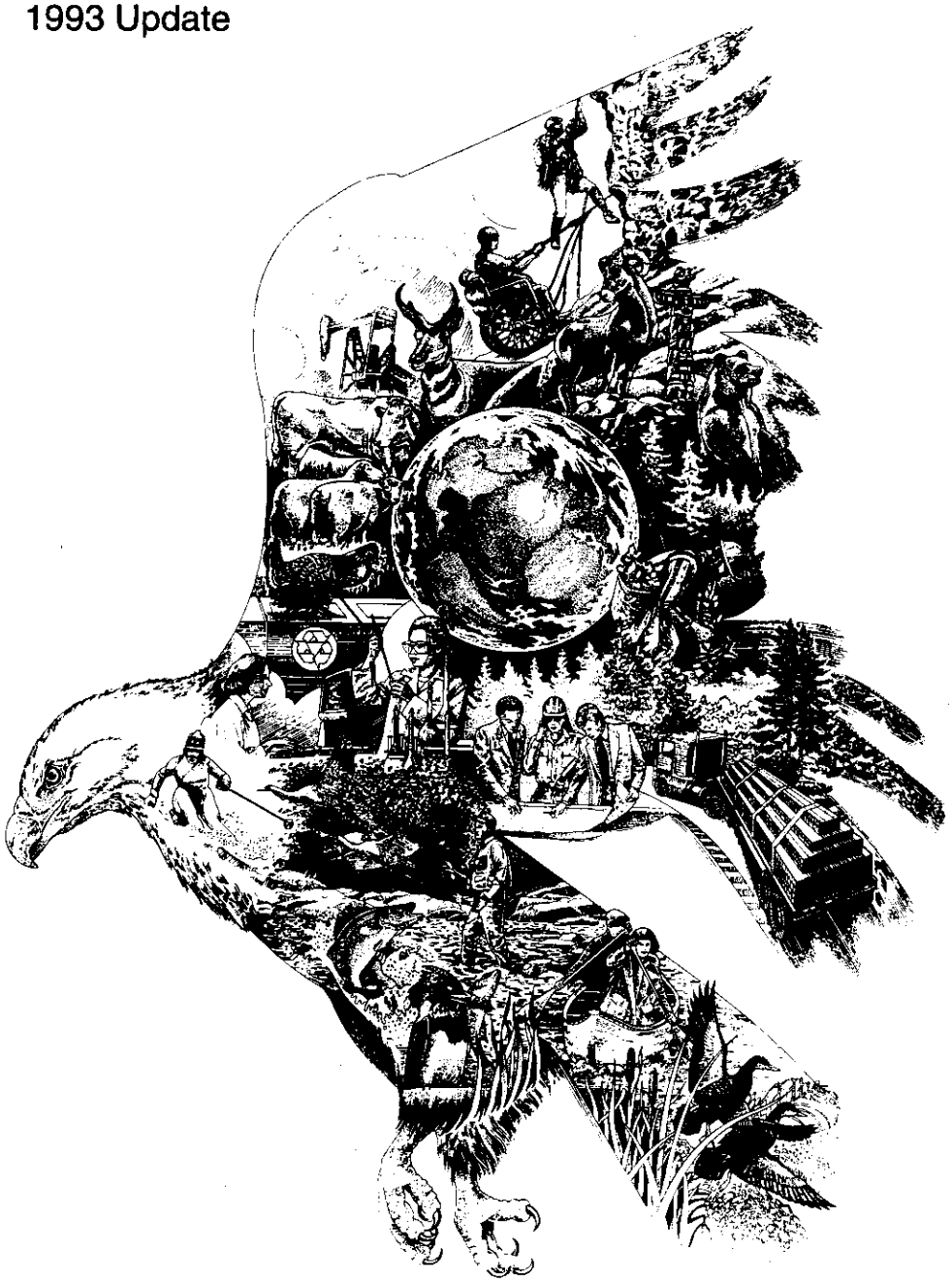
United States
Department of
Agriculture

Forest Service

Forest Resource
Report No. 27

RPA Assessment of the Forest and Rangeland Situation in the United States—

1993 Update



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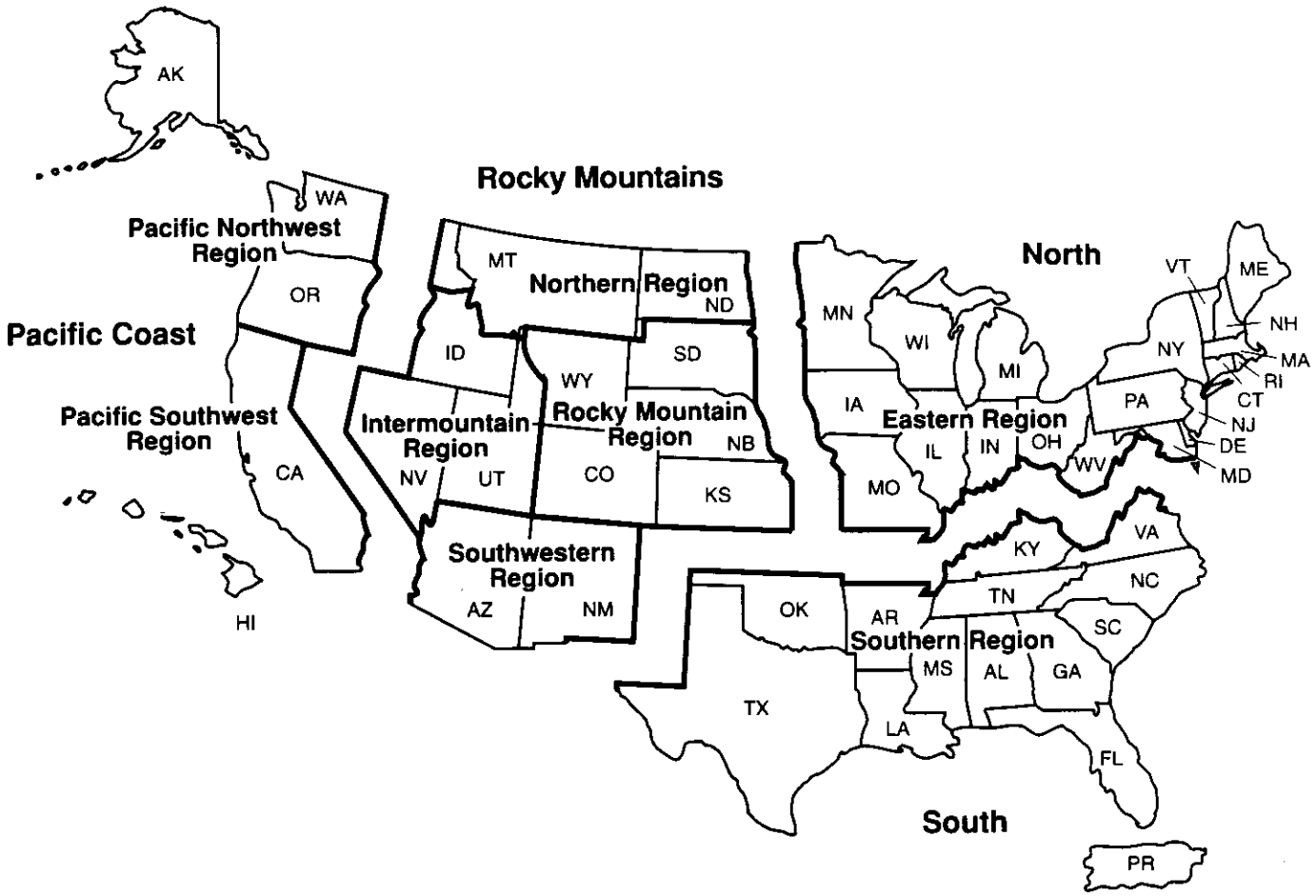

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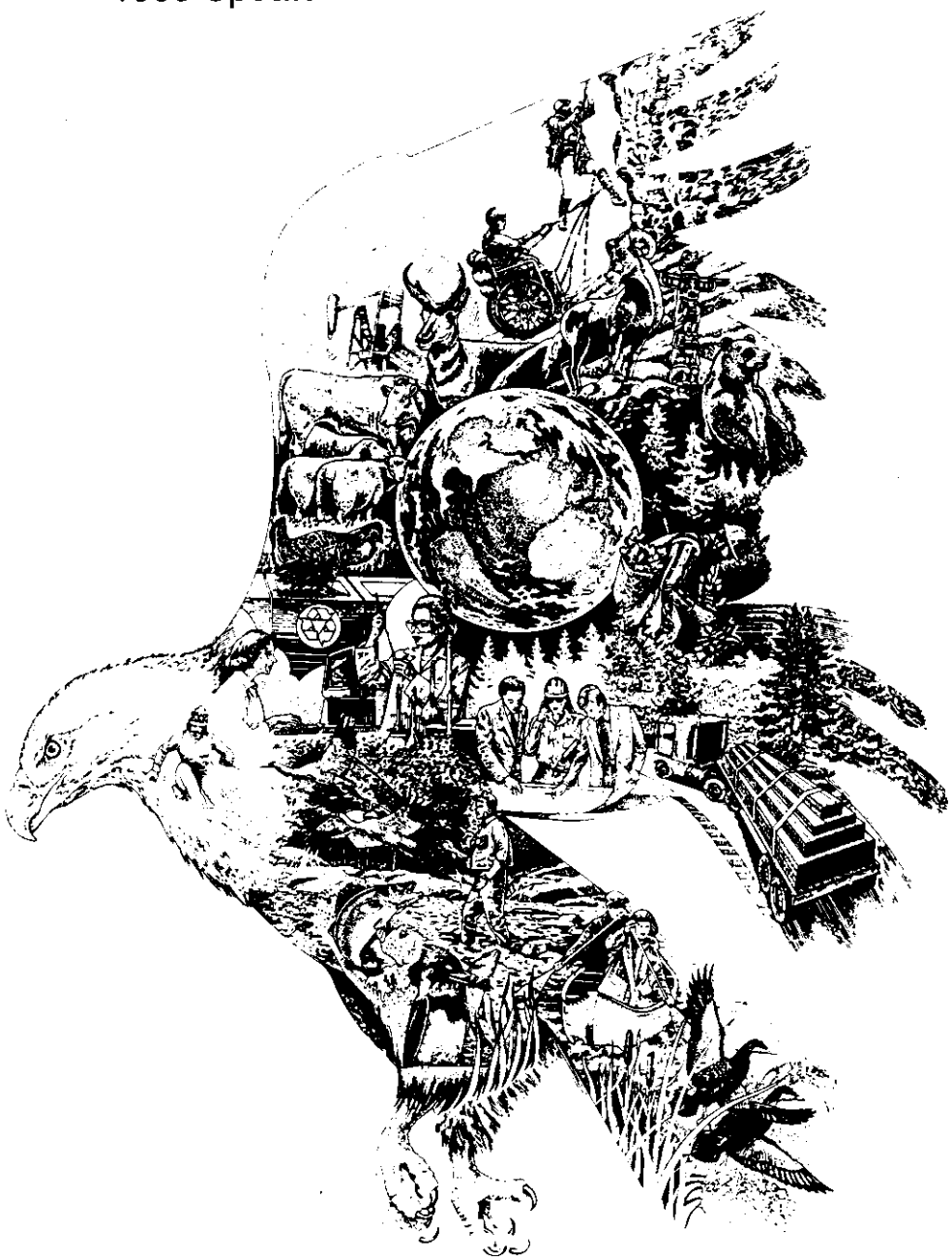

Preface

The Forest and Rangeland Renewable Resources Planning Act of 1974 RPA, P.L. 93-378, 88 Stat. 475, as amended, directed the Secretary of Agriculture to prepare a Renewable Resources Assessment by December 31, 1975, with an update in 1979 and each 10th year thereafter. This assessment is 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 relationships trends" (sec. 3.(a)).

The 1989 RPA Assessment was the third prepared in response to the RPA legislation. This Update builds on the findings of the 1989 RPA assessment. The document summarizes the findings and implications of 19 supporting technical documents. Several of these supporting documents respond to issues that were surfaced as a result of the 1989 RPA Assessment. The technical documents include an updating of forest resource statistics, international dimensions of U.S. forestry, changes in wetland area, customer diversity in recreation demand, species endangerment patterns, water quality, biological diversity, recycling, climate change, state and local regulations, and others

The Forest Service has been carrying out resource analyses 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 a expert to study and report on forest conditions. Between that time and 1974, Forest Service analysts prepared a number of assessments of the timber resource situation intermittently in response to emerging issues and preceived needs for better resource information. The 1974 RPA legislation established a periodic reporting requirement and broadened the resource coverage from timber alone to all renewable resources from forest and range lands.

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Introduction

The purpose of this document is to report the results of an assessment of resource trends and conditions as we see them today. Analyses in the 1989 RPA Assessment pointed out issues that could influence the outlook for renewable resources in the United States. The emphasis in this assessment is on analysis of these issues. In addition, the supply/demand outlooks for the various renewable resources have been updated where new information suggested that the outlook might change based on the implications of the new information. The basic data on characteristics of forests and the area of forest land have been updated to 1992 from 1987.

The land cover, forest, and rangelands of the United States are dynamic. Natural disturbances were once solely responsible for providing a random distribution of age classes and structures that supported the entire spectrum of plant and animal diversity. Human development has restricted the influence of natural disturbances, so that the present condition of these lands reflects a combination of natural and human influences that have direct relationships to ecosystem conditions such as biological diversity and ecosystem integrity.

Demands for renewable resources are largely driven by population, economic activity, and incomes. Projections of these variables indicate that population and the economy will continue to grow in the future which will induce greater use of and production from the renewable forest and rangeland resources. Greater use and production will continue to cause development of the types of issues analyzed in this update of the 1989 RPA Assessment. As these issues develop, they will be considered in future analyses.

Demands and supplies of renewable resources are dynamic. Consumers of these resources accommodate the changing nature of resource supplies in various ways, including adoption of technologies that change the ways renewable resource outputs are used. Supplies of renewable resource outputs change in response to use, management, and changing environmental laws. 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 and conditions. These accommodations will determine the nature and extent of the future forest and rangeland estate, with a special challenge to sustain the health and long-term productivity to include all values of forest and rangelands.

Some of the key assumptions and findings from the 1989 RPA Assessment have been updated to reflect new data and expectations about the future. Additional analyses have been done with the following highlights.

Highlights

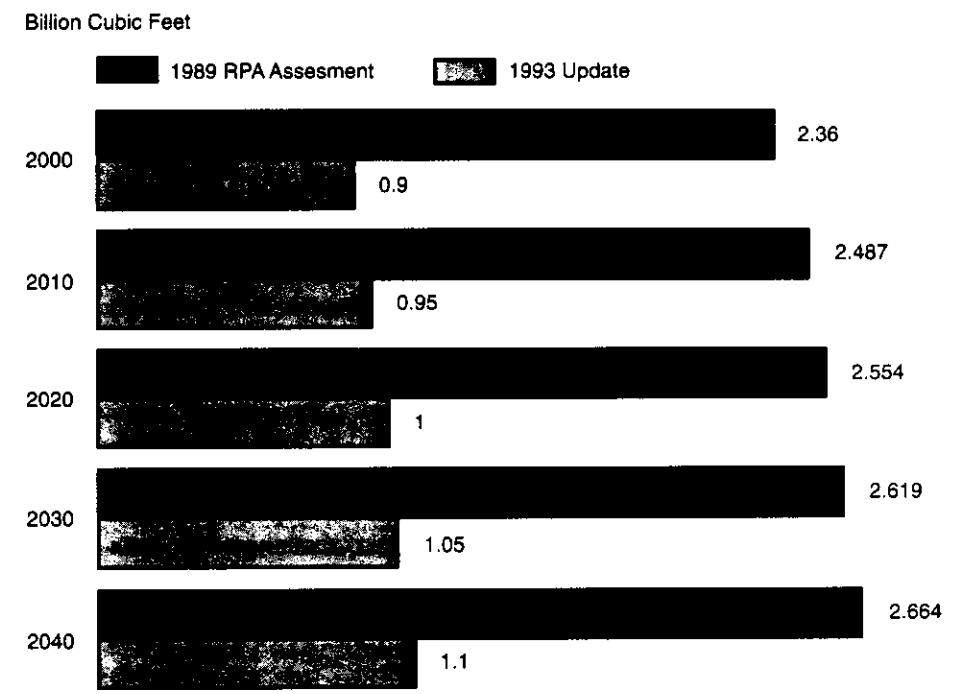
The Political and Social Environment for Management of Renewable Resources Is Changing

— In the late 1980's and culminating in the United Nations Conference on Environment and Development (UNCED) meeting in Rio de Janeiro in 1992,

there was increasing interest in the international dimensions of forestry. A supporting technical document places U.S. forests in perspective in terms of international trade, deforestation, and other global issues. For example, the U.S. forest land area amounts to about 7 percent of the world total and the United States accounts for 40 percent of expenditures on forest management and 20 percent of expenditures on forestry research.

— Increased commitment to management of Federal land for protection of watersheds, wildlife habitat, threatened and endangered plants and animals, and ecological diversity has resulted in reduced timber being offered for sale. In this update, timber volume offered from national forests is assumed to remain stable at 0.9 billion cubic feet through 2000 and then increase slowly to 1.1 billion cubic feet per year by 2040.(fig. 1) There continues to be considerable uncertainty about sales volumes, however, and the actual volume offered in the near future could easily fall in a range of 0.8 to 1.0 billion cubic feet. By contrast, the 1989 RPA Assessment assumed that national forest timber offered would increase to 2.7 billion cubic feet by 2040, up from 2.4 billion cubic feet in 2000.

Figure 1—Projected allowable timber sale quantities for National Forests.



— Across the 50 States, 23 have voluntary programs for best management practices, 13 have regulatory programs, and 5 use combinations of voluntary and regulatory measures to maintain water quality. Overall, compliance with best management practices is generally high, with at least 40 States monitoring compliance.

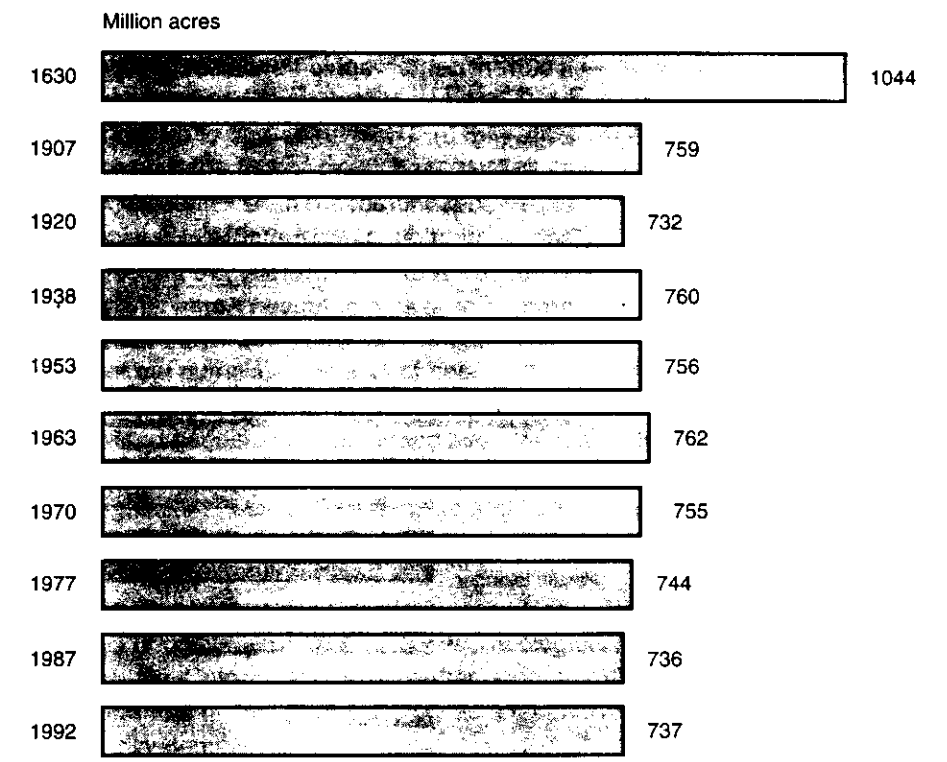
— During the 1980's, there was an increase in the number of local regulations affecting management of privately owned forest lands. These regulations were initiated for a variety of purposes, including protection of water quality and roads. For this update, studies were undertaken to enumerate the enactments and estimate their effect on timber supply. Over 600 statutes and ordinances were identified. Combined, these regulations are estimated to reduce current supplies of roundwood products by 1 to 3 percent in the North, South, and Rocky Mountains regions and by 4 to 12 percent in the Pacific Coast region.

The Character of the Forest and Rangeland Estate Is Changing

— Forest land area has stabilized between 1987 and 1992; a slight increase of 0.1 percent in area reversed a downward trend dating from 1963.(fig. 2)

— Forest and rangeland health continues to be a concern. Despite progress in restoration, much of the rangeland is in unsatisfactory condition. On forest lands, timber mortality increased substantially between 1987 and 1992 in all regions of the country, on all ownerships for both hardwoods and softwoods. Nationally, the volume of mortality on timberland was up 24.3 percent between 1986 and

Figure 2—Forest land area.



1991, from 4.4 billion cubic feet to 5.5 billion cubic feet—0.7 percent of the growing stock inventory. Annual mortality averaged 4.2 billion cubic feet between 1962 and 1986. Softwood mortality was up 17 percent between 1986 and 1991. Hardwood mortality was up 34 percent.

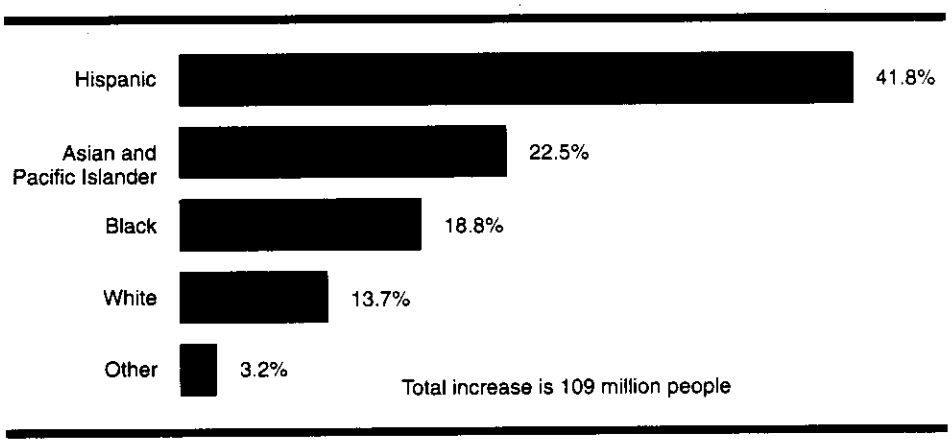
— Total forest growth on timberland declined about 2 percent between 1986 and 1991—the first decline since 1952. All of the decline was attributable to softwoods. In the South, softwood removals exceeded growth by 14.1 percent in 1991. This is the first time since 1952 that softwood removals have exceeded growth in the South. Because of a decrease in removals in the Pacific Coast region, timber growth exceeded removals by 14 percent in 1991, the first time that growth has exceeded removals in this region since 1952. For the Nation as a whole, the growth-removal ratio for softwoods was 1.09 in 1991.

— The number of species listed as threatened or endangered has increased by 197 to 728 since the 1989 Assessment. Endangered biota are not homogeneously distributed across the United States, but are concentrated primarily in the Southeast and Southwest. High species endangerment is associated with land use intensification, drought-stress climate, high levels of species richness, and endemism.

The Demand/Supply Outlook for Renewable Resources Is Changing

— If current demographic trends continue, the proportion of the population that is white and non-Hispanic will decline from 75 percent in 1992 to 56 percent by 2040 (fig. 3). The median age of the population will increase from 33 in 1990 to 43 in 2040, and the proportion of the population living in urban areas is expected to increase. These trends suggest that important changes in both participation rates and patterns of outdoor recreation are likely. The impacts of increased customer diversity are likely to be most significant in and near urban areas. For example, African Americans generally participate less in activities that ordinarily take place in a wildland setting, but participate more in sports

Figure 3—Ethnic composition of U.S. population growth between 1992 and 2040.



activities than other Americans. In part, this is because many African Americans are urban residents with fewer wildland recreation opportunities. Increasingly, older age generally results in a change in selection of recreation activities, and decreased participation rates.

— The timber demand-supply outlook varies between now and 2010, and between 2010 and 2040. In the short term, rapidly rising stumpage prices will occur, reflecting in part the restriction of harvest on Federal lands. After 2010, maturation of pine plantations in the South and increased recycling will combine to slow down increasing prices.

— Recycling of metallic mineral and paper products is likely to increase due to increased environmental awareness, changing economic incentives, and legislative mandates. The contribution of recycled metals to overall metal consumption increased from 30 percent in 1962 to approximately 50 percent in 1989. Currently, 30 percent of paper and paperboard production is based on recycled materials; an increase to about 40 percent is expected by 2000.

— One of the findings of the 1989 RPA Assessment was a trend for increased closing of private lands for general public recreation. The implied consequence was a potential shortage of recreation opportunities in the eastern United States, where public lands are relatively scarce. Further analysis has shown that closure to the general public does not necessarily reduce total recreation opportunities. For example, leasing of private lands was positively correlated to level of use.

— Exploratory and development drilling for oil and gas have decreased by more than 70 percent since the early 1980's, due to decreased economic incentives and regulatory delays that have limited access to public lands. Exploration and production activities for nonenergy minerals have been subject to increased regulation as well. Trends in exploration and development since 1989 suggest increasing reliance on imported and recycled mineral resources, and imported or alternate energy resources in the future.

Findings of the 1989 RPA Assessment and the results of additional analyses reported in this update form the basis for development of implications for the 1995 RPA Program.

Synthesis of Findings

Significant Implications of the Assesment for Resource Situations and Trends

The analyses of resource supplies and demands in this Assessment are based on many assumptions and thus are projections rather than predictions. These projections can be interpreted to evaluate potential resource conditions and trends. Although some resource situations have improved over time and may be judged acceptable, the future for others is potentially deteriorating or serious. The following discussion highlights resource situations as being potentially acceptable, deteriorating, or serious.

Potentially Acceptable Resource Situations

Potentially acceptable resource situations are those where resource conditions and/or projected levels of resource use can be sustained with current and expected future levels of management.

Big-Game Habitats and Populations Are Generally in Good Shape—Big-game habitats and populations on the Nation's forests and rangelands are generally well balanced and expected to remain so. These populations are expected to continue to sustain hunter demand. In some areas, populations of some species have grown to the point of being pests. This is especially the case for white-tailed deer.

Recycling of Metallic Minerals and Wastepaper Has Been Increasing—The contribution of recycled metals to overall metal consumption increased from 30 percent in 1962 to approximately 50 percent in 1989. Currently, 30 percent of paper and paperboard production uses wastepaper. An increase to about 45 percent is expected by 2040.

Technology for Utilization of Timber Has Increased the Options for Using Wood—Technological advances have improved the outlook for timber supplies. Examples of technological advances are structural panels made of fiber, greater use of hardwoods for pulp, and laminated products. New developments will continue to enhance resource supplies. Increasingly, raw material used in timber products will be based on wood fiber rather than solid wood. Timber can then be used from natural stands or other sources rather than from stands managed intensively for sawtimber. As a result, there should be less conflict between timber and other resource management. By reducing the costs of wood products, these technological advances will benefit consumers and the Nation's economy.

Water Quality of Streams Draining Forest and Rangelands Is Generally Good—Compliance with best management practices (where they exist) generally results in water quality that is within accepted water quality standards (fig. 4). Overall, compliance with best management practices is generally high and improving. At least 40 States are using some procedure for monitoring compliance.

The Magnitude of Opportunities for Outdoor Recreation Is Generally Adequate—If the public and private sectors continue to provide and expand opportunities at rates comparable to recent trends, the projected increases in supplies will meet most of the projected increases in demands. However, development of these opportunities will need to reflect the preferences of an increasingly diverse customer base.

Range Forage Availability Is Generally Adequate—Productive capability exists to meet demands for range forage for livestock and, potentially, wild herbivores. New and existing technology with appropriate management could double or triple production in many areas.

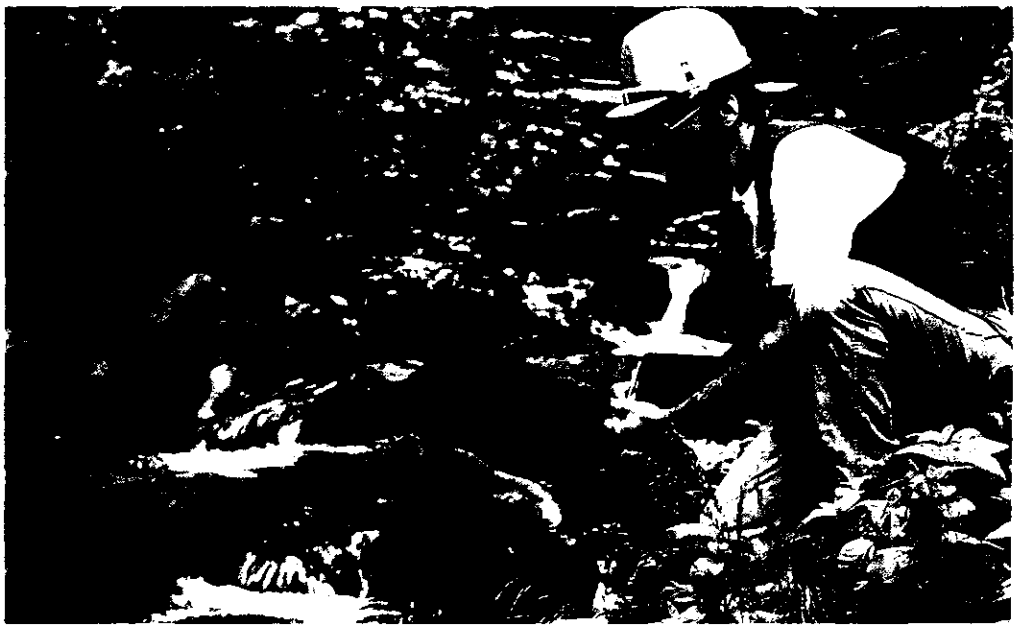


Figure 4—Water quality of streams draining forest and rangelands is a potentially acceptable resource situation.

Potentially Deterioriating Resource Situations

Potentially deteriorating resource situations occur when projected future management and technology are not expected to keep pace with people's demands for resource uses. Resource conditions may be at a deteriorated level in the future.

Forest Health Is a Growing Concern—Forest health is vital to all values associated with forests. Timber mortality increased 24.3 percent from 1986 to 1991(fig. 5). There are many causes of this potentially deteriorating situation. In the East forests are aging and becoming more susceptible to insects and diseases. Similarly, control of wildfire in the West has resulted in many aging and stagnated stands that are becoming more susceptible to insects and diseases. Older stands are more likely to be stressed by environmental changes such as drought and pollution. Introduced pests such as the gypsy moth have also taken a toll.

Continuing Loss of Biological Diversity Is a Concern—As land use intensifies, natural diversity is reduced and ecosystems are simplified. Potential impacts include reductions in the long-term productivity of ecosystems, reductions in the ability of biological communities to adapt to change, and forgone options for the future.

Some Regions Face a Shortage in Water Supply—Water shortages are projected for some arid and semiarid regions of the United States, where irrigation is the predominant consumptive use of water. Increasing demands in these regions will raise production costs for irrigated crops, disrupt local economies dependent on agriculture, and increase conflicts between withdrawal and instream use.

Figure 5—Forest health is a potentially deteriorating situation.

Water Quantity and Quality Affect Some Fish Habitat and Fish Populations—Recreational fishing is projected to double by 2040. Yet 80 percent of the Nation's streams have problems with water quantity or quality, fish habitat, or fish communities. These problems could reduce fish populations, tilt the species mix to less desirable fish, and reduce fishing opportunities and economic benefits.

Management of Nonindustrial Private Land Could Be Improved for Timber Production—Most nonindustrial private lands are not expected to be intensively managed for timber or other resources. However, pressure will increase for these lands to satisfy a greater share of the Nation's timber demand. Unless management improves, future demand will considerably strain those lands. This could further exacerbate the short-term timber supply situation and lead to deteriorated resource conditions, forgone benefits and income, and lost opportunities for rural development.

A Change in the Mix of Recreation Opportunities Is a Possibility—The U.S. population is continually becoming more diverse in terms of race and ethnicity, is increasing in average age, and is becoming increasingly urban. If recreational offerings do not match changing customer preferences, economic inefficiencies and lost recreation opportunities could result. Provision of such opportunities near population centers is particularly critical.

Despite Adequate Quantities of Range Forage, Rangeland Health Is a Concern—Despite progress in its restoration, much rangeland is in unsatisfactory condition. Increased competition between livestock and wildlife, coupled with decreased use of herbicides, could further impede range improvements.

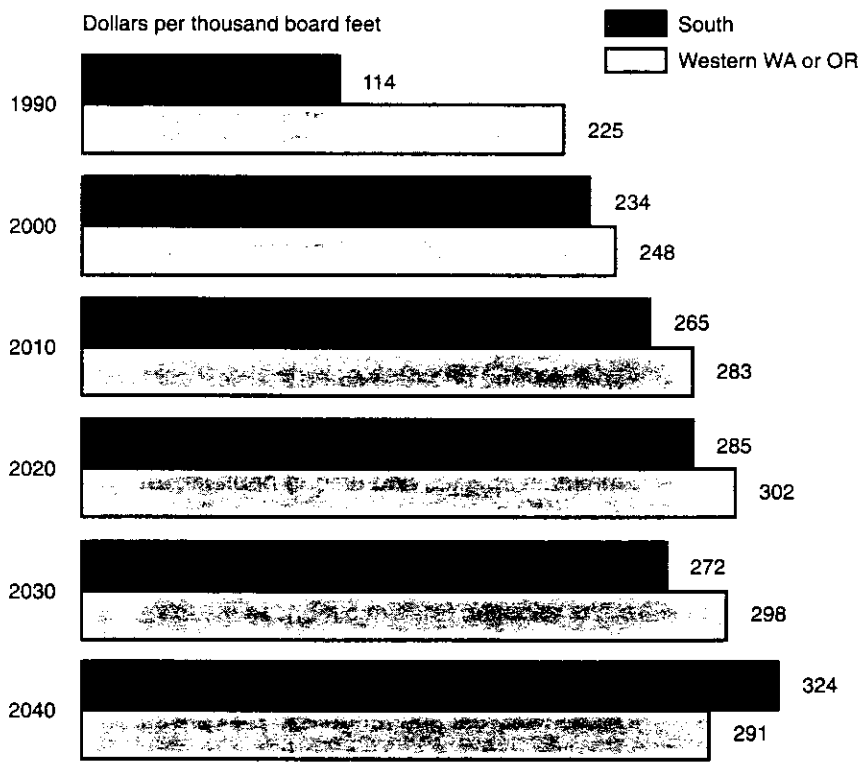
The Acreage of Wetland and Riparian Areas Is Expected To Continue To Decline—Although the rate of decline in wetland area has slowed, the loss of wetland area is expected to continue.

Potentially Serious Resource Situations

Potentially serious situations are those requiring immediate attention because they clearly present serious potential problems or because there is no known management strategy or technology for dealing with them.

The Volume of Softwood Sawtimber Supply Is a Concern, Especially Over the Next 20 Years—Timber supplies are affected by reduced harvests on public lands, increased mortality, a proliferation of State and local regulations, and inadequate supplies on private lands. Increased recycling of paper and paperboard and improved processing technologies dampen, but do not prevent increases in demand for roundwood. The next two decades will be a period of rapidly increasing prices for stumpage (fig. 6). This may lead to increased use of nonwood substitutes such as stone and metal that have environmental consequences that differ from those associated with the use of wood. These higher prices may also affect world trade patterns in timber

Figure 6—Softwood stumpage prices in the South and western Washington and western Oregon.



Prices are measured in constant (1982) dollars

products, especially around the Pacific Rim. In our projections, after about 2010, pine plantations in the South are assumed to begin to reach maturity and help alleviate roundwood price increases. However, the increase in recent years in State and local regulation of forest management on private lands has created a great deal of uncertainty about the investment climate for future plantations.

Global Climate Change Could Have Many Effects on Ecological and Economic Systems—The impacts of global change on natural ecosystems could be dramatic. Changes in the concentration of greenhouse gases in the atmosphere may warm the globe; however, regional effects could range from warming to cooling and from wetter to drier conditions. Concurrent with these climate changes could be shifts in land cover and land use, deforestation, and increases in atmospheric pollutants such as ozone and nitrous oxides. Such global changes would cause major shifts in the processes, structure, and composition of ecological systems, with potentially serious effects on economic systems.

Increases in Conflicting Demands for Private Lands Are Likely—Private lands must provide a greater share of future natural resource outputs if demands are to be met. However, there is not enough information about resource interactions to evaluate the feasibility of increasing total outputs from these lands. This situation could lead to misjudgments about the Nation's output capabilities.

Reclaiming Abandoned Mines Is a Challenge—There is a considerable backlog of unreclaimed abandoned and inactive mines, including many on public lands, that are both safety and environmental hazards. Discharges from these mines can cause extensive damage in local areas, especially if there is acid mine drainage. Because of the size of the backlog and the high cost of cleanup, this situation clearly presents serious potential problems.

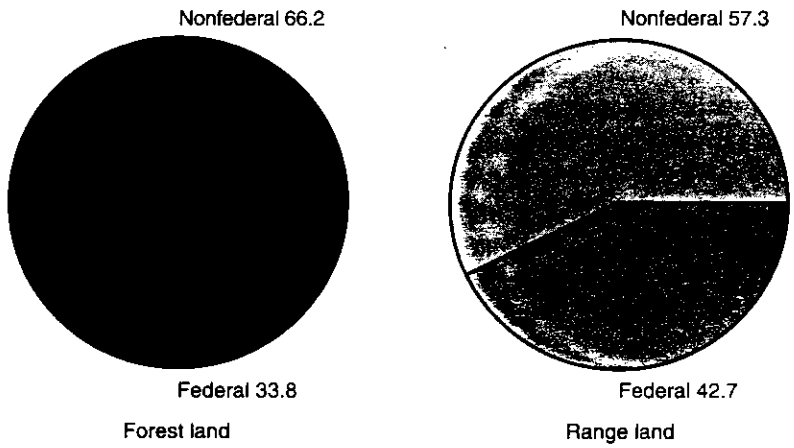
The Number of Listed Threatened and Endangered Species Continues To Grow—The official list of plant and animal species categorized as threatened or endangered continues to grow. This is occurring because we are learning more about species and because some species' populations are declining to dangerously low levels. Continuation of the decline of species will reduce benefits derived from wild species, greatly increase costs of management, require significant measures to maintain species and unique habitats, and reduce human access where human activities are inconsistent with species recovery.

The Resource Base

Size and Ownership

Some 1.7 billion acres (about two-thirds of the Nation's total area) are classified as forest or rangeland, or are covered with water (app. table 1). Over one-half of the Nation's forest and rangeland is in private ownership, and rights to water use are predominantly in the hands of the private sector. The dominant ownership of resources by the private sector is reflected in the analyses of demands and supplies presented later in this report.

Figure 7—Ownership of forest and range land.



Rangeland. A little less than half of the 1.7 billion acres of forest and rangelands is currently classified as rangeland—land on which the native vegetation (climax or natural potential plant communities) is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing use by wildlife or domestic livestock. It includes natural grasslands, savannas, most deserts, shrublands, tundra, alpine plant communities, coastal marshes, wet meadows, and introduced plant communities managed like rangelands. Most of the Nation's rangeland is found between the Great Plains and Pacific Coast, and in Alaska. Land east of the Great Plains is forested or managed in such a way as to preclude its classification as rangeland.

Some 43 percent of the Nation's rangeland is in Federal ownership (app. table 1 and fig.7) Federal rangeland is found mostly in the arid and semiarid lands of the Southwest and the tundra, shrub, and muskeg-bog lands of interior Alaska. Rangeland in private ownership is concentrated in the Rocky Mountain and Great Plains States. Private lands provide most of the forage for domestic livestock; only 10 percent of total forage consumption by domestic livestock is provided by public rangelands. Both public and private rangelands also provide forage for wild herbivores, are habitat for a variety of wildlife, and are used for recreation opportunities.

Forest Land. Almost half of the 1.7 billion acres of forest and rangelands is classified as forest land—land that is at least 10 percent stocked with trees, or that formerly had such cover, and not developed for other purposes (Powell, et al., 1993). Forest land is evenly divided between the Eastern and Western United States.

The two-thirds of the forest land (490 million acres) that can grow more than 20 cubic feet of industrial wood per acre per year is called timberland. Most of the timber harvested for roundwood products comes from this part of the forest resource base. Nearly three-quarters of the timberland is in the eastern half of the country, while in the Western United States timberland is found primarily in Montana, Idaho, Colorado, and the Pacific Coast States.

About one-third of the Nation's forest land is in Federal ownership. These lands are concentrated in the Rocky Mountains and Pacific Coast States. Some of these lands are high-elevation forests that have great scenic beauty and are important recreation sites. Most of these areas have not been harvested for timber and contain a large part of the Nation's softwood timber inventory.

About three-fourths of the Nation's non-Federal forest land is in the eastern part of the country. Much of this area has good soils, rainfall, and other conditions favorable for growing trees. These private forests are close to the largest markets for timber products. They are also closest to the most highly populated areas of the country, providing opportunities for many kinds of outdoor recreation.

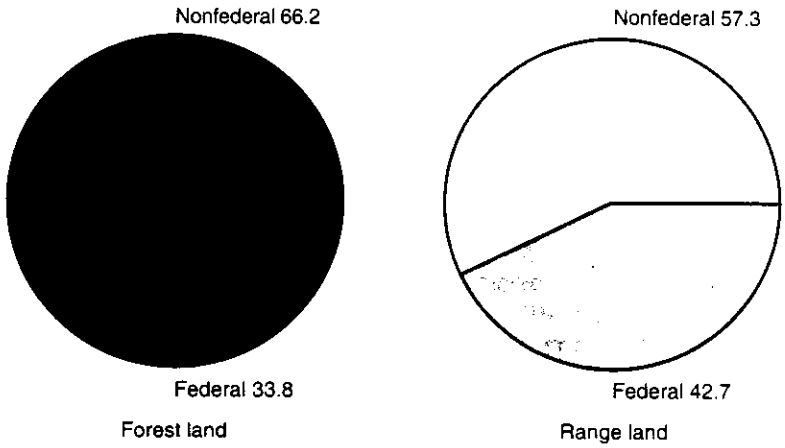
The Nation's forest ecosystems contain over 52 billion metric tons of carbon (fig. 8).

Figure 8—Forest ecosystems sequester over 52,000 teragrams of carbon.

Water. About 7 percent, or 161 million acres, of the United States is covered by water. Ownership of inland water is difficult to define because the concept of ownership and access to water can vary by State (fig. 9). Water resource laws can originate from several sources. Acts of Congress and State legislatures are interpreted by the courts and then issued by various Federal and State agencies in the form of administrative laws.

In the United States, there are two general doctrines in water law—the appropriation and the riparian. The law of appropriation, which is generally associated with the West, 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) in accordance with the date of acquisition, an earlier acquired water right will have priority over other, later acquired water rights.

Figure 7—Ownership of forest and range land.



Rangeland. A little less than half of the 1.7 billion acres of forest and rangelands is currently classified as rangeland—land on which the native vegetation (climax or natural potential plant communities) is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing use by wildlife or domestic livestock. It includes natural grasslands, savannas, most deserts, shrublands, tundra, alpine plant communities, coastal marshes, wet meadows, and introduced plant communities managed like rangelands. Most of the Nation's rangeland is found between the Great Plains and Pacific Coast, and in Alaska. Land east of the Great Plains is forested or managed in such a way as to preclude its classification as rangeland.

Some 43 percent of the Nation's rangeland is in Federal ownership (app. table 1 and fig.7) Federal rangeland is found mostly in the arid and semiarid lands of the Southwest and the tundra, shrub, and muskeg-bog lands of interior Alaska. Rangeland in private ownership is concentrated in the Rocky Mountain and Great Plains States. Private lands provide most of the forage for domestic livestock; only 10 percent of total forage consumption by domestic livestock is provided by public rangelands. Both public and private rangelands also provide forage for wild herbivores, are habitat for a variety of wildlife, and are used for recreation opportunities.

Forest Land. Almost half of the 1.7 billion acres of forest and rangelands is classified as forest land—land that is at least 10 percent stocked with trees, or that formerly had such cover, and not developed for other purposes (Powell, et al., 1993). Forest land is evenly divided between the Eastern and Western United States.

The two-thirds of the forest land (490 million acres) that can grow more than 20 cubic feet of industrial wood per acre per year is called timberland. Most of the timber harvested for roundwood products comes from this part of the forest resource base. Nearly three-quarters of the timberland is in the eastern half of the country, while in the Western United States timberland is found primarily in Montana, Idaho, Colorado, and the Pacific Coast States.

About one-third of the Nation's forest land is in Federal ownership. These lands are concentrated in the Rocky Mountains and Pacific Coast States. Some of these lands are high-elevation forests that have great scenic beauty and are important recreation sites. Most of these areas have not been harvested for timber and contain a large part of the Nation's softwood timber inventory.

About three-fourths of the Nation's non-Federal forest land is in the eastern part of the country. Much of this area has good soils, rainfall, and other conditions favorable for growing trees. These private forests are close to the largest markets for timber products. They are also closest to the most highly populated areas of the country, providing opportunities for many kinds of outdoor recreation.

The Nation's forest ecosystems contain over 52 billion metric tons of carbon (fig. 8).

Figure 8—Forest ecosystems sequester over 52,000 teragrams of carbon.

Water. About 7 percent, or 161 million acres, of the United States is covered by water. Ownership of inland water is difficult to define because the concept of ownership and access to water can vary by State (fig. 9). Water resource laws can originate from several sources. Acts of Congress and State legislatures are interpreted by the courts and then issued by various Federal and State agencies in the form of administrative laws.

In the United States, there are two general doctrines in water law—the appropriation and the riparian. The law of appropriation, which is generally associated with the West, 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) in accordance with the date of acquisition, an earlier acquired water right will have priority over other, later acquired water rights.

Figure 9—Access rights for recreational use of water are complex.

Generally, in the East, the law of riparian rights entitles adjacent riparian landowners to reasonable use of streamflow in competition with those who divert the stream for economic uses. The major thrust of the riparian law has been to protect private rather than public rights.

Access rights for recreational use of water are also complex. 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.

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

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

The Mining Law of 1872 governs mineral location activities 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.

Figure 9—Access rights for recreational use of water are complex.

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

Trends in the Resource Base

The forest and rangeland resources of the Nation have been substantially altered as a result of human development (fig. 10). These resources are resilient, but their condition has changed over time in response to changing human demands and resource management. A review of historical resource trends provides a context for evaluating the prospective future for renewable resources. We initiated two studies to compile information on resource trends. The first study compared the forest situation in 1900 with the current situation. The second study looked at the status and trends in biological diversity in the United States.

Figure 10—The forest and rangeland resources of the Nation have been substantially altered as a result of human development.

***Issue Highlight*—Long-Term Trends in the Condition of U.S. Forests**

American society in the 20th century changed from rural and agrarian to urban and industrialized (MacCleery, 1992). Although this change has been accompanied by a corresponding physical and psychological separation of people from the land and resources, today's urbanized nation is no less dependent on the products of its forests and fields than were the subsistence farmers of America's past. The current

forest situation suggests a continued capability to meet those demands.

— Following two centuries of decline, the area of forest land has stabilized. Today, the United States has about the same forest area as in 1920.

— The area consumed by wildfire each year has fallen 90 percent; it was between 20 and 50 million acres in the early 1900's and is between 2 and 5 million acres today (fig. 11).

— Nationally, the average volume of standing timber per acre in U.S. forests is 30 percent greater today than in 1952.

Figure 11—The ability of forest and rangeland systems to maintain a balance of successional stages through natural disturbances has been severely reduced by human development; the area consumed by wildfire each year has fallen 90 percent since the early 1900's.

— Tree planting on all forest land rose dramatically after World War II, reaching record levels in the 1980's. Many private forest lands are now actively managed for tree growing: 70,000 certified tree farms encompass 95 million acres of privately owned lands.

— The tens of millions of acres of cutovers or "stumplands" that existed in 1900 have long since been reforested. Many of these areas are mature forests today. Others have been harvested a second time, starting the cycle of regeneration to young forests.

— Eastern forests have staged a major comeback.

— Recreational use on national forests and other public and private forest lands has increased manyfold.

— The efficiency of wood utilization has improved substantially since 1900. Much less material is left in the woods, many sawmills produce more than double the usable lumber and other products per log input than they did in 1900, engineering standards and designs have reduced the volume of wood used per square foot of building space, and preservative treatments have substantially extended the service life of wood. These efficiencies have reduced by millions of acres the area of annual harvest that otherwise would have occurred.

Although there have been favorable trends in forest resources over the past century, increasing human demands will continue to affect natural resources. The ability of forest and rangeland systems to maintain a balance of successional stages through natural disturbance has been severely reduced by human development. For example, the present forest area does not necessarily have the same balance of stand structure, and therefore cannot support the same groups of plants and animals as found in large, natural forested areas. As a result, the distribution and abundance of biological communities has been significantly altered.

***Issue Highlight*— Analysis of Status and Trends in Biological Diversity**

Biological diversity is a broad concept that encompasses natural variety within and among ecological systems. Significant land use changes have occurred in the United States since European settlement in the 1600's (Langner and Flather, 1994). About 30 percent of the forest land, over half of the wetlands, and most of the native prairies of the Midwest have been converted to agriculture and other uses.

— On a State-by-State comparison, the loss of natural vegetation has ranged from 4 percent in Nevada to 92 percent in Iowa.

— Ten States have lost over 70 percent of their original wetland area.

— Less than 1 percent of the original tallgrass prairie of the Midwest remains in natural vegetation.

— The distribution of forest land by successional stage has been altered by human influence. For example, in the eastern forests of the Pacific Northwest the proportion of forest in mid-successional stages has increased, while the proportion in early and late stages has declined in the last 40 to 50 years.

— At least 20 percent of the Nation's 1 million stream miles have been modified by channelization, reservoir construction, or other conversions.

— Remaining forest lands tend to be more highly fragmented by roads and other types of human development.

These land use shifts have affected the distribution and abundance of species. Species tolerant of extensive land uses, such as agriculture and managed rangelands, have replaced the inhabitants of the original communities. Intensive develop-

Figure 12—Over half of the original wetlands in the United States have been converted to agriculture and other uses.

ment such as urbanization has also displaced native communities. The net result of both extensive and intensive land development is that species least adaptable or unable to adapt to these changes (e.g., large predators and forest interior birds) have become restricted in their distribution. The loss of natural habitats is one of the primary causes of both modern extinctions and endangerment of species.

— During the past century, 40 taxa of North American fish have become extinct, 19 of them since 1964.

— Seven species and subspecies were removed from the Federal endangered and threatened species list in the last 10 years because of extinction.

— Over 200 species and subspecies are no longer being considered for Federal protection because they are believed to be extinct.

— Data on trends in species populations indicate that there are significant numbers of species with declining populations. For example, ducks, forest interior birds, and Pacific salmonids are exhibiting long-term declines.

— Wildlife management has resulted in numerous successful population recoveries, including deer, elk, pronghorn, Canada goose, and wild turkey.

— Colonial wading birds (e.g., egrets and herons) have made substantial population recoveries since the beginning of the century.

— Widespread local declines in amphibian populations are raising concerns about the viability of many amphibian species.

The Federal forest and rangelands encompass a large share of natural variety in the United States. However, not all species and communities are represented on the Federal lands, and wide-ranging species will not be viable in the long run if restricted to public lands (fig. 13). Both private and public lands will play vital roles in protecting biological diversity. However, continuing land use intensification and fragmentation, combined with increasing demands for resource outputs are likely to result in further losses of natural variety.

Figure 13—Wide-ranging species will not be viable in the long run if restricted to public lands.

Projected Trends in Areas

In recent years, the area of forest land and rangeland has been declining as these lands have been converted to other uses. The water area has been increasing due to the construction of ponds and lakes (reservoirs). The total output of products from forest land and rangelands is likely to be affected in the future by changes in area.

Area projections from the 1989 RPA Assessment are used in this update. Area changes are generally slow to occur and an update of projections would probably show only minor changes. These projections include allowances for the provisions of the Farm Bills of 1985 and 1990, which had the intention of converting highly erodible cropland to grass or forest land. Partly because of these programs, the area of rangeland is projected to increase from current estimates of 770 million acres to 820 million by 2040.

Although publicly financed incentive programs may add several million acres to the forest land base, an even larger area of existing forest land is expected to be converted to other uses. The net loss is expected to be about 28 million acres by 2040, mainly in the South and Pacific coast regions. Much of the loss in forest land is due to conversions associated with roads and urban space utilized by a growing population.

Productivity of Forest and Rangelands and Water for Increases in Renewable Resources

The productivity (output per acre or other measure of input) of forest and rangelands varies widely as a result of differences in climate, soil, elevation, and latitude. The biological potential exists to increase the output of all renewable resource products. New technology or the wider use of existing technology from research is another source of higher productivity. The economic efficiency of any investment depends on the specifics of costs and revenues. Costs and revenues associated with investments are not generally considered explicitly in this Assessment document, but they are considered in the development of the 1995 RPA Program.

Water quality and yields from forest and rangelands can be improved by various management practices. Flooding, soil erosion, and the associated sedimentation of streams can be restrained.

Forest and rangelands in the United States provide forage and browse for over 70 million cattle, 8 million sheep, 55,000 wild horses and burros, 20 million deer, 400,000 elk, 600,000 antelope, and many other grazing animals. Vegetation management practices can enhance the production of forage and browse for these animals while protecting fragile soils and watersheds. For example, range forage productivity is assumed to rise 0.7 percent per year on private lands.

The 1.7 billion acres of forest and rangelands and water have a large but unmeasured capacity to supply opportunities for picnicking, camping, hiking, skiing, hunting and fishing, wildlife observation, canoeing, swimming, and most other kinds of outdoor recreation far in excess of current use.

Forest and rangelands and water also have the potential to foster diversity and increased numbers of most species of wildlife, including those of recreational and commercial importance and endangered or threatened species.

The known mineral resources on these lands are substantial. Thus, there exists the physical potential to increase the productivity of nonrenewable resources. For these outputs, productivity refers to the magnitude and efficiency of extraction. Technological advancements that facilitate exploration, improve extraction, and enhance recovery have made the energy and mining industries more productive in recent years.

The Nation's forest and rangelands and water have the physical capacity to produce much larger quantities of renewable resource products and support higher levels of use. A primary objective of this update to the 1989 RPA Assessment is to further identify conditions and opportunities for management of the renewable resource base for use in the 1995 RPA Program.

If it occurs, global change could affect the productivity, health, and diversity of forest and range ecosystems, with associated impacts on other renewable resources (fig.14). Forest ecosystems are a central concern in the global change issue because of the strong natural linkage between climate and forests, and because of the environmental, economic, and social importance of forests. Forests are likely to be affected directly by elevated carbon dioxide levels since carbon dioxide is a fundamental component of photosynthesis, as well as by changes in temperature and precipitation. While science is not currently capable of modeling and predicting the full range and complexity of global change impacts, progress is being made in assessing significant aspects and sub-components of the issue.

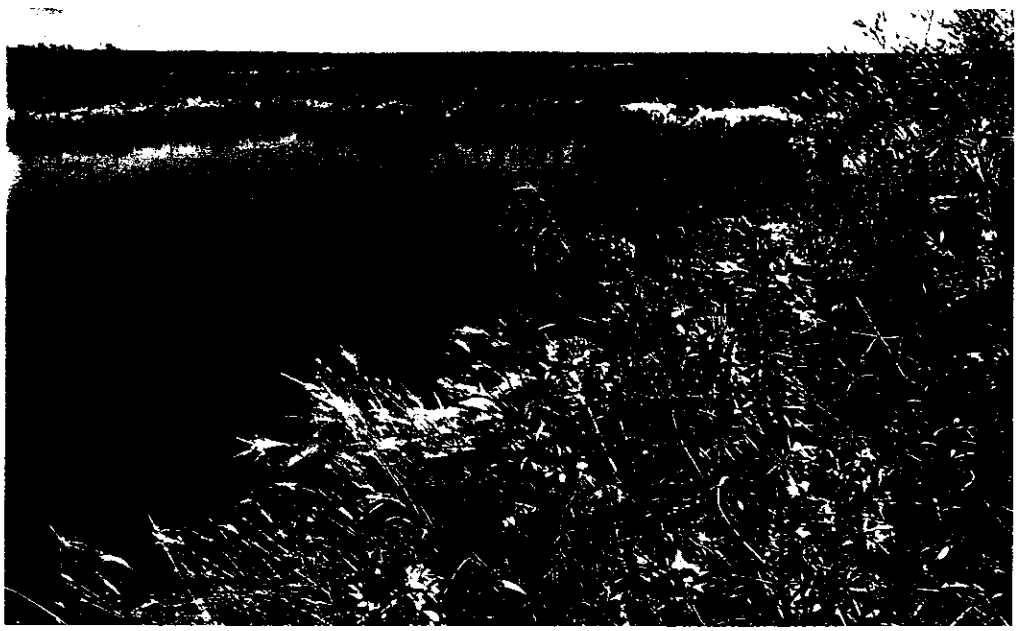


Figure 14—If it occurs, global change might alter the distribution of existing ecosystems.

***Issue Highlight*—Global Change**

A number of ecological models have been proposed to examine the biophysical effects of climate change (Joyce, 1994). The robustness of these projections has not been compared across models. Understanding the causes for differences and/or similarities in ecological projections is an important and necessary step toward improving our modeling capability as well as our understanding of climate change. We initiated a study with the objectives of comparing projected net primary productivity responses of the Terrestrial Ecosystem Model and the Osnabruck Model. We

make these comparisons based on an equilibrium future and do not consider transition phases leading to that steady state.

Study findings indicate that regression-based models such as the Osnabruck model have serious drawbacks when used to predict changes in net primary productivity associated with changes in carbon dioxide and climate. For example, important feedbacks between temperature and ecosystem processes cannot be fully expressed. The reliability of regression-based models decreases as any analysis goes beyond the range of the data used in calibrating the regressions. Clearly, a potential of global change is to produce new combinations of environmental variables for some ecosystems.

Study findings further indicate that process-based models need to consider the linkages between climate and site fertility. While elevated carbon dioxide could, in some cases, increase net primary productivity, the availability of nitrogen varies within forest type and is currently limiting to increased net productivity in eastern forests. Feedbacks between the carbon cycle and the nitrogen cycle, in response to changes in temperature and moisture, will alter the productivity response to elevated carbon dioxide. Because of the complexity of interactions among processes that are affected by changes in carbon dioxide and climate, modeling the response of net primary productivity requires the use of process-based models that integrate ecosystem functions.

Analyses of resource supply and demand have traditionally assumed an unchanging climate. Ecological analyses examining a changed climate have not extended their results to the social and economic systems. Growth and yield research has traditionally had an economic basis of planning harvest and calculating the returns from investments in timber management. A link needs to be made between ecological models describing the underlying processes in forested systems and economic models describing timber demand at the regional and national scales. We initiated a study with the objective of linking the Terrestrial Ecosystem Model to the Aggregate Assessment System and the Timber Assessment Market Model to examine the sensitivity of the forest sector to changes in net productivity resulting from changes in climate. We emphasize that transient climate change impacts remain unmodeled and may override results of the current study.

To investigate the potential implications of changes in carbon dioxide and climate for U.S. temperate forests, we ran the Terrestrial Ecosystems Model with climate output from four existing global change models. 1/ These climate models predict equilibrium climate change that corresponds to an atmospheric carbon dioxide concentration of approximately 625 parts per million, which is projected to occur by 2065.

1/ The simulations used were the Goddard Institute of Space Studies (GISS) Global Change Model; the Oregon State University (OSU) Global Change Model, and two from the Geophysical Fluid Dynamics Laboratory (GFDL 1 and GFDL 2).

For elevated carbon dioxide and no climate changes, study findings indicate that the overall response of net primary productivity of potential temperate forests in the United States would be an increase of 5.1 percent over the 75-year period. However, with projected elevated carbon dioxide and the resulting equilibrium climate, study findings indicate the mean response would be an increase of 16.2 percent, reflecting a few of the many possible synergistic interactions among the climate, the atmosphere, and the vegetation. The range in the predicted increase in productivity among temperate mixed, coniferous, and deciduous forests is between 14.6 and 21.8 percent. Higher responses are predicted for the more northerly forests and negative responses were indicated for some southern forests, which is consistent with greater warming at higher latitudes and projected precipitation changes.

These changes in net primary productivity were assumed to be analogous to changes in forest growth. Modifications to growth by timber type and RPA region were made in the Aggregate Timberland Assessment System.

> If carbon dioxide content in the air doubles by 2065, if climate change occurs as assumed in the four general circulation models, if the productivity effect of those changes occurs as described in the Terrestrial Ecosystem model, and if transient ecosystem changes and competition are not overwhelming, timber growth would generally increase for mature forests in existence in 2065. The increase would vary by species and region.

Basic Assumptions About Future Determinants of Demand and Supply

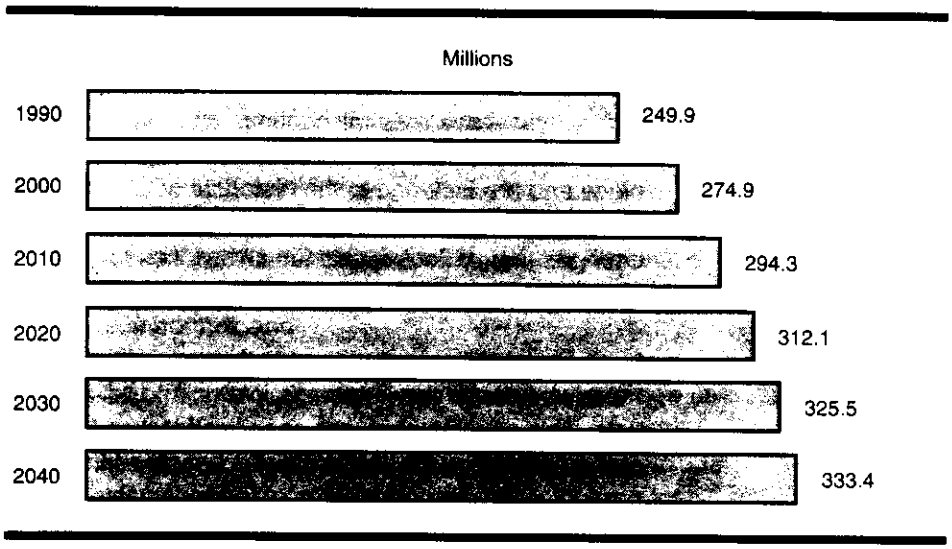
In the future, as in the past, demands and supplies of renewable resource products will be determined largely by growth in population, income, and economic activity; technological and institutional changes; energy costs; capital availability; and levels of private and public investments in human capital, forest, range, and water management, utilization, and research.

Population

In the past five decades, the population of the United States has nearly doubled—from 132 million people in 1940 to some 252 million in 1990 (app. table 2). Projections by the Wharton Econometrics Associates, using Bureau of the Census assumptions about future population demographics, indicate that population will continue to grow to about 333 million in 2040 (fig. 15). The population assumptions are the middle series projections developed by the Bureau of the Census, except that net immigration is assumed to be 750,000 people per year rather than the 450,000-person assumption used in the middle series. This adjustment in the immigration assumption is to account for net illegal immigration.

As this report was being written, the Bureau of the Census announced an updated population projection that substantially revised previous estimates. For 2040, the new projection shows a total population of 364 million, about 10 percent higher than the projection used in the 1989 RPA Assessment and this update. Of a total population

Figure 15—United States population projections.



increase of 109 million between 1992 and 2040, 13.7 percent is expected to be white, 18.8 percent black, 22.5 percent Asian and Pacific Islander, and 41.8 percent of Hispanic origin. About 39 percent of the population increase is expected to be due to net immigration. The increased ethnic diversity of the population has many implications for assessing future demands on U.S. renewable resources. For example, if skill levels for immigrants are different from those for the overall U.S. population, average per capita incomes will be affected. Diet preferences affect the demand for red meat and therefore the demand for range forage; housing preferences affect wood use and therefore the demand for timber, and recreation preferences affect the types of recreation facilities needed by the U.S. population.

Economic activity and income

Economic activity, as measured by the official gross national product in constant dollars (1982 dollars net of inflation and deflation), increased more than fivefold in the past five decades and reached $4.2 trillion in 1990. In this period, there were major economic recessions, a world war, and other major shocks to the U.S. economy. In each case, the national economy recovered, and it is expected to continue to do so in the future. The basic forces for long-run economic growth will continue. Wharton Econometrics projections indicate that the gross national product will reach $15.6 trillion in 2040, nearly four times its level in 1990 (app table 2). Associated disposable personal income will rise to $9.6 trillion, more than a threefold increase. Disposable income per capita will increase over 2.5 times, to $28,790.

The assumptions about population, gross national product, and disposable personal income suggest a future with many more people having greater purchasing power—a future with strong growth in demand continuing the historical trend.

Technological and Institutional Change

Past changes in demands and supplies have reflected the interactions and direct influences of institutional changes. We assume that the stream of institutional and technological changes will continue and that the effects of these changes on demands and supplies of renewable resources will be similar to those that have taken place and are included in the historical data base used in making the projections. For some products or processes, however, we identified possible future technological changes and projected specific allowances for them. This is especially the case for recycling paper and paperboard.

Institutional changes that lead to the reservation of forests and rangelands for designated uses such as wilderness, parks, and wildlife refuges have occurred for a long time. This development was specifically taken into account in the projections of forest and rangeland areas. Assumptions on important technological changes affecting product yields and other uses of the renewable resources are specified in the individual resource documents as appropriate.

***Issue Highlight*—State and Local Regulation of Private Lands**

A growing number of State and local governments have enacted regulatory legislation which—intentionally or incidentally—acts to restrict management of private forest land. These legislative initiatives include State forest practice and water quality acts, county regulations to control stream sedimentation or protect roads from damage by logging trucks, municipal ordinances to protect shade trees or prescribe silvicultural options, and many others. Little is known about the specific nature and extent of State and local enactments or their associated costs. Further, even though the measures clearly have the potential to influence both immediate and long-term availability, their impact on timber supply has not been systematically evaluated.

We initiated a study with the following objectives: 1) to identify and describe the State and local regulatory policies that apply to private timberland, and 2) to estimate how such regulation is likely to influence both immediate and long-term timber supplies from private forests (Greene and Siegel, 1994).

Some 117 State and 522 local enactments were enumerated around the country. Particular local measures varied considerably in their stringency and their potential effect on timber supplies. The stated objectives of most, however, fit into one of five categories: 1) to regulate timber harvesting or management, 2) to protect public roads and bridges from damage, 3) to preserve trees or wooded areas in urban areas, 4) to protect the general environment, or 5) to protect an environmentally sensitive area or habitat.

A delphi-method survey was conducted to estimate the short- and long-term effects of State and local regulation on private timber supply. Eighty-two selected members of

the forestry community were interviewed for the study. Included were representatives of State and Federal agencies, consulting and forest industry firms, universities, associations, and forest landowners.

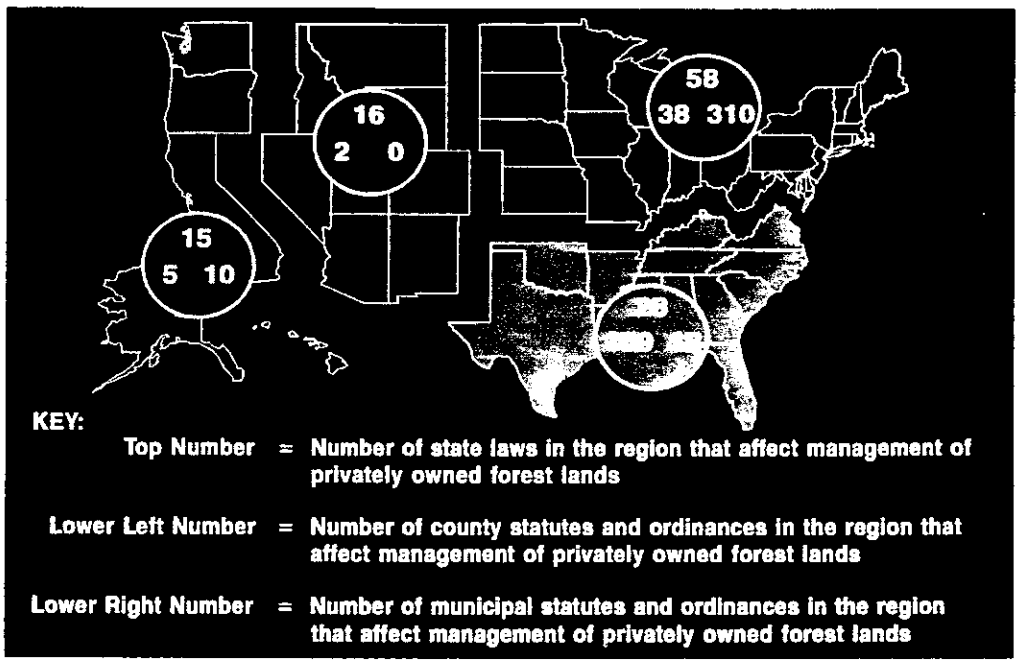


Figure 16—The number of state and local regulations has been increasing.

— The study results suggest that State and local regulations currently place the greatest constraint on private timber supply in the Pacific Coast region. (fig.16) The estimated effect ranges from a 4-percent reduction in hardwood pulpwood supply to a 12-percent decrease in softwood sawtimber supply. The overall effect of regulation is roughly equal in the North, South, and Rocky Mountains regions, with an estimated 1- to 3-percent reduction in supplies of all products.

— In the longer term, the results suggest that private timber supplies will be even more affected. Supplies of most timber products in the Pacific Coast and Rocky Mountains regions are forecast to decrease an additional 1 to 4 percent. The effect of regulation in the North and South is projected to approach that in the Pacific Coast region, with supplies declining an additional 5 to 12 percent, depending on species and product.

The estimates of future effect may be considered tentative. They required a high level of speculation and respondents' answers varied widely. However, the answers indicate a high level of concern within the forestry community over current regulatory trends.

Energy Costs

World oil prices are projected to increase to $42 per barrel (1986 dollars) in 2040. As oil prices increase, energy consumers are projected to lean more heavily on electricity, coal, and renewable energy sources (including wood). Electric power production is projected to shift more to coal, natural gas, and renewable energy sources. The effect of increasing fossil fuel prices on forest products industries will be moderated by these shifts to alternate fuels and improvements in efficient energy use. Energy costs influence wood use projections primarily through projections of fuelwood use.

Capital Availability

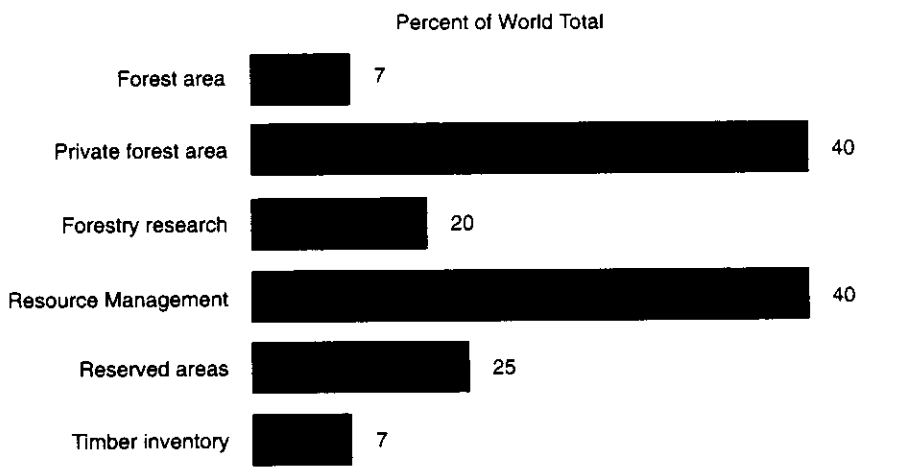
Future supplies will be determined largely by management intensity (the level of investment in forests and rangelands and associated water resources). In general, demand and supply projections are strongly influenced by the past historical trend of their basic determinants and reflect the effects of past public programs for management assistance.

The basic assumption of a growing economy implies capital generation. Therefore, we assume that capital will not be a limiting factor for projected outputs of products from forest and rangelands and associated water.

Issue Highlight—International Demensions of U.S. Forestry

There is growing interest in the international dimensions of forestry (fig. 17). A global forest agreement, biodiversity, sustainable development, and plantation forestry are examples of the issues being discussed. Development of a U.S. position on these kinds of issues has been difficult because of a lack of perspective on the U.S. renewable resource situation relative to other countries' situations. We initiated a study to review existing information about international dimensions of U.S. forestry (Brooks, 1993).

Figure 17—Measures of international dimensions of U.S. forestry.



Study findings indicate that:

— The U.S. forest land acreage of 737 million acres amounts to about 7 percent of the world's forests.

— The United States has about 5 percent of the world's population.

— The United States accounts for about 40 percent of the world's private forests.

— Relative to the rest of the world, a higher proportion of U.S. forests are managed. Half of the closed forest area of the United States is managed, while worldwide, one-third of closed forests are managed.

— The United States reserves about 10 percent of all forest land from harvest. This accounts for about one-quarter of world forests in this category and for about half of protected, closed forests in the temperate zone.

— The United States accounted for about 1 percent of the net loss in world forest area over the past decade, but the area of U.S. forest land stabilized by the start of the 1990's.

— U.S. forest land is covered with 7 percent of the world's timber inventory.

— The United States produces one-fourth of the industrial timber harvested in the world and sustains high rates of timber production across diverse forest types, at a scale greater than any other country, and in support of diverse forest industries.

— Measured in terms of harvest volume per acre of timberland, U.S. rates of production are equalled in some European countries, but are exceeded in few.

— Like a few other heavily forested and developed countries, and unlike many other developed and developing countries, the United States uses timber in place of other materials in a wide variety of applications.

— The United States consumes nearly 30 percent of the world's production of industrial timber.

— The United States is the world's leading importer of timber products and at the same time one of the leading exporters of timber products. On balance, it is a net exporter, measured in value terms.

— Most U.S. imported timber products originate in Canada.

— U.S. expenditures on natural resource management amount to about 40 percent of the world total.

— The U.S. share of forestry research expenditures is about 20 percent of the world total.

— U.S. management practices are generally sensitive to environmental concerns and therefore may be more benign than those of other countries, especially compared to practices used in tropical developing countries and Russia.

— North America accounts for 7 percent of world consumption of tropical timber products.

— Tropical timber accounts for less than 1 percent of total U.S. consumption of industrial forest products.

— Industrial products from tropical forests are seldom used as substitutes for commodities manufactured from temperate, coniferous forests.

— The United States is a net exporter of forest products to tropical countries.

The U.S. forests have proven to be resilient. They have recovered from a period in the nineteenth century that can be characterized as an era of development with little regard for renewable resource management. The forestry accomplishments of the United States have been based on good fortune, temperate zone forest biology, the strength of U.S. institutions, and investments over the years in fire control and other management practices. Our increasing awareness of the global context in which our forests, communities, and economy exist may change the ways we use and manage our own resources.

Timber Demand-Supply—The Outlook

Outlook Overview

— Demands for all timber products are expected to increase over the next 4-1/2 decades.

— Total demands for hardwoods from the domestic timber resource are expected to increase 57 percent, and for softwoods, 28 percent.

— Changes in technology that affect product recovery from roundwood and increased recycling of paper and paperboard are reflected in projections (fig. 18).

— For national forests, allowable sale quantities are projected to be 0.9 billion cubic feet in 2000 and 1.1 billion cubic feet in 2040. These volumes are much lower than those used in the 1989 RPA Assessment, which assumed 2.7 billion cubic feet in 2040. The changes were made to reflect shifts in forest management emphases.

— Harvest from Bureau of Land Management (BLM) lands, mainly in western Oregon, is assumed to be constant at 40 million cubic feet. Volume from State

Figure 18—In the 1980's, lack of landfill space stimulated interest in recycling of paper and paperboard.

of Washington lands is assumed constant at 75 million cubic feet. In the 1989 RPA Assessment, BLM lands were assumed to supply 200 million cubic feet, and the State of Washington, 150 million cubic feet. Harvest on both ownerships was reduced to reflect assumptions about management of habitat for threatened and endangered species. Supply assumptions for other public ownerships are unchanged from the 1989 RPA Assessment and amount to about 500 million cubic feet.

— Harvest on forest industry lands is projected to increase 39 percent, to 7 billion cubic feet in 2040, reflecting the assumption that these lands will be managed intensively in the future.

— Harvest on other private lands is projected to increase 64 percent, to 15.6 billion cubic feet in 2040.

— The wastepaper recycling rate is projected to reach 40 percent in 2000 and 45 percent in 2040, up from 25 percent in 1986 and 30 percent in 1992. Current investments in capacity to recycle are evidence that large portions of this recovered fiber will be recycled.

— An analysis of assumptions about investments in plantations confirms that substantial investments are expected to be made in southern plantations.

— Exports of timber products from the United States are expected to continue in the future. Uncertainties about phytosanitary restrictions in Europe add to the uncertainty of making projections about trade, especially for logs, lumber, and

plywood (fig. 19). "Green" laws, labeling, and other aspects of trade in timber products also add to the uncertainties of assessing future global trade patterns.

Trends in Timber Use and Projected Demands

Between 1960 and 1980, there was a slight upward trend in lumber consumption, punctuated by well-defined short-term fluctuations (table 1). Demand for lumber follows cycles in new housing starts and other general measures of the economy. For example, the severe recession of the early 1980's caused a decline in housing that forced a drop in lumber demand. This was followed in the mid-1980's by record consumption that peaked in 1987. From the late 1980's through the early 1990's, new housing starts have been low in comparison with the record years of the 1980's and lumber demand has been depressed (fig. 20).

Demand for softwood plywood rose rapidly through the 1950's and 1960's, reaching a peak in the early 1970's (table 1). Much of the growth was due to the substitution of plywood for lumber in many end uses. By the 1970's, opportunities for this substitution had largely been captured, and demand for plywood as well as lumber began to follow housing cycles.

The late 1970's and the 1980's were years of major changes in the structural panel industries, as first waferboard and then oriented-strand-board (OSB) began to make significant inroads into markets for solid softwood plywood. All nonplywood structural panels produced in the United States are now classified as OSB. OSB production has had major influences on the species and quality of roundwood needed in the struc-

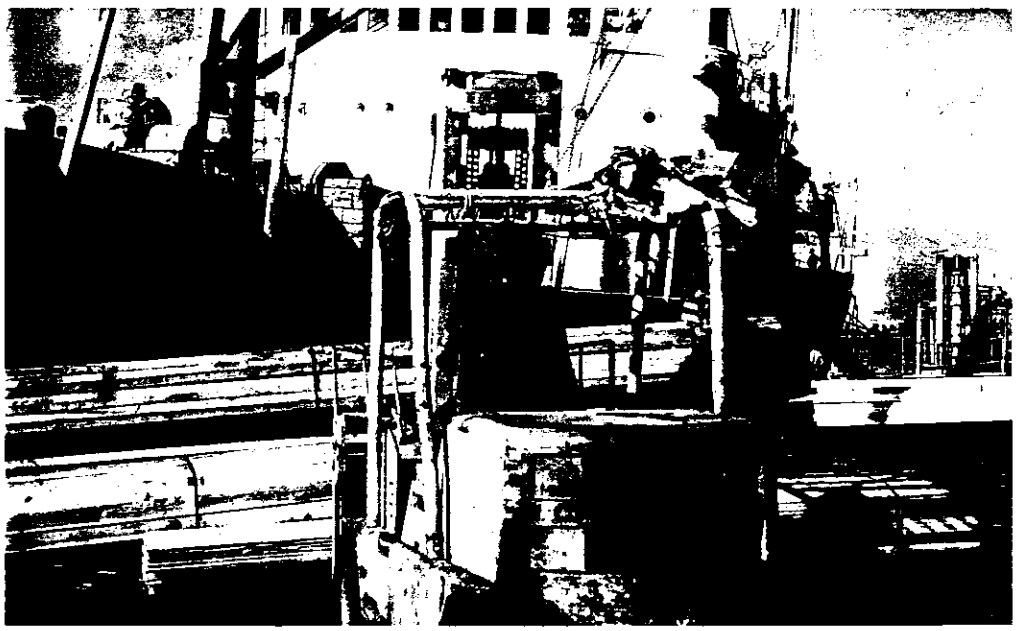
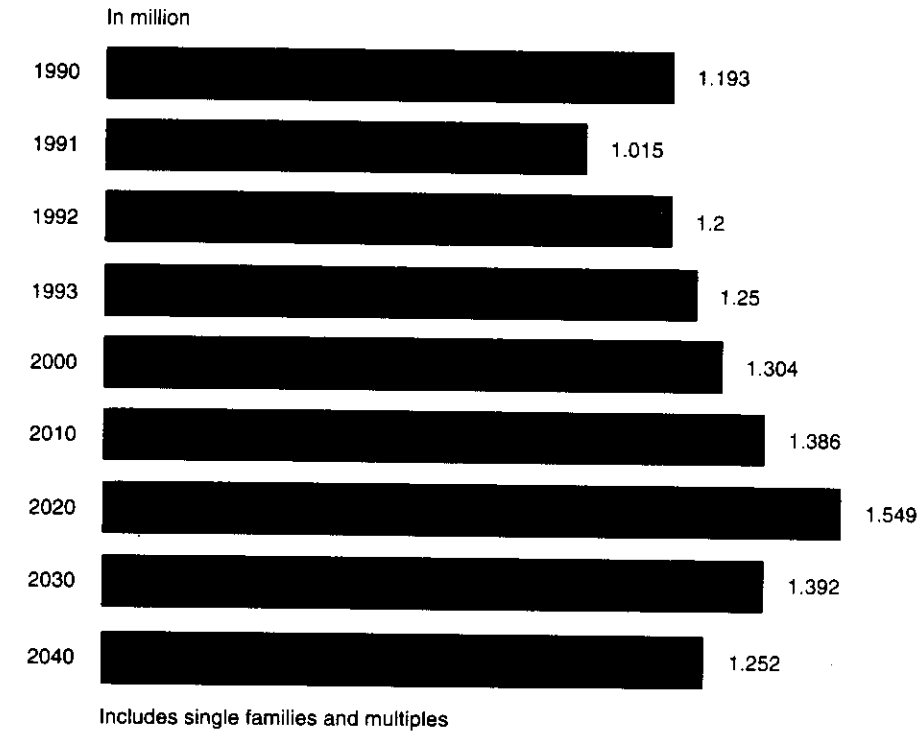


Figure 19—Phytosanitary restrictions may affect trade in timber products.

Figure 20—Number of houses started.

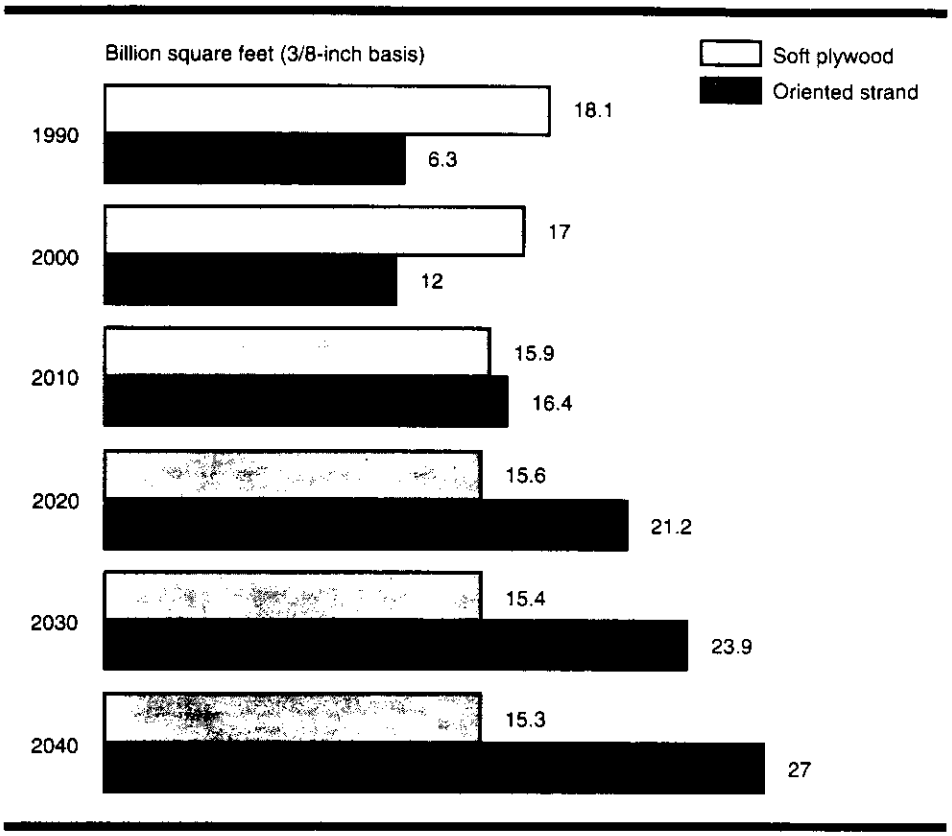


tural panel industry. These panels can be made from almost any species of wood, with the preference being soft hardwoods such as aspen. Consumption of structural panels reached record levels in response to the strong markets of the mid-1980's. Future growth in demand for structural panels is expected to be strongest for fiber-based panels .

Consumption of wood in the manufacture of pulp, paper, and paperboard grew rapidly in the decades following World War II. Growth was at a more modest pace in the 1970's and 1980's. This growth in demand was due to a corresponding growth in the economy, which stimulated consumption of packaging and other pulp-based products. Annual per capita paper and board consumption grew from 360 pounds in 1952 to 600 pounds in the early 1970's, and reached record levels of nearly 700 pounds by the late 1980's. Woodpulp consumption for paper and board productioin in the United States grew from 17 to more than 60 million tons over the same period. Much of the increase in consumption of wood fiber during the 1960's and 1990's came from the byproducts of lumber and plywood manufacture.

In recent years, the use of hardwood roundwood has increased, a trend that is expected to continue. The oil price shocks of the 1970's caused many structural shifts in the U.S. economy. The major impact on timber demand in the United States was the reversal of a long decline in the use of fuelwood. Rising costs for oil and natural gas stimulated both commercial and noncommercial demand for wood as fuel. These

Figure 21—Consumption of structural panels.



structural shifts involved new investments in technology and equipment that are not easily reversed. As a result, commercial use of fuelwood remained relatively stable through the 1980's. Noncommercial use declined in the late 1980's due to declines in fossil fuel prices and increasing regulation of wood stove emissions. Although there was a respite in energy price rises in the 1980's, they will probably increase significantly after the turn of the century, resulting in further increased demand for fuelwood.

The demands for all major wood products are projected to increase through 2040. The projection methodology used takes into account the effects of supplies of products and projects market equilibrium measures of demand and supply.

After a projected decline in 2000, consumption of softwoods will resume growth through the projection period, reflecting a growing economy and renewal of an aging housing inventory. Also, experts believe that over time, new houses will be bigger, consuming more lumber and structural panels than today's new homes. By 2040, softwood timber consumption will be about 1.2 times that in 1990.

Projected consumption of hardwood timber in 2010 will be about 1.2 times consumption in 1990, largely due to changing technologies and the rising demands of a growing economy. Demands for pulpwood, fuelwood, and pallets in particular are

Table 1—Lumber consumption in the United States by species group, and structural panel consumption by panel type, specified years, 1960-90, with projections to 2040

Year	Lumber		Structural panels	
	Softwoods	Hardwoods	Softwood plywood	OSB/ waferboard
	Billion board feet		Billion square feet 3/8-inch basis	
1960	29.6	8.1	7.8	(n)
1970	32.0	7.9	12.4	(n)
1976	36.6	8.0	17.7	0.2
1986	48.0	8.8	21.7	4.2
1990	45.9	10.8	18.8	6.2
2000	46.9	11.1	17.0	12.0
2010	50.5	11.9	15.9	16.4
2020	56.0	12.7	15.6	21.2
2030	58.6	13.3	15.4	23.9
2040	59.9	14.1	15.3	27.0

(n) = Less than 50 million square feet.

expected to increase. By 2040, consumption of hardwood roundwood is anticipated to be 1.6 times consumption in 1990.

Imports of timber products have been rising and have supplied important parts of the Nation's woodpulp, newsprint, and softwood lumber. Net imports provided 6.8 percent of total U.S. timber consumption in 1990. Most imports originate in Canada. The 1980's and early 1990's were characterized by several trade disputes with Canada centered on softwood lumber, western red cedar shakes and shingles, and softwood plywood. Similar disagreements characterized this bilateral trade relationship earlier in the 20th century. It is assumed that the current issues will be resolved, and that future imports from Canada will be determined largely by U.S. demand and the extent and competitiveness of Canada's timber resources. Canada's longrun supply potential is considerable, but there is uncertainty as to whether current harvest rates can be maintained because of increasing environmental concerns.

Exports of timber products have also been going up. The outlook for exports varies by product, however. In total, annual export volumes are projected to increase from 2.4 billion cubic feet, roundwood equivalent, in 1990 to 4.7 billion in 2040.

The volume of imports of logs into the United States has generally been small over the years and, until recently, has not been a major trade or domestic issue. In the

early 1990's there was much interest in the importation of softwood logs into the United States from Siberia. Phytosanitary concerns led to an embargo on these imports. Guidelines and restrictions that will determine what forms of wood products can be imported from the Russian Federation and other countries are being developed.

From the early 1960's and through the present, the export of softwood logs has been a controversial issue. These exports originate mainly in Washington and Oregon, affecting roundwood prices and the structure of the timber industries in that part of the country. Legislation that became effective January 1, 1991, codified and tightened a ban on softwood log exports from Federal lands in the western coterminous States. This ban had been in effect on a year- to-year basis since 1974. In addition, the legislation banned exports from other public lands in these States except that 25 percent of the annual sales volume from lands managed by the State of Washington could continue to be exported. In October 1992, this ban was extended to include all softwood logs from lands managed by the State of Washington. Questions over the legality of this legislation led to passage of the Forest Resources Conservation and Shortage Relief Amendments Act of 1993 directing the Secretary of Commerce to enforce a ban on exports from State lands in the coterminous western States. The terms of this legislation are assumed to continue in the future. Currently, there are no restrictions on exports from private lands and none are assumed for the future.

It is apparent from the above trends that domestic forest lands must supply most of the anticipated higher demands.

The Timber Resource

The Nation's timberlands contain some 858 billion cubic feet of roundwood: 92 percent of this is in growing stock (live, sound trees suited for roundwood products) and the remaining 8 percent is in rotten, cull, and salvable dead trees. Some of the latter may be suitable for lumber and veneer, but most is usable only for pulp, fuel, and other products where there are no significant log quality requirements. \2/

Timber inventories rise when net annual growth (total growth less mortality) is greater than the volumes removed by timber harvesting, clearing, or changing land use (timber removals). The growth-removals balance for the United States is positive for the total for all species (1.33), for softwoods (1.09), and for hardwoods (1.8). The ratios in the North are very high, indicating continued substantial increases in growing stock volume. The softwood ratio for the South, which was 0.88 in 1991, has been declining. This is the first time since 1952 that removals exceeded growth in the South. The growth-removals ratio in the Rocky Mountains exceeds 2.00, and for the Pacific Coast, it is 1.14.

2/ There are additional and large volumes of fiber in treetops, limbs, and bark: in trees under 5 inches in diameter at breast height; and in trees on forest land other than timberland. These volumes, also found in fence rows and in urban areas, are usable for fuel, pulp, and other products where there are no significant log quality requirements. Much of the fuelwood now being used for domestic heating comes from these sources.

Projected Trends in Timber Supplies

The outlook for timber supplies depends on the area of timberland, current level of inventories, stumpage prices, growth and removals, institutional constraints on timber harvest rates, and investments in forest management (Haynes et al., 1994).

The area of timberland has been declining consistently for the South and Pacific Coast regions. Because recent increases in the North and Rocky Mountain regions are believed to be temporary, we assume that timberland area will decline in all regions over the coming decades. By 2040, the net loss in area is expected to be less than 5 percent of today's area for the country as a whole.

The current growth-removal balances for timber show that the hardwood forests and some eastern softwood forests can support additional harvests. However, these balances will change. Future harvests, particularly in the decades beyond 2000, could vary over a wide range. Nonetheless, assuming that timberland owners continue to respond as they have in the past to price and inventory changes and manage their stands as projected, timber harvests from private lands will be increased substantially in most regions. Total projected softwood roundwood harvests rise from 11.4 billion cubic feet in 1991 to 14.6 billion cubic feet in 2040, an increase of 32 percent (table 2). Projected hardwood harvests rise from 6.8 billion cubic feet in 1991 to 10.7 billion in 2040. The largest increases will be in the South.

Table 2—Roundwood supplies from U.S. timber resources, by softwoods and hardwoods, specified years, 1952-91, with projections to 2040

Year	Total	Softwoods	Hardwoods
	Billion cubic feet, roundwood equivalent		
1952	9.5	6.9	2.6
1962	9.6	7.1	2.5
1970	11.5	8.7	2.8
1976	12.5	9.5	3.0
1986	18.0	11.7	6.3
1991	18.2	11.4	6.8
2000	19.5	11.1	8.4
2010	20.8	11.4	9.3
2020	22.4	12.5	9.9
2030	23.8	13.6	10.2
2040	25.3	14.6	10.7

Issue Highlight— The Outlook for Softwood Timber Supplies

For the first time in its history, the United States does not have a large, unreserved volume of softwood sawtimber in North America to draw upon to meet the Nation's needs for building materials and other purposes. First the Northeast, then the Lake States, the South, the U.S. West Coast, British Columbia, and the South again provided the timber for increased softwood lumber production. If softwood demands expand as projected in this Assessment Update, the interactions of rising demands and projected supplies will lead to significant price increases for softwood roundwood and lumber over the next 20 years. We project that increased recycling and maturation of pine plantations in the South will lead to more moderate price increases after about 2010. The purpose of this issue highlight is to examine in more detail the situation for softwood timber supply.

Softwood Supplies from Public Lands

Most public lands that produce timber in the United States are managed under some form of sustained yield. The National Forests have been most important in recent decades, accounting for over 50 percent of total softwood output on public lands. National forest harvest grew rapidly in the 1950's and 1960's, reaching a peak in 1987. Although harvests fluctuated in response to market conditions, allowable sale quantities were relatively stable in the 1980's. Since 1989, various legislative and judicial directives have caused the allowable sale quantity to drop from between 10-11 billion board feet per year in the 1980's to a proposed 4.6 billion board feet in 1994. We project that the allowable sale quantity for National Forests will stay at that level through 2000, then rise to 5.5 billion board feet by 2040. The assumed increase reflects the results of timber management activities.

Other public ownerships that have significant timber sale programs include the Bureau of Land Management (BLM) and a number of States. Significant among the State programs are those in the Lake States and the State of Washington. Timber harvests (removals) from State-owned lands reached a peak of 1 billion cubic feet in 1979. The allowable sale quantities on BLM lands are expected to be 40 million cubic feet in 1994 compared with an annual average of some 200 million cubic feet in the 1980's. We project future annual sales volumes to remain at 40 million cubic feet. Harvest on State of Washington lands is projected to be 100 million cubic feet as compared with 150 million in the 1980's. For both of these ownerships, the harvest reductions are assumed to be due to concerns over wildlife habitat and other aspects of the environment.

We project harvest on remaining public lands to stay near the current level of 500 million cubic feet, although there have been reports of declines on some ownerships because of management for threatened and endangered species.

As indicated by the above projections, it is highly unlikely that there will be significant expansion in timber supplies from public lands. Consequently, the rising demands projected in this Assessment Update can be met only by increases in harvest on private lands, growth in net imports (increased imports and/or decreased exports),

expanded use of recycling and other technologies that conserve on wood use and/or extend the service life of end products, increased use of hardwoods, and increased use of nonwood substitutes.

Softwood Supplies from Private Lands

Currently, softwood growing stock removals exceed growth on forest industry lands in all regions and for nonindustrial private lands in the South. For nonindustrial private lands in the North, Rocky Mountains, and Pacific Coast regions, growth is larger than removals.

Total softwood harvest on forest industry lands is projected to decline from 3.9 billion cubic feet in 1991 to 3.8 billion cubic feet in 2000 and increase to 4 billion in 2010. In 2020, harvest is estimated to increase to 4.9 billion cubic feet, continuing to rise through 2040.

Total softwood harvest on nonindustrial private lands is projected to increase throughout the projection period, expanding from 4.4 billion cubic feet in 1991 to 5.9 billion cubic feet in 2040, with some variation in regional trends. Between 1991 and 2000, harvests are projected to increase in every subregion of the country except western Oregon and Washington. After 2000, harvests should continue increasing in the North and through the remainder of the projection period for western Washington and Oregon. Harvests show mixed patterns in the remaining regions.

A key to these projections are assumptions about management of private timberland. Forest industry ownerships are projected to be managed intensively. Nonindustrial private ownerships are projected to be managed as reflected in past inventories. For the South, an effect of these assumptions is that the area of pine plantations increases to about 45 million acres by 2040, up from about 23 million acres today. Timber harvest from these plantations is projected to increase from 831 million cubic feet currently to 6.1 billion cubic feet annually in 2040. Harvest from other forest management types in the South is projected to decline. Most of the net increase in U.S. softwood harvest of 4 billion cubic feet between 1992 and 2040 is projected to come from pine plantations in the South.

If these plantations are not established as projected, long-term prices for timber products will rise more than projected. In addition, increased State and local regulation of private lands could discourage investments in timber production, causing further pressures on softwood prices. In some situations, regulations such as mandatory reforestation may enhance forest management.

Trade

This Assessment Update projects softwood lumber imports to increase from 11.3 billion board feet in 1991 to 16.7 billion board feet in 2020, reaching 15 billion board feet in 2040. Most of these imports come from Canada, although about 1 billion board feet is expected to come from New Zealand and other Pacific Rim countries by 2000.

Most of the imports from the Pacific Rim are assumed to be used in the millwork industry of the Pacific Northwest. Some people argue that timber harvest in Canada will drop by 20 percent or more by 2000, and that there is the potential threat of new forest pests and diseases arriving with increased imports from the Pacific Rim. If imports from these sources do not materialize as projected, U.S. prices for softwood lumber will increase even more than shown in this Assessment Update.

Exports of softwood lumber increased from 1.9 billion board feet in 1986 to 3 billion in 1991. We project future exports to stay near 3 billion board feet, partly reflecting the projected domestic market situation. In some foreign markets, U.S. softwood lumber fills specialty end uses. In such uses, price may not be a key concern. Consequently, there will continue to be exports despite rising U.S. domestic prices. Similarly, softwood log exports are projected to stay at 2 billion board feet per year.

Summary

The United States is in an unprecedented situation regarding softwood sawtimber supplies. Projections in this Assessment Update are especially sensitive to assumptions about future investments in plantations, recycling, and trade.

***Issue Highlight*—**
The Future of Wastepaper Recycling

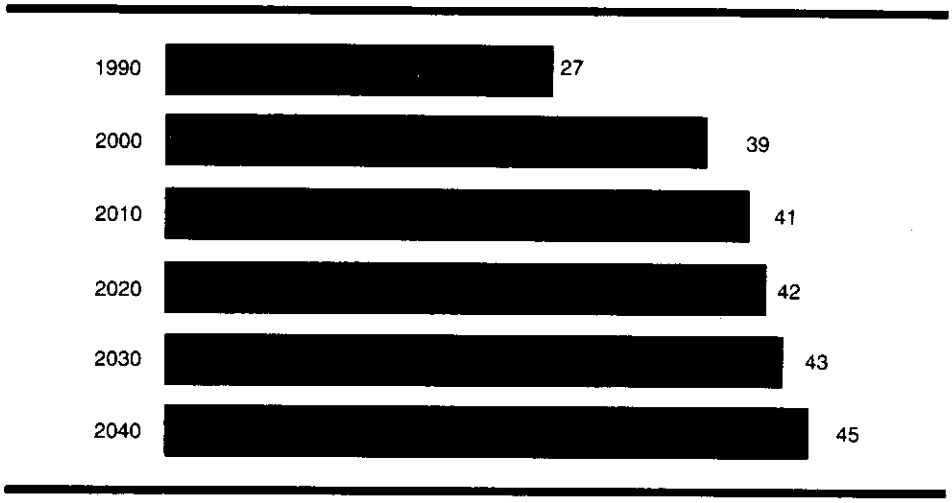
Preliminary findings from the 1989 RPA Assessment indicated that increased recycling of paper and paperboard could have wide-ranging, significant impacts on the timber industries, changing the timber demand/supply outlook. We continued to study the effects of recycling on the forest sector (Ince 1994). For this update, we analyzed economic and technological changes of the U.S. and Canadian industries and have concluded that increased paper recycling represents a fundamental long-range development which will be characteristic of the U.S. pulp and paper sector in the foreseeable future.

The study involved analysis of the competitive evolution of production processes and fiber markets in the North American pulp and paper sector. Current and near-term future technologies were considered in the study. The economic analysis encompassed regional production and trade for all of the principal pulp, paper, and paperboard commodities. The study analyzed the likely evolution of markets for fiber inputs, including various categories of recovered paper and pulpwood inputs, and analyzed how the competitive evolution of technology would respond to market conditions.

In 1986, 28 percent of the paper and paperboard consumed in the United States was recovered for recycling. Of the total amount recovered, about four-fifths was recycled in U.S. paper and board mills, and about one-fifth was exported. We project that the rate of paper recovery for recycling will reach 48 percent by 2000 and 57 percent by 2040. Only a portion of this will be recycled in the United States (fig. 22).

In 1986, the tonnage of recovered paper recycled in U.S. paper and board mills amounted to 25 percent of U.S. paper and paperboard production. By 1992, the U.S.

Figure 22—Recovered paper utilization rate, 1990 with projections to 2040.



paper recycling rate had climbed to 30 percent. Recovered paper prices have remained generally depressed in recent years due to the rapid expansion of collection programs. Low prices for recovered paper have stimulated expansion of recycling capacity in the pulp and paper industry. We project that the U.S. paper recycling rate will reach about 40 percent by 2000. By the end of the 1990s, we project that prices for most recovered paper commodities will increase substantially, eliminating the current market glut and dampening the growth in recycling capacity. However, we anticipate a gradual increase in paper recycling into the next century, with a projected recycling rate of 45 percent by 2040.

Projected increases in paper recycling should result in slower growth in pulpwood consumption and slower growth in timber harvest. This will help to extend U.S. timber supplies, especially for pulpwood-quality timber. Softwood pulpwood prices in the South are projected to remain relatively stable. Hardwood pulpwood prices in this region are also expected to remain relatively stable for the next two decades, then increase beyond 2010 because of declines in hardwood pulpwood inventories.

Without the expected increase in recycling, softwood and hardwood sawtimber prices would be even higher than projected. In the 1989 RPA Assessment, results of preliminary analysis suggested that recycling might offset significant price increases. Compared with the 1989 RPA Assessment, however, national forest harvest is lower; exports of pulp, paper, and paperboard are higher; average house size is larger; and wood consumption in new housing and residential repair and remodeling is higher in this update. These changes in assumptions tend to offset the price-lowering effects of increased recycling.

Issue Highlight— Private Forestry Investment

The 1989 RPA Assessment assumes that land owned by the forest industry will be managed intensively in the future, with management of nonindustrial private lands continuing as indicated in recent trends. These assumptions are based on trends through the early 1980's. Since then, many changes in financial markets may have

affected the industry's view of investment in forest land. Assumptions about future investments in private forestry in the South are key to determination of the timber demand-supply outlook. We initiated a study to examine factors which have influenced historical trends in management intensity on private forest lands and to project future management on these lands (Wear, 1993).

The study involved analysis of data for 1952 to 1992 in the South. During this period, the area of land in pine plantations increased from 660,000 acres to over 14.5 million acres on forest industry lands. On other private lands, the area of pine plantations exceeded 8.5 million acres. The study considers these plantations and growth of timber on timberland to be investments in forestry.

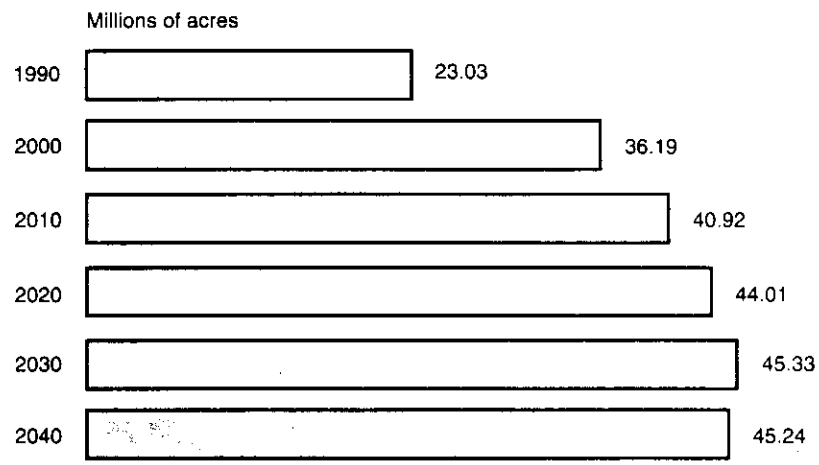
During the period 1952-59, as the area of plantations increased on both private ownerships, the area of natural pine decreased on both ownerships and the area of mixed-pine hardwood decreased on other private lands. Loss of timberland area was considered to be a disinvestment in forestry.

Study results indicate that from 1952 to 1992, forestry investment in the South replaced forest capital lost through harvesting, land-use change, and mortality, so that capital has remained essentially constant. The results also indicate that the share of forest assets held by the forest industry owners increased steadily until the late 1970's. Since then, the relative shares of assets held by the forest industry and other private owners have stabilized.

> The study assumed that the total capital stock in southern forestry will remain constant in the future. The areas of natural pine and mixed pine-hardwood are projected to decline at annual rates of 1.5 and 0.2 percent, respectively. The total area of pine plantations in 2040 is projected to range from 40 to 45 million acres, depending on assumptions about investments on forest industry lands.

These projections are generally consistent with those in the 1989 RPA Assessment, where the area of pine plantations was projected to be 45.2 million acres (fig. 23). Investments will continue to be monitored and updated as appropriate for future assessments. For example, Haight (1993) suggests that the expected present values of low-cost management options that result in mixtures of conifers and hardwoods are superior in some situations to the expected present values of intensive management options.

Figure 23—Area of pine plantations in the South.



Timber Demand-Supply Comparisons

It seems clear that real sawtimber prices (net of inflation or deflation) will continue to rise in the future under a wide range of plausible demand and supply situations. Recycling, decreasing sales volumes from public lands, and increasing State and local restrictions on use of timberland for harvest add uncertainties to the timing and extent of potential price increases. Even after accounting for the effects of recycling on roundwood prices, however, stumpage prices in 2040 in the Pacific Northwest subregion are projected to be one-third more than in 1990 and in the South, nearly double the prices in 1990. These market signals will lead to adjustments in how wood is used and grown (fig. 24 and 25). Rising prices will increase the value of the timber resource regardless of ownership.

The timber demand-supply outlook differs considerably for the periods from now through about 2010 and from 2010 to 2040. In the short term, rapidly rising stumpage prices are caused by rising demands and restriction of harvest on Federal lands. After 2010, a combination of maturation of pine plantations in the South and increased recycling will lead to declines in stumpage prices through 2040, although they will still be above current levels.

The outlook for the bulk of the hardwood timber—the smaller sized timber of common species—is for lower prices than for softwood timber. However, after 2000, as hardwood inventories begin to show substantial declines in response to increased removals, stumpage prices are expected to rise.

Figure 24—Higher prices for timber products may increase interest in recycling solid wood products.

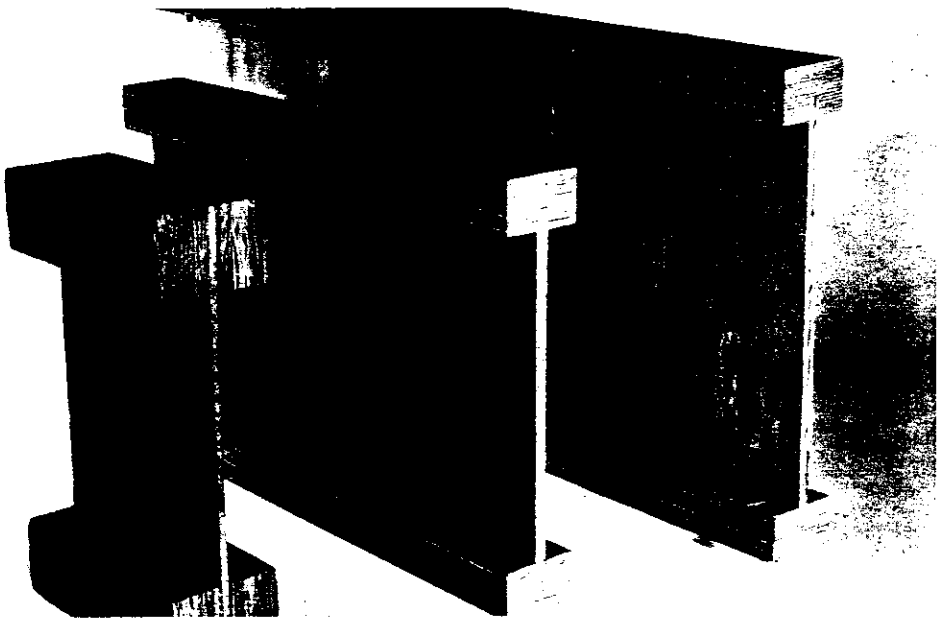


Figure 25—Higher prices for timber products may increase the application of new technologies such as laminated I-beams.

During recent decades, there have been demand pressures on high-quality preferred species such as select white and red oak, walnut, hard maple, and black cherry. The resulting stumpage price increases have led to the development of substitutes such as plastic overlays for furniture. Although analyses of the past decade have been mixed as to continuation of price rises, it is assumed that prices for preferred species will rise in the future because of strong demands.

Rising stumpage prices will be reflected in prices of timber products. For example, softwood lumber prices measured in real terms will increase by 44 percent between 1990 and 2040.

The equilibrating mechanism of rising prices has obvious but differing effects on consumers and producers of timber products. Rising prices for lumber, for example, would have a marginal effect on the cost of a house, influencing some people to reconsider decisions about the type and size of housing they could afford. Rising incomes will offset somewhat the influence of rising prices, however. Owners of timberland, on the other hand, may invest more money into land management because their real wealth will increase as prices increase and investment opportunities become more attractive.

Opportunities for Management—There are three major ways to increase supplies in response to rising demands for timber: (1) extend supplies through improved utilization, (2) increase harvests from the existing timber resource, and (3) increase net annual growth.

Timber supplies can be extended by:(1) Increasing the useful life of wood products by preservative treatments, improving designs of new structures, and renovating and maintaining existing structures rather than replacing them. (2) Improving efficiency in harvesting, milling, construction, and manufacturing. (3) Utilizing unused wood materials such as logging residues; treetops and limbs; rough, rotten, and salvable dead trees; trees in urban areas, fencerows, and low-productivity forest areas; and urban wood wastes. (4) Increased recycling of paper and paperboard.

Harvests from the existing timber resource can be incremented by increasing softwood and hardwood timber harvests on eastern forests. Sustaining these harvests beyond a few decades will require investments in regeneration and more intensive management to increase net annual growth, especially for control of fire, insects, diseases, and weeds.

Net annual timber growth can be increased by: (1) Regenerating nonstocked and poorly stocked timberlands, harvesting and regenerating mature stands, and converting existing stands to more desired species. (2) Applying intensive timber management practices such as species and spacing regulation, fertilization, and use of genetically improved trees. (3) Using management and harvesting practices to prevent or reduce losses caused by natural mortality (suppression), undesirable vegetation, wildfire, insects, diseases, and poor logging practices.

Water Demand and Supply—The Outlook

The outlook for water demand and supply is based on the 1989 RPA Assessment. Key findings from the 1989 RPA Assessment include:

— Water demands will increase significantly in the years ahead.

— Limits on water supplies will force reallocation of available supplies among users, especially in some parts of the West.

— Reallocation of supplies will generally be from lower valued uses such as irrigation (where quality is not an overriding concern) to higher valued municipal use (where quality can be all-important).

— Markets may facilitate reallocation of water use, but management of some watersheds, especially on public lands, may become more important from the standpoint of both water quantity and quality.

— Surface water quality has been a concern for much of this century. Legislation in the early 1970's targeted point sources of pollution. The private sector's response and strict enforcement have reduced point sources of pollution, creating a real success story—up to 90 percent of our inland surface waters are now fishable and swimmable.

— Various nonpoint sources of pollution are the principal sources of residual problems where surface waters do not meet designated use standards. Ground water quality concerns could engender significant changes in agricultural practices. Also, water management policies may create situations where uses are not compatible, such as management of water levels without regard to effects on fish and wildlife.

— With regard to fish and wildlife, it is estimated that about 80 percent of the Nation's flowing waters can be improved in terms of water quantity, water quality, fish habitat, or composition of the fish community. However, it is also estimated that about two-thirds of U.S. streams have habitat adequate for sports fish.

— In general, water quality has improved significantly in the last decade. Continued monitoring and enforcement of laws and regulations should make it even better.

— Average annual flood damages are expected to increase in the future mainly due to increased development and rising property values on flood plains.

***Issue Highlight*—Water Quality of Streams Draining Forest and Rangelands**

Since passage of the National Environmental Policy Act in 1969 and the Clean Water Act in 1972, water quality has received a great deal of study and large allocations of funds for controlling sources of quality impairment. As point sources of water pollution have been brought increasingly under control, emphasis has moved to nonpoint sources. Little information is available about the extent of suspended sediments and nutrients that may originate on forest and rangelands. We initiated a study to describe the nature and extent of nonpoint source pollution in water draining forest and rangelands (Brown and Binkley, 1994).

The study involved a review of available information on the relationship between forest and range management and seven categories of water pollution: pathogens,

dissolved oxygen, nitrate concentrations, dissolved solids, suspended sediment, pesticides, and temperature. Relationships between management and various forms of water pollution depend on the management practices used at the site.

> Compliance with best management practices where they exist generally results in water quality that is within standards. Across the 50 States, 23 have voluntary best management practices programs, 13 have regulatory programs, 5 use a combination of voluntary and regulatory measures, and 9 lack a formal program.

Generally, the quality of water draining from forest and rangelands is very good. However, the review of available information indicates that the three principal concerns over forest management are suspended sediment, nitrates, and water temperature, with suspended sediment being chief in importance (fig. 26). In a few specific locations, timber harvest can markedly increase nitrate levels. High levels of suspended sediment and adverse stream channel changes are potential problems in some regions, especially following road construction and some harvesting and grazing practices. Removal of overstory from along streambanks can raise water temperatures enough to adversely affect fish survival.

Water Demand-Supply Comparisons

It is apparent that precipitation provides enough surface and ground water (1.4 trillion gallons a day) to meet present and prospective withdrawals (some 500 billion gallons a day by 2040). By 2040, water consumption will still amount to only 10 percent of precipitation. There are, however, serious imbalances caused by the geographic, seasonal, and annual variations in supplies.

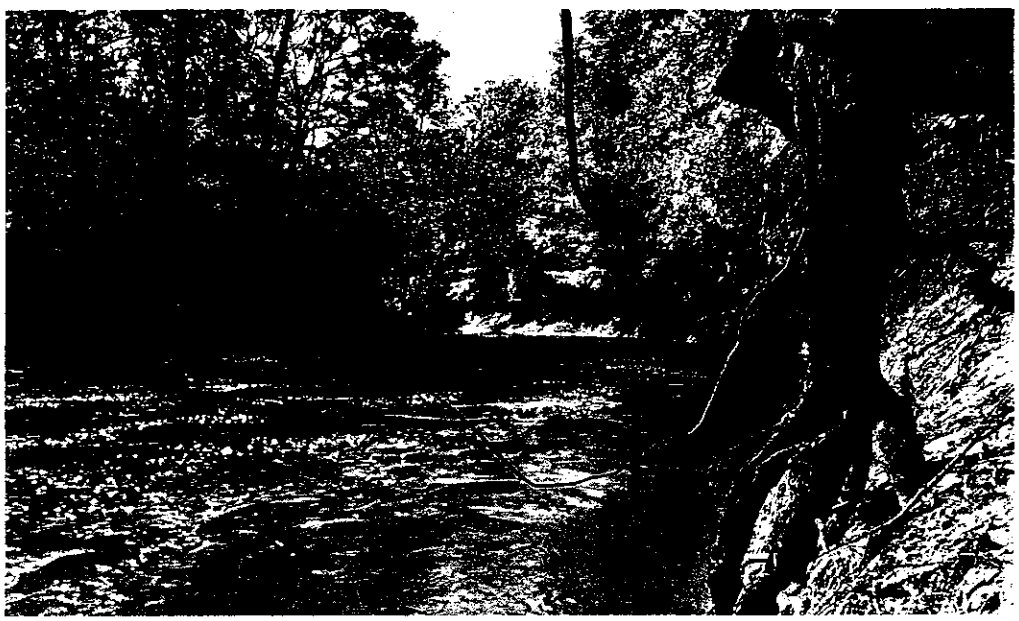


Figure 26—Suspended sediment is the most important concern about the effects of forest management on water quality.

Water quantity problems exist in the Rio Grande, upper and lower Colorado, Great Basin, and California water resource regions.

The water supply situation in some areas—such as the High Plains, which extends from central Texas and eastern New Mexico north into eastern Colorado, Kansas, and southern Nebraska—is being affected by ground water mining. As a result of ground water mining and rising energy costs, the use of ground water for irrigation over substantial areas may become uneconomic during the next two decades or so. Demand-supply situations in arid parts of the Southwestern United States are stimulating studies of ways to develop water markets. Such markets are mostly lacking under current institutional arrangements.

Most of the Nation's water shortages are caused by annual and seasonal variations in precipitation and water flows. Variations caused by unusual storms bring about another major problem—flooding. Flooding occurs in all parts of the United States. Flood damages are greatest in coastal and southern California, in a broad range extending up the Mississippi River drainage, and in another broad area extending up the Atlantic coast from South Carolina to Maine.

Water quality will continue to be a concern under the projected demand-supply situation. For example, nonpoint sources of pollution are especially important for fish habitat and the composition of the fish community. These concerns will continue to be reflected in public policies aimed at management of water quality.

Opportunities for Management—There are opportunities in local areas on forest and rangelands to increase and extend water supplies, ameliorate the effects of flooding, and improve water quality. Depending on the local situation, these opportunities can be taken advantage of by:

- Improving vegetation management to enhance the natural recharge of surface and ground water, to reduce evaporation and transpiration losses, and to change the timing of waterflows.
- Improving protection of watersheds from wildfire.
- Maintaining wetlands.

In addition, water supplies can be increased by:

- Expanding and improving reservoirs to increase storage, regulate flows, and reduce evaporation; and
- Improving snow management.

Water supplies can be extended by:

- Improving conservation, including more reuse; and
- Improving opportunities for water marketing.

Expected increases in flood damage can be limited by:

- Controlling floatable debris, such as logging residues;
- Increasing use of structures to control waterflows, providing that further flood plain development can be restricted;

— Strengthening enforcement and restrictions against development of flood plains; and
— Expanding land treatment programs to improve watershed conditions.

Water quality can be improved by:
— Reducing contamination from rural septic systems;
— Reducing leaks from underground storage tanks;
— In the use of pesticides and fertilizers, improving techniques that reduce quantities to efficient levels and also inhibit transport into ground and surface water;
— Improving timber harvesting and road building practices;
— Increasing reclamation of mine sites to reduce erosion and acid flows from abandoned mines; and
— Rehabilitating deteriorated watershed conditions.

Range Forage Demand-Supply—The Outlook

The range forage demand-supply outlook is based on the 1989 RPA Assessment. Key findings from the 1989 RPA Assessment include:

— Management of Forest Service rangelands will be oriented to vegetation management, with multiple uses as the desired output mix (fig. 27).

— Per capita consumption of beef, veal, lamb, and mutton is projected to remain near current levels during the coming decades. Thus, future demand will grow in line with the growth of the total U.S. population.

— After taking into account imports and exports, total demand on the domestic range forage resource is expected to increase 54 percent by 2040.

Figure 27—Management of rangelands has multiple uses as the desired output mix.

— Forage from public lands accounts for less than 10 percent of total forage consumption.

— It is assumed that forage production on private lands will become more productive over time. Thus, much of the current and prospective range forage supply situation depends on private lands.

— Total supply of range forage is expected to increase 52 percent by 2040, with most of the increase coming from private lands.

Range Forage Demand-Supply Comparisons

After accounting for international trade, the derived demand for forage is expected to increase 54 percent above the demand in 1985 by the year 2040. This represents the demand for all sources of grazed forage, including the demand for forages from range and forest lands. The combination of increased rangeland area (5 percent) and productivity increase (47 percent) would lead to a 52-percent increase in supply by 2040. Forage supplies are approximately equal to demands under these assumptions.

Based on projected population estimates for the Western United States, we anticipate that wild herbivores will need 19 percent more forage in 2000 than they did in 1985. Since forage supplies were projected to approximate the forage demand for livestock, wildlife forage needs may require attention through range enhancement.

Opportunities for management—The opportunities for management of the range forage resource relate to range vegetation management, management of grazers and browsers, resolving social issues, and more effective planning for multiple demands on rangelands.

Range vegetation management is the management of vegetation for a mix of resource outputs, including herbaceous and shrub forage for domestic and wild animals, water quality and quantity, air quality, open space, genetic material, recreational use, plant diversity, community stability, and scenic quality.

Opportunities for range vegetation management include:

— Increasing the seasonal availability of forages by interseeding of species, converting part of the grazing land to other forage species, or adjusting the mix of animal species;

— Integrating range forage management more fully with the management of forest and rangelands for other renewable resources, especially for wildlife and fish and water in riparian zones;

— Developing biological controls for noxious weeds; and

— Restoration of rangeland currently in deteriorated condition.

Opportunities for management of grazers and browsers include:

— Increasing the use of multiple-species grazing management so as to take full advantage of forage capabilities and improve range vegetation;

— Increasing the use of livestock as a vegetative management tool to meet resource objectives for forage, timber, wildlife, and recreation;

— Predator control; and

— Increasing domestic livestock reproduction and forage utilization efficiency.

Opportunities for responding effectively to social issues include:

— Increasing communication between land managers and the public to promote understanding of how proper livestock grazing practices contribute to soil productivity and water quality, the protection of watersheds, improvement of wildlife habitat, survival of threatened and endangered plants and animals, ecological diversity, and forage production for domestic and wild herbivores.

Opportunities for more effective planning include:

— Increasing multiresource planning across ownerships, public agencies, and resources; and

— Developing an understanding of biological and ecological concepts applicable to multiple-use management of rangelands.

Outdoor Recreation Demand-Supply—The Outlook

The outdoor recreation demand-supply outlook is based on the 1989 RPA Assessment. Key findings from the Assessment include:

— The number of people participating in recreation is expected to increase across all recreational activities during the next five decades (fig. 28).

— The percentage of the total population participating in recreation has stabilized in recent years, as has the per capita allocation of leisure time to recreational pursuits.

— Total demand for recreation would keep in line with population growth if this pattern continues in the future.

— In addition, real per capita income is projected to more than double by 2040. This extra income will contribute to differential rates of growth in recreational activities. For example, demands for snow-related recreation are expected to grow at a faster rate than for most land- and water-based activities, but the latter activities will continue to dominate total recreation patterns.

Figure 28—Most of the increase in demand for recreation will be near existing population centers.

— If the public and private sectors continue to provide and expand opportunities at rates comparable to recent trends, the projected increases in supplies will meet most of the projected increases in demands.

— Closure of private land to free public access does not necessarily mean that the land is lost to recreation opportunities.

— Most of the increase in demand will be near existing population centers, which are generally far away from the bulk of the federal lands in the West .

— National forests and other public lands in the North, South, and Pacific Coast regions are expected to become relatively more important for all forms of recreation if access remains generally unrestricted and free.

— Instead of national trends affecting all regions alike, the differential rates of growth in activities indicate that specific areas of the country will be affected differently by the expected growth in recreation. For example, greater demand for downhill skiing has obvious implications for areas of the country with the unique terrain and climate needed for this activity.

— Over 90 million acres are currently in the National Wilderness Preservation System. About 1 of every 6 acres in the National Forest System is designated as wilderness.

— Wilderness use accounts for less than 1 percent of all outdoor recreation. Total time spent in wilderness areas has been relatively stable in recent years.

— Wilderness areas contribute to maintenance of species diversity and protection of habitat for threatened and endangered species. They are important in other ways unrelated to onsite recreation.

Issue Highlight—Effects of Land Closure and Leasing on Total Recreation Opportunity

The 1989 RPA Assessment found that the percentage of private lands open to the public for recreation declined from 29 to 23 percent from 1979 to 1989. It was not certain if this trend resulted in decreased recreation opportunities. For example, leasing of land might lead to investments that increase recreation opportunities on the affected land. We initiated a study to determine the effects of decreased accessibility of private lands on total recreation opportunities (Cordell, et al., 1993).

The study involved analysis of a combination of secondary and primary data to examine subdivision, land and landowner characteristics, access policies, and recreation opportunity and use of private lands. Statistical analysis of data from the 1987 National Resources Inventory of the Soil Conservation Service and the 1987 Census of Agriculture of the Department of Commerce indicated that use and access trends in the States of Georgia, Indiana, and New York are likely indicative of statewide and regionwide trends. A telephone survey was made of a total of 506 landowners in the 3 States. The survey was designed to elicit information describing the tract, recreational access policies, the history of tract subdivision, and other information about the household.

Overall, the study found that other than complete closure to all recreation use, various forms of access restrictions do not appear to reduce either the number of people having recreational access on private lands or the overall amount of use.

Figure 29—Land leasing is positively correlated with the number of people having access to activities such as hunting.

Leasing is often associated with greater access and use (fig.29). Thus, reductions in private land access will not necessarily add pressure for use of public land. Aside from the continuing loss of private rural acreage to other uses, private lands might play a greater, not lesser future role in meeting recreation demand pressures.

***Issue Highlight*—Analysis of Customer Diversity and the Future Demand for Outdoor Recreation**

Changes in the composition of the U.S. population may alter the demand for outdoor recreation in the years ahead. Several demographic changes are occurring: the average age is increasing, the proportion of the population classed as minority is increasing, and the proportion of the population in urban areas is increasing. If these changes affect the ways that the population recreates, they have many implications for development of opportunities to recreate on both public and private lands. We initiated a study to examine customer diversity in the future and its implications for outdoor recreation (Dwyer, 1994).

The study involved review and analysis of existing information on the relationship between recreation participation and age, race/ethnicity, and urban/rural residence. Recreation behavior is complex and difficult to explain and interpret. Individual recreation behavior is driven by a wide range of important goals, in addition to the sociodemographic characteristics of individuals. These variables include the physical, biological, managerial, and social attributes of recreation opportunities; individual and group goals and preferences; the availability of equipment; skills and experiences; leisure time; companions to participate with; and knowledge of and accessibility to recreation opportunities. Thus, demographic variables such as age, racial/ethnic background, and urban/rural residence explain only a small portion of the variation in participation in recreation activities. The following summarizes available information about the effects of demographic variables on recreation participation. In this discussion, participation rate means the proportion of a group of people that participates in a recreation activity.

Age—Leveling of participation rates in most activities seems to occur as the individual reaches middle age. Participation in more physically strenuous activities such as jogging and downhill skiing starts to decline at early ages, with participation in other activities beginning to decline later in life. Exceptions are walking and observing nature, which are apparently enjoyed by people of all ages. Available projections from the Bureau of the Census indicate that the U.S. population will continue to age. In 1980, the median age was 30. This is projected to increase to 36 in 2000 and to 41 in 2025.

Race/ethnicity—National data on the recreation participation patterns of Caucasians, African Americans, Hispanics, and "other groups" indicated significant differences by race/ethnic background. For example, Caucasians and Hispanics had significantly higher participation rates than African Americans in almost all recreation activities. In athletic activities such as jogging/running and aerobics, participation rates for African Americans exceeded participation rates for Caucasians, but not for Hispanics. African Americans also tended to stay

closer to home when engaging in outdoor recreation, and consequently had relatively low participation rates in activities that involve a wildland environment. Hispanics and "other groups" had significantly higher participation rates than Caucasians in a number of activities, including bicycling, saltwater fishing, and downhill skiing. Caucasians had significantly higher participation rates in camping, hunting, canoeing, and mountain climbing.

There is little doubt that there will be increased racial/ethnic diversity in the years ahead (fig. 30). Between 1990 and 2025, the U.S. population is expected to increase by 50 million, of whom 17 million will be Hispanic Americans, 14 million African Americans, and 10 million from other groups. Thus, 81 percent of the increase in population will be in minority groups.

Urban/rural residence—Differences in outdoor recreation participation by urban/rural residence appear to reflect the availability of recreational opportunities in fairly close proximity. Activities generally associated with substantial wildland areas such as freshwater fishing, camping, hunting, and snowmobiling are more likely to be participated in by individuals living in an area with a population of less than 50,000 than in areas with a larger population. Activities requiring the development of specialized facilities or programs are more likely to be participated in by individuals living in large urban areas where there are usually substantial recreation facilities and programs such as golf and tennis.

There are prospects for increased urbanization. The 1980's witnessed a return to the long-term trend of greater growth in metropolitan areas than in nonmetro areas. The Nation's nonmetro areas grew at only half the rate of their metro counterparts.

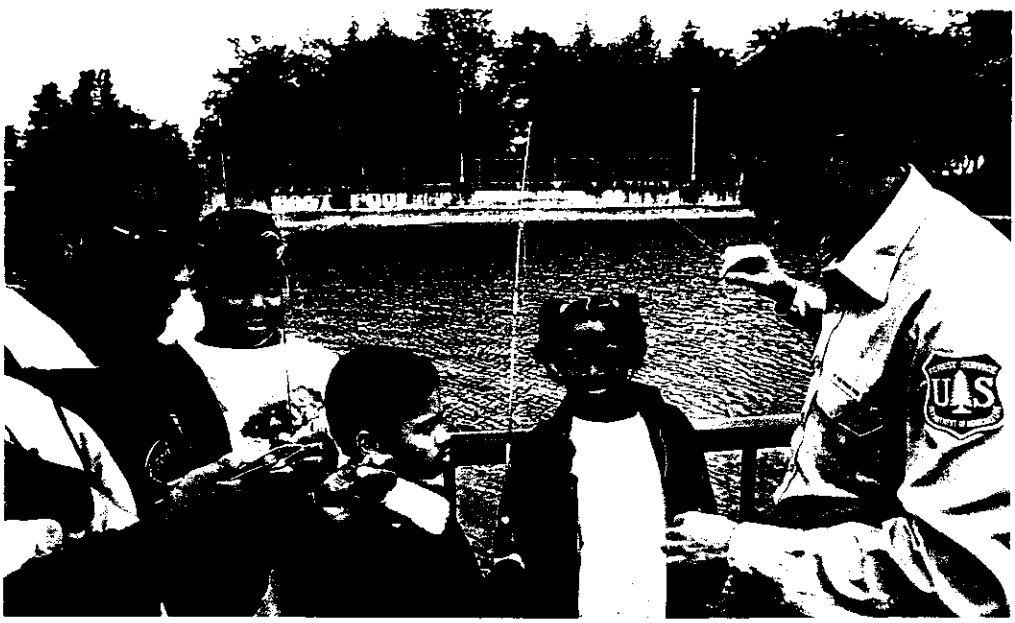


Figure 30—Customers for outdoor recreation will become increasingly diverse in terms of race and ethnicity.

Implications for future outdoor recreation behavior—Predicting the implications of demographic changes for future outdoor recreation behavior is a difficult challenge, in part because of scarcity of data to document trends in outdoor recreation participation over time. For example, we do not know if today's 40-year-olds will participate in recreation in 20 years as today's 60-year-olds do. Nor do we know what facilities and recreation-based equipment will be available in 20 years. Recreation preferences and participation rates of racial/ethnic groups may change over time. If participation rates for specified age and racial/ethnic groups are held constant (in 20 years, today's 40-year-old recreates as today's 60-year old), projections indicate that growth in the number of U.S. participants in most recreation activities will be lower than the growth expected in the U.S. population. For other activities such as birdwatching, participants are projected to grow in numbers at a slightly faster rate than the U.S. population.

It is possible to argue that there will be a convergence of activity-specific participation rates by racial/ethnic groups that will accompany increasing affluence and the enculturation process. Alternatively, it can be argued that differences between groups will be maintained as minority groups seek to preserve racial/ethnic identity. Discrimination by one group against another could play a key role and future trends in participation rates and future recreation patterns will also depend on trends in relations among various racial/ethnic groups.

Of the three demographic variables—age, race, and urban/rural residence—age is probably the most consistent indicator of recreation participation. As the population ages, participation in more strenuous activities decreases and participation in activities such as birdwatching increases. Even for age, however, it can be argued that participation rates of older adults will increase in response to improved health care as well as changing attitudes towards recreation behavior of this group.

Outdoor Recreation Demand-Supply Comparisons

If the public and private sectors continue to provide opportunities and to increase them at rates comparable to recent trends, the projected changes in supplies will meet most of the projected increases in demands. For others, where the number of recreational trips Americans would prefer to take exceeds the expected supply of opportunities for trips, demands will be brought into balance through increased fees, higher densities of use, or rationing. In general, demand pressures are projected to be greatest for dispersed land-based activities, such as day hiking and backpacking, and dispersed snow-based activities, such as cross-country skiing. For other activities, continuing past trends in resources means that sufficient growth will occur in resources to allow Americans to take as many activity-specific recreational trips as they choose. These activities include developed camping, downhill skiing, picnicking, swimming, and motor boating.

The future general availability of recreation opportunities is largely determined by projected population growth and expected changes in recreation resources. Resource

trends for undeveloped recreation resources reflect broad social and land use patterns, including conversion of land from open space to urbanized areas, and from forest to agricultural uses. Offsetting increases in undeveloped lands owned by State and Federal agencies are not expected, so opportunities for most undeveloped environments are expected to decline. Developed opportunities are expected to increase, due both to additional park land acquisition by local governments and to increased opportunities provided by the private sector.

National-level analyses of recreation activities mask variations among regions. Each region has a unique combination of resources, travel behavior, population characteristics, and projected changes in these factors. In general, the western regions have greater amounts of resources, larger effective travel distances, and higher projected rates of population growth as compared to the eastern regions. Because of these combinations, the availability of recreation opportunities in the western regions is not expected to be as sensitive to population increases as in the eastern regions. Although population is expected to grow more rapidly in the West, higher effective travel distances mean that the demand for recreation resources will be spread over a broader area. In the eastern regions, where travel distances are shorter, resources closer to population centers will bear a relatively greater share of increased demand. As the capacity of these resources is reached more rapidly, the availability of these resources for other recreating households will be reduced. Thus, there is likely to be a higher level of use pressure put on recreation resources located near population centers in the eastern half of the country compared with resources in the West.

Of the various recreation resources, a relatively high degree of use pressure will be placed on trail and scenic resources near population centers. These are the resources that provide a primary resource base for activities such as day hiking, backpacking, horseback riding, sightseeing, and pleasure driving. Since much wildlife observation activity also occurs on or near trails, enjoyment of this activity could also be affected.

Opportunities for Management—The major ways of increasing supplies include:

— Rehabilitating deteriorating sites and adequately maintaining existing facilities;

— Expanding activities concerned with visitor information services, including field interpretive and educational services that match recreational opportunities in a particular area;

— Improving coordination and encouraging partnerships among private groups, nonprofit organizations, and public agencies so as to deliver recreational opportunities more efficiently (fig. 31);

— Developing stable sources of revenue to cover costs of providing recreational opportunities (for example, user fees for recreational use on private and public lands);

Figure 31—The urban tree house in Atlanta is an example of a partnership that promotes understanding of outdoor recreation and the environment.

— Constructing additional facilities such as trails, campgrounds, picnic areas, boat ramps, and other sites;

— Improving the coordination and integration of outdoor recreation uses with other uses; and

— Improving access to forest and rangeland and inland water suitable for outdoor recreation, including private lands.

Wildlife and Fish Demand-Supply—the Outlook

The wildlife and fish demand-supply outlook is based on the 1989 RPA Assessment and an updated analysis of participation in wildlife and fish-related recreation. Key findings include:

— As land use intensifies on private lands, the National Forest System and other public lands will become more important for their unique wildlife and fish habitats. This is especially significant for the some 192 threatened and endangered species found on national forests.

— Population trends for wildlife and fish species have not changed significantly since the 1989 RPA Assessment. Updates on nongame birds indicates a slight increase in the number of species with a declining population trend. Duck populations have recovered from the low point of the mid-1980's, but remain below historical means.

— An additional 47 animal species were added to the threatened and endangered species list between 1989 and 1992.

— Small-game hunting is expected to decline slowly in the next five decades. Big-game hunting is expected to remain relatively stable in all regions except the North, where it declines. Migratory bird hunting will decline somewhat before 2000, when it will rise again.

— More opportunities for cold water fishing, migratory bird hunting, big-game hunting, and small-game hunting could lead to somewhat higher demand trends for these wildlife and fish recreation activities.

— Increases in nonconsumptive uses will grow about twice as fast as the population to 2000. Warm water and cold water fishing activity will increase at about the same rate as the population. These will accelerate slightly after 2000.

— Analysis of participation in wildlife recreation opportunities indicates that national forests and other public lands are expected to become relatively more important for big- and small-game hunting and cold water fishing if access remains generally unrestricted and free.

— Hunting in designated areas for a fee, especially on private lands, is expected to become more important in the future and may increase the pressure on public lands. Closure of private lands to free access does not necessarily mean fewer recreation opportunities.

***Issue Highlight*—Patterns of Species Endangerment**

The number of species being listed as threatened and endangered continues to increase. At the time of the writing of this report, a total of 728 plant and animal species receive protection under the Endangered Species Act—an increase of nearly 197 species since publication of the 1989 RPA Assessment. The number of species listed, however, represents only a fraction of those that could be listed in the coming decade. The probability of a species being listed increases as land use and/or land cover changes. We initiated a study to determine if there are broad synecological patterns in the geographic distribution of species endangerment that may be related to land use and land cover patterns (Flather, et al., 1994).

The study involved analysis of available information on 660 of the species currently listed as threatened or endangered under the terms of the Endangered Species Act. The information included taxonomy, known and potential county occurrence, known or potential occurrence on public lands, land-type associations, reasons contributing to species endangerment, and actions recommended for recovery.

Land-Type Associations Among Listed Species

The number of threatened and endangered species among the general land cover categories was distributed equally among forest land, rangeland, and aquatic habitats. Approximately 250 species were associated with each of these land cover types.

The majority of species associated with forest environments was composed of terrestrial vertebrates: slightly more plants than animals were associated with rangeland systems, and invertebrate species were commonly associated with aquatic environments.

Reasons Contributing to Species Endangerment

Without question, habitat loss associated with agricultural development, mining, urbanization, and other intensified human-induced land uses was the single most important reason contributing to species endangerment in the United States (fig.32).

Figure 32—Habitat loss associated with human-induced land-use intensifications, such as clearing land for urban development, is the single most important reason contributing to species endangerment in the United States.

The second most frequent reason for species endangerment was human overuse associated with the harvest or collection of species. Other reasons included disease and predation, impact of nonnative species, grazing, siltation, and environmental contaminants/pollution.

Effects of Land Ownership Patterns on Listed Species

Federal lands support a large number of threatened and endangered species. Of the 660 species included in the study, lands managed by the Department of Defense, Forest Service, and the BLM supported 26, 24, and 17 percent of the species, respectively.

County-Level Distribution of Listed Species

Counties that supported many endangered species were grouped according to climate, physiography, soils, vegetation, and land use. This resulted in the identification of 10 regions of high species endangerment. These regions were concentrated in the Southern United States, with all but the Colorado/Green River Plateaus occurring south of 40 degrees North latitude.

> In general, regions of high species endangerment in the Eastern United States were associated with forest ecosystems, while those regions in the West were associated with rangeland ecosystems. Endangerment regions in the East were associated with intensive human land use activities. In the West, collecting rare plants (Southern Desertic Basins, Plains, and Mountains), surface mining and oil and gas development (Central Desertic Basins), and exotic species and water diversions (Southern Nevada/Sonoran Basin) were the most frequently cited causes for endangerment concern.

Spatial Distribution of Candidate Species

Category 1 species include species for which the Fish and Wildlife Service has sufficient biological evidence to support their official listing as threatened or endangered. There were 526 of these species in 1989-90. These species were tabulated by State of occurrence so as to gain an understanding of where new listings of species might occur in the future.

The Southeast and Southwest remain areas where species endangerment will be concentrated. The only new region of species endangerment that may emerge in the future is the Pacific Northwest, including Oregon, Washington, and Idaho.

***Issue Highlight*—Analysis of Trends in Non-Federal Wetland Habitats**

Wetlands are among the most productive of ecological systems. Between 1954 and 1974, wetland habitats were lost at a rate of 460,000 acres per year. Studies of wetlands since the mid-1970's suggest that the rate of wetland loss is declining. Continued significant declines in wetland area could affect the outlook for some species of wildlife and fish. We initiated a study with the objective to determine recent trends in non-Federal wetland habitats (Brady and Flather, 1993).

The study involved analysis of wetland area trends in data from the National Resources Inventory for non-Federal lands for the period 1982-87. The trend for this period was compared with estimates of others for earlier periods.

> The National Resources Inventory estimated that there were 83.1 million acres of wetlands in 1982 on non-Federal rural lands in the coterminous United States. Analysis of change between 1982 and 1987 indicates that net wetland area declined 1.1 percent (897,000 acres) during this period. The average annual rate of loss of 179,000 acres is about 40 percent of that reported for the period from the mid-1950's to the mid-1970's and about 60 percent of the rate reported for the period from the mid-1970's to the mid-1980's.

Conversion to open water, primarily caused by natural flooding in western inland basins, was responsible for 47 percent of the wetland conversion (fig. 33). Of the human-induced wetland conversions, conversion to urban and developed lands was responsible for 48 percent of the wetland loss, while agricultural development was indicated in 37 percent of the converted wetland area.

Wetland losses due to agriculture have declined since the mid-1950's. During the mid-1950's to mid-1970's, 87 percent of wetland losses were estimated to be due to agriculture and for the mid-1970's to mid-1980's, 54 percent.

There was a net loss of 262,400 acres of forested wetlands between 1982 and 1987. This amounted to 62 percent of the human-induced conversions.

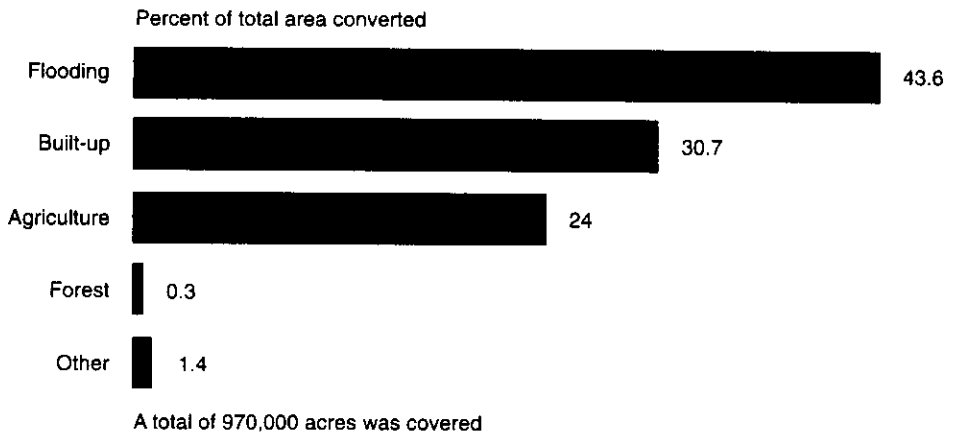


Figure 33-Causes of wetland loss, 1982-1987.

Wildlife and Fish Demand-Supply Comparisons

The number of people who hunt and fish is determined in part by the availability of wildlife and fish habitats and populations. There are no reliable estimates of supply variables for use in comparing fish and wildlife supplies and demands. Demand and supply together determine consumption, which is measured by numbers of hunting trips, animals harvested, or other means. Because it is so difficult to separate demand and supply in analysis, it is difficult to interpret demand-supply comparisons. For example, the demand for hunting might decrease because there are fewer animals to hunt.

To test these demand and supply interrelationships, we examined future consumption under conditions of increased supply. This examination indicated that the biggest potential gap between demand and supply is for cold water fishing, followed by migratory bird hunting, big game hunting, and small game hunting. For these activities, increases in supply would lead to increases in consumption.

The big increases in demands for nonconsumptive uses and all forms of fishing imply that constraints on the use of public lands and increased access fees may be necessary to match the availability of the resources with the desires of the American people. This may create some investment opportunities on private land.

Although demands for most forms of hunting are not expected to increase, there will still be millions of people who want to hunt in the future. Management of fish and wildlife resources to provide this experience will be especially challenging because of the competing demands that will be placed on the forest and range resources by a growing and affluent citizenry.

Opportunities for Management—Management opportunities for increasing the quantity and/or quality of the resource relate in one way or another to habitat, wildlife and fish populations, users, and planning.

Opportunities for management of habitat include:

— Improving wildlife and fish habitats by increasing food supplies and suitable habitat cover, improving water quality, and increasing the size, diversity, and distribution of habitat areas;

— Controlling land and water pollution, especially the use of pesticides, which can adversely affect wildlife and fish species;

— Expanding wetlands nesting habitats through fee purchase of key tracts and easements in the United States and Canada, and preserving and enhancing migration and wintering habitats;

— Increasing efforts to define, protect, improve, and augment critical habitats of endangered and threatened species and the important habitats of other species being adversely affected by changes in management or use; and

— Removing barriers to fish migration.

Opportunities for direct management of wildlife and fish populations include preventing habitat deterioration by control of fish and wildlife populations.

Minerals Demand-Supply—The Outlook

The outlook for minerals demands and supplies is based on the 1993 Minerals Technical Document. (Shields, 1994) Key findings include:

— Over 90 percent of total energy needs (as measured in 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.

— Total energy consumption is expected to grow at a rate far lower than that of overall economic growth, due to the moderating effects of energy conservation.

Electricity is forecast to capture an increasing share of the total energy market. Oil and natural gas prices are expected to increase and may double by 2040, depending upon international developments and the rate of technological change.

— Total United States production of liquid and gaseous hydrocarbons has remained relatively constant since 1989, though the rate is lower than that of the late 1970's and early 1980's. Only 27,370 exploratory or development wells were drilled in 1991, compared with 27,740 in 1989 and 70,000 as recently as 1985. Similarly, capitalized expenditures for exploration and development of crude petroleum and natural gas dropped almost 80 percent between 1982 and 1987.

— Proven oil reserves of 22.6 billion barrels and natural gas reserves of 167 trillion cubic feet will provide for approximately 8 years of production at current rates. Recoverable undiscovered and inferred crude oil resources in the United States are estimated to range from 98 to 144 billion barrels, depending upon technology. Recoverable natural gas resources are estimated to be between 930 and 1,339 trillion cubic feet. Much of the significant onshore undiscovered recoverable crude oil and natural gas is thought to reside under public lands. Demand is expected to continue for these energy resources, particularly if increased emphasis is placed on natural gas production.

— The demonstrated reserves for coal exceed 450 billion short tons. 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 the practice today, acid mine drainage from abandoned or unreclaimed mines and subsidence remain as problems, particularly in the East.

— Eastern coal resources are extensive; however, coal recoverability has become an issue in some areas. Typically, 80 percent of the coal is recovered at open cast mines, and 50 percent from underground mines. The remainder is lost in waste materials, left in place to provide support or prevent subsidence, or cannot be mined profitably due to its physical characteristics or location. Recently revised estimates place recoverability at as low as 30 percent for some underground mining districts in the East. As a result, minable coal resources in these areas may be depleted sooner than previously expected (in some cases within 50 years).

— The United States is a mineral-rich nation, with supplies of many metallic and precious metals sufficient to accommodate domestic demand through 2040. 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 used in the United States are imported.

— In the Eastern United States, most mineral rights are privately held, including many underlying acquired public lands. In the Western United States, many mineral claims have been patented, thus transferring both the minerals and the land to private ownership. As a result, most mineral production is private even though the mineral location previously may have been or may still be part of the public estate.

— 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 2040. Consumption of agricultural minerals is expected to remain at or near current levels. Consumption of sand, gravel, and crushed stone will follow trends in population and economic growth.

— Domestic reserves of metallic minerals such as copper, lead, and zinc are being depleted. These will need to be replaced through exploration and developmental drilling if current production levels are to be maintained.

Production of gold has increased significantly since 1989, due largely to technological advances facilitating production from disseminated lode deposits. The United States is currently the second largest gold producer in the world. Much of this production has come from public lands in the Western United States. Exploration and development activities are expected to continue as reserves at current operations are depleted.

The United States depends on imports for 80 percent of the chromium and 88 percent of the platinum used annually. No chromium is produced domestically; platinum group metals are produced at only one mine. World resources are large, but short-term disruptions in supply are possible in the major producing countries of South Africa and the former U.S.S.R. This could lead to more demand for domestic exploration, development, and production of these metals.

— Although there are vast reserves of sand, gravel, and crushed stone, high-quality deposits located near urban areas are being depleted or may be unavailable. This is shifting demand to more remotely located resources. In addition, a national program of infrastructure development may lead to increased interest in these resources on public lands.

— 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. The ultimate result may be increased reliance on imported resources.

— Overall, energy and mineral industry contribution to the Gross National Product was 3.08 percent in 1989, but in some areas of the country represented a large percentage of Gross State Product (e.g., 22 percent in West Virginia, 23 percent in Louisiana, 11.5 percent in Montana, 19 percent in New Mexico, 36 percent in Wyoming, and 50 percent in Alaska). Production activities are usually located in rural areas, where they are important sources of jobs and income.

Minerals Demand-Supply Comparisons

The United States used 81.51 quadrillion Btu's (qbtu) of energy in 1991, up slightly from 1989 levels (81.35 qbtu's.) Consumption is forecast to increase to 106.7 qbtu by 2010 and to between 114 and 138 qbtu by 2040. Petroleum (crude oil and natural gas liquids) currently supplies 39 percent of energy needs, of which 17 percent is imported. Coal supplies 27 percent of the Btu's, natural gas 25 percent, and all other sources (including nuclear, hydroelectric, and solar) the remaining 9 percent. Concerns about environmental quality, availability of supply, and changing economic incentives may alter these ratios.

At current consumption rates, proven and undiscovered resources of oil will be depleted in approximately 13 years, and natural gas in approximately 20 years. Oil and gas exploration, drilling, and production will be necessary if these resources are to be used and replacement reserves discovered. Alternate energy sources such as solar or wind generation cannot currently replace petroleum products and natural gas, implying either increased domestic production or increased import reliance in the short run. In the longer term, the proportion of energy needs supplied by petroleum products is expected to decrease, while that supplied by coal, natural gas, and alternate sources is forecast to increase.

The United States is in no danger of running out of coal (fig. 34). At current consumption rates of approximately 1 billion short tons per year, there are ample reserves. Even at reduced recoverability levels or increased utilization, supply is adequate for at least a century. Revised coal recoverability estimates and altered consumption patterns, in response to increased air quality regulation, may induce changes in the level of mining activity in some locations. If extraction decreases near communities

Figure 34—The United States is in no danger of running out of coal.

historically dependent on coal for jobs and income, associated economic and social consequences will result.

Nonfuel minerals are supplied by a combination of domestic primary production, imported primary and refined production, recycling, and the import of minerals embodied in final products. The amount supplied by each source differs among the minerals. Recycling rates for light, heavy and precious metals have risen since 1989, a trend which is expected to continue given increasing regulatory and economic incentives. However, some agricultural and industrial uses of minerals are dissipative, in which cases recycling is neither feasible nor economical. This implies domestic exploration, development, and production or further reliance on imports for several metallic minerals.

Overall, world resources of energy and minerals are extensive, with Canada and Mexico important producers of many commodities including natural gas, oil, and metallic and industrial minerals. Availability of supplies will depend on market prices, and in some cases the politics and stability of the government of the producing country. For energy and those nonfuel minerals present in the United States, domestic production levels will be determined by relative cost, access to resources, and regulation.

***Issue Highlight*—**
Abandoned Mines

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 1994). The failure to reclaim these mines has left a legacy of abandoned mines across the United States, with numerous associated environmental problems. Among the more serious of these are acid and other toxic mine drainage, which can contaminate both surface and underground water, physical danger from open mine shafts, and sedimentation of streams from acres of unrevegetated spoil piles (fig. 35). While these abandoned mines continue to harm the environment, current reclamation practices can do a great deal to alleviate past problems. Most new mine sites can be and are reclaimed. Moreover, new approaches are being developed to identify areas at high risk for acid mine drainage, with the goal of designing mine and waste management plans to prevent or mitigate adverse impacts.

— Over 89,000 past producing mines have been identified by the Bureau of Mines. Only 10,000 of the estimated 50,000 to 60,000 past producing coal mines are included in this figure. Current estimates of the total number of past producing mines exceed 500,000, many of which date from the 1800's through the 1940's.

— Past producers range in size from small prospecting holes to large underground mines. Environmental impacts similarly range from minimal at the majority of sites to severe at several thousand locations.

— Over half the locations had surface mining operations, with sand, gravel, and crushed stone operations accounting for 22 percent of the sites. Mines where the primary product was copper, gold, lead, silver or zinc account for 44 percent

Figure 35—Abandoned mines can adversely affect the environment through acid drainage.

of noncoal past producers. Most of these mines were underground operations (69 percent, 61 percent, 76 percent, 68 percent, and 83 percent,respectively).

— Both surface and underground mines can be affected by acid mine drainage, although this problem is more commonly associated with underground mines. When sulfide-rich strata are exposed to air, acid forming reactions are triggered and oxidized sulfides are created. During and after mining, water comes into contact with the oxidized sulfides. Acid mine drainage problems are exacerbated when the low-pH water comes in contact with mineralized zones and dissolves heavy metals, many of which are toxic to aquatic life.

— In the Eastern United States, most acid mine drainage is the result of past coal mining operations. In the western parts of the country, most acid mine drainage flows from abandoned underground metal mines. Estimates of the number of western mines affected by acid drainage range from 20,000 to 50,000.

— Over 13,000 past producers are located within the administrative boundaries of the National Forest System. Many of these are patented and unpatented mining claims dating from the turn of the century. In the Western United States, 1,500 of these sites have been identified as having significant acid mine drainage problems.

Responsibility for abandoned mines is shared among Federal and State governments and private land owners. The Surface Mining Control and Reclamation Act of 1977 (SMCRA), due to expire in 1995, requires surface-mined coal operators to pay a quarterly fee to the Abandoned Mine Reclamation Fund. The Energy Policy Act of

1992 extends the requirement for payment of these Title IV funds through 2004. Under Title V of SMCRA, States may assume responsibility for permitting coal mines, with oversight from the Office of Surface Mining. States that have a Title V program under SMCRA may also have Title IV abandoned and inactive mine programs, making them eligible to receive Title IV funds. The funds may be used for the reclamation of hardrock mines if coal mine reclamation in the State is largely completed.

Programs vary from State to State, depending in part on the level of coal mining activity and the amount of money being paid into the Abandoned Mine Reclamation Fund. Each State has its own reclamation objectives, with the Office of Surface Mining providing a level of consistency. Usually, the land owners are responsible for safeguarding hazards on their property, including abandoned mines. The State inactive mine program assists owners with the closure of mine openings using Title IV funds. Federal agencies are responsible for abandoned and inactive mines on lands under their jurisdiction and the Forest Service has an ongoing program on National Forest System lands. Abandoned and inactive mines are being located, and mitigation or reclamation work is undertaken as appropriate and as funding permits.

Opportunities for Management—There are several ways to accommodate the projected increase in the Nation's demands for various minerals of all kinds over the next 50 years. They include:

— Increasing domestic production by improving the business climate, encouraging minerals production on private lands, facilitating mineral development on Federal lands, and by improving information on domestic mineral location, quantity, and quality;

— Increasing imports through tax and trade measures and bilateral agreements with foreign nations;

— Extending supplies through more efficient recovery during mining and processing, more efficient use in manufacturing and consumption, and recycling;

— Substituting nonmineral materials for minerals and abundant minerals for scarce ones; and

— Improving, through research, the basic information for more effectively mitigating the environmental effects of mining.

Futures

Background

Projections of longrun demands and supplies are strongly influenced by prevailing shortrun conditions. The last 10 years have been a turbulent time as measured by fiscal and monetary policies and other indicators of the macroeconomic situation. The basic assumptions for this Assessment Update, however, are consistent with historical conditions, and the assumptions are generally consistent with long-held national goals

of continued economic growth and increasing income, although the future may be different from that described in the basic assumptions. In recognition of this uncertainty, this section of the Assessment Update presents the results of five different futures. These futures differ from the base Assessment Update projection in key assumptions about the future. Projection results for other futures are compared with the base Assessment projections of consumption and other key measures of the renewable resource base. The alternative futures are timber-oriented because data and analytic capabilities in other resource areas are not sufficiently advanced to differentiate meaningfully among alternative futures. The following descriptions highlight key points in each of the futures.

Description of Futures

Alternative future number 1 can be described as reduced imports of softwood lumber. This modifies the base Assessment Update projection by reducing softwood lumber processing capacity in Canada by 20 percent. This is assumed to be the result if lower harvest reductions in Canada are sustained, as some people suggest.

Alternative future number 2 can be described as increased state and local regulations. This modifies the base Assessment Update projection by increasing State and local regulations, as suggested by the results of the study for our issue highlight on the subject.

Alternative future number 3 can be described as reduced demand. This modifies the base Assessment Update projection by reducing projected growth rates for the Gross National Product (to be Gross Domestic Product in future Assessments) and associated macroeconomic variables. These assumptions include estimates of future population as issued by the Bureau of the Census in November 1992.

Alternative future number 4 can be described as reduced investment. In this alternative the base Assessment Update projection is modified by reducing the area of pine plantations in the South by 20 percent in 2040.

Alternative future number 5 can be described as maximum paper and paperboard recycling. This alternative modifies the base Assessment Update projection by an increase in the use of recycled paper for the production of paper and paperboard. In this future, the utilization rate for paper and paperboard reaches 60 percent in 2040 compared with 45 percent in the Assessment Update. Because of cost, leakages in the waste stream (such as personal hygiene products), and problems with recycling some products, we believe that a utilization rate of 60 percent is about the maximum feasible.

Effects

All of the proposed futures indicate the possibility of significant effects on the timber demand-supply outlook. In general, the effects for each future were in the expected directions. The reduced softwood lumber imports future (future number 1) leads to

higher prices for softwood lumber and higher prices for stumpage, especially in the South. Increased State and local regulations (future number 2) leads to reduced harvests in all regions. However, because these regulations change the relative competitiveness of the various regions, much of the impact in harvest reduction occurs in the South. Lumber and plywood prices increase, as do imports of softwood lumber. Reduced demand (future number 3) causes imports from Canada and end product prices to be lower. Reduced investment (future number 4) leads to increased stumpage prices in all regions, increased end product prices, and increased imports from Canada. Maximum paper and paperboard recycling (future number 5) slows the rates of increase in stumpage and end product prices, and reduces imports from Canada.

This analysis of alternative futures has demonstrated the sensitivity of the future timber demand-supply outlook to changes in factors potentially affecting production and use of timber products. Further details are available in the supporting technical document for timber. It is difficult to visualize the potential market interactions if all futures were to occur simultaneously. For example, reduced demand and maximum paper and paperboard recycling would tend to offset the effects of reduced imports of softwood lumber, increased State and local regulations, and reduced investments. Key measures of these alternative futures will be monitored for implications for the future outlook.

Ecosystems Management and Resource Interactions

At the 1992 UNCED meeting in Rio de Janeiro, the United States announced a policy of ecosystem management for natural resources. In June 1993, at the second Ministerial Conference on the Protection of Forests in Europe, the United States announced a goal of managing forests on a sustainable basis by the year 2000. As implemented by the Forest Service, ecosystem management means to produce desired resource values, uses, products, or services in ways that also sustain the diversity and productivity of ecosystems. An emphasis on ecosystem management may change the nature of production possibilities and feasibilities.

The emphasis on ecosystems management for public lands is occurring in part because of the cumulative effects of past management activities on public and private lands. These activities often led to increased sedimentation in streams; less productive rangeland conditions; fragmented plant, animal, and fish habitats; and increased forest health problems. Population growth, increased use, and other factors have also caused significant declines in the range and numbers of many native flora and fauna. Public lands are the last refuge for many vanishing species.

Past management has often focused more on selected parts of ecosystems than on the wholes or on the processes that keep ecological systems healthy, diverse, and productive. New information and a better understanding of ecological processes highlight the role of biological diversity as a factor in sustaining the health and productivity of ecosystems.

Ecosystem management recognizes that natural systems—their composition, structure, and function—must be sustained in order to meet the social and economic

needs of future generations. Managing for healthy ecosystems conserves biological diversity, allows for sustainable development and thus provides economic opportunities.

Ecosystem management does not eliminate the necessity for making tough choices. The range of natural ecosystem variability is likely to differ in some important respects from future conditions of ecosystems and landscapes desired by society. In virtually all possibilities, compromises must be struck between natural processes and societal demands. In attempting to reach a desired future condition, managers may alter the hierarchy of ecosystems and create resource interactions in both space and time. The nature of ecosystem disturbance and recovery will partly determine these interactions.

Resource interactions, as results of ecosystem management or other types of management, are difficult to predict across multiple spatial and temporal scales because they tend to be site specific and complex. Each one must be viewed individually. Findings of the 1989 RPA Assessment and this Update indicate that resource interactions will likely increase in the future as demands grow for all of the uses of the forest and rangeland resource base. As ecosystem management strategies are refined through implementation of adaptive management, new information will become available on resource interactions through coarse- and fine-scale analyses at a variety of spatial and temporal scales. Another future source of information will be ecoregion assessments of function, process, and condition, similar to the East Side Ecosystem Health Assessment which has been completed. This information will be considered in future RPA Assessments.

Epilog

Renewable natural resources will always be important to the economic welfare and quality of life for the citizens of the United States and the world. This Assessment has pointed out the many opportunities Americans have to use their resources to improve the public's economic welfare and quality of life. The 1992 UNCED meeting highlighted the importance of forests to the global environment. International dimensions of U.S. forestry help to put the U.S. situation in perspective relative to the forest resource situation in other countries. Establishment of a Deputy area for international forestry within the Forest Service is tangible evidence of a commitment to be outward-reaching with forestry programs. Establishment of U.S. positions on global issues such as deforestation and biological diversity is especially challenging because of the diverse nature of ownership and management of the domestic forest resource.

Through activities such as cooperation with the Food and Agriculture Organization and the Economic Commission for Europe in a Global Forest Assessment, the United States can help to establish the information base necessary to make judgments about issues such as deforestation. Active membership in organizations such as the International Tropical Timber Organization provide a basis for exchange of information and views from importing and exporting countries. Experience in these international activities can also serve to help further define the U.S. role in international forestry matters.

The nation has made a great deal of progress over the past several decades in production of resources and enhancement of productivity. Past performance clearly indicates that U.S. resources are resilient and renewable and responsive to management. Their resilience and renewability account for the management opportunities we have today to increase their products and uses as will as their contribution to the environment.

As our Nation continues to grow in the coming decades, Americans' perspectives on natural resources will change in terms of problems, opportunities, and the appropriate mix of management inputs to manage the country's renewable resources. Increasingly, international dimensions of U.S. forestry will be part of the framework for identifying problems and opportunities, and pursuing them. This is why periodic assessment of the renewable resource situation is so important in providing the factual basis for the 1995 RPA.

Appendix table 1—Land and water areas in the United States, by region and class of land and water[1]

Class of land and water	Total	North-east	North Central	South-east	South Central	Rocky Mountain	Great Plains	Pacific Coast[2]	Alaska
1,000 acres									
Land (Non-Federal)									
Rangeland[3]	441,466	16	238	4,192	111,365	168,407	74,080	33,212	49,956
Forest land[4]	487,547	82,262	73,158	78,897	113,893	40,458	3,129	44,020	51,730
Other land[5]	692,720	40,393	201,354	53,382	147,516	66,789	111,279	50,351	21,656
Total	1,621,733	122,671	274,750	136,471	372,774	275,654	188,488	127,583	123,342
Land (Federal)									
Rangeland	328,887	—	172	197	—	167,411	3,500	34,828	122,779
Forest land	249,134	3,118	9,950	9,181	9,866	95,042	1,103	43,471	77,401
Other land	63,504	1,028	1,802	1,571	4,460	9,812	1,209	2,105	41,517
Total	641,525	4,146	11,924	10,949	14,326	272,265	5,812	80,404	241,697
All land									
Rangeland	770,353	16	410	4,389	111,365	335,818	77,580	68,040	172,735
Forest land	736,681	85,380	83,108	88,078	123,760	135,499	4,232	87,492	129,131
Other land	756,224	41,421	203,156	54,953	151,976	76,601	112,488	52,456	63,173
Total land	2,263,258	126,817	286,674	147,420	387,101	547,918	194,300	207,988	365,039
Water									
Total water	160,682	14,322	42,475	15,016	14,140	4,795	2,480	12,381	55,073
Total Land and Water	2,423,940	141,139	329,149	162,436	401,241	552,713	196,780	220,369	420,112

— = not available.

[1] Data for range land as of 1982; data on other land and water as of 1990; data for forest land as of 1992.

[2] Includes Hawaii

[3] Land on which the climax vegetation (potential natural plant community) is predominantly grasses, grasslike plants,forbs, or shrubs suitable for grazing and browsing. It includes natural grasslands, savannas, many wetlands, somedeserts, tundra, and certain forbs, and shrub communities. It also include areas seeded to native or adapted introduced species that are managed like native vegetation.

[4] Land at least 10 percent stocked by forest trees of any size, or formerly having had such tree cover and not currently developed for nonforest use. The minimum area for classification of forest land is 1 acre and must be at least 100 feet wide. Forest land is distinguished from rangeland in transition vegetation types if the tree canopy cover exceeds 10 percent. Forest lands include cutover areas temporily unstocked as well as young stands and plantations established for forestry purposes which do not yet have 10 percent crown cover.

[5] Includes crop and pasture land and other. Cropland is defined as land used for the production of adapted crops for harvest, alone or in rotation with grasses and legumes. Adapted crops include row crops, small grain crops, hay crops, nursery crops, orchard and vineyard crops, and other similar specialty crops. Pasture land is definded as land used primarily for the production of adapted, introduced, or native forage plants for livestock grazing. Pasture land may consist of single species in a pure stand, grass mixture, or a grass-legume mixture. Culture treatment in the form of fertilization, weed control, reseeding, or renovation is usually a part of pasture management in addition to grazing management. Native pasture is included in pasture land in these land area statistics. Other land is defined as a category of land cover and land use that includes farmsteads, other land in farms, strip mines, quarries, gravel pits, borrow pits, permanent snow and ice, small built-up areas, and all other land that does not fit into any other land cover or land-use category.

Sources: Forest land: U.S. Department of Agriculture (USDA), Forest Service. 1993. Forest Resources of the United States. Rangeland: USDA Forest Service estimates based on data supplied by the USDA Soil Conservation Service and USDA Forest Service reconciled data, 1982. Other land and water: U.S. Department of Commerce, Bureau of the Census.

Appendix table 2—Population, Gross National Product, and disposable personal income in the United States, specified years, 1929 to 1991, with projections to 2040

Year	Population[1]		Gross national product		Disposable personal income		Per capita disposable personal income	
	Millions	Annual rate of change, percent	Billion 1982 dollars	Annual rate of change, percent	Billion 1982 dollars	Annual rate of change, percent	1982 dollars	Annual rate of change, percent
1929	121.8	—	709.6	—	498.6	—	4,091	—
1933	125.7	0.8	498.5	-8.4	370.8	-7.3	2,950	-7.8
1940	132.1	.9	772.9	7.9	530.7	6.2	4,017	5.4
1945	139.9	1.1	1,354.8	-1.9	739.5	-1.3	5,285	-2.4
1950	152.3	2.1	1,203.7	8.5	791.8	8.0	5,220	6.2
1955	165.9	1.8	1,494.9	5.6	944.5	5.6	5,714	3.8
1960	180.7	1.6	1,665.3	2.2	1,091.1	2.2	6,036	0.1
1965	194.3	1.3	2,087.6	5.8	1,365.7	5.8	7,027	4.5
1970	205.1	1.2	2,416.2	-0.3	1,668.1	4.3	8,134	3.1
1975	216.0	1.0	2,695.0	-1.3	1,931.7	1.9	8,944	.9
1976	218.0	.9	2,826.7	4.9	2,001.0	3.6	9,175	2.6
1977	220.2	1.0	2,958.6	4.7	2,066.6	3.3	9,381	2.2
1978	222.6	1.1	3,115.2	5.3	2,167.4	4.9	9,735	3.8
1979	225.1	1.1	3,192.4	2.5	2,212.6	2.1	9,829	1.0
1980	227.8	1.2	3,187.1	-.2	2,214.3	0.1	9,722	-1.1
1981	230.1	1.0	3,248.8	1.9	2,248.6	1.5	9,769	.5
1982	232.5	1.0	3,248.8	-2.5	2,261.5	.6	9,725	-.5
1983	234.8	1.0	3,279.1	3.6	2,331.9	3.1	9,930	2.1
1984	237.0	.9	3,501.4	6.8	2,469.8	5.9	10,419	4.9
1985	239.3	1.0	3,618.7	3.4	2,542.8	3.0	10,625	2.0
1986	241.6	1.0	3,721.7	2.8	2,640.9	3.9	10,929	2.9
1987	242.8	0.5	3,853.7	3.5	2,676.6	1.3	10,970	0.4
1988	245.0	0.9	4,024.4	4.4	2,793.2	4.4	11,337	3.3
1989	247.3	0.9	4,142.6	2.9	2,906.7	4.1	11,681	3.0
1990	249.9	1.1	4,168.8	0.6	2,930.4	0.8	11,726	0.4
1991	252.7	1.1	4,120.5	-1.2	2,924.2	-0.2	11,572	-1.3
Projection								
2000	274.9	.7	5,402	2.8	3,827	2.4	13,920	1.6
2010	294.3	.6	7,031	2.6	4,922	2.3	16,730	1.6
2020	312.1	.5	9,166	2.8	6,136	2.4	19,660	1.8
2030	325.5	.3	11,957	2.7	7,660	2.2	23,530	1.9
2040	333.4	.2	15,627	2.7	9,599	2.3	28,790	2.1

— = Not available.

[1] Data for 1929, 1933, 1940 exclude Alaska and Hawaii. Data for 1929 to 1986 are as of July 1.

Sources: Historical data: Council of Economic Advisers. 1993 Economic Report of the President. Washington, DC: U.S. Government Printing Office. Projections: The Wharton Econometrics Forecasting Associates Group Special Report to the Forest Service. (Copy on file with the USDA Forest Service. Washington, DC.) 1985.

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