegetation. For example, older residential neighborhoods are more likely to have established mature tree canopies and more tree cover than newly developed residential areas.

Forest structure is also affected by the nature of management activities. For example, tree planting and removal, lawn mowing, use of herbicides, and other management activities that alter vegetation all directly affect urban forest structure. Natural forces and phenomena such as weather, fire, insects and diseases, and earthquakes can affect urban forest structure.

The Nation's population is projected to increase by 49 percent between 1998 and 2050; thus, it is likely that the area of the urban forest will increase in size. States with the greatest projected population increases between 1990 and 2050 are in the southern and western regions. Many cities, particularly in the Southeastern United States, are surrounded by forest land; the expansion of these cities is likely to have impacts on the extent, use, and management of forest resources. As urbanization spreads into less developed rural areas, a growing percentage of the Nation's natural resources will become part of urban forest ecosystems.

Implications of World and National Economic, Demographic, and Institutional Trends for Sustainable Management of U.S. Forest and Range Lands.

There will be increasing demands for all uses and services of forests and rangelands around the world. A larger population with increasing incomes will result in increased demands for timber, recreation, and other human uses, as well as vital ecosystem services such as carbon sequestration and clean air and water. There will be continuing pressure to fragment landscapes as land is developed to accommodate increased populations.

Domestic forest policies will continue to evolve with special emphasis on management policies on public lands and public oversight of management on private lands.

Within the U.S. economic system, markets will continue to evolve as opportunities arise (for example, fees for viewing wildlife on private lands).

Globalization of the economy, populations, and ideas will increasingly bring global views to questions of environmental policy.

Management of forests and rangelands within this dynamic environment will require information from indicators of socioeconomic and ecological health. Worldwide, some 150 countries are working to develop indicators of sustainable management.

Criteria and Indicators of Sustainable Forest and Range Management

Conservation of Biological Diversity[5]

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 impact biodiversity by altering habitats, introducing invasive species, or reducing the population or ranges of species. Conserving the diversity of organisms may support the ability of some ecosystems to function and remain productive to meet human needs. Thus, there are indicators of ecosystem diversity, species diversity, and genetic diversity (Montreal Process Technical Advisory Committee, 2000).

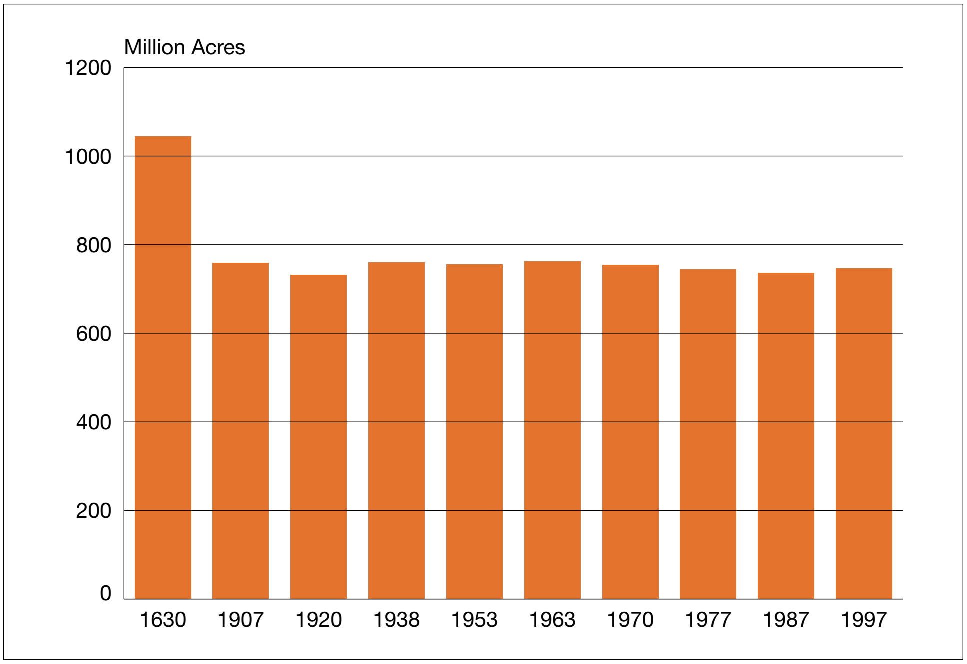


Figure 17 — Area of forest land in the United States, 1630 to 1997

Ecosystem Diversity

Historical trends in land cover: With the arrival of European immigrants around 1630, the total area of forest land in the United States is estimated to have been 1,044 million acres (figure 17) (Smith et al., 2001). This 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. The forest land area has been relatively stable since the 1920's, and in 1997, the area amounted to 747 million acres. Stability in total forest land area does not mean that there have been no changes in this area. There have been shifts from agriculture to forests and vice versa. Some forest land has been converted to more intensive uses, such as urban uses. Even on areas where the area of forest land has remained stable, there have been changes as forests respond to human manipulation, aging, and other natural processes.

Area of forest land[6] by forest type[7]: Between 1977 and 1997, the area of loblolly-shortleaf pine, oak-gum-cypress, oak-hickory, and maple-beech-birch increased in the Eastern States (figure 18). During this same time period, the area of Douglas-fir, hemlock-Sitka spruce, redwood, other softwoods, pinyon-juniper, and western hardwoods increased in the Western States, except for Alaska (figure 19).

In Alaska, the area of western hardwoods declined between 1977 and 1997 (figure 20). The area of fir-spruce and other softwoods increased. The area of hemlock-Sitka spruce was little changed.

Overall, hardwood forests are getting older in the Eastern States. This is demonstrated by the increase in the area of forest types that are more representative of later stages of succession and the decrease in the area of forest types that are more representative of earlier successional stages. Any 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.

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[5] An assessment of the applicability of Montreal Process indicators of conservation of biological diversity on rangelands found that unambiguous definitions, data, and methods were woefully lacking at a national scale (Flather and Sieg., in review)

[6] Timber land is forest land that is producing or is capable of producing crops of industrial wood and that is not withdrawn from timber utilization by statute or administrative regulation. See Smith et al., 2001, for more details.

[7] More detailed data for forest types can be found in the RPA Data Dictionary at: http://www.srsfia.usfs.msstate.edu/wo/review.htm

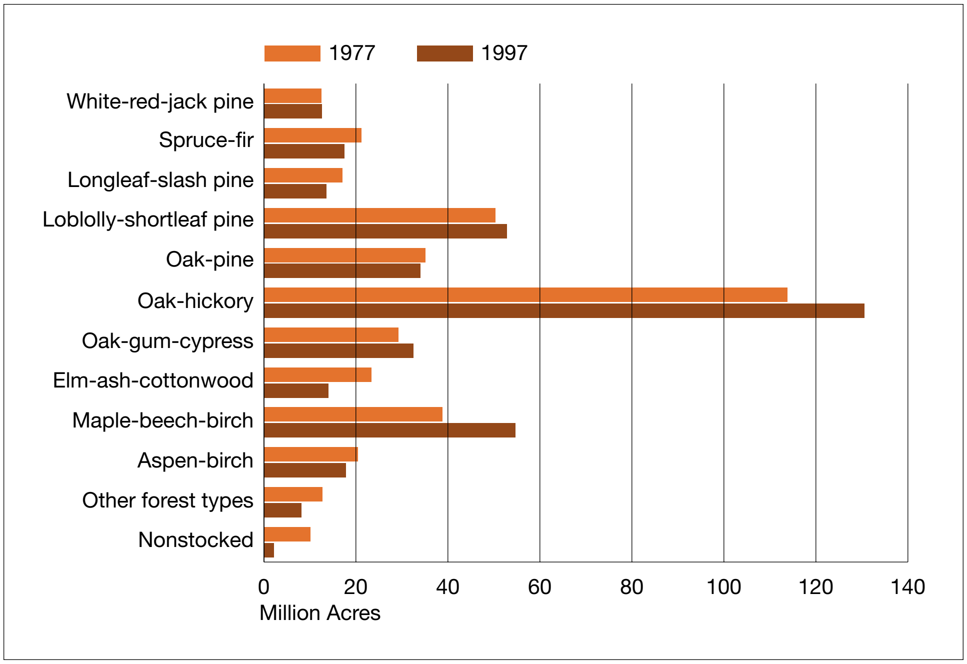

Figure 18 — Unreserved forest land area in the East by forest type group: 1977 and 1997

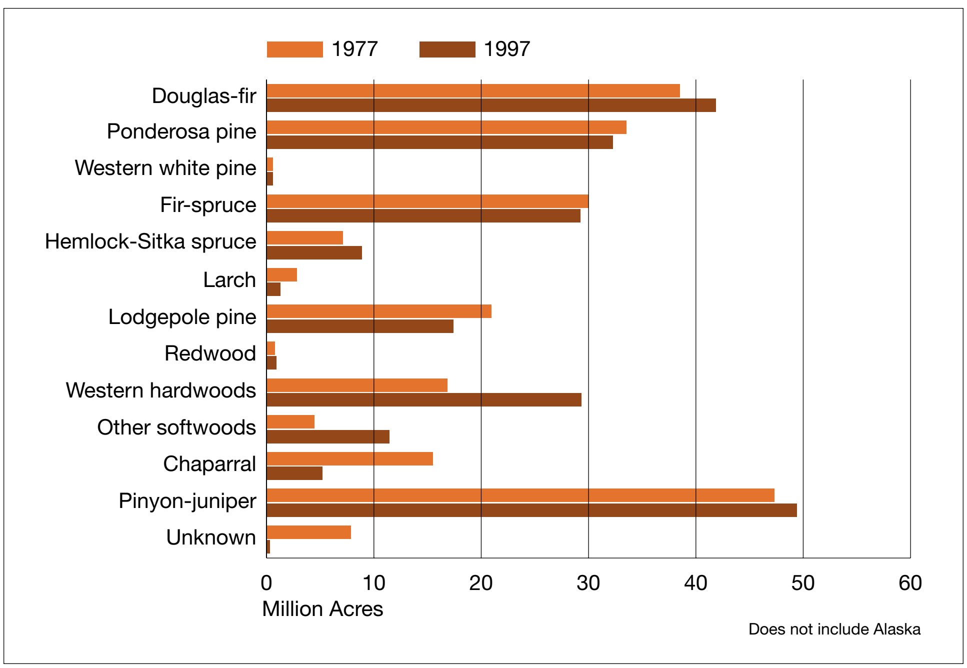

Figure 19 — Unreserved forest land area in the West by forest type group: 1977 and 1997

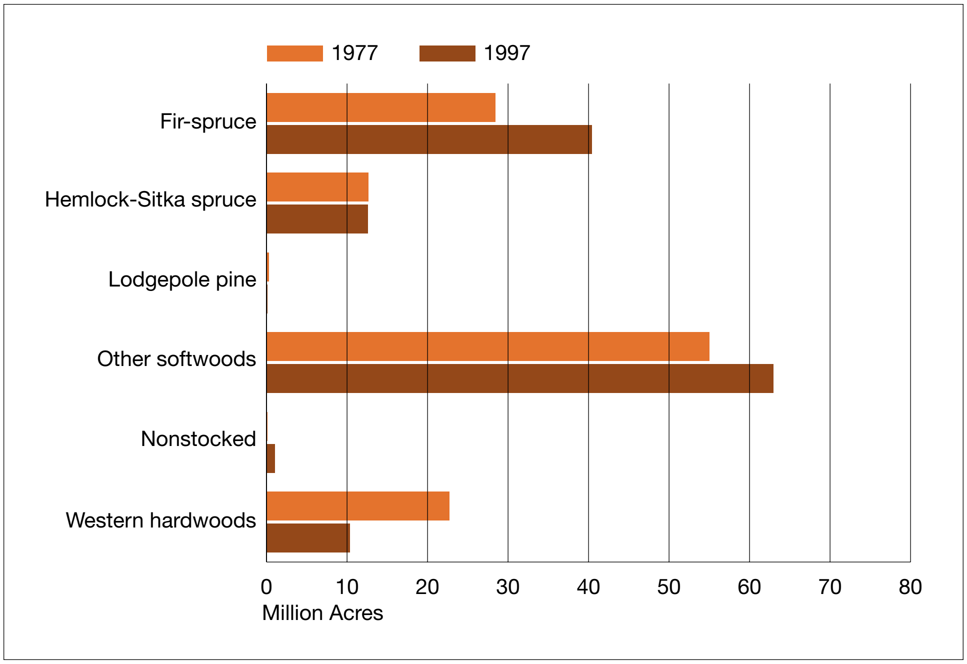

Figure 20 — Unreserved forest land area in Alaska by forest type group: 1977 and 1997

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 a decrease in the area of some forest types, such as longleaf pine, which has been replaced largely with loblolly pine. Even as forests age, duplication of pre-European conditions is not possible. For example, the ravages of the exotic, chestnut blight forever changed the composition of forest ecosystems in the East.

Extent of timber land 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 and its diameter and height) and successional stages (variable species of vegetation).

In the East, some 71 percent of all timber land is classed as having an average stand age of more than 40 years, 13 percent is between 20 and 40 years in average stand age, and 16 percent has an average stand age of less than 20 years (figure 21). In the West, the average stand age is older than for the East, reflecting in part the fact that there are more areas in the West that have never been harvested. Some 30 percent of the timber land area in the East is classed as uneven aged compared with less than 1 percent in the West (Smith et al., 2001).

In 1997, some 64 percent of all timber lands were classified as sawtimber-size in the Western United States.[8] Most of the remaining area was split between seedling-sapling (17 percent) and poletimber (14 percent) (Smith et al., 2001). The area of nonstocked timber land amounted to 4 percent of total timber land area. In the East, 46 percent of timber land area was classed as sawtimber in 1997, 29 percent was poletimber, and 25 percent seedling/sapling. By comparison, in 1952, 30 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. However, the extent of some seral stages and forest types will likely decrease 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. There are various ways of classifying the degree of protection given to an area. The classification scheme used by the International Union for the Conservation of Nature (IUCN) includes the following

[8] To be classed as sawtimber, softwood trees must be at least 9.0 inches in diameter at 4.5 feet above the ground. Hardwood trees must be at least 11.0 inches in diameter. Seedlings are live trees less than 1.0 inch in diameter at 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 at 4.5 feet above the ground. Poletimber trees are live trees at least 5.0 inches in diameter but smaller than sawtimber trees.

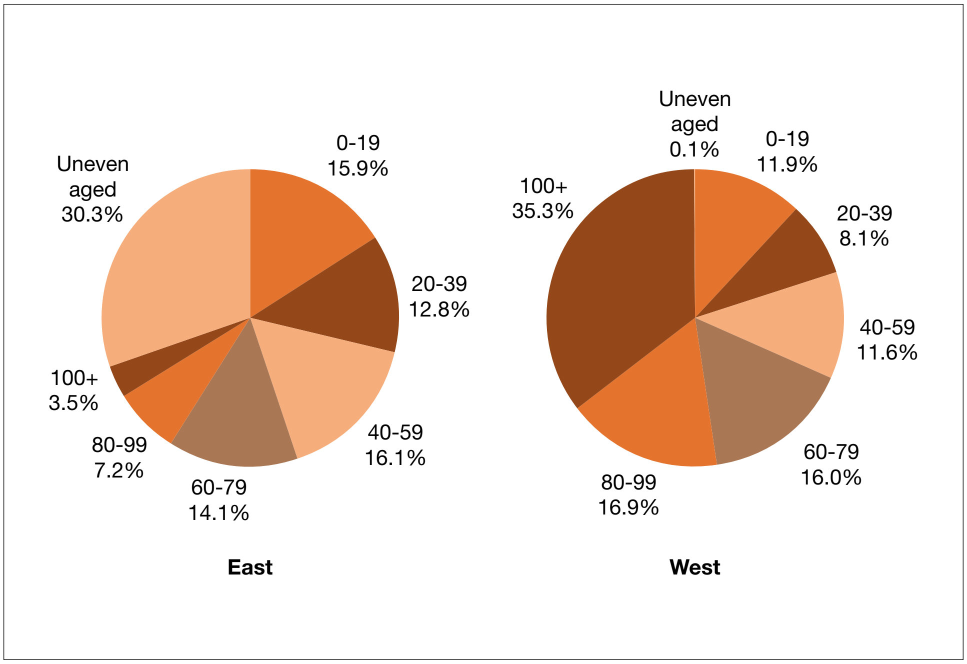

Figure 21 — Timber land area by stand-age class

with the intention of preservation, but this protected status may change as organization objectives change over time.

In 1997, some 52 million acres of forest land were classed as reserved (Forest land withdrawn from harvest by statute or administrative regulation) and include wilderness areas on Federal and State lands and national parks (Smith et al., 2001). Reserved forest land is assumed to fit in IUCN categories I and II. This estimate does not include any allowance for private lands. The reserved forest land area in 1997 amounted to 3 percent of the total forest land area in the East and 11.1 percent in the West (figures 22 and 23). The area classed as reserved in 1997 was about double the area classed as

categories: I. Strict nature reserve/wilderness area, II. National Park, III. National monument, IV. Habitat/species management area, V. Protected landscape/seascape, and VI. Managed resource protection area.[9]

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

reserved in 1953. Much of the remaining public forest land (223 million acres) is probably appropriately classed in IUCN categories III-VI. It is in national monuments or other custodially managed areas or it is in areas managed for the sustainable use of natural ecosystems. There will likely always be debate about how this management relates to protection and maintenance of biological diversity. There are currently tens of millions of acres on Federal lands classed in Category VI, even though they may never be available for harvest. They are protected by administrative action rather than legal statute.

[9] 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. The area of land and/or sea is available primarily for scientific research and/or environmental monitoring or is 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 harmful to the purposes of designation of the area, and (c) provide a foundation for spiritual, educational, 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.

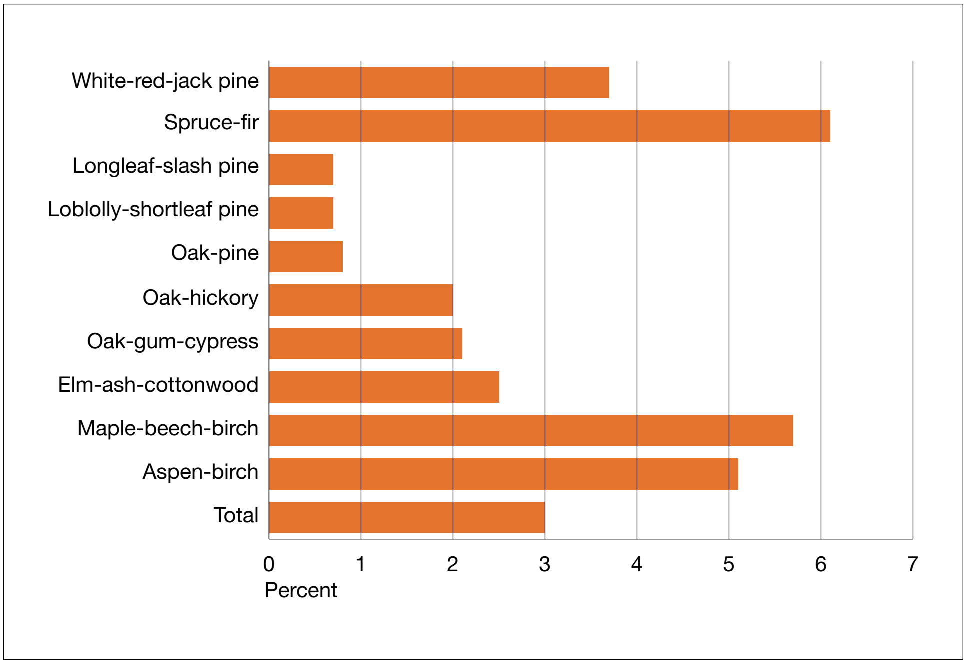

Figure 22 — Percent of forest land in reserved status by forest type in the East: 1997

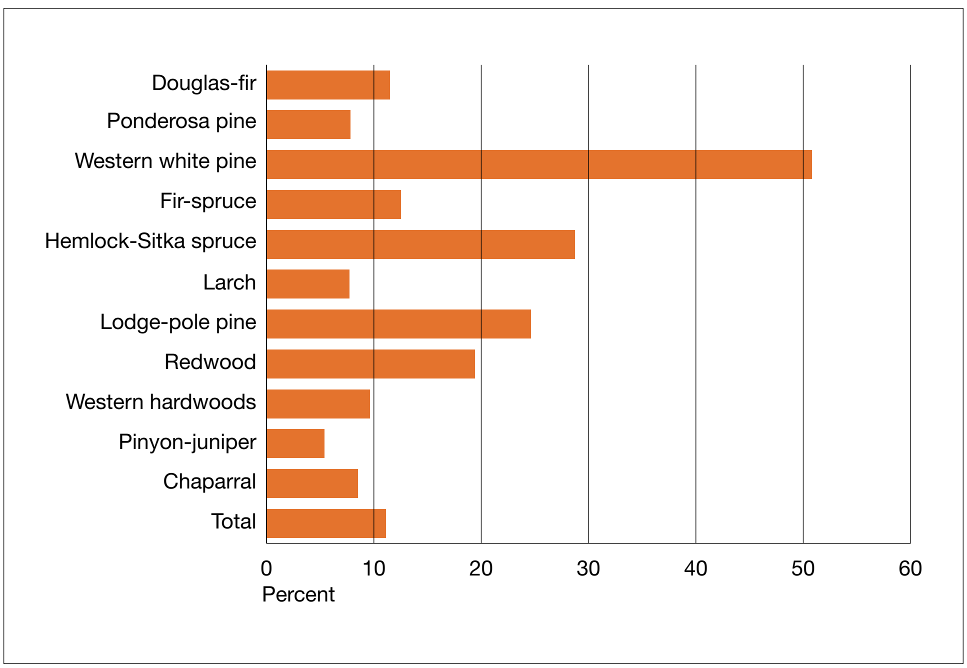

Figure 23 — Percent of forest land in reserved status by forest type in the West: 1997

There are no national-scale data for the area of forest type in protected areas by age class or successional stage. The area of reserved mid- to late-successional forest types, such as maple-beech-birch, is likely to 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.

Fragmentation of forest types: Fragmentation of a forest type into smaller pieces disrupts ecological processes and reduces the availability of habitats for some wildlife species. Fragmented areas may be too small to maintain viable breeding populations of some species. The distances between and among forest fragments can interfere with pollination, seed dispersal, wildlife movement, and breeding. Ultimately, excessive fragmentation can contribute to the loss of plant and animal species that are unable to recolonize after an area is disturbed. While detrimental to some wildlife species, fragmentation will improve the habitat for other species; especially those that prefer forest edges.

Various case studies, using data primarily from the Eastern United States support the hypothesis that bird diversity attributes are associated with variation in landscape structure attributes (Flather et al., 1999). Many of the landscape structure attributes are related to land use. These case studies used spatial crossectional data for analysis. Other case studies confirm that more fragmented landscapes not only reduce the numbers of some forest breeding birds, but may also be responsible for destabilizing bird community structure over time through increased rates of local extinction and turnover.

The case studies support the need to study the relationships between biological diversity and landscape structure and support the notion that the composition, extent, and spatial layout of land types have the potential to fundamentally affect the flow of ecosystem goods and services in a region. Case studies support the hypothesis that land use intensification results in simplified bird communities with higher temporal variation that may signal broader-scale extinction events. However, the population of permanent bird residents showed few correlations with landscape structure and temperate migrants were associated with habitat diversity and edge attributes rather than the amount, size, and dispersion of habitats. Thus, patterns observed in the East may not hold for other geographic areas.

Increased interactions of people and the environment increase the likelihood of forest fragmentation. The number of forest land owners is increasing and the average size of ownership is decreasing for land in the smaller sized parcels (Birch 1996). As people move onto forested land or otherwise develop their properties, there will be increased fragmentation (change in forest cover). Smaller tract sizes also leads to parcelization in that multiple ownerships make landscape-level planning and management more difficult.

There are various measures of fragmentation, each conveying different information about the phenomenon. Thus, there are measures for patch size, edge, distances between habitat areas, and interconnectedness.

Riitters and others (In press) developed indices of various types of fragmentation for the North and South. They used satellite imagery from the Multi-Resolution Land Characteristics consortium (Loveland and Shaw, 1996, and Vogelmann et al., 1998a and 1998b). The forest fragmentation indices combine measurements of forest area density and adjacency within the surrounding approximately 18-acre "landscape" to assign a fragmentation category to each 0.22-acre unit of land. The resulting maps describe landscapes, not individual parcels of land. The fragmentation categories include interior (completely forested), perforated (mostly forested with nonforest inclusions), edge (mostly forested with the forest and nonforest land-cover types tending to form distinct clumps), transitional (about half forested with no spatial pattern defined), and patch (mostly nonforested but containing distinct patches of forest).

The results of the analysis show that 47 percent of the North was classed as highly forested landscapes (interior, perforated, and edge) compared to 61 percent of landscapes in the South:

Fragmentation Categories	*Percent of Landscapes* North	South
Interior	21	27
Edge	11	15
Perforated	15	19
Transitional	26	4
Patch	7	29
No forest	20	6

The South had a greater proportion of landscapes that were highly forested. Of the landscapes in the South, 27 percent were classed as interior compared with 21 percent for the North. The South also had a smaller proportion of landscapes that are completely without forest.

Species Diversity

Number of forest-dependent species: In the United States, there are—

- An estimated 865 native tree species
- 419 native species of mammals
- 281 species of reptiles
- 240 species of amphibians
- 800 freshwater species

In addition, more than 650 species of birds are known to roost regularly on the North American continent north of Mexico (Ehrlich et al., 1988). It is estimated that at least 90 percent of the total bird, amphibian, and fish species of the country and at least 80 percent of mammal and reptile species can be found on forested land (USDA Forest Service, 1997).

The status of threatened and endangered species: Since passage of the Endangered Species Act of 1973, about 1,000 species have been listed as threatened or endangered (Flather et al., 1999). These species occur in forest, grassland, aquatic, and special habitats (for example, wetlands and caves) throughout the United States. Although there have been notable success stories such as the American bald eagle, the number of species (238) awaiting final listing decisions, and the number (182) of candidate species awaiting listing proposals, far outnumber the species that have recovered.

A review of 631 listed species that occur in the conterminous United States found that endangered species are most highly concentrated in several distinct geographic regions, including the southern Appalachians, coastal areas, and the arid Southwest. After consideration of the counties with the largest number of threatened and endangered species and associated climate, physiography, soils, vegetation, and land use, 12 hotspots of high species endangerment were identified (figure 24).

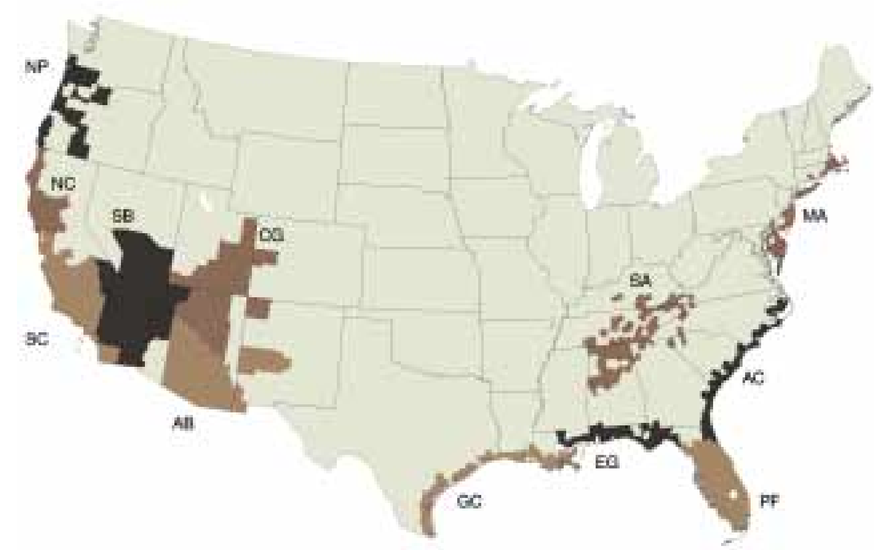

Figure 24 — Hotspots of species endangerment

The listed species occurring within eastern coastal hotspots were characterized by relatively high proportions of birds and reptiles, were associated with forest and aquatic habitats, and were negatively impacted by general human development activities. Of the eastern coastal hotspots, Peninsular Florida had the highest level of endemism, with 78 percent of the species having their distribution restricted to this hotspot.

Endangered species located in the arid southwest hotspots were characterized by high proportions of plants and fish and were associated with rangeland and wetland habitats. Their populations were impacted by extractive resource uses and the introduction of exotic species.

The California hotspots were distinguished from other regions by the relatively high proportion of insect fauna listed, high endemism, and a mixture of forest and rangeland habitat associates. Like the east coast, residential and industrial development was the most common factor contributing to species endangerment in California, although exotic species also had a major impact on listed species populations. The hotspots help define characteristics of species or environments that are susceptible to endangerment and thus provide a means of anticipating where species endangerment may be a problem in the future.

Genetic Diversity

Number of forest-dependent species that occupy a small portion of their former range: Analysis of taxa that included mammals, reptiles, amphibians, birds, and fish indicated that mammals have the greatest proportion of species with reduced ranges (26 percent) while amphibians have the least (9 percent) (table 4). In total, 187 forest-dependent species were found to occupy a small portion of their former range (USDA Forest Service, 1997).

Some degree of genetic erosion occurs in species that occupy small portions of their former range. However, we cannot determine the extent of genetic erosion, what proportion of the former gene pool of the species remains, or how important it may be to adaptation, survival, or potential human use. This information does not show if important physical characteristics are being lost.

Existing data are not sufficient to determine the role of genetic diversity in population levels or trends in unmanaged species. Management activities such as transplanting programs and harvest have definite genetic effects such as inbreeding that may not be evident when looking only at demographic parameters. Consequently, population levels or trends in these species may indicate only population abundance, not trends in genetic diversity.

Population trends in wildlife species: The ecosystems within the United States support some of the most diverse temperate forests, warm deserts, and shallow-water wetland systems found globally. The presentation of information on populations of resident and common migrant harvested species that occur within the United States is organized by major species category, including big game, small game, migratory game birds, and furbearers. Because these species are harvested, they are generally subject to State or Federal regulations and thus information is gathered and reported on population levels. For many species that are not harvested or in special protection status, there is little information available on population trends. Exceptions are trends in populations of breeding birds in the United States.

Big game—Big game are primarily comprised of large mammal species that are taken for sport or subsistence. The species comprising big game were the first to stimulate widespread public interest in wildlife conservation and many of these species are now highlighted as wildlife management successes.

Nationally, big game populations have increased substantially since 1975. Population increases have varied by species with wild turkey populations increasing by over 200 percent over the 1975 to 1993 time period and pronghorn populations increasing by 56 percent. Elk now occupy more suitable habitat and are more numerous than at any time since the turn of the century. Populations of some big game species have increased to the point of being pests in some areas of the country. For example, management of deer populations in the East will likely represent one of the more challenging wildlife management problems during the next decade. Deer populations in the West have declined (Flather et al., 1999).

Small game—Species treated as small game typically include resident game birds and mammals that are associated with upland (forest, range, or agricultural) habitats. Few State wildlife agencies monitor small game populations. The following information is based on information from States responding to a questionnaire on small game populations.

Small game populations have shown the capability to withstand increased predation and severe weather, so that changes in populations are likely related to habitat quality. Species associated with rangeland or agricultural habitats show evidence of declining populations, while species associated with forest habitats show a mixed pattern over time. Thus, northern bobwhite, prairie grouse, hare, and western quail populations all show evidence of decline since the mid-1970's or early 1980's. Two species associated with agricultural habitats that have shown recent evidence of population increases are cottontail rabbit and ring-necked pheasant. Cottontail populations are now estimated to exceed mid-1970 estimates.

Table 4 — Number of forest-associated species by taxa that occupy a small portion of their former range

	Taxa				
	Mammals	*Birds*	*Reptiles*	*Amphibians*	*Fish*
Number	37	30	10	13	97
Percent of Listings	26	13	11	9	15

Forest-associated species including squirrel and forest grouse show mixed trends. Squirrel numbers show steady but slight gains in the North, declines in the Rocky Mountains, and declines since 1985 in the South.

Migratory game birds—Migratory game birds refer to a collection of species that include waterfowl (ducks, geese, and swans) and webless migratory species including woodcock and mourning doves. Federal authority to conserve and manage migratory birds is rooted in a series of statutes that were passed in the early 1900's (Migratory Bird Act of 1913, Migratory Bird Act Treaty of 1918, and Migratory Bird Conservation Act of 1929). These early international agreements were with Great Britain on behalf of Canada. Subsequent treaties were established with Mexico, Japan, and the former Soviet Union. The primary objective of these treaties is the protection and conservation of migratory bird populations. The long history of migratory bird management in North America that was initiated by these agreements has resulted in perhaps the premiere monitoring system for population and harvest of continentally distributed species in the world.

The status of duck populations varies from species to species, but recent trends suggest substantial recovery of many species over recent years. The 1996 estimate of 37.5 million ducks is approaching levels not observed since the early 1970's and late 1950's. It is believed that an increasing trend in wetland habitats in breeding areas in the 1990's due to unusually wet conditions corresponds to the rapid population growth in ducks.

The North American Waterfowl Plan specifies an overall goal of 62 million breeding ducks under average environmental conditions. Based on the goals established for each species, the 1996 population estimates exceeded those goals for 6 of the 10 principal duck species.

Species comprising goose and swan populations include Canada geese, snow geese, Ross' geese, greater white-fronted geese, brant, and tundra swans. Available data indicate that 80 percent of goose and swan populations are increasing or stable. Two Canada geese—the Atlantic population and the dusky Canada goose—have shown declining populations and four populations did not have sufficient data to indicate trends.

Of the 29 goose and swan populations that are monitored, 28 have population goals specified in the North American Waterfowl Management Plan. There is growing evidence that some populations may exceed acceptable levels. A contributory factor may be agricultural activities that provide wintering geese with waste grain near human-caused open water habitats. This may lead to increased survivorship, an increased number of birds, and habitat degradation.

Available information suggests that changes in farming practices, especially the trend toward larger farms and increased use of pesticides and herbicides have been factors in declining populations of mourning doves. Woodcock prefer early successional stages of second-growth hardwood forests associated with fields and forest openings on mesic sites. The declines in woodcock breeding populations are thought to be related to a deterioration of preferred breeding habitats due to forest succession and land use intensification.

Aquatic species—Despite State and Federal agencies collecting data on the status and trends for specific fishery resources, the data needed to complete a comprehensive assessment of the status and trends of freshwater species in the United States are not currently accessible (Loftus and Flather, 2000). It is clear that in specific instances, land use practices including forest and range activities, do impact the integrity of aquatic communities. In the case of the Pacific salmon, the availability and quality of spawning habitat is restricted by inadequate flow levels, high stream temperatures, sedimentation, low pool/riffle ratios, and other factors.

Furbearers—Collectively, furbearers constitute a resource that is valued ecologically, recreationally, and commercially. The secretive nature of these species makes it difficult to evaluate the population status of most species. For many species, the only available information is on temporal trends in harvests that are likely more reflective of fur prices than population status. Results of a survey of State biologists indicated that populations of most furbearers—including beaver, raccoon, muskrat, coyote, bobcat/lynx, and red/gray fox—included in the survey were estimated to be at or above carrying capacity (Flather et al., 1999). In addition to improving habitat conditions, decreased harvest caused by low fur prices were prominent reasons cited for population increases.

Nongame species—Nongame species are defined as those vertebrate species that are not consumptively taken for sport, subsistence, or profit. As such, nongame species comprise the majority of the approximately 3,000 vertebrates that are resident or seasonal inhabitants within the United States. There are very few data sources available for most nongame species that would permit an exploration of national and regional population trends. One taxonomic group where sufficient population information does exist to support broad-scale analyses is abundance of birds.

Results from the North American Breeding Bird Survey were used to examine the relative abundance trends for approximately 400 species, nationwide, for the period of 1966 to 1996 (Flather et al., 1999). Relative abundance trends for each species were summarized two ways. First, the number of species with increasing, decreasing, or stable trends were estimated nationwide and for each region. Second, birds were grouped according to several life-history characteristics, including nest type/location (cavity, open cup, ground or low, or midstory or canopy nesters), migration status (Neotropical migrant, short-distance migrant, or permanent resident), and breeding habitat (woodland, shrubland, grassland, wetland or open water, or urban nesting). The number of species with increasing, decreasing, or stable trends was estimated separately for each life-history group.

Nationally, 48 percent of the species showed no trend in relative abundance. The numbers of species with increasing and decreasing trends were nearly equal. Among the 12 bird groups examined, those with the greatest proportion of declining species were observed among species that nest in or around urban areas or human settlement (54 percent), nest in grassland habitats (44 percent), or nest on or near the ground (36 percent). Those life-history groups with the greatest proportion of species with increasing trends included wetland or open water nesting species (40 percent), cavity nesting species (37 percent), or short-distance migrant species (31 percent). Over the 1966 to 1996 period, nearly 55 percent of Neotropical migrant species had stable populations, 27 percent had declining trends, and 19 percent had increasing trends.

Existing data indicate that population levels are high enough that genetic diversity does not appear to be a major concern for most species of large carnivores, herbivores, and large game birds. Populations for these species generally increased or at least remained steady. Populations of small game mammals and birds are not as secure; however, genetic diversity is probably not threatened in these species because geographic distribution remains widespread—and census numbers and consequently effective breeding population sizes—remain relatively high.

Implications of Historical Trends for Expectations for the Future Conservation of Biological Diversity

The area of forest land in the United States has been relatively stable since the 1920's. Although the total area has been relatively stable, there has been change in the area of forests. During the 20th century, there was much conversion of forests and wetlands for crops, urban development and other purposes. For example, demands for soybeans and other crops stimulated conversion of bottomland forests to cropland in the lower Mississippi Valley in the 1960's and 1970's. Conversely, abandonment of crop and pasture land in the East led to reversion of this land to forests. The increasing movement of people into forest and rangeland ecosystems has implications for how these systems will function. The area in urban forests continues to grow as population centers expand.

Actions taken to protect biodiversity can affect other values as well. For example, reservation of land from harvest can mean increased pressure on other areas for commodity production. Lands reserved from timber harvest may also contain aesthetic qualities and areas of cultural significance.

Those wildlife species that have been able to adapt to human activities have done well in this century, as have species such as elk that are highly valued and managed by humans. Those wildlife species that need large undeveloped landscapes or specialized habitats vulnerable to development pressures have not done as well. Thus, the number of plant and animal species found on forest and rangeland and added to the Federal list of threatened and endangered species continues to increase.

The area considered to be protected from harvest on public lands increased from 15 million acres in 1952 to some 52 million in 1997.

As the eastern forest has gotten older, early successional forest types such as aspen have decreased in area, with concomitant implications for plants and animals associated with these forest types. There have been declines in the areas of some forest types such as longleaf pine in the South and scrub oaks in California.

Some exotic species, especially those adaptable to humans have, in some cases, replaced native species that have been displaced by human activities. Some exotic species have inbred with domestic species, affecting the overall gene pool. Exotic diseases such as the Chestnut blight and the Dutch elm disease have forever changed the composition of some domestic forested ecosystems. There are known exotics such as the Asian longhorned beetle that could wreak havoc if released on America's forests.

Threatened and endangered plants are currently distributed throughout the Northeast, peninsular Florida, the southern Appalachian Mountains and piedmont, the prairie and plateau areas of southern Texas, the plateau and mountain areas of the southwest, and the Mediterranean climate region of the central California coast (figure 25) (Hof et al., 1999).

Threatened and endangered animals are currently concentrated in the Southeastern United States, the Ozark Highlands of southern Missouri and northern Arkansas, the Great Plains from Nebraska to North Dakota, the central California coast, and the Washington-Oregon border (figure 26) (Hof et al., 1999).

Breeding Bird Survey data indicate that native breeding birds species richness is high in the Northeast, the northern Great Plains, the Ozark Highlands, along the southern Appalachians, in areas of the Pacific Northwest, and along the tidewater area of northeastern North Carolina and the Chesapeake Bay. Areas of relatively low bird species richness are located along the shortgrass prairie of the western Great Plains and in the desertic basin and range region of the Southwest (figure 27) (Hof et al., 1999).

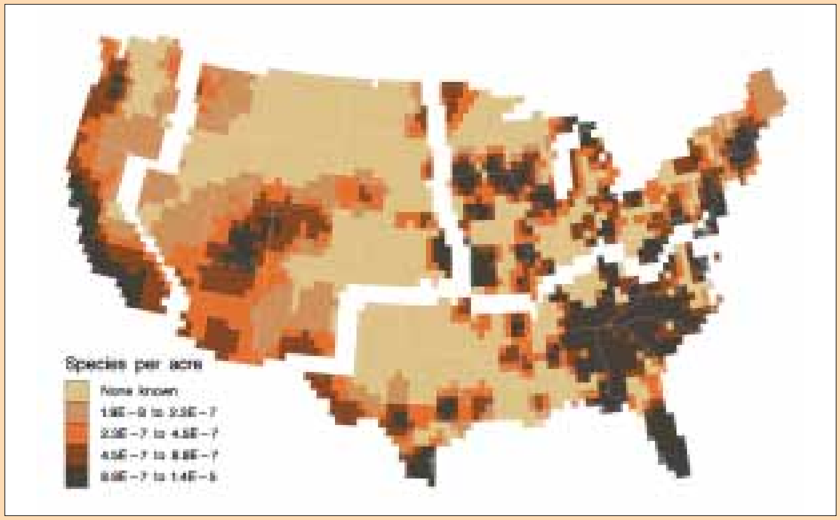

Figure 25 — Current threatened and endangered plants condition indicator

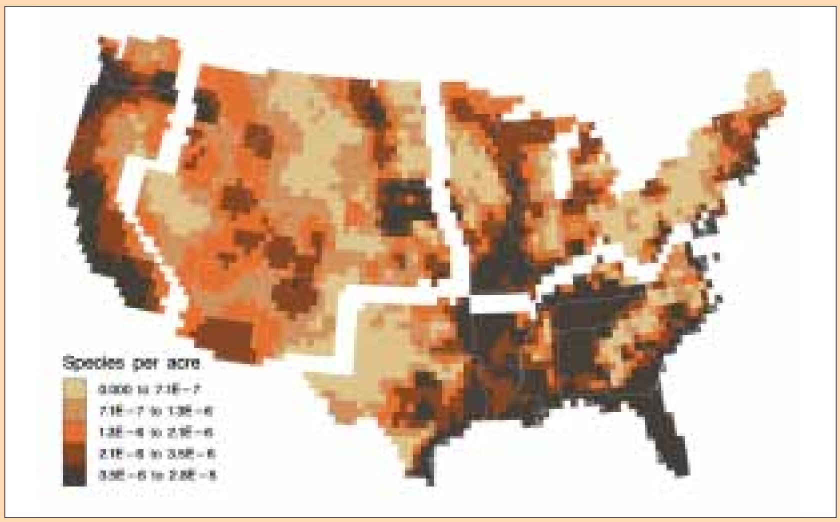

Figure 26 — Current threatened and endangered animals condition indicator

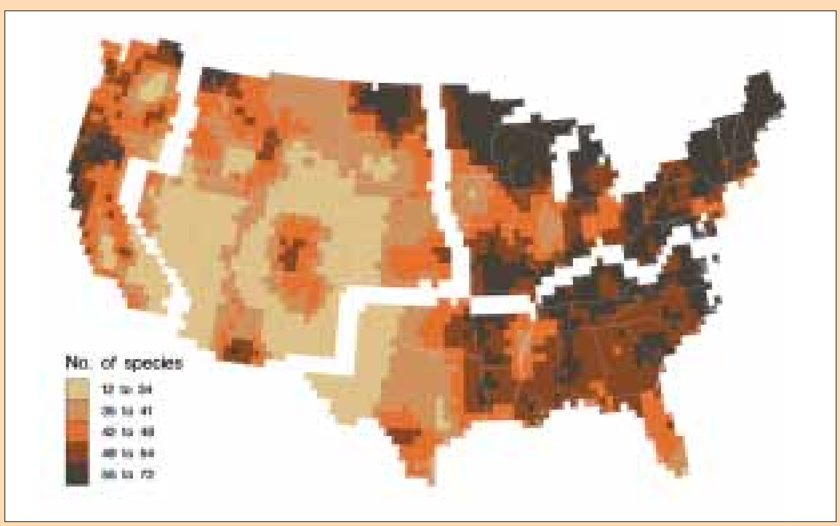

Figure 27 — Current native breeding birds condition indicator

Intensive land use activities (for example, agriculture and urban development) are associated with bird communities dominated by nonnative species. It is thus not surprising that the Corn Belt of the Northern Region, parts of northern Texas, southern Arizona and Nevada, southern California, and the Pacific Northwest are dominated by the highest class of exotic breeding birds (figure 28) (Hof et al., 1999).

Habitat structure is measured as the ratio of area in natural vegetation to area in intensively used land. Areas that are currently characterized by low habitat structure include the Corn Belt, the Mississippi valley, and northern plains regions of the central United States (figure 29) (Hof et al., 1999).

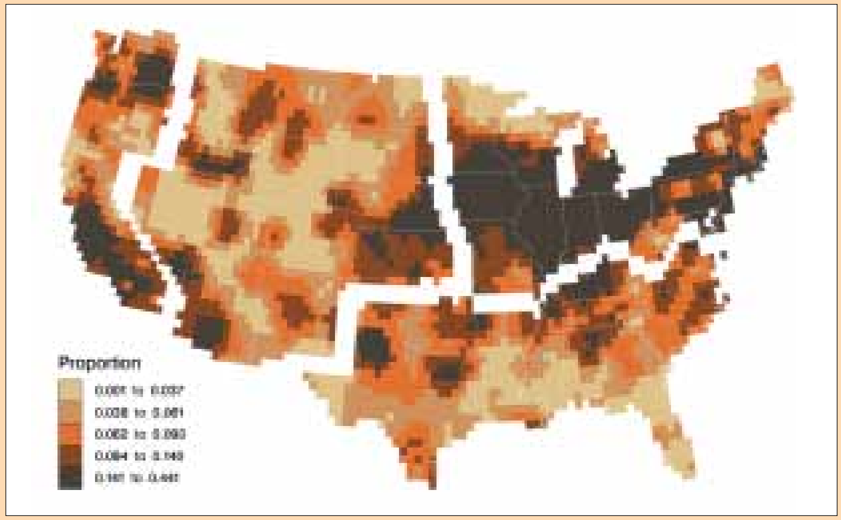

Figure 28 — Current exotic breeding birds condition indicator

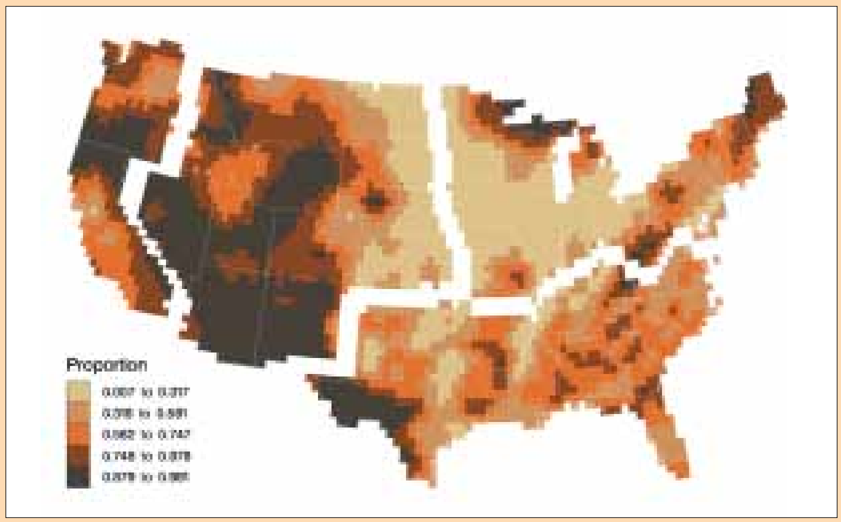

Figure 29 — Current habitat structure condition indicator

Expectations About the Future for Conservation of Biological Diversity

- In the absence of human intervention, there will continue to be changes in ecosystem types. The area of early seral species will likely continue to decline.
- In the South, the area of pine plantations is expected to increase to the point where approximately 44 percent of the area of softwood types will be in plantations by 2050 (Haynes et al., 2001).
- The changing mix in forest cover and the age structure of this cover will lead to changes in the composition of some wildlife populations.
- The area of forest land in protected areas is expected to increase. Much of this increased area will likely be on public lands in the West and will contain the softwood species associated with these lands. Conservation easements and other innovative tenure arrangements may lead to more protection for privately owned forested areas.
- The projected increases in human populations and incomes leave little doubt that fragmentation of forest types will continue in the future. This will especially be the case around existing population centers.
- Increasing land use intensity and continued introduction of exotic species are expected to lead to more listings of species as threatened or endangered. Recovery efforts will lead to delisting of some species. Development and other pressures are likely to affect both forest and nonforest dependent species.
- Populations of both small and large game animals are expected to be relatively stable in the future.
- As in the past, the future of migratory bird populations will be subject to their management at a continental scale.
- Improving habitat conditions and low fur prices contribute to expected increases in fur bearer populations.
- Projected hotspots of increasing plant endangerment indicate that the southern desertic basin, plateau, and plains regions of western Texas have the potential to become an important area for resource conflicts, resulting in new concentrations of threatened and endangered plants (figure 30) (Hof et al., 1999). New concentrations of endangered plants are also projected to occur in the central desertic basin and range regions of southern Nevada, western California, and along the southern California Coast Range and valleys. Other projected hotspots include the southern Appalachians, southern Piedmont, and peninsular Florida.
- Both the east and west slope of the Pacific Northwest Cascade Range, and the central California Coast Range and interior valleys, indicate a geographic extension of the areas currently supporting a high number of threatened and endangered animals (figure 31) (Hof et al., 1999).
- New hotspots indicative of habitat structure degradation are projected to occur in the southwest desertic basin and range and in the Cascade Range of the Pacific Northwest (figure 32) (Hof et al., 1999).

Figure 30 — Projected threatened and endangered plants condition indicator

Figure 31 — Projected threatened and endangered animals condition indicator

- Many of the hotspots for decreases in native breeding birds occur in areas already experiencing high occurrences (figure 33) (Hof et al., 1999). Thus, hotspots occur in the central till plains region, the Laurentian mixed forest region of coastal Maine, the southern Appalachians, and the southern Mississippi valley.
- Increasing use of nontimber forest products may put pressure on some plant communities.

Figure 32 — Projected habitat structure condition indicator

Figure 33 — Projected native breeding birds condition indicator

Maintenance of Productive Capacity of Forest and Rangeland Ecosystems[10]

If 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 and that the ecosystem is functioning, everything else being equal. If inventories are declining, a more detailed examination is necessary to draw inferences about ecosystem function. Inventories and outputs reflect the influences of harvesting, land use changes, and natural disturbances, as well as natural processes and management activities. However, these measures can mask other influences such as disease that may have long-term effects on inventories and outputs.

Forest Products

Area of forest and net area of forest land available for timber production: Some 504 million acres or 67 percent of the total forest land area is classed as timber land—forest land that is capable of producing more than 20 cubic feet per acre per year of industrial wood and that is not withdrawn from timber utilization by statute or administrative regulation (Smith et al., 2001). Timber land is used here as a proxy for the net area of forest land available for timber production. Timber land 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. Some 72 percent of the timber land is in the eastern half of the country, while in the Western United States, timber land is found primarily in Montana, Idaho, Colorado, and the Pacific Coast States.

Timber land area has consistently amounted to about two-thirds of the forest land area since the 1950's.

Growing stock available for timber production: The volume of hardwood growing stock generally increased for the Nation as a whole and across ownerships during the period, 1952 to 1997 (figure 34) (Smith et al., 2001). 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 increased from 1952 through 1977, declined from 1977 to 1987, and increased from 1987 to 1997 (figure 35). Between 1987 and 1997, the volume increased on national forest and nonindustrial private timber land. During this same time period, volume decreased on other public and forest industry ownerships. 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 high and larger. As with the definition of timber land, no allowance is made for economic accessibility or operability and, thus, growing stock volume overstates the volume actually available.

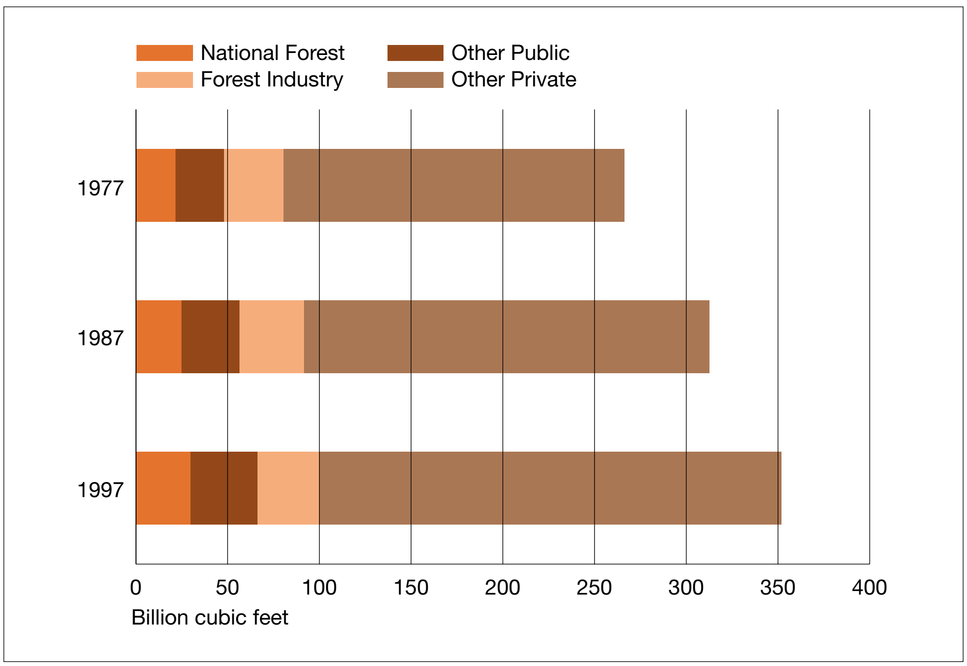

Figure 34 — Hardwood growing stock inventory by ownership

[10] An assessment of the applicability of the Montreal Process indicators of productive capacity for rangelands found that while the indicators are appropriate for monitoring sustainable management of rangelands, data are not available at a national scale (McArthur et al., in review).

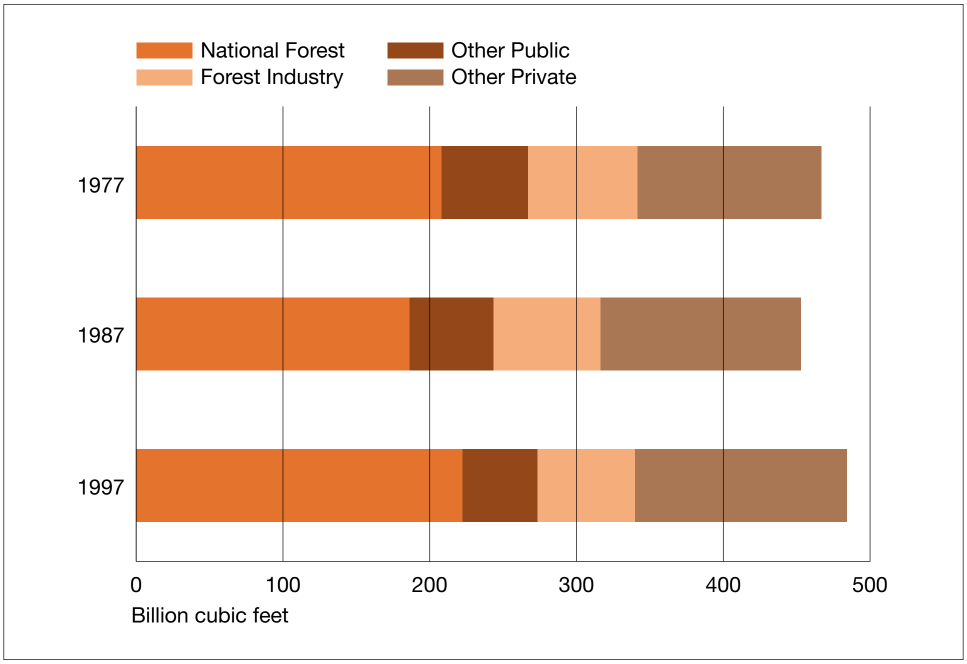

Figure 35 — Softwood growing stock inventory by ownership

case for all U.S. forest lands. 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 for all resources. These plans generally have in them some notion or intention to manage resources in a sustainable fashion. For timber, this would, at a minimum, include the objective that timber harvests should be attainable through management that would also sustain the forest ecosystem.

According to Birch (1996), some 5.3 percent of private forest landowners nationwide had prepared written management plans that covered 39 percent of the total private forest land area. Some plans on private lands may include consideration of sustainable outputs; others may be based solely on financial considerations. On private lands, the concept of sustainable outputs may be dependent on price and other workings of the market place. For example, higher wood prices may lead to more intensive management that could increase the level of sustainable output of wood products. In 1996, some 11 percent of the Nation's timber output was produced on public lands and 89 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. However, the indicator conveys no information about quality, biodiversity, forest types, size, and other attributes of ecology, growth, and harvest and, thus, has many shortcomings as a measure of sustainability. Also, the growth-removal ratio may be misleading as a long-term indicator if market downturns and temporarily reduced harvesting causes the ratio to turn up. Trends for the Nation as a whole indicate that growth exceeds removals for both softwoods and hardwoods (figure 36). In total, the ratio of growth to removals was 1.42 in 1996. The growth-removal ratio for all species declined from 1976 to 1991. The increase from 1991 to 1996 reflects primarily the decrease of timber harvest on national

Area and growing stock of plantations: The area of plantations in the East amounted to 40.1 million acres in 1997 (Smith et al., 2001). The planted area amounts to 10.4 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.

There are an estimated 13.6 million acres of planted areas in the West (Smith et al., 2001). 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.

In the Southern United States, there has been 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 harvests.

Annual removal of wood products compared to the volume determined to be sustainable: Within the context of the Montreal Process, the presumption is that forest management plans exist and that a sustainable volume of timber harvest has been determined (Montreal Process Technical Advisory Committee, 2000). This is not the forests. The growth-removal ratio for hardwoods continued to decline through 1996.

A striking trend is an increase in the ratio for softwoods for the Pacific coast region, which reflects decreased harvesting on public lands and increased growth on timber stands that were regenerated after harvest during the past century (figure 37). Growth and removals are about equal in the South, reflecting increased harvesting, especially during the past 25 years. 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 (figure 38). The decrease in harvest on national forests is reflected in an increase in the growth-removal ratio between 1991 and 1996. The growth-removal ratio is decreasing on the nonindustrial private ownership.

Annual removal of nontimber forest products compared to the level determined to be sustainable: As with wood products, the Montreal Process presumes a management plan that determines sustainable levels of removals of nontimber forest products (Montreal Process Technical Advisory Committee 2000). Many nontimber forest products, such as floral greens, are subject to limited regulation or are not regulated at all, either because their use is highly localized or their harvest rates do not appear to immediately threaten

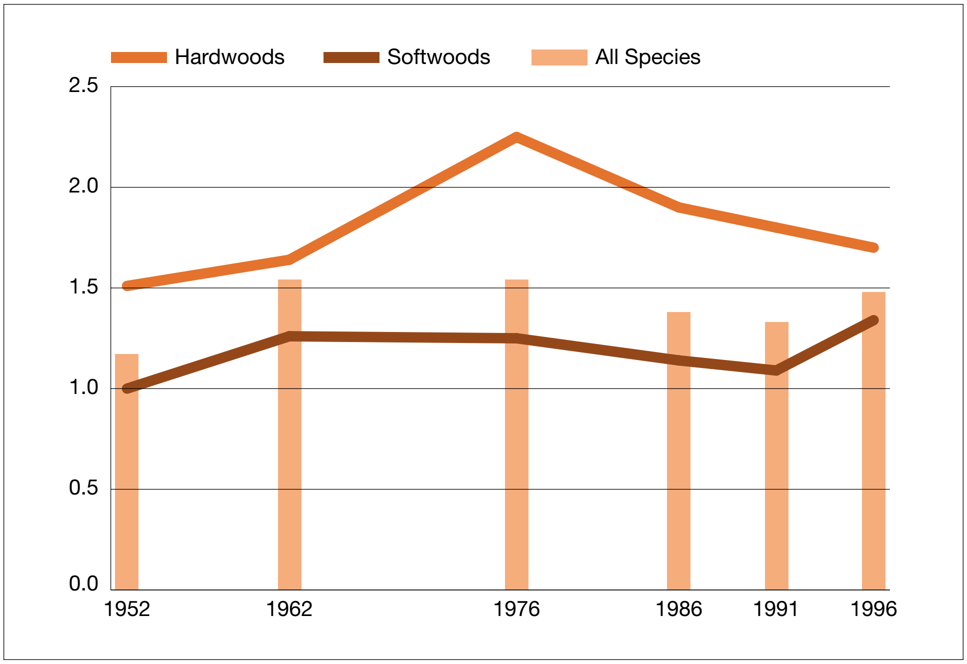

Figure 36 — Growth-removal ratios by softwoods and hardwoods

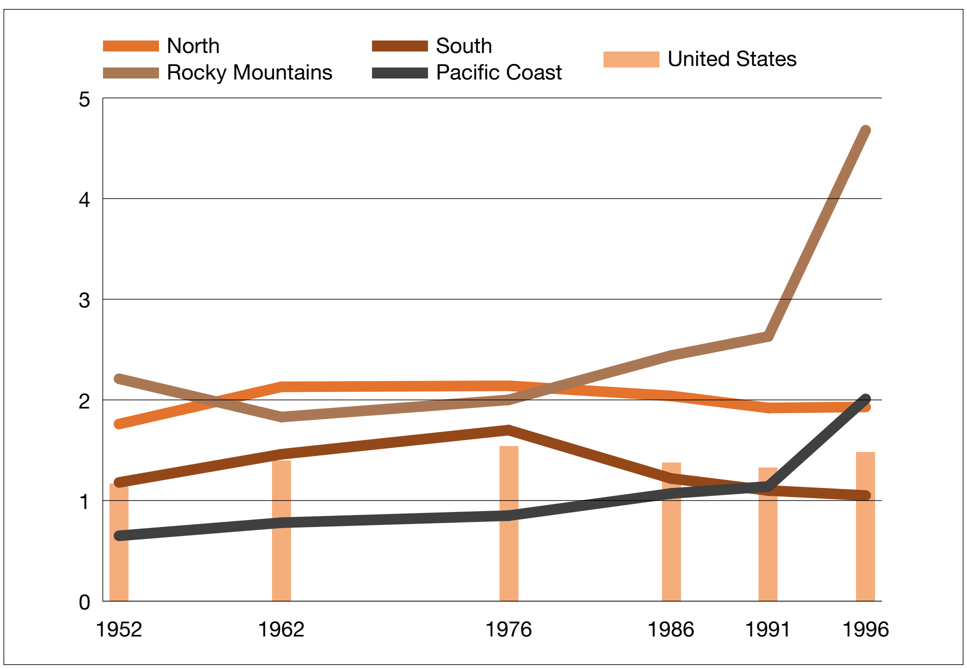

Figure 37 — Growth-removal ratios by region

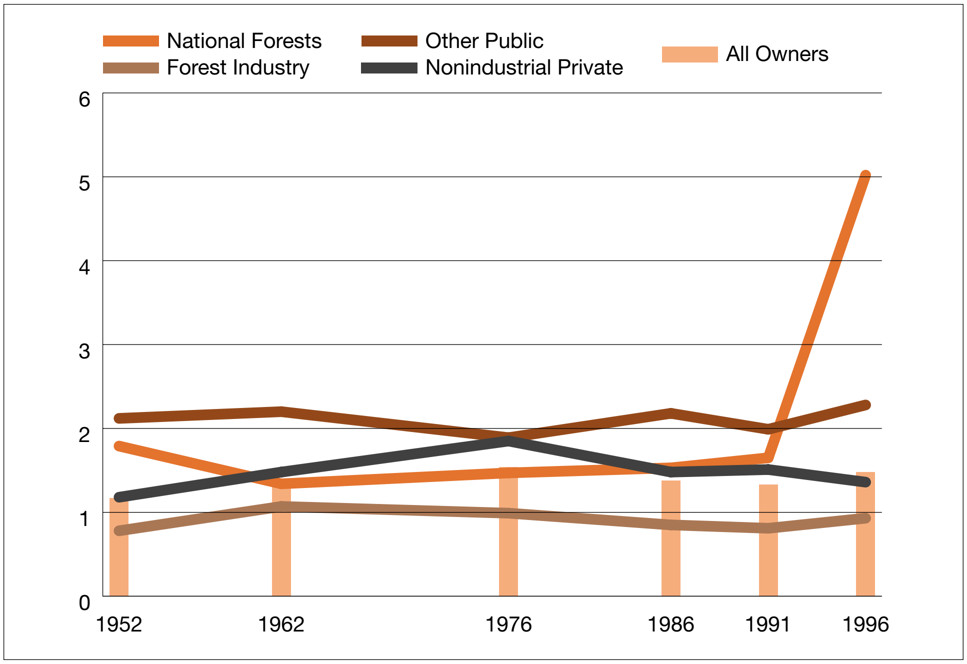

Figure 38 — Growth-removal ratios by ownership

In cases where harvest of the nontimber product involves removing plants, such as with oils, foliage, and medicinal plants, maintenance of the habitat may result in natural replenishment. Management may also help ensure replacement.

A measure of the productive capacity of forest and rangeland ecosystems is the harvest of commercial and game wildlife and fish species. If harvests are stable or increasing, it is presumed that habitats are in good shape and that the productive capacity of ecosystems is being maintained. However, harvest of commercial and game wildlife and fish species depends on animal and fish populations, as well as access to hunting and fishing and the people who hunt and fish. For example, large populations of white-tail deer near human population centers may be off-limits to hunters. In addition, changes in preferences and cultural values toward hunting and fishing may also affect hunting and fishing effort. A decline in the number of people from rural backgrounds is believed to reduce the number of people who enjoy hunting.

For many commercial and recreational species, regulations are driving harvests in aquatic systems and the presumed relationship between habitat and harvest does not hold. For example, the declining trend in striped bass harvest in the 1980's did not reflect the trend in population (figure 39) (Loftus and Flather, 2000).

Over the last 20 years, harvests of big game species tended to mirror population trends. The harvest rate, or the proportion of population harvested, has varied from about 10 percent for black bear to nearly 20 percent for elk (Flather et al., 1999). At the regional level, not all harvest trends reflected population levels. For example, elk populations in the Pacific coast region grew between 1980 and 1990, but harvests declined. Similarly, bear harvests in the Rocky Mountain region declined while populations increased. Decreased harvest in the face of increased populations may reflect more stringent regulations, reduced access to private lands, and/or reduced participation in hunting activities.

the sustainability of the resource. Many nontimber products have considerable importance to Native American Tribal members and are specifically identified in treaty rights. However, because their economic importance or the potential impacts of their harvest are often not recognized in the larger society, individual subsistence or recreational harvesting of products is often less regulated via permits than are other activities.

Trends are difficult to determine because available data on the removal of nontimber forest products are anecdotal or localized. Some studies suggest that nontimber forest products have considerable market value. For example, the harvest of mushrooms in Washington, Oregon, and Idaho was estimated to be about $40 million in value in 1992 (Blatner, 1997). In general, the sustainability of nontimber products depends on the integrity of habitat, and harvesting generally does not destroy the habitat. For example, berry production is dependent upon a habitat that supports the plant that produces the berries. Up to a point, berry collection in any given year does not directly affect the sustainability of berries, since only the fruiting bodies are being harvested and not the plants themselves. This holds true for many nontimber products such as mushrooms, nuts, and seeds.

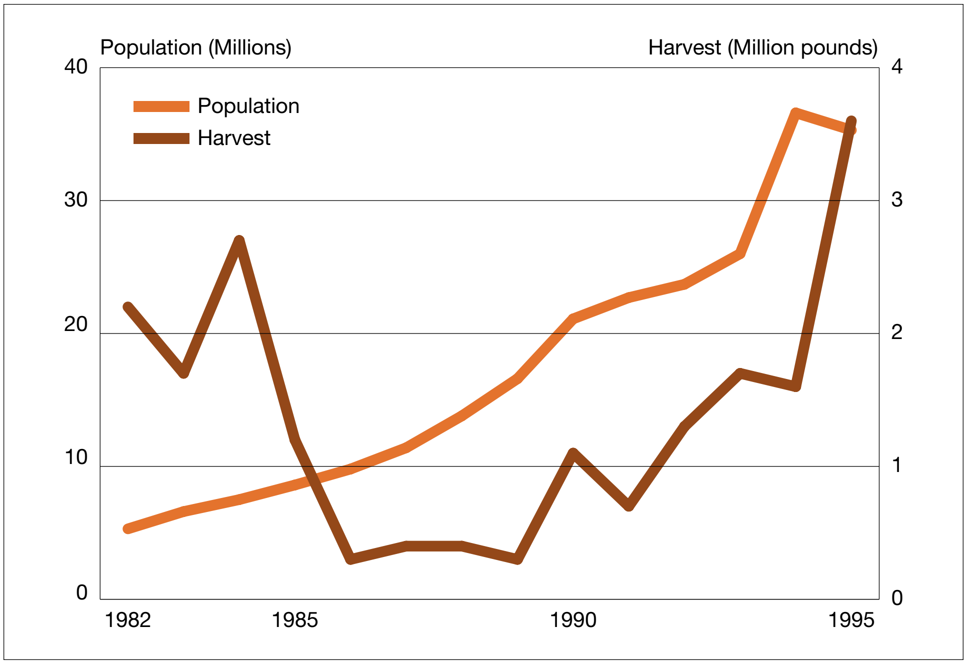

Figure 39 — Atlantic coast striped bass harvest and population

Although trapping of furbearers is often done for recreation, prices that trappers receive for their pelts are strong determinants of harvest. Prices are driven in part by consumer demand for fur products, which is affected by income, weather, and consumer tastes and preferences. The wearing of fur products is controversial for some people. The majority of pelts used in fur garment manufacturing are produced by fur farms that primarily raise mink and fox.

An outcome of the issues affecting fur harvest is that harvest is increasingly unrelated to animal population levels. A survey of State biologists indicated that for most of the fur bearers in the survey, populations were estimated to be at or above carrying capacity (Flather et al., 1999).

Available data suggest that small game harvests have declined for the past two to three decades. In some cases, the decline may reflect declines in populations such as bobwhite quail in the South, or it may reflect decreased hunter effort or opportunity such as decreased harvest of cottontail and squirrel despite increased populations.

Management of duck populations through the annual establishment of harvest regulations has been a key Federal activity directed at ensuring healthy duck populations. Waterfowl management has long focused on the four major pathways or flyways used by the birds: Atlantic, Mississippi, Central, and Pacific.

National duck harvests since the early 1960's track duck populations closely. Populations and harvests have rebounded from a low in 1988. This was true as for all of the flyways.

Goose harvests in the Central and Mississippi Flyways accounted for 80 percent of the birds harvested in 1995. The record numbers of birds harvested in recent years in these two Flyways masks a trend of relatively stable harvests in the Pacific Flyway and declines in goose harvests in the Atlantic Flyway.

Rangeland Products

Number of cattle and sheep: Cattle numbers have historically followed 10-year cycles since the mid-19th century. The national herd size gradually increased until reaching a maximum of 132 million head in 1975. The latest cycle peaked in 1996 at 103.5 million head (figure 40).

Per capita consumption of beef and veal continues to slowly decline (figure 41). 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 National Forest System 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 (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 animal unit months. Livestock grazing on Bureau of Land Management lands has been relatively stable at around 10 million animal unit months.

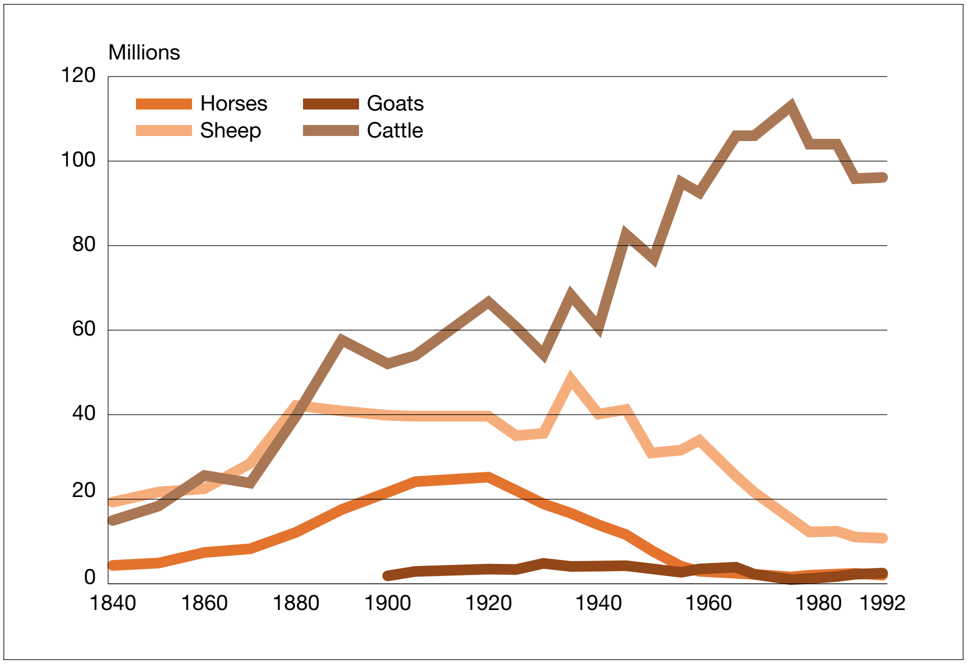

Figure 40 — Number of animals

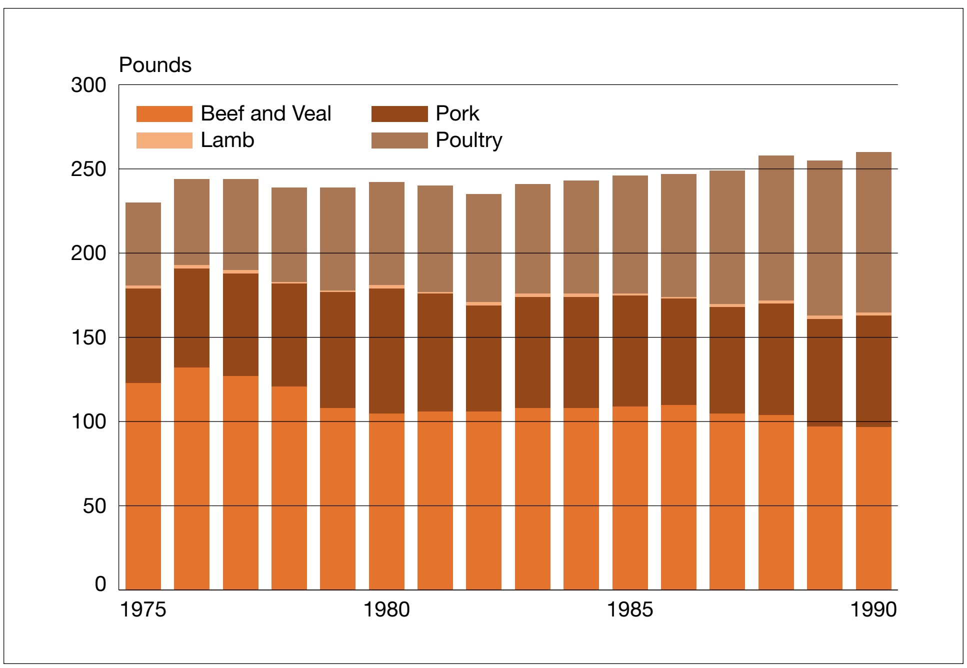

Figure 41 — Per capita consumption of meat

Implications of Historical Trends for Expectations for the Future

The renewable resources of the United States have shown resiliency in the face of providing increasing levels of goods and services for a growing populace. Although the total forest area remained relatively constant for the past 50 years, timber harvest more than doubled. During this time, the volume of timber on timber land continued to increase. There are continuing opportunities to harvest wildlife. Forests in the United States continue to offer opportunities for management to enhance recreational and other values desired by society. Millions of acres of plantations have been planted over the past four decades and will provide a basis for future timber harvests.

Management to maintain productive capacity for timber production can offset other values desired from forests. For example, increased areas of plantations can affect biodiversity, scenic values, and forest health.

Despite increased interest in nontimber forest products, there are few data to judge sustainable levels of removals. Some wild species such as ginseng have been hunted to the point of scarcity, but some wildlife populations such as fur-bearers may be above sustainable levels.

Expectations About the Future for Maintenance of Productive Capacity of Forest and Rangeland Ecosystems

- The existing renewable resource situation is the result of inherent biological productivity and ecosystem processes and human intervention in these processes.
- The total area of privately owned forest land is expected to decline by about 2 percent over the next 50 years (Alig et al., 2000 and Butler et al., 2000). Losses to development and other uses will likely be offset to some degree by reversion of agricultural lands to forests, especially in the East. The area of publicly owned forest land is assumed to be constant through time.
- Although the area of forest land per person is expected to decline, the volume of growing stock inventory per person is expected to remain relatively stable through 2050.
- As for forest land area, the total area of privately owned timber land is also expected to decline slowly over the next 50 years — 2 percent for industry-owned lands and 2.1 percent for other privately owned forest lands (Alig et al., 2000, and Butler et al., 2000). The area of timber land on Federal and other publicly owned lands depends in large measure on how much area is reserved from timber harvest.
- The total amount of grazing land and rangeland is expected to continue to slowly decline over the next 50 years.
- Domestic grazing on forests and rangelands is expected to decline as the use of public and privately owned grazed forages for beef cattle is anticipated to decline over the next several decades (Mitchell, 2000).
- The total growing stock on timber land is expected to continue to increase in the future for both hardwoods and softwoods. Decreases in softwood inventories in the South are expected to be more than offset by increases in other regions.
- Plantation area is expected to continue to grow and will be planted with domestic species (Haynes et al., 2001).
- Timber harvest on USDA Forest Service lands is projected to be relatively stable at about 800 million cubic feet per year through 2050, with potential for increase in the out years of the projection period.
- The growth-removal ratio for timber is expected to continue to exceed 1.0 for the Nation as a whole for both hardwoods and softwoods.
- Management of USDA Forest Service rangelands will continue to be oriented to vegetation management, with multiple uses as the desired output mix (Mitchell, 2000).
- Sheep and goat populations should be maintained by an expected increase in use of these livestock for purposes of controlling weed infestations (Mitchell, 2000).
- Management of wildlife populations will likely become more challenging in the future as a growing human population competes for the ecosystem goods and services that are provided by forest and rangelands.
- More outputs must be produced from a slowly declining land base to meet projected demands for a growing population. Multiple use management of lands not reserved from timber production will be even more challenging in the future.

Maintenance of Forest and Rangeland Ecosystem Health and Vitality[11]

In the Montreal Process, forest ecosystem vitality refers to the ability of an ecosystem to perpetuate itself (Montreal Process Technical Advisory Committee, 2000). Also from the Montreal Process, a forest ecosystem is considered to be healthy if it retains the ability to maintain its biological diversity, biotic integrity, and ecological processes over time. Other points of view would suggest that other societal values should also be considered in evaluating forest health.

There is a basic need to know how and why our forest ecosystems are changing and to determine the importance of human influences on these changes. Forest ecosystems are naturally dynamic, often changing species composition and abundance as the ecosystem evolves through succession or reacts to disturbances such as wind and insects. These dynamics are an essential ingredient of a healthy forest. Human stresses on forest ecosystems include introduced insects, diseases, plants, and wildlife; fire suppression; air pollution; and land-use practices such as timber harvesting (Natural Resources Canada, 1999, and Walker et al., 1999).

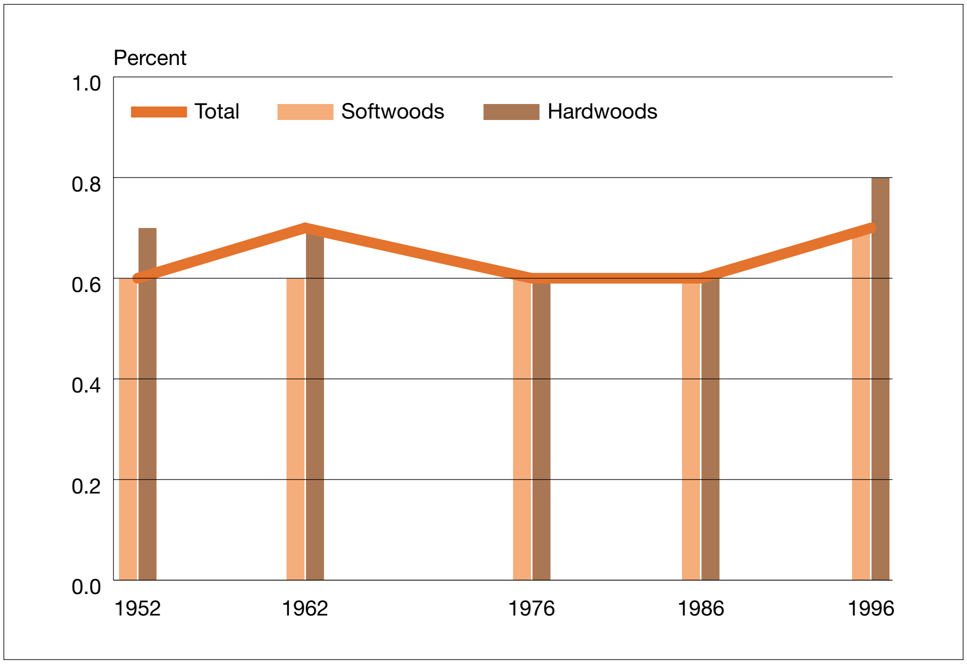

Figure 42 — Average annual mortality as a percent of growing stock inventory by softwoods and hardwoods

Forest Health and Vitality

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 (figure 42). This has been the case across all ownerships. Mortality is a coarse-filter measure of ecosystem condition. If dead and dying trees are salvaged and used, this volume is not reflected as mortality in timber inventories. Thus, there can be relatively large losses of volume due to disturbance agents that are not measured as mortality.

The USDA Forest Service Forest Health Protection Program[12] has developed estimates of the area of forests where increased mortality rates from insects and diseases are expected to occur. These areas were termed to be at risk because there was an expectation of at least 25 percent mortality—over "normal" mortality rates—over the next 15 years from insects and pathogens. Twenty-six insects and pathogens were evaluated using current survey data, models, and expert opinion to estimate forested areas at risk.

An estimated 58 million acres or 8 percent of the forested acres in the United States were 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.

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 historic conditions and trends may have been. Analyses of tree rings and other materials do provide clues to estimate some past conditions. 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

[11] An assessment of the applicability of Montreal Process indicators of ecosystem health and vitality found them to be appropriate for rangeland, but data are not available or incomplete at a national scale (Joyce et al., in review)

[12] Additional detail is available at http://www.fs.fed.us/foresthealth/risk_maos/risk_maps.html

of disturbance by various agents. The range of variation for some disturbance agents in existing ecosystems is being established by the USDA Forest Service Forest Health Protection Forest Health Monitoring Program and the USDA Forest Service Forest Inventory and Analysis Program (USDA Forest Service, no date).

Area and percent of forest affected by insects and diseases: In 1998, over 54 million acres of forested land in the United States were affected by southern pine beetle, mountain pine beetle, spruce budworm (eastern and western), spruce beetle, dwarf mistletoe, root disease, and fusiform rust[13] (USDA Forest Service, 1999). Fusiform rust is a fungal disease that affects over 13 million acres of slash and loblolly pine trees in the South. These are conservative estimates, since not all forested land is monitored for insect and disease damage and several million more acres contain trees affected by native insects and diseases other than these high profile species. For the most part, outbreaks of native insects and diseases have been episodic with eventual collapse of populations/infestations by natural agents or fires.

Exotic species: There are over 4,500 exotic free-living species in the United States today—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 (USDA Forest Service, 1997).

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 other than 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 has had a tremendous impact on urban forest ecosystems.

One 1994 to 1995 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 and others, 1998).

The scope, impact, and trends of invasive plants are outlined in a recent 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).

Wildfire: The frequency and scope of wildfire has changed dramatically over time (figure 43). Fire suppression resulted in relatively stable areas burned during the decades of the 1950's through the 1970's. Beginning in the 1980's, 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 caused increased forest density and biomass, changes in forest composition and the resulting increases in insect and disease susceptibility and mortality, and buildup of fuels (Hill 1998).

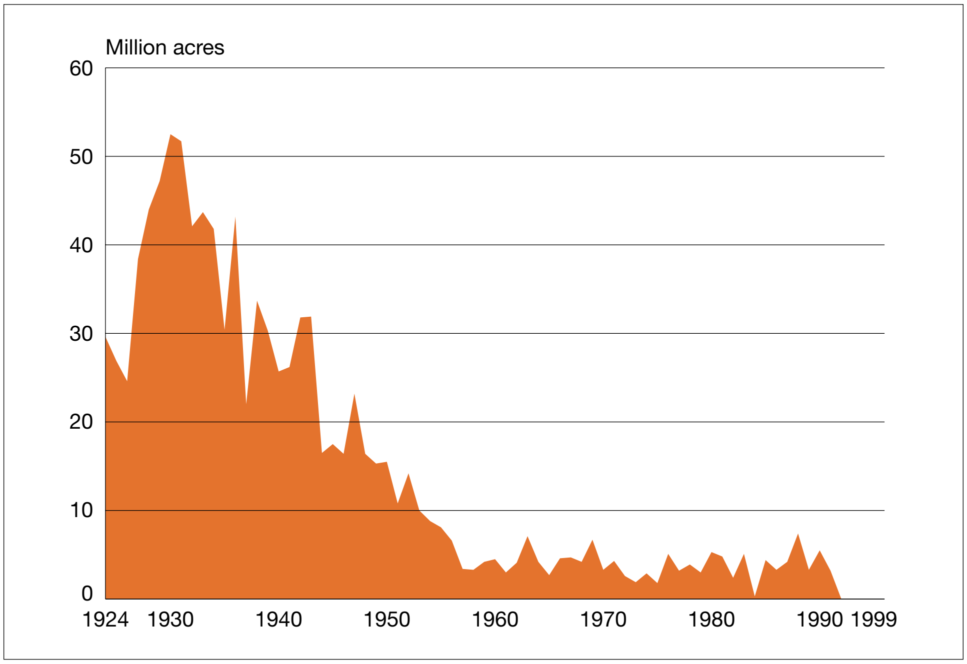

Figure 43 — Area burned by wildfire

[13] Affected acreages for individual insects and diseases are not additive. Thus, an acre infested with 1 insect and 1 disease would be counted as two acres.

Historic (pre-European-colonization) fire regimes were reconstructed from tree ring analyses and fire scars (USDA Forest Service Fire Sciences Lab, 1999a and 1999b) to identify areas of relatively high change in forest condition. Current condition classes categorize departure from the historic 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 historic fire regimes. Condition class 2 is a deviation from ecological conditions compatible with historic fire regimes that would require some silvicultural management to restore conditions compatible with historic fire regimes. Current condition class 3 represents a major deviation from the ecological conditions compatible with historic 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 historic 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.

Climate and weather: Weather can be a cause of severe forest disturbance. It can affect recreational and other uses of the forest, as well as its structure and other attributes. Weather refers to the local and short-term variation of temperature, wind, cloudiness, precipitation, and humidity. Climate encompasses weather and refers to the conditions over large areas or a long time, or both. Weather is the pattern of temperature over the next several days. The average winter temperature and the average snowfall typical of a Maine winter are features of the local climate. Climate involves not only the averages of temperature and precipitation, but also the variability of these features, for example, the frequency and intensity of blizzards in New England.

Weather forecasts are based on scientific understanding of atmospheric processes, actual observations, and computer models of these processes. Weather is forecasted for a few days and these forecasts retain some accuracy up to 2 to 3 weeks. The movement of winds and temperatures are highly unstable, and thus, predictions beyond 2 to 3 weeks are inherently random. Beyond a few weeks, the patterns of the atmosphere must be examined by studying the statistical properties of the atmosphere. Seasonal temperature and precipitation anomalies appear to have certain traits or cycles and examination of these cycles contributes to increased understanding of climate and the forecasts of climate. For example, recent climate models have been able to predict the occurrence of El Niño events where for certain regions of the globe, unusually heavy or light precipitation occurs. These longer term forecasts are predictions of climate and it is the changes in these longer term phenomena that are referred to in the term "climate change."

Plants are sensitive to the day-to-day weather events and are adapted to the local climate. The day-to-day weather events such as rainfall or high temperature influence the physiological processes such as photosynthesis and evapotranspiration. The local climate conditions encompass the annual precipitation, the seasonal temperature and precipitation patterns, wind patterns, the occurrence of frosts and snowfall, and the occurrence of events such as thunderstorms, tornados, and hurricanes. These climate conditions establish the availability of water, the growing season, and the nature of the climatic disturbances within the area. In total, these environmental factors establish the environmental conditions for the plant. Adaptation to these conditions can be seen by looking across the types of plants that occur in the tropical rainforest through ecosystems where forests lose their leaves seasonally, to grasslands or shrubland ecosystems without trees, and finally, to deserts. Water availability influences the canopy structure, tree height, and leaf surface area. To minimize water loss, leaves disappear entirely for some desert plants such as cacti. Within temperate deciduous forests, water availability influences the tree species one finds; the most moist sites dominated by maples and basswood, slightly drier sites by oak, and the driest sites by pines.

The United States has within its boundaries a variety of climates. Descriptions of these regional climates are contained within the Ecoregion Classification (Bailey, 1995). Within the Pacific Northwest, the climate is characterized by mild winters, relatively cool summers, and abundant rainfall that can be markedly reduced in the summer. The climate of the California redwoods forest province is characterized by cool and dry summers, a narrow temperature range annually, and heavy fog along the coasts. This region has the greatest number of days with dense fog within the United States. The absence of really cold winters characterizes the climates found in the Southeastern United States. Climate abnormalities such as droughts, small-scale wind events, extreme winter storms, and hurricanes can occur.

Droughts are extended periods—a season, a year, or several years—of deficient rainfall relative to the multiyear average for the region. Droughts are known to occur in nearly all forest ecosystems within the United States. While tree species in the Pacific Northwest have adapted to the relative lack of precipitation in the summer, longer or more intense dry periods can be severe, resulting in reductions in biomass for these species. Summer droughts can occur in areas that typically receive sufficient moisture, such as the 1999 summer drought in the Eastern United States. In the Western United States, winter precipitation is critical in recharging soil moisture and low precipitation during the winter months followed by even average summer temperatures can place moisture stress on plants. When the drought extends over multiple growing seasons, forests are more susceptible to insects or diseases. In addition, the loss of species or large areas of trees is possible. The occurrence of forest fires is often linked to the occurrence of drought. Two droughts in California preceded the forest fires that spread through Santa Barbara residential neighborhoods in 1977 and Oakland urban areas in 1991. The frequency and intensity of drought vary by region within the United States. At the national level, no analysis has shown that the frequency of drought alone is increasing.

The impact of flooding depends on the individual characteristics of the area. In general, flooding results in poor soil aeration, alters the acidity of the soil, and reduces the decomposition of organic matter. Some trees such as eastern cottonwood and willow have relatively more tolerance for flooding and may need it to reproduce, while species such as sugar maple and various conifers will be killed by prolonged flood waters.

Hurricanes are serious disturbances for forests of the eastern and southern coastlines of the United States and the forests of the islands of the Caribbean. For example, Hurricane Hugo significantly damaged 4.5 million acres of timber land. Volume of softwood growing stock was reduced by 21 percent, with nearly one-third of the remaining volume damaged to some degree (Sheffield and Thompson, 1992). Hurricane damage can result in tree mortality, altered forest regeneration patterns, high species turnover, opportunities for species change in forests, faster biomass and nutrient turnover, and increased landscape heterogeneity and associated effects on wildlife. Increasing population numbers and economic development along the U.S. coastlines have placed increasingly greater numbers of people and industry in the way of hurricane paths. While hurricane forecasts have reduced the number of human lives lost, the rising levels of economic costs associated with recent hurricane damages are the result of the increasing coastline development. The intensity and frequency of hurricanes have not been shown to be conclusively increasing, but even small rises in hurricane frequency and intensity will increase the economic costs associated with hurricane landfall.

Small-scale wind events occur across the United States and show much regional variation in form, frequency, and type. The highest concentration of tornadoes occurs across the Central Great Plains States of Oklahoma, Texas, Kansas, and Nebraska. Tornadoes may form in association with thunderstorms, and occasionally, with hurricanes. Downbursts are another example of a small-scale wind event where strong winds literally blow down large areas of trees. This type of wind disturbance is more common than tornadoes in the Great Lakes region and can occur in the Western United States. Examples of downbursts include the events on 969,000 acres of forests in the Adirondack Park in upstate New York in 1995, on nearly 13,000 acres of the Routt National Forest in 1998, and on nearly 250,000 acres on the Boundary Waters Canoe Area in 1999.

Ice storms occur throughout the United States, except the southwestern borders and parts of the Plains. Generally, frequency and severity of ice storm events increase toward the Northeastern United States. Ice storms are caused by a combination of rain falling through subfreezing air masses close to the ground that can supercool the raindrops so that they freeze on impact. Ice accumulation can vary dramatically with topography, elevation, aspect and areal extent of the region. Even though the weather conditions producing ice storms are well understood, little is known about the dynamics of ice accumulation. Ice damage to trees can range from breaking a few twigs, to bending stems to the ground, to moderate crown loss, to outright breakage of trunks. Effects on forest stands can include shifts in overstory species composition, loss of growth, and damage to stem form. The January 1998 ice storm in New England affected 13 million acres in Maine and even larger areas in Canada.

Both high (increased flooding) and low (water diversion or acquifer drawdown) streamflow could indicate ecosystem degradation. Because current streamflow patterns are closely tied to precipitation, current high streamflow is found in the southeast, northeast, northern Pacific coast, and southwest ecosystems (figure 44) (Hof et al., 1999). Current areas of low streamflow occur throughout the Great Plains.

High sediment discharge is currently found in areas of intensive agricultural activities such as the Great Plains and the Mississippi river basin, intensive timber harvesting such as the Pacific Northwest, and in areas with naturally highly erosive soils such as the southern desertic basins and plateaus and coastal California (figure 45) (Hof et al., 1999).

Climate change: Climate change is one of several pressures on forests encompassed under the term "global change." Human use of forests through land conversion alters the productivity and diversity of forest ecosystems. The management of forests influences forest productivity. The deposition of atmospheric trace gases such as nitrogen oxides, sulfur dioxide, and ozone reduces tree growth. Introduced species, such as the Chestnut blight fungus, impact forest communities. While some of these forest changes may occur at a faster rate than those resulting from climate change, particularly in the near term, climate change has the potential to alter the large-scale distribution of U.S. forests and their productivity.

The energy of the Earth's atmosphere is strongly influenced by the chemistry of the atmosphere. Certain atmospheric gases have the potential to warm the atmosphere and are collectively known as greenhouse gases: Carbon dioxide, methane, nitrous oxides, chlorofluorocarbons, and water vapor. The amount of warming is a function of the atmospheric concentration of each gas and the ability of these gases to absorb solar radiation (radiative properties of the

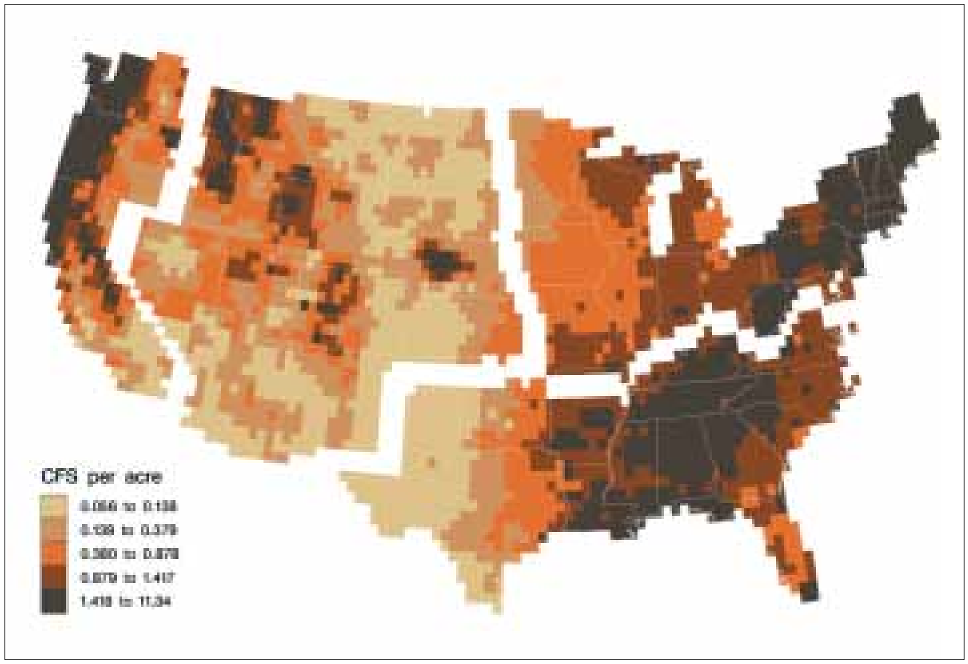

Figure 44 — Current streamflow condition indicator

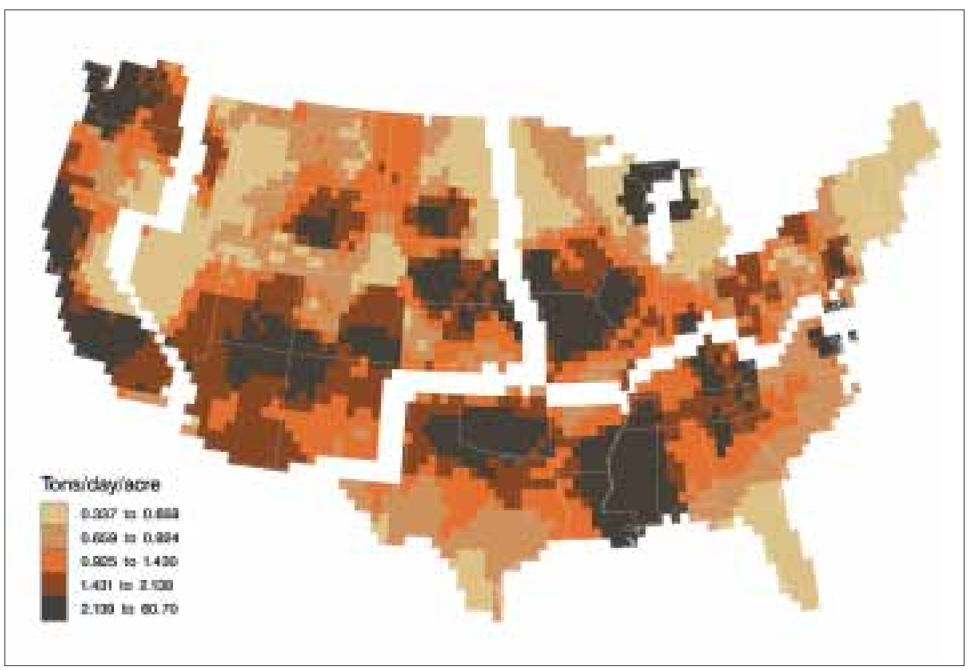

Figure 45 — Current sediment discharge condition indicator

gases). The radiative properties of these gases are constant; however, the atmospheric concentration of gases such as carbon dioxide, methane, nitrous oxides, and chloroflourocarbons are altered by natural processes and human activities. It is the rise in concentration of these gases that is of concern globally.

The atmospheric concentrations of carbon dioxide, methane, nitrous oxides, and the chloroflourocarbons have increased since preindustrial times (table 5). Increases range from 13 percent for nitrogen oxides to 145 percent for methane. The atmosphere did not contain chlorofluorocarbons in preindustrial times. Increases in carbon dioxide are mainly the result of fossil fuel emissions from industrial and domestic activities, and land use conversions. Methane increases result from the production and use of fossil fuel and human activities such as livestock production. The sources of nitrous oxides are small and hard to quantify but include agriculture and industrial processes.

The rise in atmospheric concentration of these gases has led to changes in the climate. At the global scale, increases in air temperature of 0.3 to 0.6 degrees Centigrade, and increases in total annual precipitation of about 1 percent, have been documented in the historical record of observation. Observed changes related to temperature have generally a higher confidence than observed changes in hydrological cycles. In addition, a number of indirect indicators such as the retreat of mountain glaciers and underground temperatures in boreholes have supported the notion of climate change. Within the United States, an analysis of the near-surface air temperature reveals that temperatures have warmed over much of the United States in the last 100 years. Precipitation has also increased since 1970, although the most dramatic increases with respect to precipitation are the increases in the last 100 years of the amount of land area in the United States receiving extreme 1-day precipitation events. These changes in the long-term record of temperatures vary across the United States, with the largest increases seen in Alaska, where winter temperatures have increased by 4 degrees Centigrade.

The use of future climate scenarios and ecological models suggests that the impact of climate change on U.S. forests could include increases in forest productivity in the short term—as a response to elevated levels of carbon dioxide and as climate changes advance—and shifts and extinctions in tree species and their associated wildlife species (Joyce and Birdsey, 2000; Hansen et al., in review). As climate changes advance, there are some indications that there will be increases in disturbances such as forest fires and drought (Dale et al., in press).

Many factors complicate our ability to project the impact of future climate changes on U.S. forests. Land use change influences atmospheric-biospheric relationships and most climate models have rudimentary expressions of vegetation and land use. The conversion of vegetation

Table 5 — A sample of greenhouse gases affected by human activities

	CO_2	*CH_4*	*N_2O*	*CRC-11*	*HCFC-22 (A CFC substitute)*	*CH_4 (A perfluoro-carbon)*
Preindustrial concentration	280 ppmv	700 ppbv	275 ppbv	0	0	0
Concentration in 1994	358 ppmv	1720 ppbv	312[1] ppbv	268[1] pptv[2]	110 pptv	721 pptv
Rate of concentration change[5]	1.5 ppmv/yr	10 ppbv/yr	0.8 ppbv/yr	0 pptv/yr	.5 pptv/yr	1.2 pptv/yr
	0.4%/yr	0.6%/yr	0.25%/yr	0%/yr	5%/yr	2%yr
Atmospheric lifetime (years)	50-200[3]	12[4]	120	50	12	50,000

[1] Estimated from 1992-93 data.

[2] 1 pptv = 1 part per trillion (million million) by volume.

[3] No single lifetime for CO_2 can be defined because of the different rates of uptake by different sink processes.

[4] This has been defined as an adjustment time which takes into account the indirect effect of methane on its own lifetime.

[5] The growth rates of CO_2, CH_4, and N_2O are averaged over the decade beginning 1984; halocarbon growth rates are based on recent years (1990s).

from forest to grassland, through harvest or burning, changes the roughness and albedo of the land surface, thereby influencing temperature in urban areas and the weather downwind of urban areas. Land use changes have been shown to influence the development of weather disturbances such as thunderstorms in the Great Plains. In addition, emissions from fossil-fuel combustion and biomass burning contribute aerosols to the atmosphere that alter the amount of solar radiation reaching the Earth's surface.

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 variation, (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 information is available to identify integrative indicators for assessing changes in ecological processes at a broad scale.

Implications of Historical Trends for Expectations for the Future

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 put stress on forest health.

The forest resources of the United States have always been affected by insects, diseases, fire, and other natural disturbances. European settlement brought land clearance, new domestic animals, new species of plants and animals, and other sources of disturbance beyond the range of historic 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.

Forest health is essential for the goods, services, and other values desired by society. For example, dead and dying trees can degrade scenic values.

Pre-European-settlement conditions will never again exist for U.S. forest and rangeland ecosystems. 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 forest health-monitoring program of the USDA Forest Service is establishing a baseline to be used to evaluate changes in forest ecosystem health and vitality. The program is now active in over 24 States. As more States are included, this program will provide the basis for more wide-scale statements regarding ecosystem health and vitality. Until there is such a baseline, episodic outbreaks and damage from insects and disease, fuel buildups, and other symptoms of ecosystem health and vitality will continue to be of concern and will be the source of much speculation as to implications for resource management and ecological processes. For example, exclusion of fire is known to affect ecosystem functions and processes for some forested ecosystems. The implications for forest ecosystem health and vitality are currently being assessed. An issue in this evaluation is the lack of a consensus definition of forest health in the United States.

The Forest Health Monitoring Program includes measures of the effects of ozone and several other air pollutants on forests as well as measures of biological indicators of key processes such as epiphytes and vegetation communities. For example, the annual change in hardwood foliar transparency is shown in figure 46 for those States covered by the program. When this program has been expanded to all States, there will be opportunities for reporting at a national scale.

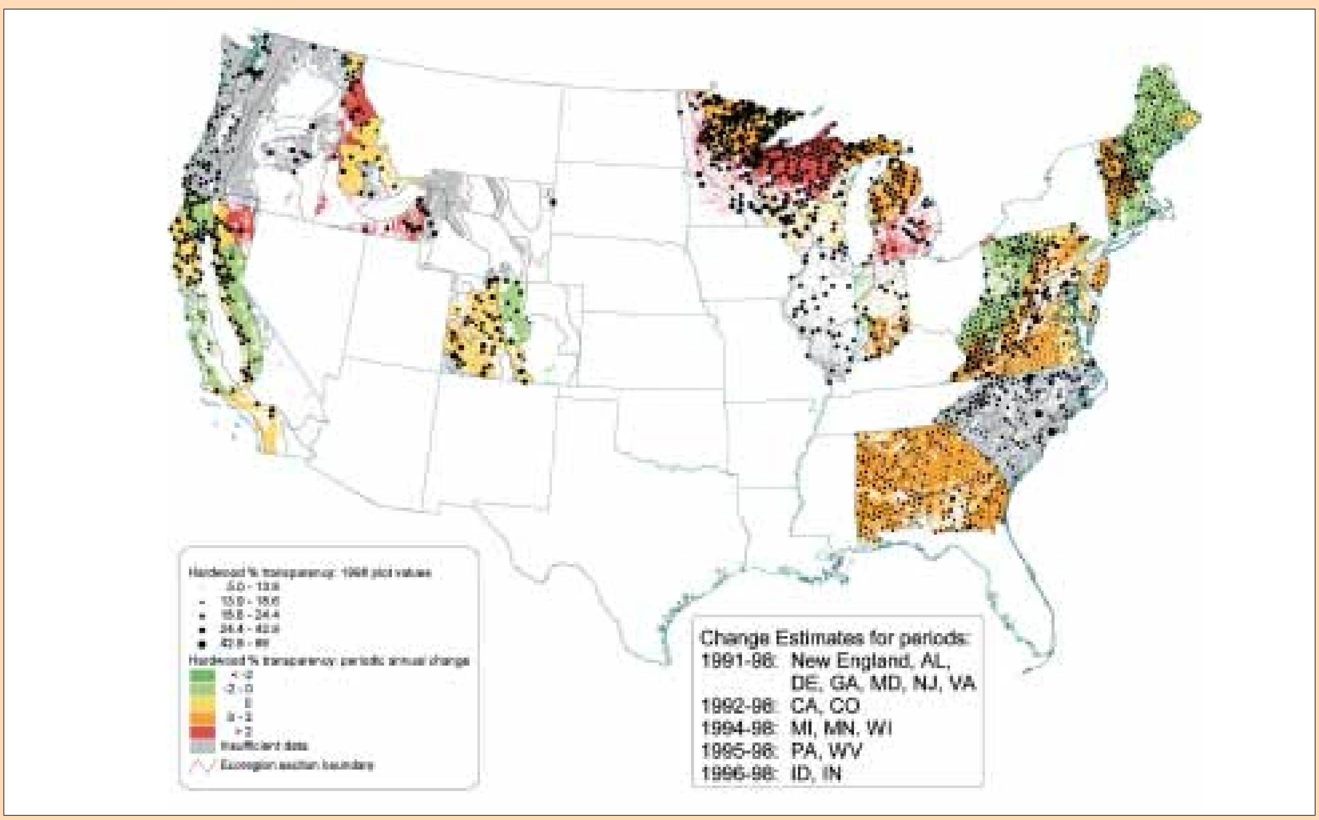

Figure 46 — Periodic annual change in hardwood foliar transparency by ecoregion section

Expectations About the Future for Maintenance of Forest Ecosystem Health and Vitality

- Projected hotspots for increased exotic breeding birds occur in more arid, less forested environments (figure 47). The central till plains of Iowa, the central high plains of western Kansas, and the southwest and southern desertic basin regions are projected to undergo shifts toward more exotics in the local avifauna (Hof et al., 1999).
- High streamflow hotspots are concentrated in the southeast, including peninsular Florida, the southern Appalachians, and the east Texas coastal plain (figure 48) (Hof et al., 1999).
- Low streamflow hotspots are primarily concentrated in the Western United States. The west slope of the northwest and northern California mountains both have high current streamflow but are projected to lose flow under our future land use scenario. The lone eastern low streamflow hotspot projected to occur is in the Allegheny plateau and Catskill Mountains region (Hof et al., 1999).
- Sediment discharge hotspots are projected to occur in the southeast and Pacific coast States (figure 49). Sediment discharge hotspots in the projections appear to be associated with increased grazing, mining, or agriculture (Hof et al., 1999).

Figure 47 — Projected exotic breeding birds condition indicator

Figure 48 — Projected streamflow condition indicator

Figure 49 — Projected discharge condition indicator

Maintenance of Forest Contributions to Global Carbon Cycles[14]

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. The main sources of carbon dioxide in the atmosphere include fossil fuel consumption and land use change, particularly deforestation in the Tropics (Joyce and Birdsey, 2000). 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 century time scale.

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 6). The carbon source of land clearing in the Tropics is approximately balanced by a combination of the carbon reservoir of forest growth in the Northern Hemisphere and the uptake of carbon in vegetation stimulated by the increased atmospheric carbon dioxide and nitrogen fertilization from the deposition of nitrogen in the atmosphere.

Carbon cycles through the land surface, the ocean, and the atmosphere. While the ocean is the largest reservoir, vegetation and soils together comprise 55 percent of the stored carbon and nearly 40 percent of the annual flux of carbon between the atmosphere and the land/surface ocean reservoirs (Schimel, 1995).

At the global scale, rangelands occupy up to one-half of the Earth's land area. Plant carbon from rangelands is estimated to be only 10 percent of plant carbon globally but soil and detritus carbon from rangelands is nearly 50 percent of the global soil and detritus carbon (Joyce, in press). Thus, as with forests, the maintenance of rangelands' contribution to the carbon cycle is critical to the global cycle. However, inventory data do not exist to establish a baseline for carbon stocks on rangelands.

Forests in the United States are a sink for carbon in that more carbon is sequestered than is emitted. The carbon balances shown in figure 50 reflect an accounting for net annual growth and use of timber in the coterminous United States. There are significant regional differences in past and projected carbon storage. These differences reflect long-term changes in land use and harvesting. It is expected that these estimates will change with updated inventory data and, perhaps, under a different accounting system. In addition, new research in the areas of biomass, soil carbon, and forest litter is expected to influence the estimates.

[14] An assessment of the applicability of Montreal Process indicators of maintenance of forest contributions to global carbon cycles found them to be appropriate for rangeland and that first order approximations could be made for the indicators (Joyce, in press).

Table 6 — Annual average anthropogenic carbon budget for 1980 to 1989: carbon dioxide sources, sinks, and storage in the atmosphere

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 ± 1.1
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

Accounting systems can have a large effect on results. Accounting issues include the definition of forests, imports and exports of wood, and the carbon implications of projects that affect fossil fuel emissions. The Intergovernmental Panel on Climate Change is scheduled to release a report on land use, land use change, and forestry. This report is expected to clarify issues in accounting for carbon in forests and forest products (Watson et al., in review).

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. Wood consumption in 1910 was not exceeded until 1990 (figure 51 shown as units of carbon). 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.

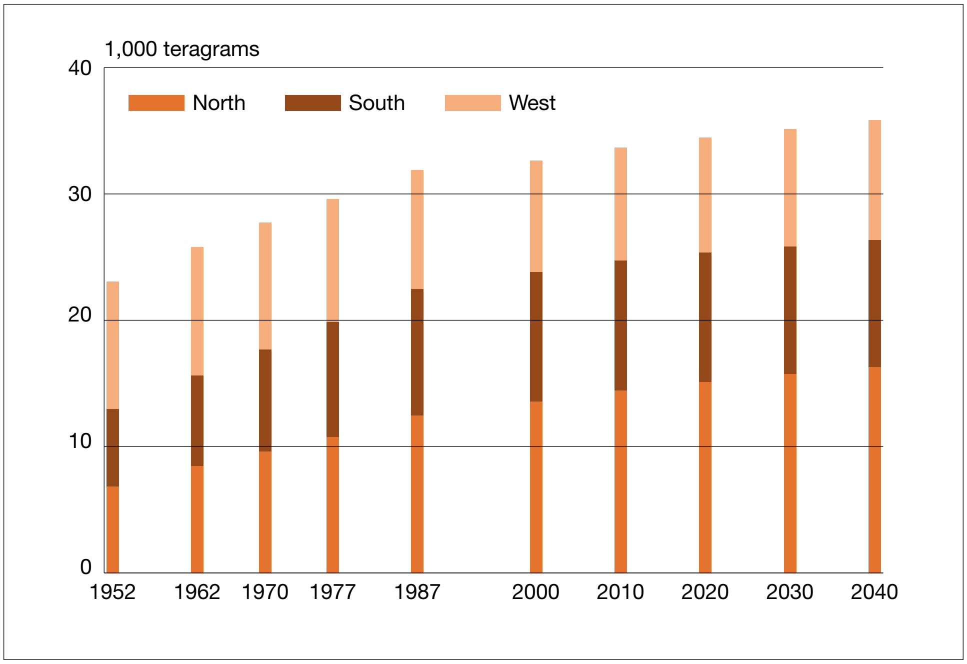

Figure 50 — Carbon stored on U.S. forest land

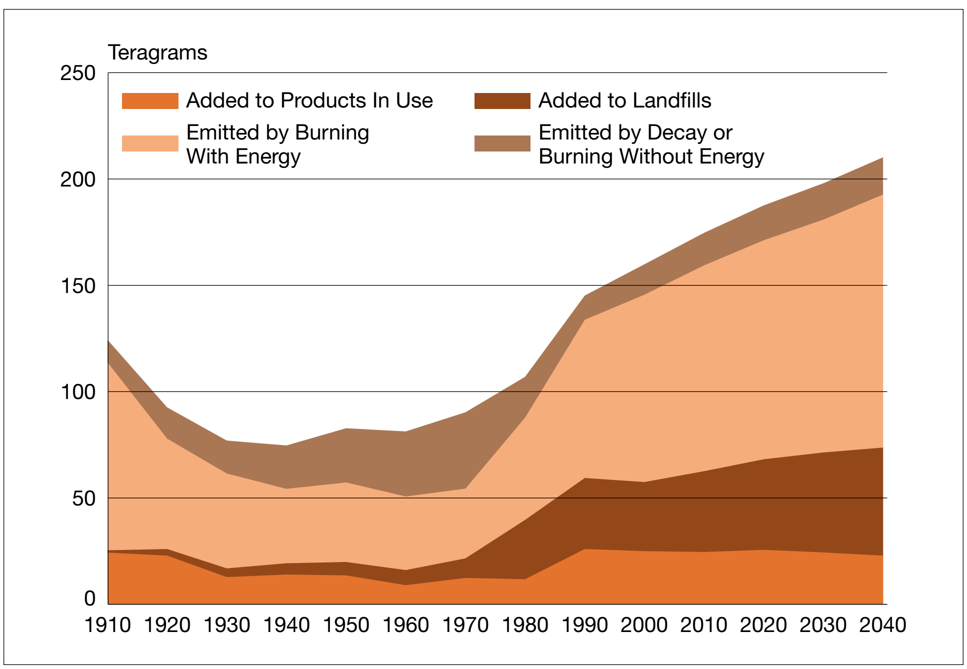

Figure 51 — Wood carbon consumption by source

Both forests and wood and paper products are sinks for carbon. In terms of net annual additions of carbon, the change in carbon in forests amounted to 82 percent of the change in the total stock of carbon in forests and products in 1990 (table 7) (Skog and Nicholson, 2000).

Table 7 — U.S. net carbon accumulation, emission, net imports, and drain from the atmosphere

	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[b]	333.4	246.47	255.88	244.11	237.16	234.6
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[c]	331.07	243.21	252.21	240.24	234.32	233.1
Drain from atmosphere in CO_2 Equivalents, S_g[d]	331.07	238.61	242.21	228.04	221.92	222.1

[a]Base Case projections

[b]Change in stock of carbon = CIC + ***P*** + ***L***

[c]***S*** = CIC + ***P***–(***I–E***) + ***L*** (Net carbon drain from atmosphere)

[d]S_g = CIC + ***P***–(***I–E***) + L–20(ECH_4) (Net carbon drain from atmosphere in CO_2 equivalents)

Historical Trends and Implications for Expectations for the Future

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 1980's, the amount of carbon stored in products increased, especially for paper and other fiber-based products. In 1990, the total carbon removed from the atmosphere to U.S. forests and forest products was 24 percent of U.S. fossil fuel carbon emissions levels.

- 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 is due entirely to the increasing rate of accumulation in landfills (table 7) (Skog and Nicholson, 2000).
- The net annual addition to products in use is projected to decrease slightly due in part to the increasing proportion of wood that is used in paper products that have a shorter use-life than do solid wood products.

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

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. Thus, it is important to understand the values that people assign to the existence and use of renewable resources. This part of the assessment describes outcomes for indicators of socioeconomic values held by society. Indicators are presented for each renewable resource.

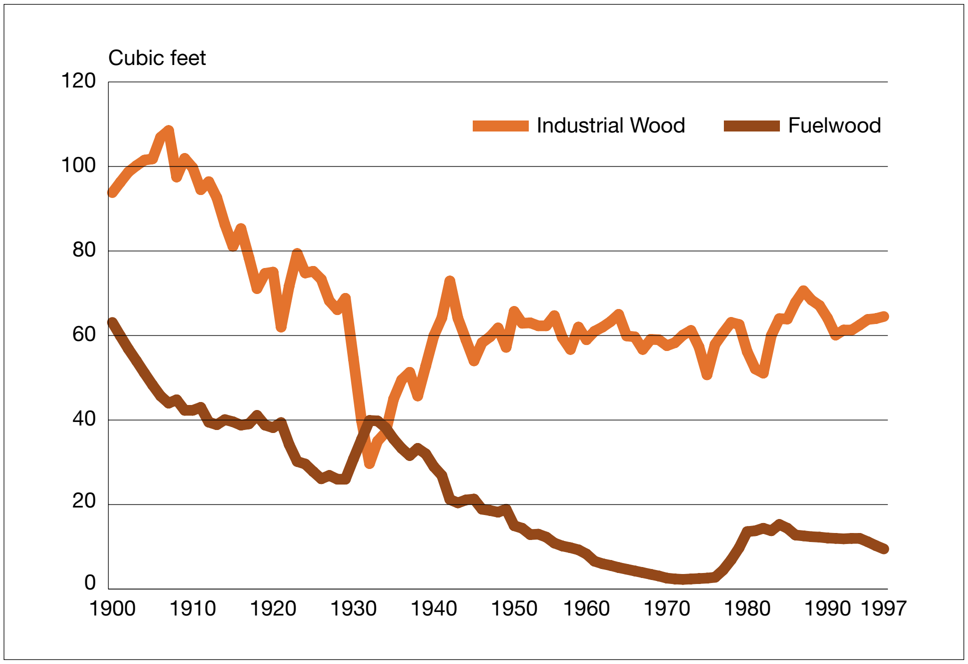

Figure 52 — Per capita consumption of industrial wood and fuelwood

Timber

Production and consumption:
Per capita consumption of roundwood to make products for U.S. consumers has been relatively stable over the past several decades (figure 52) (Howard, 1999). However, total consumption of wood has increased, reflecting the increase in population during this time (figure 53). While per capita consumption of roundwood has been relatively stable, per capita consumption of recycled paper has increased. There have also been substantial changes in the mix of products consumed. Although per capita consumption of roundwood has been relatively stable, per capita consumption of wood and paper products increased 30 percent between 1965 and 1998. This was due to increased use of recycled paper, increased use of wood mill residue for paper and panel products, and other increases in wood use efficiency. The downward decline in fuelwood consumption through the 1960's and 1970's reflects increased consumption of fossil fuels as substitutes for wood. Increased fuelwood consumption following the 1970's reflects consumer and industry response to the oil price shocks of the 1970's. In recent decades, much of the increase in wood consumption has been for fiber for use in pulp manufacture. The wood pulp is then manufactured into paper and paperboard products used in everyday life.

In the 1990's, each 1 billion cubic feet of timber harvest provided on average the following products for U.S. consumers:

- 88,031 new homes of all types
- 5.2 million tons of pulp, paper, and paperboard products
- 24.7 million new shipping pallets
- 121 trillion Btu's of wood energy
- 3.7 million tons of other wood products, such as furniture and telephone poles

In 1996, a total of 16.4 billion cubic feet was harvested.

In volume terms, the United States has been a net importer of timber products since 1915 (USDA Forest Service and Commodity Stabilization Service, 1960). Except for hardwood plywood from Southeast Asia, much of the import volume over the years has consisted of softwood lumber, newsprint, and wood pulp from Canada. More recently, imports of oriented strand board and medium density fiberboard have increased. Within the last decade, imports of both solid wood products and fiber-based products from offshore sources have increased, but Canada remains the dominant supplier of traditional imports. For example, Canada accounted for over 95 percent of U.S. imports of softwood lumber in 1998.

Over the past several decades, Canada and Japan have been the most important customers for U.S. exports of timber products measured in value terms. Maturation of the Japanese economy, structural shifts in the Japanese housing market (for example, aging of the workforce knowledgeable in constructing traditional post and beam housing), and the macroeconomic issues of the late 1990's in Southeast Asia cloud the outlook for U.S. exports. The structural shifts in the Japanese market have contributed to a continuing decline in U.S. exports of softwood logs, which reached a peak of 4.6 billion board feet in 1988 and declined steadily to 1.6 billion board feet in 1998 (USDA Foreign Agricultural Service 1999).

In volume terms, roundwood to make timber products for export has ranged from 5.6 to 18.7 percent of all roundwood used for U.S. wood and paper product production since 1965. During this time, the roundwood equivalent of imports has ranged from 14.4 to 22.4 percent of the roundwood equivalent of timber used for all wood and paper products consumed in the United States. Imports had an increase in market share during the 1990's (figure 54).

Demand for any one wood product is dependent in part on prices for substitute products and their relative costs when put in place. Historically, the substitution of one wood product for another has been common. For example, there was substitution of softwood plywood for softwood lumber and substitution of oriented strand board for softwood plywood. More recently,

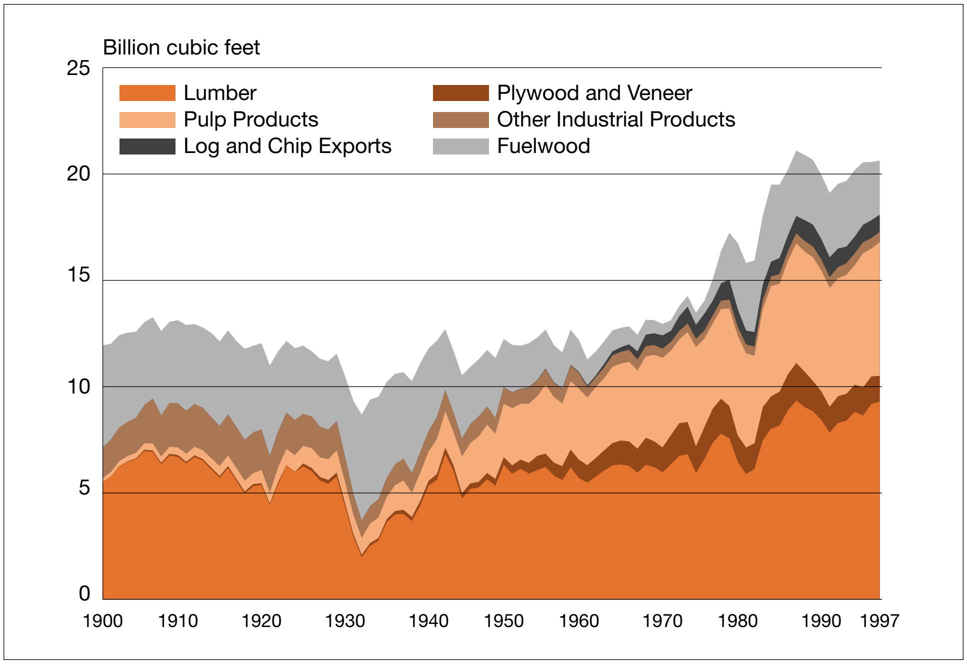

Figure 53 — Consumption of timber products by major product

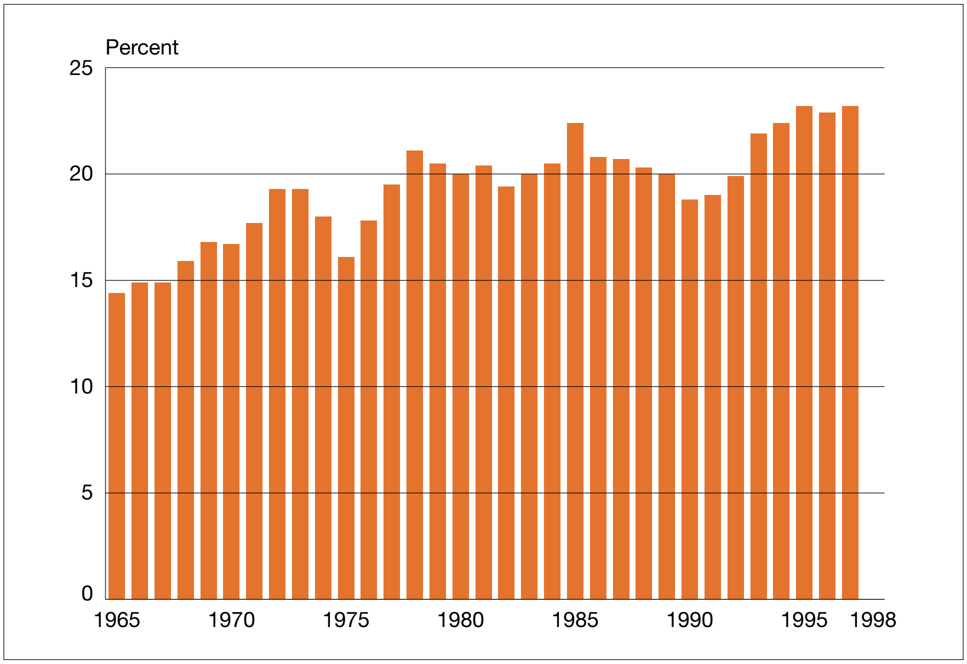

Figure 54 — Imports of timber products as a percent of consumption

engineered wood products such as I-Joists have substituted for solid wood products of wide dimension. There have been periods of relatively high prices for wood products (for example, late 1970's/early 1990's) when nonwood products—such as steel and aluminum—were thought to substitute for wood on a large scale. However, in these situations, the prices of wood products declined and forestalled adoption of nonwood substitutes on a large scale.

In the U.S. economy, prices for solid wood products such as lumber are determined by the interactions of supply and demand. Historically, price changes for solid wood products have been driven by demands in major end use markets. For lumber, new housing has been especially important in determining price changes because new housing markets have been cyclical and account for over one-third of lumber consumption (figure 55). The apparent change in the relationship in the late 1980's and early 1990's reflects increased use of lumber in repair and remodeling of housing. Price changes for fiber-based products are more tied to the overall economy such as industrial production and advertising.

During the past two centuries, the relative producer price index for lumber has been generally increasing (figure 56). There have been periods of relative price stability, such as the 1960's and 1980's. Lumber prices in the 1990's increased faster than an index of prices for all commodities.

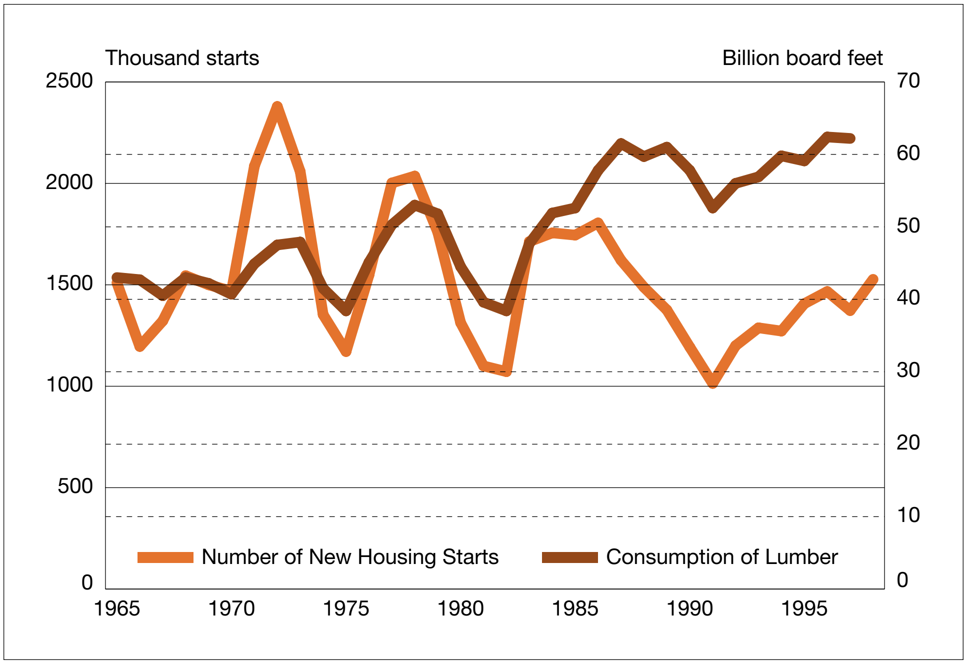

Figure 55 — Number of new housing starts and lumber consumption

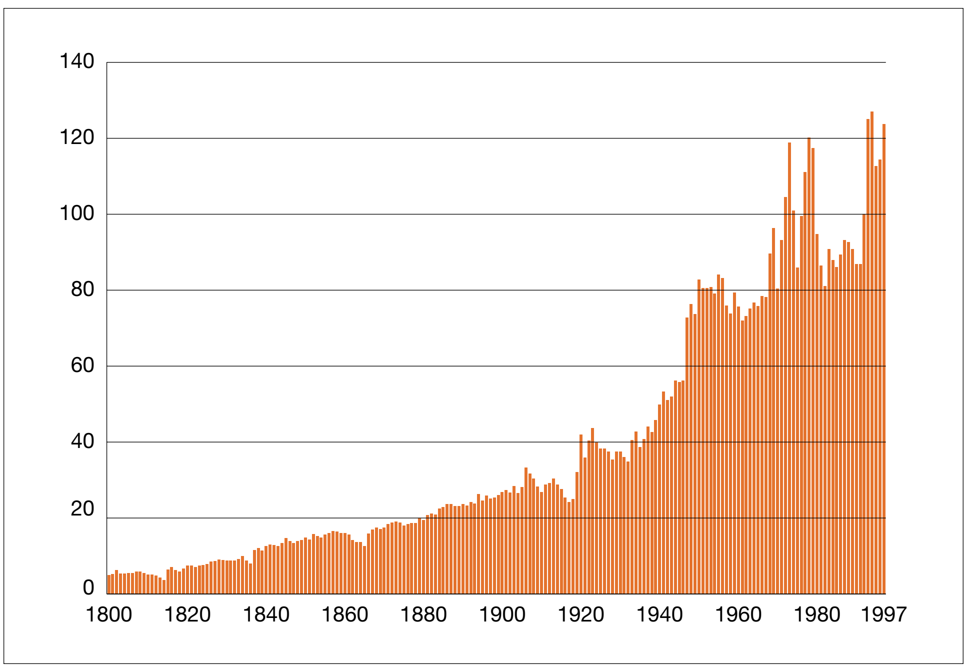

Figure 56 — Relative producer price index for lumber (1992 = 100)

Supply shifts can also affect short- and long-term prices. For example, the decrease in harvest on Federal lands in the early 1990's contributed to a period of price instability for softwood lumber during this time.

Over time, there has been some shift in construction markets from wood to nonwood products, such as interior walls in commercial buildings. Use of nonwood—as opposed to wood products—creates a set of environmental side effects different from the use of wood products.

The wood products processing industries over time have become more efficient in the use of wood (Ince, 2000). Over the last 50 years, there has been a 39-percent increase in the amount of wood and paper products produced per cubic foot of wood input (figure 57). This improvement is due to increased use of wood mill residue to make pulp and panel products, increased paper recycling, and improvements in converting roundwood to lumber, panels, and paper. Paper recycling has contributed to improved output from roundwood as the rate of use of recycled paper has increased from 27 percent in 1990 to 38 percent in 1997.

The value of primary wood product production as a percent of gross domestic product is a measure of the relative importance of the wood products industries to the U.S. economy. Since 1960, this percent has fluctuated, but reached a peak of just over 3.5 percent in the 1970's. It has generally declined since that time (figure 58). The 1970's were years of exceptional housing demand and account for the

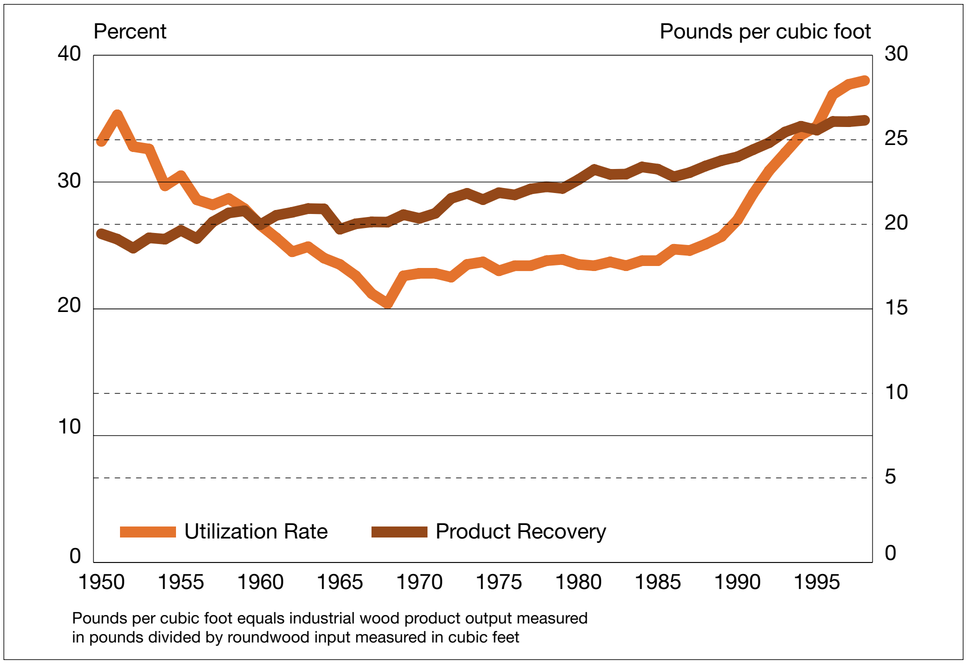

Figure 57 — Waste paper utilization rate and product recovery rate

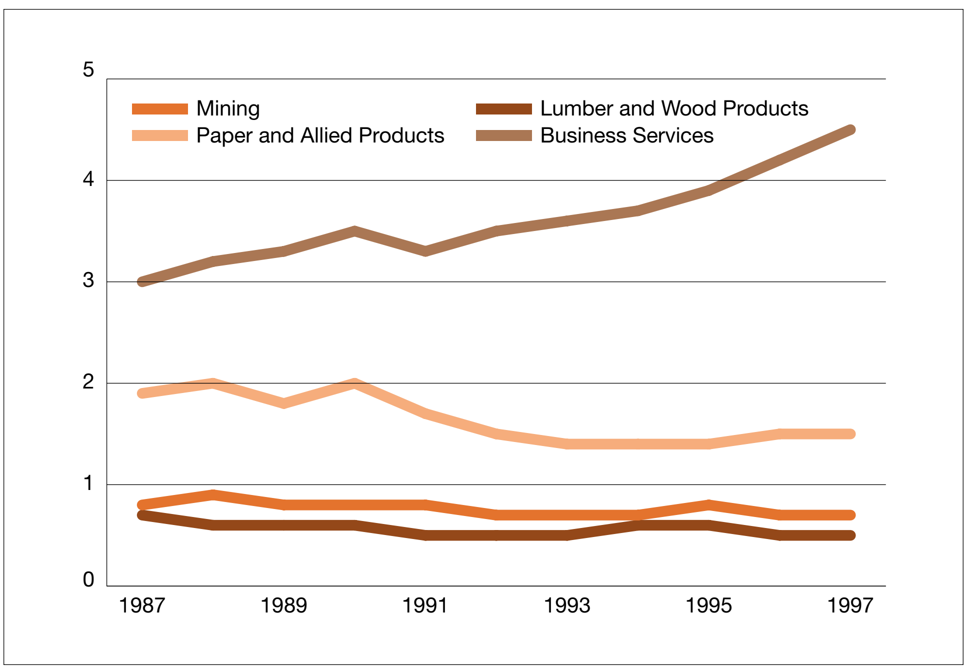

Figure 58 — Gross domestic product by industry as a percentage of gross domestic product

relative strength of the industries at that time. Much of the growth of the U.S. economy in recent years has been based on information management and sharing—activities that are not heavy consumers of traditional commodity products. Consumption of forest products continues to grow, but these other sectors have grown even more rapidly.

A large proportion of U.S. production of wood products consists of what are considered to be commodity products—lumber, panel products, and wood pulp that are of standard specifications and put in place as manufactured (for example, wood studs used in home construction). In this sense, the United States captures much of the value added associated with these products. As products become more specialized, there is increased likelihood of imports accounting for a larger share of production. For example, furniture of species or styles not found in the United States may be imported.

Whether commodity or specialty grade, price is an important factor in the origin of products consumed. For example, the Canadian processing industries are competitive in U.S. commodity markets and Mexican furniture manufacturers are competitive in some niches of the U.S. furniture market.

When unprocessed products are exported, the possible loss of value added to the exporting country often becomes an issue. Potential loss of value added and many associated issues developed over the export of softwood logs from the United States, especially from the Pacific Northwest. Although export volumes have declined over the past decade, the propriety of export limitations versus free trade continues to be debated.

Similar arguments have developed around the export of wood chips (mainly hardwood) from the South. The export of wood chips has been associated with chip mills in the South. According to Hansen and Hyldahl (2000), chip mills in the South have been around since the 1940's and are also an integral part of fiber supply for the domestic pulp industry. These mills currently supply about 25 percent of the hardwood fiber received by pulp mills in the South. About 10 percent of the chip mills are involved in exports. Hardwood chip exports declined between 1996 and 1999.

Investment: The extent of investment in the forest sector is a measure of how people value the resource and make investments that will help assure sustainable forest management in the future. There are two ways to view investment in the forest sector:

- Input of dollars invested
- Outcome measures that suggest the results of previous investments

There is no doubt that billions of dollars are invested in the U.S. forest sector each year: Even partial measures of such investment quickly add up to a large sum. For example, well over 2 million acres of trees have been planted each year since 1978 (figure 59). While data for private sector investment are not available, public agencies spend hundreds of millions of dollars each year for infrastructure to support the use of forests and associated lands and facilities. University and USDA Forest Service forestry research is funded at levels exceeding $250 million. The amount of privately funded forestry research is unknown, but is probably measured in the hundreds of millions of dollars (Ellefson, 1994).

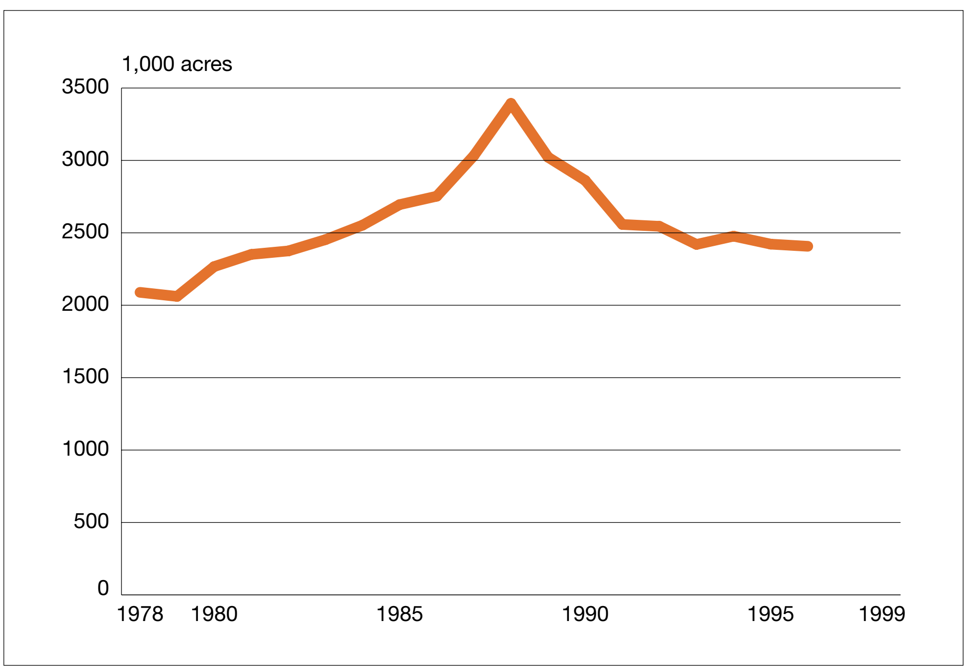

Figure 59 — Tree planting in the United States

The lumber and wood products and paper and allied products industries spend over $10 billion per year for equipment and structures. Other industries, such as oriented strand board and other engineered wood products, and end users of wood products, such as the home construction industry, have all made unknown, but probably substantial investments in plants and equipment and technologies. Billions of dollars have been spent during the 1990's to develop the capacity to recycle paper products.

It is clear from various outcome measures that substantial investments have been made in the U.S. forest sector:

- The growth-removal ratio for timber inventory exceeds 1.0 despite increased harvesting to meet the needs of a growing population.
- Timber processors have increased efficiency in wood use over time—the output of usable products per unit of wood input has been increasing.
- Paper and paperboard recycling has increased.
- Engineered wood products and construction processes have been developed that conserve on the use of wood.
- Despite the large investments in plant and equipment, total factor productivity indexes have leveled off in recent years, possibly indicating a decline in development and application of new technologies or an indication of expenditures for pollution abatement or other purposes that are unrelated to traditional measures of technologies that improve productivity (figure 60).
- Available information suggests that rates of return on investment in some forest management activities are well below 5 percent, indicating that investors are willing to accept relatively low rates of return as compared with higher rates of return more likely associated with exploitive management practices (USDA Forest Service, 1997). Some management practices on high-site lands can earn well in excess of a 5 percent return.
- The forest estate has been able to accommodate huge increases in the number of recreationists pursuing activities on forest land.

Employment: The forest products industries provide direct employment for several hundred thousand people—about 0.3 percent of the total workforce. Employment is cyclical and is driven in large measure by the new home construction industry, which accounts for about one-third of lumber and construction panel consumption. After accounting for economic linkages within the forest products industries and with other industries, some 2 million people depend on the forest products industries for jobs—about 1.5 percent of the total labor force.

Trends in forest industry employment are affected by technical change and by the mix of products produced. The importance of employment in the forest products industries varies by location. There are some counties in the South that are more than 50 percent dependent on forest products manufacturing.

In addition to direct employment in timber processing, forests provide employment for many other people. For example, the changing foliage colors brings millions of people to the Northeast in the fall, providing employment in the recreation and tourism industries.

Relative to manufacturing as a whole, wages in sawmilling amount to 83 percent of the average hourly wage rate (Howard, 1999). Wage rates for employees in the paper and allied products industries tend to be higher

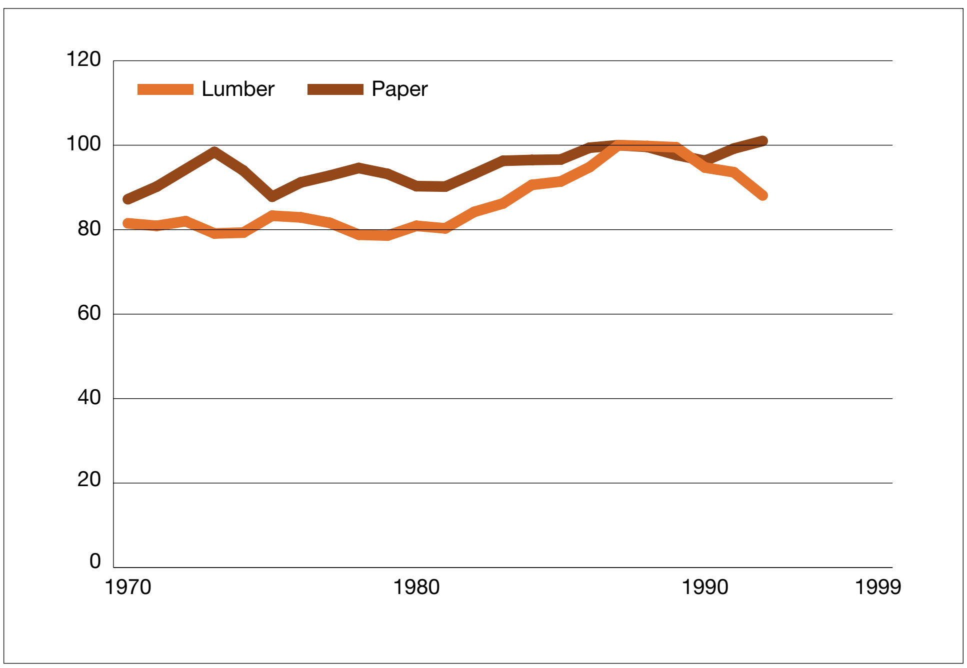

Figure 60 — Total factor productivity indexes for the lumber and wood products industry and the paper and allied products industry (1987 = 100)

than for sawmilling and amount to 114 percent of the average for all manufacturing. Relative to all manufacturing, wage rates in the forest industries have been falling (figure 61).

According to the U.S. Bureau of Labor Statistics (1999), injury and illness rates for the timber-related industries suggest that these industries are relatively dangerous. For logging, the number of instances of injuries and illnesses per 1,000 employees was 10.5, for sawmills and planing mills—7.5, and for all manufacturing—0.5.

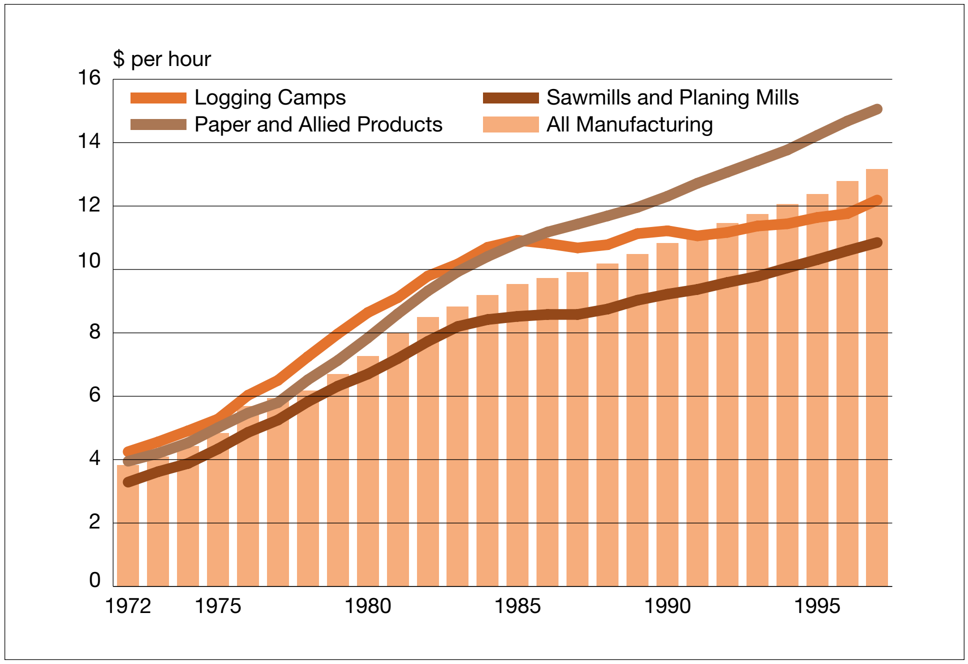

Figure 61 — Average hourly earnings in selected industries

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 to use to 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 annually in rivers and lakes for human and wildlife use (Sedell et al., 2000).

The supply of usable water is largely fixed. Most opportunities to develop water sources have been implemented. Some existing sources of water, such as reservoirs, are losing their utility because of siltation. The demand for water continues to increase. Water-based recreation is growing with growth dependent in part on clean, accessible water (Cordell, 1999). Because of fixed supply and increasing demand, the value of the water resource is increasing.

Significant portions of the Nation's freshwater supplies originate in the forested mountain areas of the West and in the eastern forests. Excluding Alaska, about two-thirds of the Nation's water runoff comes from forested areas. National forests alone contribute 14 percent of the total runoff (Sedell et al., 2000). Available data for withdrawals are for withdrawals from all sources of water.

After continual increases in the Nation's total water withdrawals for offstream use for the period 1950 to 1980, withdrawals declined from 1980 to 1995 (figure 62). The 1995 estimate of total withdrawals is nearly 10 percent less than the 1980 estimate even though population increased 16 percent during this period (Brown, 1999). The public supply and rural categories are the only ones to show continual increases from 1950 to 1995, reflecting an increase in human populations and an increase in animal specialties withdrawals, such as for the production of fish in captivity, respectively. In 1995, irrigation and thermoelectric use each accounted for about 130 billion gallons per day of freshwater withdrawals.

Industrial withdrawals peaked in 1980 and declined through 1995, reflecting in part the adoption of water-conserving technologies. Total irrigation withdrawals were about the same during 1955 and 1960, then increased through 1980, followed by a decline through 1995. The total number of acres irrigated in the United States was relatively constant from 1980 to 1995. This overall stability masks decreases in irrigated acreage in the Western United States and increases in irrigated acreage in the Eastern United States. Formerly irrigated land in the West has been replaced by dry land farming, urban development, and irrigation rights being sold to municipal water suppliers. Decreased withdrawals for irrigation reflect more efficient irrigation systems and techniques and lower water application rates in the more humid Eastern United States.

In terms of water quality, 70 percent of the Nation's assessed river miles, lake acres, and estuarine area can support the "aquatic life use" designated under the Clean

Water Act (Loftus and Flather, 2000). Generally, the water draining from forest and rangelands is very good (Binkley and Brown, 1993).

In summary, the general increase in water use from 1950 to 1980 and the decrease from 1980 to 1995 can be attributed, in part, to the following major factors (Solley et al., 1998):

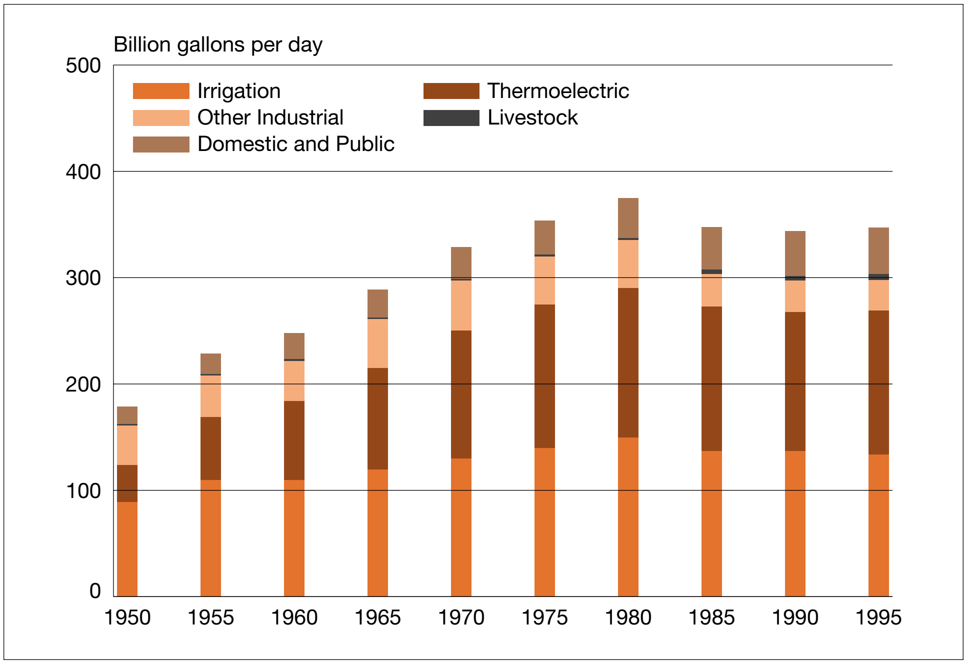

Figure 62 — Water withdrawals for off-stream use by type of use

- Most of the increases in water use from 1950 to 1980 were the result of expansion of irrigation systems and increases in energy development. The development of center-pivot irrigation systems and the availability of plentiful and inexpensive ground-water resources supported the expansion of irrigation systems.
- Higher energy prices in the 1970's and large drawdown in ground-water levels in some areas increased the cost of irrigation water. In the 1980's, improved application techniques, increased competition for water, and a downturn in the farm economy reduced demands for irrigation water.
- The transition from water-supply management to water-demand management encouraged more efficient use of water. New technologies in the industrial sector that require less water, improved plant efficiencies, increased water recycling, higher energy prices, and changes in laws and regulations to reduce the discharge of pollutants resulted in decreased water withdrawals and less water being returned to the natural system after use. The enhanced awareness by the general public to water resources and active conservation programs in many States have contributed to reduced water demands.
- Total water withdrawals in the United States are expected to increase slowly in the future, largely in response to population increases.

Especially in the West, water from national forests is essential for human activity. For example, 45 percent of the total water runoff in California is estimated to originate on national forests (Sedell et al., 2000). The value of water flowing from national forests, in both offstream and instream uses, is conservatively estimated to be at least $3.7 billion per year.

Minerals

Production and consumption: International trade plays a large part in the supply of many minerals commodities. Some minerals, such as sand and gravel, have a high weight-to-value ratio and are mined close to home. Other minerals, such as some of the metals, are relatively rare and are traded extensively. Each year, the U.S. economy consumes over $132 billion worth of domestically produced minerals plus domestic reclaimed metals and mineral materials and inputs of energy and mineral raw material (Shields, 2001).

Over 90 percent of total energy needs (as measured by Btu's) are met by petroleum, natural gas, or coal. Foreign sources currently supply over 40 percent of the petroleum and 7 percent of the natural gas used annually. The United States is a net exporter of coal.

The United States is a mineral-rich Nation, with supplies of many metallic and precious metals sufficient to accommodate domestic demand through 2050. The country is a net exporter of gold, phosphate rock, and molybdenum. Nonetheless, 40 percent of the unprocessed metals and 12 percent of fertilizer and chemical minerals currently used in the United States are imported (Shields, 2001).

The demonstrated reserves for coal exceed 450 billion short tons and are adequate for the next 50 years and beyond. Much of the coal in the Eastern and Midwestern

United States is privately held, including valid and existing rights to deposits underlying some national forests. Extensive reserves also exist beneath the northern Great Plains. While environmentally sound mining is practiced today, acid mine drainage from abandoned or reclaimed mines and subsidence remain as problems, particularly in the East.

Prior to the 1970's, reclamation of abandoned mine sites was not required and consequently was not performed for the majority of mines (Shields et al., 1995). The failure to reclaim these mines has left a legacy of abandoned mines across the United States, with associated environmental problems. Most new mine sites can be and are being reclaimed.

Investment: The mining industry is capital intensive. For example, a typical new copper mine may cost in excess of $250 million. Capitalized mineral exploration and development expenditures have generally declined for all minerals, with gold being the exception. Billions of dollars are still being spent to explore and develop crude petroleum and natural gas deposits each year (Shields, 2001).

The contribution of the energy and minerals sectors to the national gross domestic product decreased from 2.56 percent in 1977 to under 2 percent in 1990. Despite this decline in relative importance, the industry remains essential to the national economy and is especially important for the economies of a number of States (Shields et al., 1996). In 1990, the energy and minerals sectors accounted for 37 percent of the gross State product of Alaska, 30 percent for Wyoming, 16 percent for Louisiana, 12 percent for West Virginia, and 11 percent for New Mexico. Nonrenewable resources account for 0.57 percent of the gross State product in the North, 4.48 percent in the West, and 3.6 percent in the South.

Employment: Employment in all sectors of the energy and minerals industries peaked in the late 1970's or early 1980's, with oil and gas experiencing the greatest expansion. Thereafter, job numbers declined to below 1977 levels for all sectors. This latter change reflects declines in production levels (oil and gas), increases in productivity (coal), and changes in extraction technology (metals). In 1990, the energy and minerals industries employed approximately 711,000 people.

Real hourly wages for all private jobs were fairly consistent over the 1978 to 1993 period. Total industrial wages were lowest in 1991 at $7.41 per hour. Wages in the extractive industries were more variable and consistently higher by comparison. As of 1993, the real average wage in nonmetallic mining was $8.71 per hour; in oil and gas, $9.70; metal mining, $10.49; and coal, $11.84. Real wages in the oil and gas, coal, metallic, and nonmetallic mining industries all rose during the 14-year period, but declined to near or below 1977 levels by 1993.

Outdoor Recreation

Availability of forest land and associated facilities for recreation and tourism, and their use by people, are indicators of whether people enjoy the forest for these purposes and are therefore likely to manage the forest on a sustainable basis. Available data are primarily for participation in recreational activities regardless of the type of land or its ownership.

Almost all publicly owned forest land (36.7 percent of the total forest land area) is available for recreational purposes. Wilderness areas may limit recreational use of these lands to specific types of activities such as camping and backpacking. Access to privately owned forest lands for recreational purposes can vary by ownership. Recreational use of their land is a primary objective for many land owners (Birch, 1996). The proportion of privately owned forest land open to the public and free of charge has declined from 29 percent in 1979 to 23 percent in 1989 and 15 percent in 1996 (Cordell, 1999). 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: The decades of the 1980's and 1990's and continuing into the 21st century, have been a time of strong growth in Americans' pursuit of outdoor recreation. Participation in outdoor recreation has been growing; many of these activities most likely occur on forest land (Cordell, 1999). Between 1983 and 1995, outdoor recreation activities that had greater than 50-percent increases in the number of recreation days of participation included hiking, bird watching, camping in a primitive area, and backpacking (table 8). The percentage of the U.S. population that is 16 years old or older that participates in at least some form of recreation grew for most recreation activities between 1983 and 1995. In total, some 89 percent of the U.S. population participated in outdoor recreation in 1983 and 94.5 percent in 1995. Activities with declining participation rates included hunting and fishing. Although the participation rate for fishing declined between 1991 and 1996, the number of people fishing remained about the same and the number of fishing trips increased 22 percent (Cordell, 1999). Bird watching is one of the most popular types of outdoor participation.

Table 8 — Millions and percentage change of persons 16 years or older participating at least once in 12 months in land, water, snow/ice, and other recreation activities in the United States

	Number in Millions		
Resource Base and Activity	*1982-83*	*1994-95*	*Percent Change*
Land-resource-based activities			
Bird watching	21.2	54.1	+155.2
Hiking	24.7	47.8	+93.5
Backpacking	8.8	15.2	+72.7
Primitive area camping	17.7	28.0	+58.2
Off-road driving	19.4	27.9	+43.8
Walking	93.6	133.7	+42.8
Sightseeing	81.3	113.4	+39.5
Developed area camping	30.0	41.5	+38.3
Picnicking	84.8	98.3	+15.9
Running/jogging	45.9	52.5	+14.4
Bicycling	56.5	57.4	+1.6
Horseback riding	15.9	14.3	–10.1
Hunting	21.2	18.6	–12.3
Water-resource-based activities			
Motorboating	33.6	47.0	+39.9
Swimming — river, lake, or ocean	56.5	78.1	+38.2
Swimming — pool	76.0	88.5	+16.4
Water skiing	15.9	17.9	+12.6
Fishing	60.1	57.8	–3.8
Sailing	10.6	9.6	–9.4
Snow- & ice-resource-based activities			
Downhill skiing	10.6	16.8	+58.5
Snowmobiling	5.3	7.1	+34.0
Cross-country skiing	5.3	6.5	+22.6
Sledding	17.7	20.5	+15.8
Ice skating	10.6	10.5	–0.9
Outdoor sports & spectator activities			
Attending an outdoor concert or play	44.2	68.4	+54.7
Attending a sports event	70.7	95.2	+34.7
Golf	23.0	29.7	+29.1
Outdoor team sports	42.4	53.0	+25.0
Tennis	30.0	21.2	+29.3

Enthusiasts (the one-third of participants who are the most active) account for much of the time spent by people recreating in some activities. For example, one-third of the people who participate in camping account for 76 percent of the days spent participating in this activity (table 9). Activities where enthusiasts account for more than 85 percent or more of the total time spent in the activity include bird watching, wildlife viewing, and studying nature near water. Enthusiasts accounted for at least 58 percent of total participation in the activities surveyed. Because so few people account for so much of the time spent in these activities, there are many management and other implications. For example, if another downhill ski facility is constructed, will new people be drawn into the activity or will existing enthusiasts spend additional time in the new facility? Marketing and outreach about the activities pursued by enthusiasts can be targeted at participants. Because enthusiasts spend so much time pursuing their activities, they are probably likely to have strong interests in the management of forest and other areas where the activities occur.

National forests in many areas supply a unique role in providing recreation opportunities. The National Forest System has 18 national recreation areas, 7 national scenic areas, 4 national monuments, 133 scenic by-ways, 96 wild and scenic rivers, and 4 national scenic or historic trails.

There are over 100,000 heritage sites inventoried on national forests representing over 10,000 years of history. They range from the renowned Anasazi cliff dwellings to more subtle indicators of the Nation's past, such as arrow heads.

The USDA Forest Service State and Private Forestry program works in partnership with States to assist communities in promoting tourism and recreation.

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.

Between 1987 and 1997, the opportunities for factors that relate to developed resources were increasing (table 10). Outdoor recreation facilities are not uniformly distributed across the United States. For example, camping is generally more available along ocean coasts and in the North.

Wilderness: Since passage of the National Wilderness Preservation Act of 1964, Congress has more than doubled the initial designation of 12.2 million acres in the coterminous States (Cordell, 1999). These designated areas serve to protect biodiversity and provide clean air, water, and other ecosystem services, as well as being places for some types of outdoor recreation. In 1995, the USDA Forest Service managed about one-third of the Federal area in the National Wilderness Preservation System. Some 18 percent of the total area of the National Forest System is classed as wilderness. Other Federal agencies that manage land in the National Wilderness Preservation System include the National Park Service, Fish and Wildlife Service, and the Bureau of Land Management.

There are additional millions of acres considered suitable for designation as wilderness and the area in the system is likely to grow (Cordell, 1999). Visitor use of wilderness areas on national forests is forecasted to grow between 0.5 and 1 percent per year for the next 50 years (Cordell 1999).

Investment: There is no doubt that expenditures for outdoor recreation make a substantial contribution to the gross domestic product. Estimates of consumer spending on outdoor recreation include: $67.9 billion spent by hunters and anglers in 1996, $29 billion spent by bird watchers in 1995, and $6.4 billion spent by visitors to national parks in 1995 (Cordell, 1999).

Employment: An estimated 767,000 jobs are generated by nonlocal recreation visitation in nonmetropolitan counties (Cordell, 1999). Some 39 percent of these jobs are associated with food and beverage purchases. The remainder is more evenly distributed among accommodations, retail trade, and recreation services. Income and jobs associated with recreation and tourism are relatively more important in many counties of the West. Jobs tend to be seasonal and relatively low paying. Thus, this sector accounts for 3.1 percent of jobs and 1.5 percent of income.

Range

Much of the forage consumed by livestock is produced from nonirrigated pasture owned by the livestock enterprises and, therefore, 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 is set by multiple resource management objectives and public policy.

Table 9 — Percent of population, days annually, and percent of total days by the one-third of participants who are the most active by activity and age group

Activity	Percent of U.S. population classified as enthusiasts	To be classified as an enthusiast, an individual had to participate at least this number of days annually	Percent of total participation days by enthusiasts	Percent of enthusiasts by age group		
				16-24	25-49	50 and over
Fitness Activities						
Biking	7.4	30	80	24.4	56.9	18.7
Walking	21.4	112	76	15	45.4	39.6
Viewing Activities						
Visiting a prehistoric site	4.3	3	75	17.2	53.1	29.7
Visiting a historic site	11.8	4	72	14.7	55.9	29.4
Bird-watching	9.1	50	91	4.9	44.3	50.8
Wildlife viewing	9.6	12	92	10.6	57.7	31.8
Fish viewing	3.7	10	85	9.5	58.3	32.2
Sightseeing	17.4	12	78	13.1	50.5	36.4
Visiting a beach or waterside	19.7	15	84	20.4	57.6	22.0
Studying nature near water	8.5	10	89	12.3	58.8	28.8
Snow and Ice Activities						
Downhill skiing	2.6	6	74	35.8	53.6	10.6
Cross-country skiing	0.9	6	73	16.8	54.4	28.8
Snowmobiling	1.1	5	84	22	62.6	15.5
Camping (overall)						
Developed area	6.3	8	76	15	59.7	25.2
Primitive area	4.1	7	76	24.2	60	15.9
Hunting						
Big game	2.4	12	74	20.8	64.6	14.6
Small game	1.9	10	77	18.6	64.6	16.8
Migratory bird	0.6	7	71	20.2	57.1	22.8
Fishing						
Freshwater	7.1	15	79	16.5	55.7	27.7
Saltwater	2.6	7	85	17.2	57.4	25.4
Warmwater	6.2	14	82	18.7	54.7	26.5
Coldwater	2.3	10	76	13.2	55.9	30.9
Anadromous	1.0	6	80	16.6	57.2	26.2
Catch and release	3.9	15	80	19.3	58.2	22.5
Boating						
Sailing	1.4	5	81	23.4	49.8	26.8
Canoeing	1.8	4	73	27.6	49.4	23.1
Kayaking	0.2	5	78	22.5	71.3	6.2
Rowing	1.1	3	79	15.5	51.3	33.1
Floating/rafting	1.9	4	75	37.1	55.5	7.5
Sailboard/windsurfing	0.3	4	81	24.5	56.6	18.8
Swimming Activities						
Surfing	0.3	15	89	54.2	38.6	7.1
Swimming — pool	13.0	25	80	26.9	55	18.1
Swimming — nonpool	11.9	13	78	27	58.7	14.3
Snorkeling/scuba	1.8	5	77	20.2	68	11.9
Outdoor Adventure Activities						
Hiking	7.1	10	83	24.4	58.3	17.3
Orienteering	0.6	5	75	32.2	55	12.8
Backpacking	2.4	5	81	33.4	56	10.7
Mountain climbing	1.3	5	74	29.5	55.6	14.8
Rock climbing	1.0	3	78	45.5	48.4	6.2
Caving	1.1	2	58	34.4	54.6	11
Off-road driving	4.5	14	87	25.6	57	17.3
Horseback riding	2.3	6	94	36.8	52.6	10.5
Social Activities						
Picknicking	15.0	7	73	13.5	64.0	22.6

Table 10 — Percent of regional population living in counties with stable or increasing recreation availability index values by recreation resource type and region

	Region				
Recreation Resource Type	*North*	*South*	*Rocky Mountain*	*Pacific Coast*	*U.S. Total*
Local facilities	41.3	94.6	1.7	6.8	57.6
Open space	100.0	99.8	100.0	100.0	99.9
Great outdoors	2.3	72.8	28.0	22.3	28.8
Wildlife land	69.7	52.3	61.4	82.6	66.1
State & private forests	100.0	69.0	48.9	45.9	74.2
Western land	26.3	42.3	3.8	2.0	26.3
Camping areas	9.6	36.3	43.3	2.4	19.5
Other Federal land	0.7	46.6	9.6	0.0	15.4
Large water bodies	1.4	31.9	67.1	4.0	16.2
Whitewater	35.8	88.1	50.9	40.6	54.0
Flatwater	0.7	10.1	5.4	55.4	8.5
Lowland rivers	100.0	98.3	98.4	99.8	99.3
Developed winter	100.0	91.8	72.0	29.9	85.7
Undeveloped winter	12.9	91.4	15.5	20.8	38.7

Forage production is not inventoried. 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 market commodities such as meat, hides, wool, tallow, and secondary products such as pharmaceuticals. These demands in turn are based largely on human population and income. Forage demand for livestock production depends on the technology associated with livestock production, the prices of alternative feeds, the total feed mix, and the price of livestock.

Beef cattle and sheep consume approximately 431 million animal unit months of grazed forages each year (Mitchell, 2000). 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 (Mitchell, 2000). 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.

In addition to providing forage, rangelands—

- Contribute to meeting people's needs for recreation
- Conserve biodiversity
- Are sources of clean water
- Store carbon
- Provide vistas and other amenities enjoyed by many people

Implications of Historical Trends for Expectations for the Future

During the past century, the human population of the United States has more than tripled. During this time, attitudes toward renewable resources have evolved, reflecting the changing values of the Nation, as well as the capabilities of the resources and the possibilities for their uses.

Americans enjoy many values from their forests and rangelands. This is evident from timber harvest that meets 90 percent of domestic needs; hundreds of millions of visits for recreation on forest and rangelands each year; and use of these lands to satisfy cultural, social, and spiritual needs and values. In addition, forests and rangelands are used for subsistence purposes by many people and there is increasing interest in nonwood goods and services. Forests are the basis for employment for hundreds of thousands of people.

Forests are valued, as is evident from hundreds of millions of dollars spent each year in research, recreation, forest management, and processing of harvested wood. Increased recycling of forest products has as an outcome conserving on the use of wood.

The legal, institutional, and economic framework for forest conservation and sustainable management in the United States has evolved over time. Property rights and land tenure arrangements continue to be interpreted within legal institutions. The number of regulations affecting forest management and timber processing on private lands has been increasing. Some 43 States now have best management codes for forest management. The need for public involvement and education is now widely recognized and practiced for decisions affecting public lands. The need for reliable, up-to-date data is widely recognized and forest inventory and monitoring programs continue to evolve to reflect evolving demands for the frequency and scope of data. Thousands of people are trained each year in the various disciplines necessary to understand and manage forest and range ecosystems (USDA Forest Service, 1997).

Prospects for plantation forestry in Brazil and other countries open up possibilities for increased trade with nontraditional sources. This is especially the case for pulp and other processed fiber products. Concerns over importation of forest pests and diseases will likely limit U.S. importation of raw material from nontraditional sources.

The nature of long-term multiple socioeconomic benefits from the forest will evolve over time as the needs of U.S. society and the character of the resource change over time. Employment in the forest sector will not increase proportionately to timber harvest because of continual adaptation of labor-saving technologies in the processing and application of wood products. There will be continuing changes in products and end-use applications of wood that economize on the use of wood and adapt products to the capabilities of the resource (for example, smaller diameter timber). There will be technological changes in the growing of wood. Short-rotation woody crops offer the potential to expand into a significant source of wood fiber for the pulp industry.

There has been a 39-percent increase in wood and paper products produced per unit of roundwood input in the United States over the past 50 years. Although efficiency improvements will continue, the pace of improvements will likely be slower. This is because the contributions of increased recycling and increased residue use will be much slower. There will be continued improvements in converting wood fiber to wood and paper products but, in the absence of unforeseen major technological improvements, roundwood harvest needs may not be dampened by efficiency improvements over the next 50 years as much as they have over the past 50 years.

Demands for recreation and tourism and nonwood forest products will evolve and increase over time as the population increases and becomes more diverse. The most popular recreation activities through the years have been those which can be enjoyed close to home without large outlays of time or money and those which do not require high levels of specialized skills (Cordell, 1999).

Employment in the recreation and tourism sectors will likely increase over time, given the projected increases in population and income.

Technology will continue to evolve in the manufacture of equipment used in recreation. For example, advances in snow shoe design have increased the popularity of winter hiking and camping.

According to grazed forage experts, the amount of land available for forage production will likely decrease in all regions. Local impacts from environmental concerns and government policies will be significant in areas where resource concerns have already emerged (Van Tassel et al., 1998). Urban sprawl, suburbanization, and increased demands for recreation are expected to be the major factors leading to decreased grazing lands. A decline in the use of grazing lands by livestock is anticipated in the West and North: Use in the South probably will not change much. An increase is expected in the use of sheep and, especially, goats for brush and weed control. Driven in part by nonconsumptive utilization of wildlife, wildlife utilization of grazing lands is expected to increase in all regions. Technology development in forage production may play a role in maintaining use of grazed forages in the West and South, but not as much in the North. Grazing system technology and biological control of weeds are the two most likely developments.

Expectations About the Future for Maintenance and Enhancement of Long-Term Multiple Socioeconomic Benefits To Meet the Needs of Societies

- Total roundwood harvest in the United States is projected to be 22.2 billion cubic feet in 2050 (figure 63). Softwood harvest is projected to increase 26 percent to 13.3 billion cubic feet as compared with 1996 and hardwoods 20 percent to 8.9 billion cubic feet.
- The proportion of the roundwood consumed in the United States to manufacture wood pulp versus solid wood products is expected to remain relatively constant at 30 percent over the next 50 years. However, with increased use of recycled paper and continued use of mill residue, the pulp, paper, and paperboard share of U.S. forest products production is expected to grow from 54 percent to 60 percent by 2050 (Ince 1998).
- The bulk of the Nation's timber harvest is likely to occur in the East (80 percent in 1996 and 81 percent in 2050) and especially in the South (59 percent in 1996 and 56 percent in 2050).
- Canada is expected to continue to be the primary source of imports of wood products (over 75 percent), but imports from nontraditional sources are also expected to increase. Canada is likely to provide roughly one-third of U.S. lumber consumption over the next 50 years, but imports from other countries are expected to increase to 5 percent of U.S. softwood lumber consumption.
- Timber prices are expected to stabilize, after increasing in the 1990's. After 2020, stumpage prices may decline slightly as millions of acres of softwood plantations reach merchantable size.
- By 2050, roughly two-thirds of the softwood timber harvest is projected to come from plantations.
- The United States will likely continue to rely on domestic sources for most of its fiber needs. Imports are projected to amount to 19 percent of consumption in 2050, as compared with 23 percent in 1996. Exports are projected to amount to 11 percent of production in 2050, as compared with 15 percent in 1996.
- Product prices are expected to be roughly constant after 2000, after rising in the 1990's (figure 64).

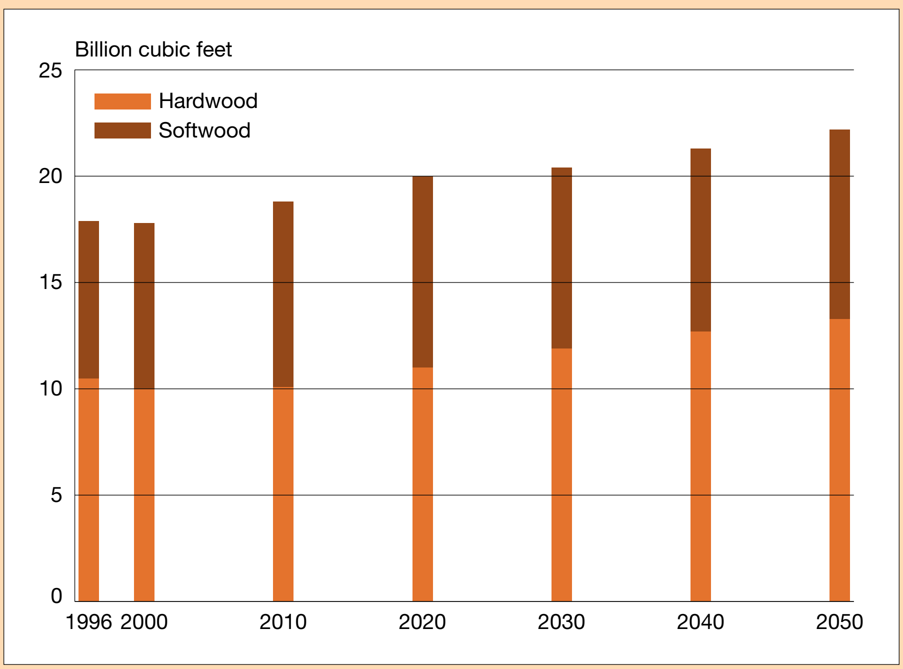

Figure 63 — U.S. timber harvest

- Improvements in the efficiency of water use will likely continue if the kind of influences that encouraged past improvements continue into the future (for example, environmental pollution regulations, price increases, reductions in government subsidies, and plumbing fixture ordinances).
- Voluntary water trades that reallocate water to its most valuable use will be particularly important in the West where water is relatively scarce.
- Increased off-stream water needs of a growing population will unavoidably decrease instream flows, increasing environmental conflicts and potential injury to aquatic resources. The potential for controversy in the development of law and policy related to water use will continue to increase.
- Total U.S. withdrawals of water are projected to rise by less than 10 percent by 2050, despite a 49-percent increase in population (Brown, 1999) (figure 65).
- Improving efficiencies projected for municipal and industrial and thermoelectric sectors and a nearly constant level of total irrigation withdrawal account for much of the slowing in total water withdrawals.
- Interactions among ground water pumping, surface withdrawals, and salt-water intrusion will become more common in some coastal areas in the South.
- Total U.S. water withdrawals are expected to rise only slightly by 2040, but large increases are projected for areas of the South, much of it from increased groundwater pumping that may diminish surface-water flow.

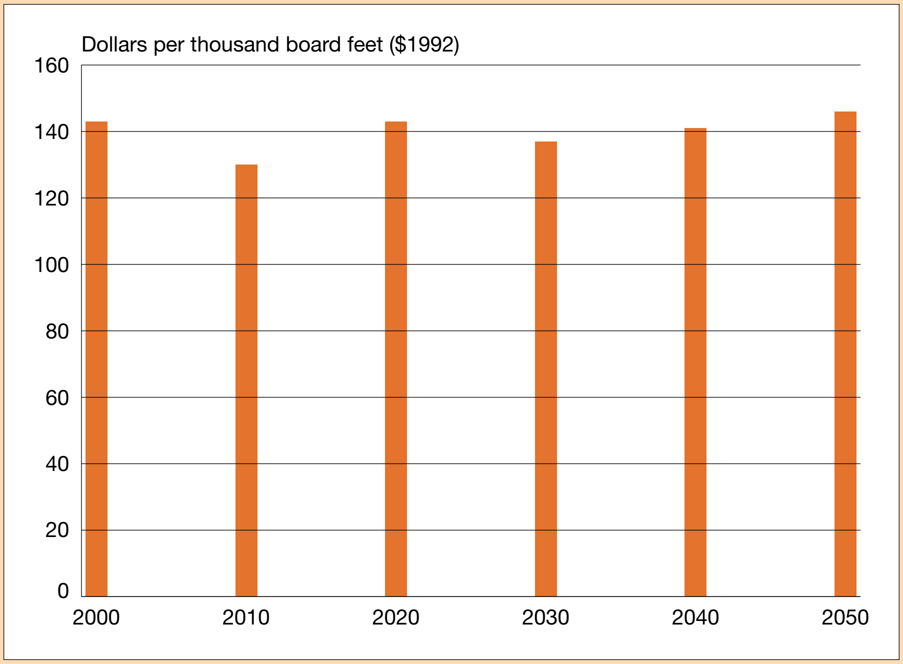

Figure 64 — U.S. softwood lumber price

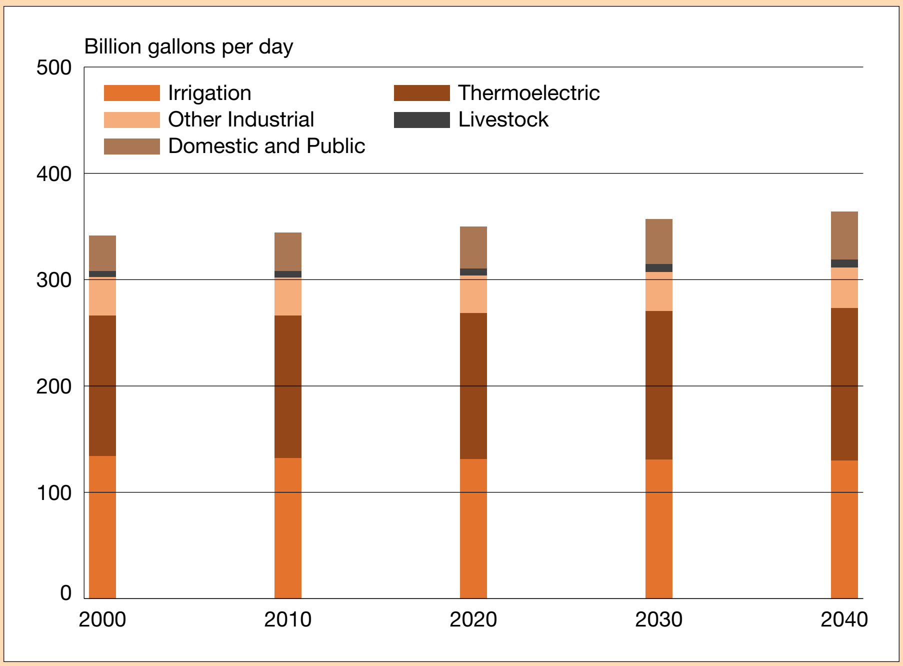

Figure 65 — Projections of water use in the United States

- Per capita consumption of many metallic minerals is expected to decline or remain constant; however, increasing population is expected to lead to net increases in demand for most minerals by 2050.
- Technological changes in mining, such as gold production from disseminated lode deposits or in end uses such as the use of platinum in fuel cells, can shift the supply and demand outlook for some minerals.
- Environmental regulations in the United States are among the strictest in the world. The costs of compliance with general environmental laws, plus those directed specifically at energy and mineral production activities, have made some previously economic mineral deposits and wells unprofitable to operate. An outcome may be increased reliance on imported resources.
- 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 with associated increases in employment opportunities.
- Increased rates of participation are expected in most recreation activities.
- Recreation activities with the greatest potential for future demand growth on private land include hunting and fishing, wildlife observation, and hiking. The growth in the numbers of participants in hunting and fishing is projected to be less than the growth in population.
- Across all levels of government, there appears to be a nationwide trend toward increasing the number, quality, and scope of developed land-based recreation activities.
- The expected increasing number and diversity of the U.S. population will affect future recreation patterns. For example, 82.8 percent of the population was classed as white in 1996. In 2050, an estimated 74.8 percent of the population will be white. The population is also aging and fewer people come from a rural background.
- Recreational use of existing designated wilderness areas is projected to increase by about 0.5 percent per year. In addition to recreational use, wilderness areas serve to protect biodiversity and water quality and serve as carbon reservoirs (Cordell, 1999).
- There is a trend toward closing more private land to outdoor recreation in the future in all regions. The area of private land with free and open access to individuals whom the landowner does not know declined from 25 percent to 15 percent between the mid-1980's and mid-1990's.
- The five fastest growing recreation activities through 2050, as measured by number of participants, are projected to be: Cross-country skiing (95 percent growth), downhill skiing (93 percent), visiting historic places (76 percent), sightseeing (71 percent), and biking (70 percent).
- Continuing changes in livestock infrastructures are expected, with more vertical integration in the industry and more confinement operations.

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