

The 2005 RPA Timber Assessment Update

RICHARD W. HAYNES, DARIUS M. ADAMS, RALPH J. ALIG,
PETER J. INCE, JOHN R. MILLS, AND XIAOPING ZHOU



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Authors

Richard W. Haynes and **John R. Mills** are research foresters and **Xiaoping Zhou** is a forester, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory, P.O. Box 3890, Portland, OR 97208; **Darius M. Adams** is a professor at Oregon State University, Department of Forest Resources, Corvallis, OR 97331-5703; **Ralph J. Alig** is a research forester, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory, 3200 SW Jefferson Way, Corvallis, OR 97331; **Peter J. Ince** is a research forester, timber demand and technology assessment research, U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, 1 Gifford Pinchot Drive, Madison, WI 53726-2398.

Abstract

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This update reports changes in the Nation's timber resource since the *Analysis of the Timber Situation in the United States* was completed in 2003. Prospective trends in demands for and supplies of timber, and the factors that affect these trends are examined. These trends include changes in the U.S. economy, increased salvage of British Columbia beetle-killed timber, and a stronger U.S. dollar. Other prospective trends that might alter the future timber situation are discussed including changes in U.S. timberland area, reductions in southern pine plantation establishment, impacts of climate change on forest productivity, increased restoration thinning on Western public lands, and the impact of programs to increase carbon sequestration through afforestation. Various management implications such as the influence of prices on forest management, concerns about changes in forest area, the emerging open space issue, forests as a set of commons, seeking to find greater compatibility in forest management, and the stewardship agenda are discussed.

Keywords: RPA assessments, timber projections, supply, demand, management alternatives, resource trends.

Summary: 2005 RPA Timber Assessment Update

The 2005 update base projection envisions a 38-percent expansion in total U.S. forest products consumption to 27.0 billion cubic feet per year by 2050. Per capita consumption will decline slightly below historical averages. Imports will continue to rise but supply a smaller portion of the growth in domestic wood requirements (consumption plus exports), and domestic sources a correspondingly larger share, over the next 50 years than was the case during the previous five decades. At the same time, real product price growth will fall below long-term historical rates for all products.

Product Output and Trade

- Domestic product output will shift toward pulp and paper products, with a declining share for lumber and a steady share for composites.
- The share of imports in U.S. timber consumption will rise from 25 percent to nearly 30 percent over the next decade, then decline to 28 percent by 2050 as domestic production expands.
- U.S. softwood lumber production will expand 20 percent by 2050 relative to recent levels with increases primarily in the South and Pacific Northwest West. Pulp and paper production will increase primarily in the South.
- Canada's share of U.S. lumber consumption will rise to nearly 39 percent in the period to 2015 as salvage of mountain pine beetle (*Dendroctonus ponderosae*) mortality in interior British Columbia proceeds, then decline to 26 percent by 2050 in the face of growing restrictions on allowable cut and strong competition from offshore imports.
- Offshore softwood lumber imports (from Europe and the Southern Hemisphere) will capture nearly 15 percent of U.S. consumption by 2020.
- Oriented strand board (OSB) will largely displace softwood plywood in all markets; hardwood lumber output will show little growth.

Timberland Area and Forest Management Types

- U.S. timberland area will decline 3 percent by 2050 owing primarily to conversion to developed uses.
- Land held by the firms integrated to processing will continue to decline through sales to institutional investors (timberland investment organization and real estate investment trusts).

- The area of planted pine in the South will continue to expand as U.S. timber production is concentrated on fewer acres. By 2050, 54 percent of U.S. softwood harvest will come from 9 percent of the U.S. timberland base.
- Hardwood types will continue to dominate the forest land base in the South (60 percent) and throughout the Eastern United States (67 percent).

Timber Harvest and Inventories

- U.S. softwood growing-stock removals rise 24 percent over the projection, driven by expansion of pulpwood consumption (for OSB and wood pulp).
- Hardwood removals rise 15 percent by 2025, again owing to expansion of pulpwood use.
- Aggregate U.S. forest inventory rises 35 percent for all owners; cut is less than growth over the next five decades.
- For all regions and private owner groups, softwood inventories rise by 2050 despite increasing removals.
- Private hardwood inventories rise sharply by 2050, with continued expansion in the North offsetting modest reductions in the South.

Prices

- Solid-wood products prices will rise at rates less than 0.3 percent per year, well below historical experience.
- Prices of paper and paperboard are expected to decline in real terms.

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Chapter 1: Overview

Introduction

For the past century, national assessments of supply-and-demand trends for timber have helped shape public perceptions of future commodity consumption and have informed discussions of the need for, or the effectiveness of, various forest policies.¹ The Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974 (amended by the National Forest Management Act of 1976) formalized the conduct of these analyses by directing the Secretary of Agriculture to prepare a renewable resource assessment every 10 years. The purpose of this assessment is to analyze the timber resource situation to provide indications of the future cost and availability of timber products to meet the Nation's demands. The analysis also identifies developing resource situations, emerging policy issues, and opportunities that may stimulate both private and public investments.

This report presents the results of the sixth RPA timber assessment in five parts. Chapter 1 sets the context for the 2005 timber assessment update. Chapter 2 describes the major demand and supply assumptions including a description of the models used to make the various projections. Chapter 3 describes the base projections for both the product and stumpage markets. Chapter 4 describes how the base projections would be modified if we considered selected alternative futures. Chapter 5 describes selected implications, conclusions, and emergent lessons.

The map shown on page 212 shows the regions used in the timber assessment. Much of the information presented will be for four summary assessment regions (North, South, Rocky Mountains, and Pacific Coast). Some of the projections and industry descriptions will be provided in subregion detail (Northeast, North Central, Southeast, South Central, Northern Rocky Mountains, Southern Rocky Mountains, Pacific Southwest, Pacific Northwest West (the west side of the Cascade crest in Oregon and Washington, also called the Douglas-fir subregion) and Pacific Northwest East (the east side of the Cascade crest in Oregon and Washington, also called the ponderosa pine subregion). The RPA timber assessment regions correspond to USDA Forest Service regions in the East and aggregations of USDA Forest Service regions in the West. All dollar values for price and costs are given in constant dollars (1982 dollars² unless otherwise noted).

This is the sixth RPA timber assessment.

¹The past five timber assessments were the 1982 timber situation (USDA Forest Service 1982), the 1983 timber update (Haynes and Adams 1985), the 1989 timber assessment (Haynes 1990), the 1993 RPA timber assessment update (Haynes et al. 1995) and 2000 analysis of the timber situation (Haynes 2003). Hereafter these reports will be referred to by the year such as the 1989 assessment.

²The producer price index (1982 = 100) is used as the primary deflator.

Background

This assessment continues a long tradition of forest sector assessments starting in 1878 with F.B. Hough's *Report Upon Forestry* prepared for the U.S. Congress (see app. C of the 1989 RPA timber assessment for a brief history [Haynes 1990]). Much of the impetus for the early timber assessments derived from the observations made by George Perkins Marsh (1864) about human impact on nature. He argued that by deforesting hillsides, Mediterranean cultures had brought about their own collapse as erosion destroyed the natural fertility that sustained well-being (see Marsh 1864). His warnings inspired conservation and reform leading to a century of conservation efforts that included the retaining of common spaces as public lands, increased attention to maintaining agricultural productivity, and, more recently, the use of various incentives such as tax policies and conservation easements to modify private management practices.

Marsh's concerns are manifest in the traditional assessment questions that focus on the dual goals of conserving valuable natural resources while simultaneously meeting demands for timber resources. These questions dominated the timber assessments until the 2000 timber assessment showed that increasing demands for forest products could be met by increases in trade of forest products and increases in U.S. harvest owing to continued expansion in inventory despite decreasing private timberland area.

During the past century, both public and private actions have combined to produce a large and rapidly growing (in volume if not in area) forested estate in the United States. In the public sector, key efforts included the reservation of portions of the public domain as national forests and parks and the provision of fire protection for all forests. On private lands, driven in part by persistently rising stumpage prices and anticipated financial return, owners have invested in forest management and protection that have enhanced forest growth and vigor. This vast forested estate produces a variety of services and goods for society. Some, like the harvestable timber on private lands, are available only to their owners or those who acquire the rights to their consumption. Others, including amenities and ecosystem services such as carbon sequestration, watershed protection, and wildlife habitat, are more like positive externalities being essentially free to those who choose to enjoy or appreciate them and like public goods in that they are not depleted by others' appreciation. Although largely unheralded, the emergence of this estate has conditioned society's views about the treatment of forests and led to expectations that future forests will be equally well-managed and productive, capable of producing a wide array of goods and services.

Changing conditions, however, raise concerns that future U.S. forests may be unable to meet societal expectations for sustainable forest management (see Haynes 2004) and the provision of the variety of ecosystem services expected by increasingly urbanized populations. Expanding global competition has acted to stabilize product prices, and domestic production costs remain high relative to other regions, limiting expected returns to private investment. And public lands, altered by decades of fire suppression and restricted silviculture, are facing declining growth and an array of hazards from catastrophic fire and insect attacks. These changing conditions set some of the context facing those who advocate for improving forest management whether they are landowners, managers, or activists.

Growing public recognition of the array of goods and services provided by forests has changed the nature of governance for forest management actions. Here governance is defined as exercising authority over actions and has evolved in the United States from being market based to a mix of market and regulatory functions (see Haynes et al. 2003 for an expanded discussion of how this has evolved in the Pacific Northwest). For federal forest lands, formal forest plans are developed to implement forest management. These involve formal processes, broad management objectives, and increased stakeholder participation. Management on private forest lands is determined by a mix of market and regulatory functions. Different regulations (e.g., state forest practice acts) influence both the design and application of forest management practices.

For the most part, these planning processes and regulations reflect a manifestation of public concern about forest lands or forest conditions. These evolving public concerns have been a determinant of forest policies, and since the early 1990s, forest policy has increasingly been internationalized (see the discussion in Brooks et al. 2001) in both the context of economic globalization and sustainable development. Currently, much of the international debate on forest policy deals with different suggestions about the need to supplement market-determined actions with processes that endeavor to find an equilibrium among interests advocating environmental protection, employment that contributes to economic prosperity, public access, and social justice (see Andersson et al. 2004 for a variety of perspectives on these issues).

The combination of resource, market, regulatory, and societal changes set the context for assessing prospective trends in timber supply, demand, and resource conditions. This assessment will provide input to the discussion about measures to further forest-based conservation over the next several decades. It also provides background to the following questions: How do we prevent our open spaces from

dwindling away? What tools and approaches do we have to help landowners and managers stay on the land and to manage it sustainably? How can there be social or civic engagement that seeks to increase environmental protection, rewards responsible behavior of landowners and managers, respects property rights, and increases economic prosperity?

Forces Shaping Demand and Supply

The U.S. demand for forest products is varied and large (it averages 71.4 cubic feet or about 1,800 pounds per person per year) and is shaped by economic forces and evolving consumer tastes. In general, the per capita consumption of wood products has been relatively constant over the past 50 years as shown in figure 1. Consumers value wood in a variety of uses because of its abundance and versatility. Since World War II, the trends among the three main types of products (solid wood, pulp, and fuelwood) have changed, reflecting changes in tastes, relative prices, the attractiveness of wood for home and building construction, and changes in the role of wood as an industrial commodity. The United States has undergone significant shifts in its competitive position relative to other country markets leading in the last decade to increased imports of wood products to satisfy consumer demands.

Per capita consumption of forest products is about 1,800 pounds per year.

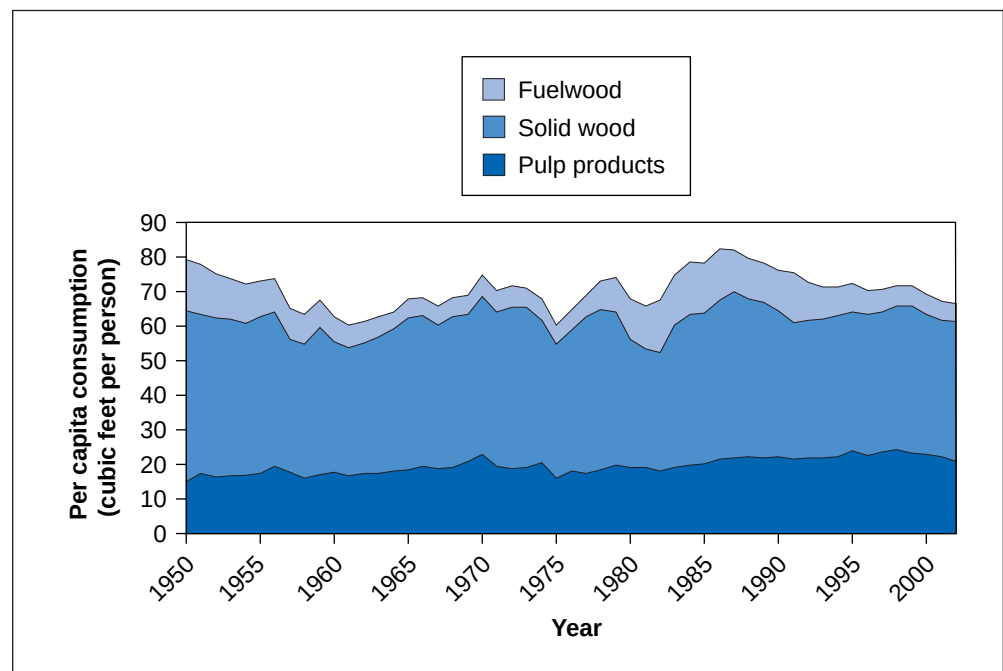


Figure 1—Per capita consumption of timber products by major product.

The supply of wood has been shaped by a changing array of forces influencing land use and forest management. In the past 200 years, these forces have included clearing land for agricultural uses while using the wood for products such as rails for fences and logs and lumber for homes and barns. After the Civil War, concerns arose about potential timber famines from rapid land clearing, rising industrial use of wood, and settlement of the West (see Marsh 1864). In 1866, these concerns were addressed in the first study of forest conditions (Starr 1866) and by the development of several federal agencies that eventually evolved in 1905 to the U.S. Forest Service.

The advent of forest management focused the development of land management strategies on an understanding of the relations between timber inventories, their attributes, land management objectives, and timber markets. Since World War II, much attention has been given to the development of explicit forest regulation models (both area and volume approaches) and to the notion of timber availability as a function of owner objectives and an array of stand and market conditions. Various state initiatives that have increased regulation of private timberlands have influenced the behavior of timberland owners over the past 20 years (see Greene and Siegel 1994 for a discussion of the various state regulatory efforts).

The forest products industry remains an important manufacturing industry in the United States. In 2002, roughly 16.5 billion cubic feet of roundwood timber products were harvested in the United States (Howard 2003). Overall, roundwood timber remains one of the highest valued agricultural commodities differing in importance among regions. In the North American Industry Classification System (NAICS), the timber industry comprises 3 of the 21 manufacturing industry categories in the U.S. economy, but employment has fallen since the late 1990s mirroring overall trends in manufacturing employment. In 2002, in terms of total value of industry shipments, paper manufacturing (NAICS 322) ranked 9th at \$152 billion, wood products manufacturing (NAICS 321) ranked 16th at \$88 billion, and furniture and related product manufacturing (NAICS 337) ranked 17th at \$74 billion. In 2002, these three timber processing industries combined accounted for slightly over 8 percent of all manufacturing shipments and nearly 11 percent of U.S. manufacturing employment. Total employment in 2002 by the timber processing industries totaled more than 1.6 million people, with the Eastern States having the largest timber-processing industry employment.

The U.S. Forest Sector in the Context of Global Forest Resources and Wood Use

Forests in the United States account for about 6 percent of world forest cover (table 1). World forests cover nearly 9.6 billion acres (just under 3.9 billion hectares) of the Earth's surface, about 30 percent of the land area. Almost 84 percent of the world's forests are in some form of public ownership (FAO 2005). The world's forest land includes all types of forests: closed and open natural forest, forest plantations, and other forest land. Shrub, scrub, and brushland cover about 2.5 billion additional acres (about 1 billion hectares). This forest land can be broken into four broad forest types: tropical, subtropical, temperate, and boreal/polar. As table 1 shows, the proportions among these types differ considerably among regions.

Table 1—Population, population growth rate, and forest area in 2000, and average annual change in forest area 1990–2000, by geographic region

Region	Population		Total forest area ^b	Forest types				Per capita forest area	Average annual change, 1990–2000
	Total ^a	Annual growth rate 1995–2000		Tropical	Sub-tropical	Temperate	Boreal/polar		
	Millions	Percent	Million acres	Percentage of region's forest area				Acres/person	Percent
Asia	3,634	1.4	1,354	61	23	14	2	0.37	-0.1
Africa	767	2.4	1,606	98	1	0	0	2.09	-8
Europe ^c	729	0	2,566	0	5	22	73	3.52	.1
North and Central America	478	1.6	1,356	15	16	29	40	2.84	-1
United States ^d	276	.8	558	0	37	48	15	2.02	.2
South America	341	1.5	2,188	96	2	1	0	6.42	-4
Oceania	30	1.3	487	62	30	8	0	16.22	-2
World	5,978	1.3	9,556	52	9	13	25	1.60	-2

^aData for 1999.

^bData do not include "other wooded land."

^cIncludes Russian Federation.

^dUnited States data are included in North and Central America.

Source: Food and Agriculture Organization (2003). Original area data are metric, converted to acres.

Half of the world's forests, and 80 percent of the world's population, are in Asia, Latin America, and Africa (table 1). These are predominantly, although not exclusively, developing countries, and the forests are predominantly, although not exclusively, tropical. About one-fourth of the world's forests, nearly half of the world's tropical forests, and more than half of the world's wet tropical forests (rain forest, and moist lowland forest) are in Latin America. Nearly 58 percent of the world's forests are in temperate zones; the boreal region in the temperate zone accounts for more than one-third of the world's forests.

Between 1990 and 2000, the area of forest worldwide declined by 2 percent, while world population increased by nearly 15 percent. By 2000, world forest cover (excluding other wooded land) was 1.6 acres (0.65 hectare) per capita, but was only about one-third of the world forest endowment in the early 1900s (Gardner-Outlaw and Engelman 1999). Deforestation is still occurring at rates estimated from 0.3 to 0.6 percent per year (27.2 million to 49.4 million acres [11 million to 20 million hectares] per year) mostly as a function of agricultural expansion, especially in densely populated countries. Since 1987, the Brundtland Commission report (WCED 1987)³ has set the context for discussions of sustainable development. In those discussions, the forest sector is receiving greater attention because of the growing emphases on environmental protection, food security, and poverty alleviation (FAO 2003). At the same time, there are fundamental institutional changes underway because of restructuring mostly involving decentralization, shifts in ownership patterns that result in property rights devolving to individuals and communities, and wider recognition of the multiple benefits that forests provide (FAO 2003).

About 4.8 percent of the world's forests are plantation forests (FAO 2003). Plantations are estimated to account for about 7 percent of the forest area of the United States. They are an important component of industrial timber production in the temperate zone and are a source of both industrial timber and nonindustrial products in the tropical zone. Temperate zone plantations, predominantly coniferous species, are mostly managed for industrial wood products and are the consequence of reforestation rather than afforestation. Native species account for the majority of the plantation area in most Northern Hemisphere, temperate zone countries. In the temperate zone of the Southern Hemisphere, most plantations are fast-growing, exotic species with a shorter production cycle than that of native species. Production from exotic softwood plantations in the Southern Hemisphere is increasing and is expected by the year 2020 to be as much as four times current harvest. Worldwide, plantations are projected to account for more than 40 percent of world timber harvest by 2030 (ABARE 1999).

Forest management goals differ among countries, but in the developed countries these goals increasingly recognize that forests are valued for a variety of goods and services including both the production of industrial commodities and environmental services (such as maintaining biodiversity and sequestering carbon).

³The Brundtland Commission Report defined sustainable development as meeting "the needs of the present without compromising the ability of future generations to meet their own needs."

In developing countries, forests are predominantly a source of fuel and land for food production, although there is growing appreciation of their role in providing local as well as regional and global environmental services. These differences in basic needs and values contribute to the challenge of finding a basis and means for implementing global agreements on management and use of forests.

Wood consumption in the United States (on a per capita basis) is similar to other developed, wood-rich countries (for example, Canada, Sweden, Finland, Norway, and Austria), about twice the average for all developed countries, and more than three times the world average for developing countries (see Brooks 1993). As in other wood-rich countries, consumption of timber in the United States is primarily (91 percent in 2000) in the form of industrial raw material (FAO 2003).

Chapter 2: Assumptions and Projection Methods

Introduction

Projections of the U.S. forest sector in this 2005 update are based on a set of underlying assumptions about future developments in the overall economy, forest products trade, and conditions affecting timber supply on public and private lands. The following sections summarize key aspects of these conditions with special emphasis on differences from the 2000 Resources Planning Act (RPA) timber assessment.

Macroeconomic Activity

The starting point for forest sector projections is an estimate of future general activity in the U.S. economy.¹ Levels of aggregate output and income, such as gross domestic product (GDP) or disposable personal income, are critical to projections of future demand for paper and paperboard products because they are widely used across many sectors of the economy. Estimates of activity in construction, particularly new residential construction and residential upkeep and alteration, are important determinants of future demand for the solid wood industry.

The macroeconomic outlook (see table 2) entails the following major developments.²

- Labor force growth will decline, averaging only 0.8 percent over the period to 2050 because of the sharp drop in population growth after the baby boom of 1946–66. Growth in the core population (ages 18 to 65) will fall below 1.0 percent to average 0.5 percent.
- Labor productivity (GDP/employed worker) will average 1.1 percent over the period to 2050, roughly equivalent to average productivity growth since 1960.
- Consumer price index (CPI) inflation will stabilize at about 3.0 percent per year owing to long-term balance in the federal budget and an absence of materials cost pressures.

¹The basic structure of the macroeconomic forecast was developed for the USDA Forest Service by the USDA Economic Research Service, Commercial Agricultural Division. On file with: Linda Langner, WO RVUR Staff, Forest Service, RP-C 4th floor, P.O. Box 96090, Washington, DC 20090. Street address is 4th floor RP-C, 1601 North Kent Street, Arlington, VA.

²The projection presented here was based on an earlier U.S. population projection discussed by Day (1996) completed prior to the 2000 census. Subsequent projections (USDC BC 2004) show somewhat higher levels of projected population and population growth. The revised 2050 total resident population projection from USDC Bureau of the Census (2004) is 6.2 percent higher than the estimate shown in table 2 (420 million versus 394 million), and the projected population growth rate is 0.80 percent compared to 0.69 percent in the earlier projection. Given the assumptions used to generate our GDP forecast, this difference would raise our GDP projection by roughly 0.1 percent per year.

Table 2—Population, gross domestic product, and disposable personal income in the United States, selected years, 1950–2002, with projections to 2050

Year	Population		Real unchained gross domestic product		Real unchained disposable personal income		Labor force participation rate	Civilian labor force annual growth	Labor productivity annual growth
	Annual growth		Annual growth		Annual growth				
	Millions	Percent	Billion 1987 dollars ^a	Percent	Billion 1987 dollars ^a	Percent			
1950	151.7	1.7	1,419	8.7					
1955	165.3	1.8	1,768	5.6	1,182	7.4	59.2	2.0	3.5
1960	180.8	2.1	1,971	2.2	1,377	2.4	60.0	1.9	.3
1970	194.3	1.3	2,874	0	2,095	3.1	61.2	2.6	-2.5
1980	226.5	1.0	3,776	-.5	2,644	-2.3	65.7	1.9	-2.4
1981	229.5	1.3	3,843	1.8	2,659	.6	65.4	1.6	.2
1982	231.7	1.0	3,760	-2.2	2,662	.1	65.3	1.4	-3.5
1983	233.8	.9	3,907	3.9	2,769	4.0	65.1	1.2	2.7
1984	235.8	.9	4,149	6.2	2,918	5.4	65.5	1.8	4.3
1985	237.9	.9	4,280	3.2	2,997	2.7	65.9	1.7	1.4
1986	240.1	.9	4,405	2.9	3,123	4.2	66.5	2.1	.8
1987	242.3	.9	4,540	3.1	3,206	2.6	66.9	1.7	1.3
1988	244.5	.9	4,719	3.9	3,340	4.2	67.1	1.5	2.4
1989	246.8	.9	4,838	2.5	3,462	3.7	67.5	1.8	.7
1990	249.6	1.1	4,897	1.2	3,528	1.9	68.1	1.6	-.4
1991	253.0	1.3	4,868	-.6	3,518	-.3	67.5	.4	-1.0
1992	256.5	1.4	4,979	2.3	3,644	3.6	67.6	1.4	.9
1993	259.9	1.3	5,135	3.1	3,700	1.5	67.3	.8	2.2
1994	263.1	1.2	5,344	4.1	3,846	3.9	67.4	1.4	2.6
1995	266.3	1.2	5,513	3.2	3,954	2.8	67.2	1.0	2.2
1996	269.4	1.2	5,710	3.6	4,071	3.0	67.3	1.2	2.3
1997	272.6	1.2	5,966	4.5	4,215	3.5	67.6	1.8	2.7
1998	275.9	1.2	6,215	4.2	4,462	5.8	67.3	1.0	3.1
1999	279.0	1.2	6,492	4.4	4,594	3.0	67.3	1.2	3.2
2000	282.2	1.1	6,730	3.7	4,817	4.8	68.2	2.3	1.3
2001	285.1	1.0	6,780	.8	4,910	1.9	67.7	.8	-.1
2002	287.9	1.0	6,906	1.9	5,061	3.1	67.3	.8	1.1
2003	290.8	1.0	7,117	3.0	5,178	2.3	67.3	1.2	1.8
2010	297.7	.8	8,018	2.1	5,693	1.9	74.1	1.0	1.1
2020	322.7	.8	9,750	2.0	6,922	2.0	74.1	.9	1.1
2030	346.9	.7	11,671	1.8	8,266	1.4	74.3	.7	1.1
2040	370.0	.6	13,889	1.8	9,861	1.8	74.6	.6	1.1
2050	393.9	.6	16,569	1.8	11,781	1.8	76.0	.7	1.1

^a Unchained (see glossary, chain weighted) GDP (gross domestic product).

Sources: GDP, labor force participation rate, labor force and productivity growth projections from U.S. Department of Agriculture, Economic Research Service, Commercial Agriculture Division (see footnote 1 in chapter 2). Historical population data from USDC BC 1997, projections from Day 1996.

- Long-term nominal interest rates will stabilize at about 5.0 percent despite near-term growth in the federal debt relative to GDP and in trade deficits because of a higher savings rate from an aging population, low anticipated inflation, and the expected continued attractiveness of the United States for foreign investments. Low inflation will reduce the risk premium on long-term bonds, and the term structure of interest rates will flatten somewhat. Higher savings rates will increase the supply of loanable funds. The long-term interest rate will drop to 5.5 percent stimulating capital spending and allow a return to long-term labor productivity growth rates of roughly 1.1 percent.
- Combining productivity and labor force growth, real GDP will grow at about 2.0 percent per year in the period to 2050.

Population and Labor Force

Population change is one of the primary drivers of long-term economic growth because it determines in large part the growth of the labor force. In the United States, as in other developed countries, population growth has slowed steadily over the past two to three decades. In the projection, growth of the U.S. adult population (over 18 years) slows to roughly 0.6 percent by 2040 and remains at that rate through 2050. Growth of the core population (ages 18 to 65), from which the bulk of the labor force is recruited, will decline from about 1 percent in recent years to near zero by 2025, then rise slowly until 2050. At the same time, the population will continue to grow older on average. The ratio of persons over 65 years to the core population (persons age 65+/persons age 18–65) will rise from about 21 percent today to nearly 37 percent by 2040.

These demographic trends imply declining growth in the labor force. They also suggest that future patterns of labor force participation will play an important role in long-term U.S. economic growth. Labor force participation rates have been relatively stable in the United States since the late 1980s (see table 2). The projection envisions sharply rising rates in the near term, with lengthening periods of working years (retirements well beyond age 65), continued growth in female participation, and an increase in the currently static male participation rates (induced in part by rising compensation). But even with these higher participation rates, growth in the civilian labor force (and employment) averages only 0.8 percent per year over the full projection (table 2). After 2030, employment growth drops between 0.6 and 0.7 percent annually, the lowest rates since the 1932 Depression.

Productivity

Long-term growth in labor productivity depends on investment in production technology and facilities, research and development, domestic infrastructure, and education. Although productivity expansion has been quite rapid in recent years, the projection calls for an average productivity growth of 1.1 percent over the period to 2050. This is roughly equal to the average growth of productivity since 1960. Although lower than growth in recent experience, the projection is based on positive signs: low raw material input cost growth, likely expansion in personal savings rates as the population ages, and low overall inflation. The rate is no higher, on the other hand, because of the aging population (and loss of skilled workers) and, accompanying an aging population, a shift away from durable goods consumption toward services.

Gross Domestic Product

Gross domestic product growth is the sum of growth rates of the labor force and labor productivity. As shown in table 2, the projection calls for a post-2000 real GDP growth rate of nearly 2.0 percent. In contrast, the average post-World War II GDP growth rate has been about 3.4 percent. The primary reason for the lower projection is the slowdown in labor force growth. Despite marked projected increases in participation rates, labor force growth falls steadily in the projection. In this context, per capita GDP will continue to increase steadily, but maintaining aggregate GDP growth in the neighborhood of the post-World War II average would require productivity growth more than double our historical experience.

Prices, Inflation, and Interest Rates

The core rate of annual consumer price inflation is projected to be 3.0 percent, whereas producer prices grow at 2.5 percent per year. This is a stable inflationary environment because it means less uncertainty about the future for investors. As noted above, this is based in part on an assumption of limited growth in key raw material and energy costs. Mineral prices are assumed to rise at less than 2 percent, and agricultural prices will continue to fall in real terms. Real crude oil prices are assumed to rise at about 2 percent per year, a modest rate of increase that will be largely offset by likely gains in energy efficiency and use of renewable energy in sectors such as pulp and paper.³ Between 1982 and 1998, real petroleum import

³ Recent petroleum price projections are consistent with this view. For example, the Energy Information Administration's *Annual Energy Outlook 2005* (USDE EIA 2005) reported a range of future real world oil price projections, the highest of which (termed, "High A") shows a 2003–2025 growth rate of 1.6 percent.

prices in the United States declined by 3.4 percent per year on average (real domestic prices declined by nearly 6 percent per year). Recent real price increases (beginning in 1999) are considered to be due, in part, to (1) long-term efforts by the Organization of Petroleum Exporting Countries (OPEC) to recover the loss in real petroleum prices over the past 25 years and to maintain values in the future, (2) particularly rapid expansion of energy consumption in developing economies, and (3) conflicts in the Middle East.

Real long-term interest rates are projected to average 2.5 percent after 2010, or 5 percent in nominal terms after adding inflation (2.5 percent) in the all-commodity producer price index (PPI). The long-run real Treasury bill rate (short-term interest rate) is expected to range near 1.5 percent (4.0 percent nominal)—close to its average since 1970 (averaged over years with inflation less than 5 percent).

Housing

Housing starts of all types are projected to remain at relatively high levels, reflecting, in part, growth in the number of households.⁴ The number of new households will average 1.4 million per year over the next 50 years, while housing starts will average 1.9 million per year. This compares to roughly 1.4 million new households and 1.8 million housing starts per year in the period 1963-2003. The gap between housing starts and new households does not narrow in the future because an aging, but healthy, retired population will be more likely to acquire second homes, and the aging housing stock will require higher than historical replacements of existing units.

Single-family dwellings will account for most of the increase in housing starts relative to new households. The decreasing proportion of young adults in the population will lead to less demand for multiple-family housing (apartments). And increasing income will raise the likelihood that home ownership will be attainable. The upward shift in the single-family homes projection in 2010-2015 derives from the housing of the “Baby Boom echo” (children of the Baby Boom). The increase after 2030, in contrast, depends on growth in numbers of second homes and the replacement of older housing units in the stock.

The average size of single-family homes doubled between 1953 and 2003, while multifamily units increased in size by roughly 50 percent and mobile homes more than tripled in average size. The projection envisions a stabilization of the average size of all types of units at near current levels until 2030 or 2040. As the population in older age cohorts (with smaller average numbers of occupants per household)

⁴Details of the housing model and an analysis of housing forecasts are given in Montgomery 2001.

begins to rise rapidly over the next four decades, the expanding wealth that has led to increased house size in the past is expected to be reflected instead in multiple-dwelling-unit ownership. After 2030–2040, sizes begin to rise again but at a reduced rate.

Expenditures on residential upkeep and alteration depend heavily on family income, age of household occupants (middle-aged householders spend more) and an array of interest rate, inflationary expectation, and taxation considerations. In the projection, continued steady income growth and an aging population drive residential upkeep and improvement spending to roughly 80 percent above its current levels by 2050. Although this is a substantial increase, it actually entails roughly constant expenditures per household until 2030, in amounts no larger than observed on average since 1986. After 2030, expenditure per household begins to rise slowly, reflecting continued growth in income.

International Trade in Forest Products

The past decade has seen two fundamental shifts in U.S. forest products trade. First, there has been a shift in the relation between import and export levels. Second, there has been a shift in the importance of trade across geographic regions in the United States.

In the past, there were periods when the values of imports and exports were either in balance or rising simultaneously, but since 1994, the value of exports has been in a gradual decline while the value of imports has continued to increase (see fig. 2a). Figures 2b and 2c illustrate trends in values of imports and exports for pulp, paper, and paperboard (2b), and solid wood products (2c). A decline in the value of solid wood product exports began in the early 1990s around the same time that pulp, paper, and paperboard exports peaked and leveled out, with notable declines in log and high-quality lumber exports to Pacific Rim countries. The impact of a highly valued dollar in the late 1990s on paper exports to Western Europe and the downturn in Asian economies starting in 1997 are cited often as reasons for recent shifts in pulp, paper, and paperboard trade. The slowdown of the Japanese economy during the 1990s is often cited as a reason for the collapse of the log export market (see Daniels, n.d.). In addition, during this period, China has emerged as a major global economy developing a large paper manufacturing capacity, further reducing U.S. exports.

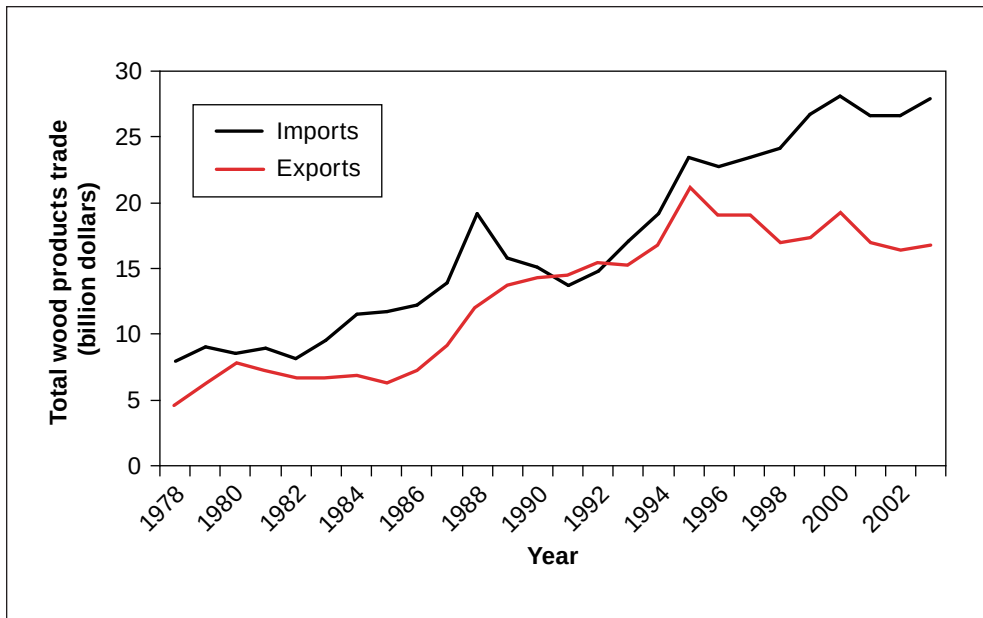


Figure 2a—United States wood products trade balance, 1978–2003.

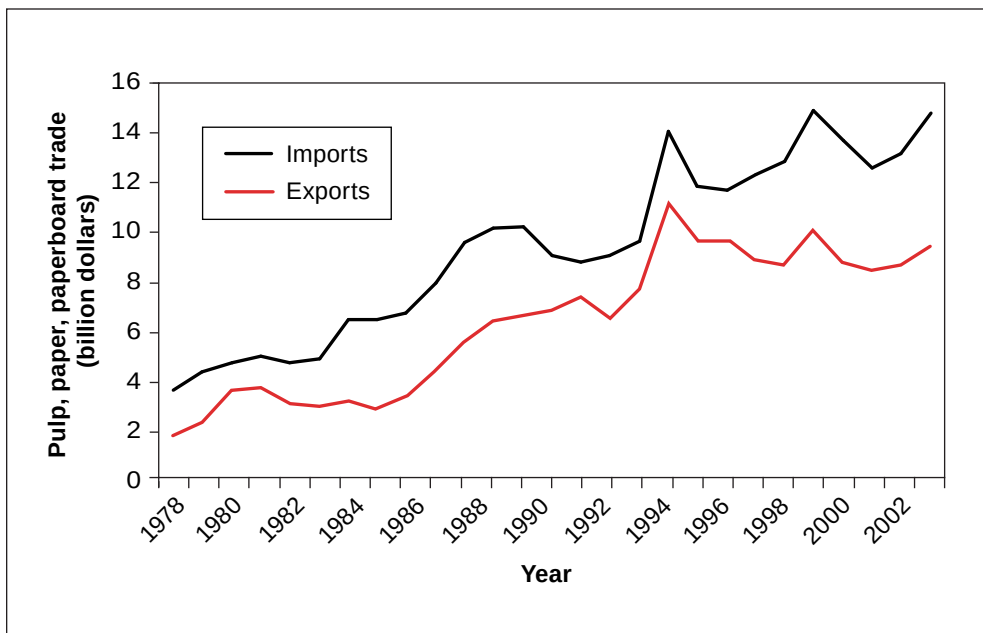


Figure 2b—United States pulp, paper, and paperboard trade balance, 1978–2003.

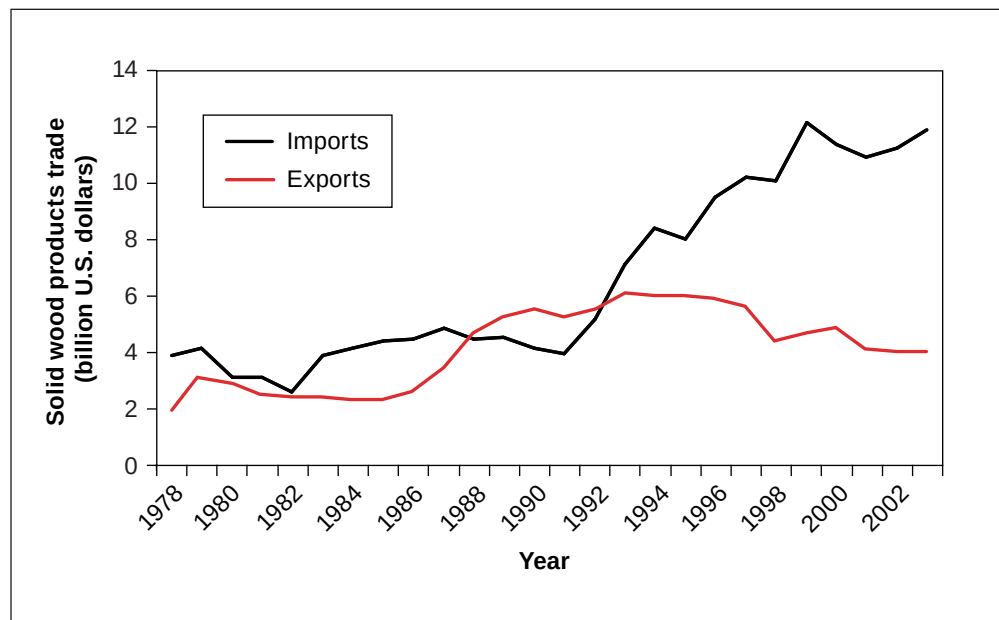


Figure 2c—United States solid wood products trade balance, 1978–2003.

The rise in imports has come from an increasing variety of suppliers to the U.S. market (see fig. 3a). For example, we now import softwood lumber from a variety of European countries that are relatively new in U.S. markets. Their share is growing, but Canada still supplies about 90 percent of all lumber imports. This is also true for fiber products, but Canada has been less dominant among the suppliers than in the solid wood products (see fig. 3b).

The second shift reflects changes in the origin of exports and where imports enter the United States. These changes are summarized in table 3 and reveal the relative shifts among U.S. regions. For example, although the bulk of imports still arrive in the North (reflecting both its population and proximity to Canada), an increasing amount is arriving at Southern ports. Among exports, the declines in the Pacific Northwest reflect changes in industry structure associated with reductions in timber harvest on federal timberlands and the decline in the Japanese economy. Federal timber was generally of relatively high quality, and some was manufactured into high-value products for Japanese housing construction (there have been prohibitions on the export of federal logs since the mid 1960s). The increases in exports from the North reflect increased trade with Canada and the European Union. The higher participation of the Pacific Northwest in export markets generally raised stumpage prices in the region relative to other regions, giving higher returns to land management. Stumpage prices in the Pacific Northwest have decreased as export markets have declined. There has been speculation that the increases in lumber

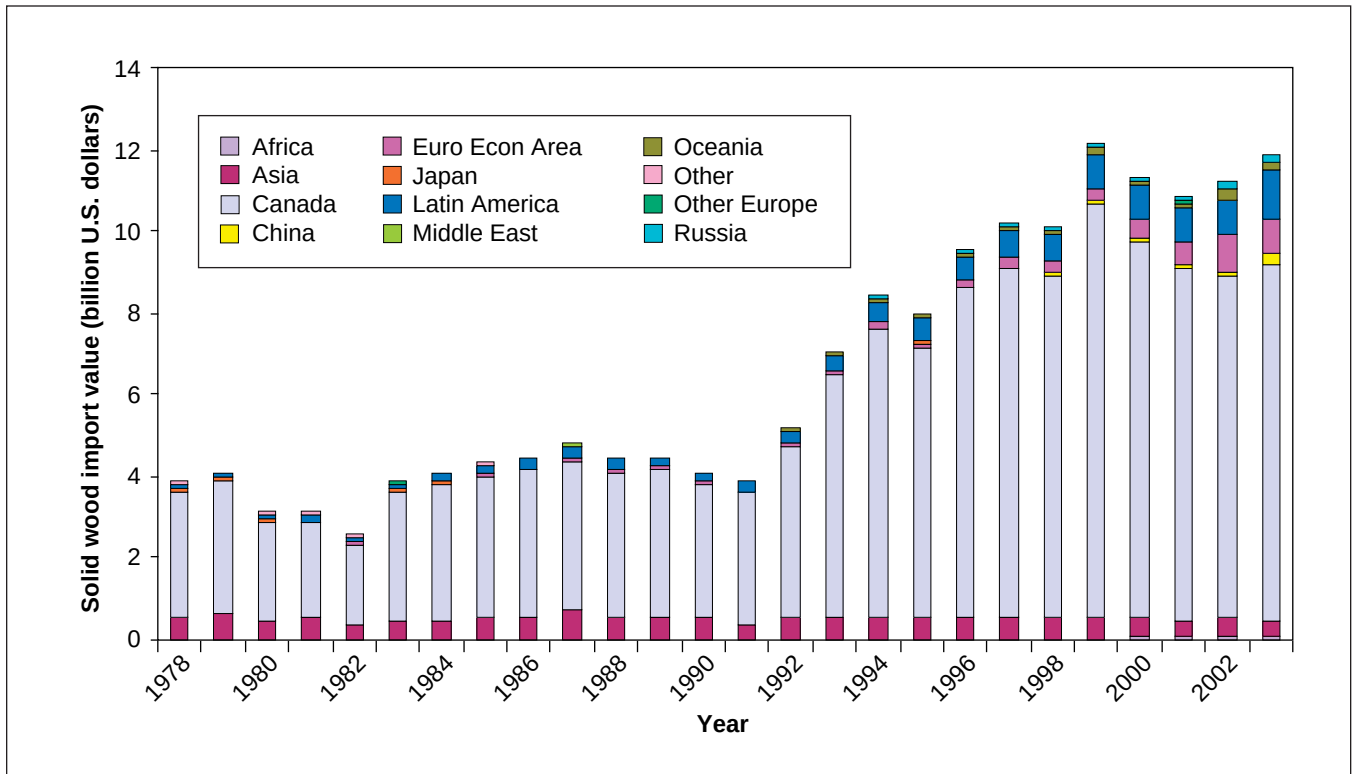


Figure 3a—Total value of U.S. wood product imports by source, 1978–2003.

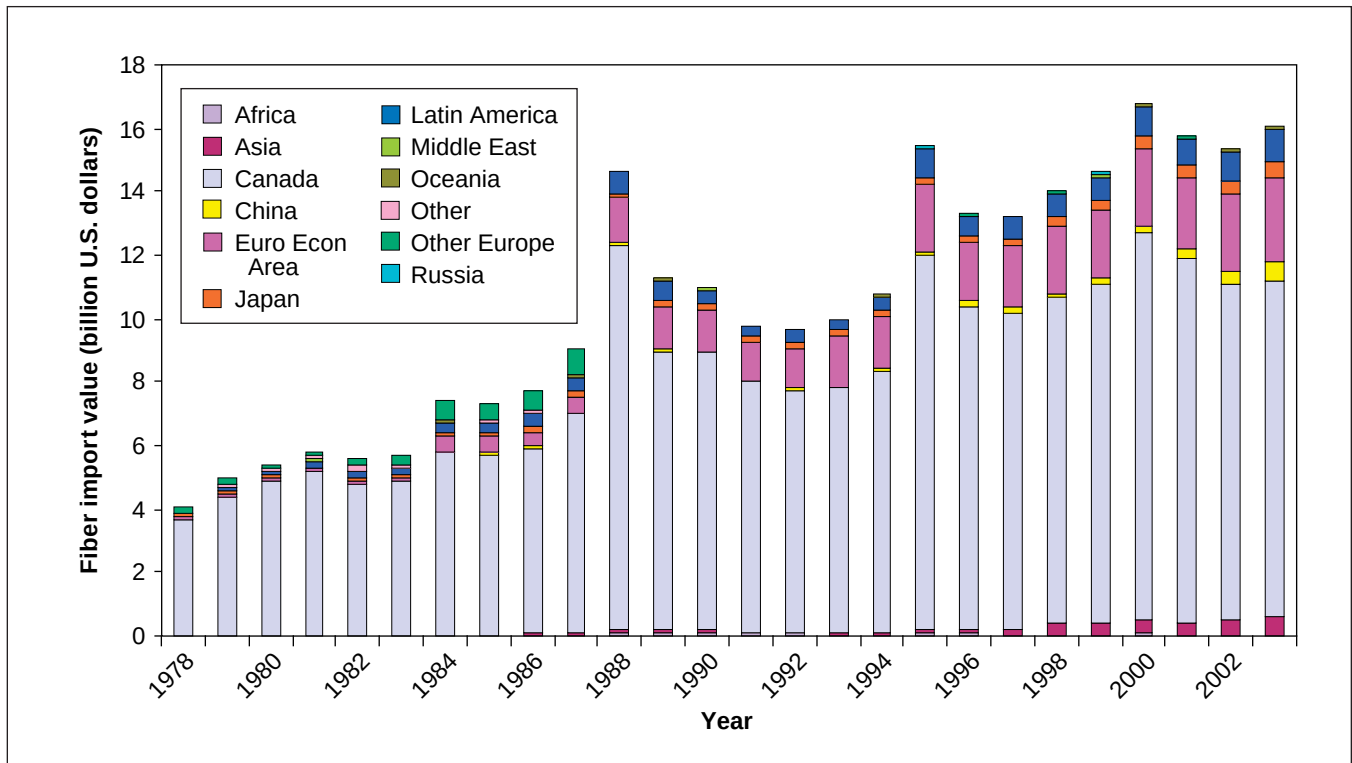


Figure 3b—Total value of U.S. fiber product imports by source, 1978–2003.

Table 3—Value of all wood products imported to and exported from U.S. customs districts

	Customs districts				
Year	Northern	Southern	Pacific Northwest	Other Western	Total
	Million dollars				
Imports:					
1978	5,435	923	1,117	465	7,940
1986	8,227	1,793	1,294	873	12,187
1991	9,641	1,549	1,621	892	13,703
1997	16,337	2,645	3,011	1,440	23,433
2002	17,396	4,045	3,023	2,143	26,607
Exports:					
1978	861	1,415	1,901	357	4,534
1986	1,079	2,737	2,680	609	7,105
1991	2,662	6,063	4,547	1,444	14,716
1997	4,551	8,521	4,027	1,868	18,967
2002	5,234	7,108	2,214	1,866	16,422

Source: Daniels, n.d.

imports in the past decade have been the primary reason that lumber prices have remained relatively stable during a strong housing market.

Beyond the noted shifts in the values of imports and exports over the past decade or so, there was also a noteworthy shift in the locus of growth in global demands for forest products, particularly for pulp, paper, paperboard, hardwood lumber, and nonstructural wood panel products, as the concentration of growth in manufacturing capacity has generally shifted from the United States to other global regions. Over the past decade, foreign inflows of capital, low interest rates, a doubling of home mortgage debt, and rising home prices facilitated a housing construction boom that helped the United States to retain its global lead in demand for softwood lumber and structural wood panels (used chiefly in housing construction). At the same time, declining growth in U.S. manufacturing and the shift of some industrial manufacturing to other countries contributed to a shift in global wood product demands. For example, as growth in manufacturing capacity moved to other countries, so did growth in demand for paper and paperboard (used heavily in packaging and print advertising). Thus, world paper and paperboard output and consumption increased by 26 percent in the decade from 1994 to 2003 (DeKing 2004), whereas there was essentially no net increase in U.S. paper and paperboard output and only a small net increase in U.S. consumption (3 percent) over that decade. Similarly, as production of wood furniture shifted over the past decade from North America to other global regions such as Asia (and particularly China) growth in U.S. demands for hardwood lumber and nonstructural wood panels peaked and then fell, as demands shifted to other regions. In general, economic

globalization throughout manufacturing is contributing to global realignment of growth in raw material demands, with countries such as China emerging in the 21st century as growth leaders in wood raw material and industrial wood product demand (Ince et al., in press). Except for the buoyant housing sector, growth in U.S. demand for wood fiber and wood products has generally fallen far behind other growth leaders (such as China) over the past decade. Many of the shifts observed in the last decade will continue. For example Turner et al. (2005) predicted that China will be the world's largest market for raw wood and intermediate and final forest products. They predicted that the United States would increase its share of global exports but that Finland, Austria, Latvia, Chile, Republic of Korea, and New Zealand would also increase their market share.

Fuelwood Demand Projections⁵

In the United States, roundwood use for fuelwood declined from 3.53 billion cubic feet (bcf) in 1986 to 1.52 bcf in 2002, but is projected to increase to 3.46 bcf by 2050. Industrial, commercial, and utility use of roundwood for fuel is projected to increase steadily from 0.18 bcf in 1996 to 0.52 bcf in 2050 owing to increasing non-wood fuel prices for these sectors. Residential use is projected to decline, however, from 2.95 bcf in 1986 to 2.15 bcf in 2000 then slowly increase to 2.94 bcf in 2050.

The growing-stock portion of roundwood used for fuel is assumed to remain relatively constant over the projection period at 27 percent. The proportion of growing stock used for fuel that is hardwood is projected to decline from 77 percent in 1996 to 66 percent in 2050.

Timber Supply Assumptions

The supply of timber derives from harvests on national forest, other public, forest industry, and nonindustrial private ownerships. Harvest from public landowners is set by policies of the respective agencies and in the long term is generally not sensitive to prices or other timber market conditions. In the 2005 update, public

⁵ National projections of roundwood used for fuel have been constructed in three steps. First, USDA Forest Service estimates of roundwood used for fuel in 1986 (Waddell et al. 1989) are linked by conversion factors to Department of Energy (DOE) estimates of total wood energy use in each sector—residential, industrial, commercial, and utility. Only a portion of wood energy in each sector comes from roundwood; mill residue and black liquor are excluded. Second, DOE projections of wood energy use to 2020, by sector, (USDE EIA 1997, reference case) are extended to 2050 by using GDP to project total energy use in each sector. Third, projections of roundwood use are made for each sector by multiplying the extended projections of wood energy use in each sector by the portion that is made from roundwood. Projections of roundwood use for fuel are subdivided by region, and into hardwood or softwood, growing stock or other source by using Forest Service estimates (Powell et al. 1993, Smith et al. 2001, Waddell et al. 1989).

harvests for the base projection follow a set of fixed patterns designed to mimic current agency timber programs. Timber supplies from the two private landowners, in contrast, are influenced by market activity and are modeled, in part, as functions of private timber inventory levels and stumpage prices. That is, as inventories and prices rise so should harvest levels. Private harvests also depend on the area of private land available for timber production (timberland) and the forest cover types on this land, trends in future silvicultural practices and management investment, the efficiency of harvest utilization, and the relation between the volume of timber harvested for products and the volume of timber removed from the live growing stock in the forest.

Projected Area Changes for Land Uses and Forest Management Cover Types

Change in total timberland area is the net result of the conversion of timberland to nonforest uses and the shifting of nonforest uses to timberland by natural reversion or afforestation. Ownership changes in the timberland base may also occur and result in different land management objectives or new owners with different resources available to invest in forest management. Changes in the areas of forest cover types often reflect differences in land management objectives among owners and indicate the differential influence of natural and human-caused management forces.

Projections of area changes for the timberland base were made for major regions in the United States and within regions for two private forest ownership classes—forest industry (FI), and nonindustrial private forest (NIPF). Public timberland projections were developed from estimates provided by public agencies and modified for recent harvest trends (see Adams et al. 2006). The private area projections involve two major steps: (1) estimation of future shifts in the major land uses (among forestry, agriculture, urban or developed, and other), and (2) projection of changes in area by forest cover type (e.g., among planted pine, natural pine, and an array of other types in the South or among Douglas-fir and other coniferous and hardwood types in the Pacific Northwest West). Details of the methods are described in Alig et al. (2003), Alig and Butler (2004), and Haynes (2003).

These projections maintain the traditional classifications of “forest industry” and “nonindustrial private” timberland ownerships, although the nature of firms in the FI class is rapidly changing. In the past, FI has been composed of firms that own and grow timber for industrial use and own processing facilities. These FI timberlands are managed with a primary objective of timber production. The emergence of timberland-holding firms with timber production objectives (timber

investment management organizations [TIMOs] and real estate investment trusts [REITs]) that are not linked to processing facilities has created some difficulties in this traditional taxonomy. Lacking processing facilities, these firms would be grouped in the NIPF class. Yet their timber management behavior is more closely akin to the integrated firms in FI. Shifts from traditional integrated FI ownership to the TIMO/REIT class have been extremely rapid in the late 1990s and early 2000s, and it is likely that the future will see still further decline in traditional integrated FI ownership.

In the current projections, these classification changes and associated timber management and harvesting behavior are treated in two ways. We do not employ a separate TIMO/REIT owner category and do not project future spinoffs to the TIMO and REIT classes. Our inventory database did not allow this split, although changes underway in the inventory process will enable this distinction in future assessments. As a result, lands in the FI class in the inventory at the start of the projection are not differentiated as to their linkage to processing over the projection. All lands in the FI class are assumed to be managed in similar ways and to respond to market price signals in a similar fashion regardless of their link to processing. Also in the inventory at the start of the projection, some of the lands in the NIPF group are in TIMO/REIT ownership, having been shifted to NIPF in earlier inventory measurements because they lacked processing facilities. In general, this group is classed as “miscellaneous corporate” within the NIPF category. In the projections, silvicultural investments on these lands are assumed to follow more closely the behavior in the FI group, whereas harvest responses to price and other market signals are the same as the general NIPF class. Thus the overall TIMO/REIT group is modeled with a mixed FI/NIPF form of timber supply response but with silvicultural investment behavior more closely aligned with traditional FI.

The U.S. forest area has declined by 1 percent in the last 50 years.

Historical Trends in Timberland Area

Between 1760 and 1920, the area of forest land in the United States declined by more than 300 million acres or 30 percent, as the country was settled (Smith et al. 2004). Some of the converted forest land was used for urban and infrastructure developments, but most was cleared for agriculture. Since 1920, the rate of net forest area loss has slowed, with some land returning to forest cover either naturally or through afforestation. Between 1920 and 2000, the area of forest land in the United States declined in net by 13 million acres or 2 percent (Smith et al. 2004).

Between 1953 and 2002, U.S. forest area declined in net by about 7 million acres or 1 percent. Changes in the timberland subset of forest land roughly parallel those for total forest land. Between 1953 and 2002, the net loss in U.S. timberland

area has been 5 million acres, or 1 percent (Smith et al. 2004). This 50-year interval was marked by cycles in timberland area change, with losses from 1953 to 1987, major gains from 1987 to 1997, and then a slight net loss between 1997 and 2002. However, rural land use remains highly mutable in the short term, and substantial acreages continue to shift back and forth between uses each decade. Over the last 40 years, an average of 1.8 million acres per year of cropland and the same area of pastureland have been transferred either into or out of the agriculture base, while 1.5 million acres per year have moved in and out of forestry (USDA ERS 1995).

Trends in timberland area differ notably by ownership. For the largest forest ownership aggregate in the country, NIPF, timberland areas declined by 14 million acres, or 5 percent, between 1953 and 2002. The largest concentration of NIPF owners is in the South, and this timberland area fell 6 percent. Most forest land development for nonforest uses occurs on land owned by NIPF owners (Alig et al. 2003). The NIPF owners control the largest share of U.S. timberland—58 percent (291 million acres) of the total.

The declining trend for NIPF timberland area observed in the South is also seen in the Pacific Northwest and Pacific Southwest, two other regions experiencing above-average growth rates in population and increases in developed area. In the Pacific Northwest, NIPF timberland area dropped by 4.4 million acres or 34 percent between 1953 and 2002, while the corresponding reduction in California (Pacific Southwest) has been 1.5 million acres and 25 percent, respectively. In the Pacific Northwest, NIPF owners often control land that is critical to threatened and endangered species, such as lowlands or riparian areas (Bettinger and Alig 1996).

Land ownership can be an important determinant of how forest land is managed and the levels of investments in different practices (e.g., Alig et al. 1999). The relative proportions of private and public timberland have remained fairly stable since 1953, with about 29 percent of U.S. timberland in public ownership. Within the private timberland group, the proportion of NIPF ownership dropped slightly, from 84 percent to 82 percent of total private between 1953 and 2002. Forests owned by families are a large component of the NIPF ownership class. The number of family forest owners increased from 9.3 million in 1993 to 10.3 million in 2003, and these owners control 42 percent of the Nation's forest land (Butler and Leatherberry 2004). The NIPF ownership class is the one most subject to land use changes (Alig et al. 2003), as evidenced by the 14-million-acre reduction in NIPF timberland area since 1953. In contrast, FI ownership increased by 7 million acres. Overall, forest area per person has declined notably since 1953 (fig. 4).

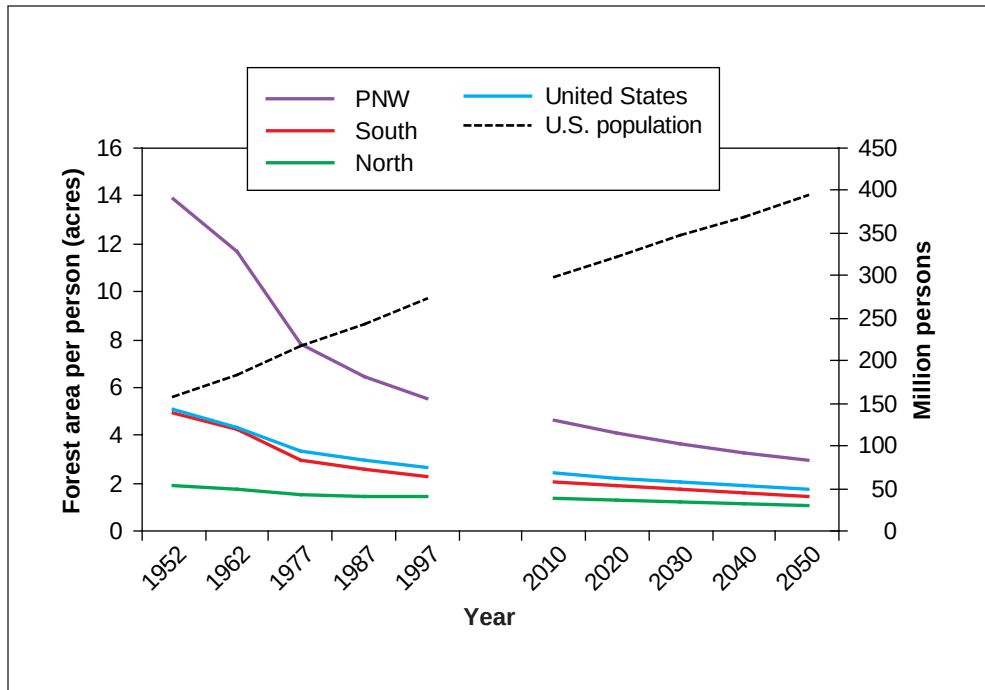


Figure 4—Forest acres per resident in selected regions, 1952–1997 (Smith et al. 2001), with projections to 2050 (Alig et al. 2003) and U.S. population.

Since 1953, the area of U.S. FI timberland peaked in 1987 at 70 million acres. Since then, U.S. FI timberland area has declined by about 5 million acres (Smith et al. 2004), with some reclassified as NIPF timberland because of a transition to institutional and other financial investors without timber processing facilities.⁶ About half of that net reduction was in the Southeast, with a transition of land ownership from consolidated forest products companies to stand-alone financial ownerships. Institutional investors currently hold about 8 percent of the investable U.S. timberland (Wilent 2004). By the end of 2003, one source estimated that the top 10 TIMOs managed about 9 million acres of U.S. timberland, and some analysts predicted that TIMOs and other investor groups will purchase another 10 to 15 million acres in the next decade (Wilent 2004).

The South has the largest concentration of both FI and NIPF ownerships in the United States, and that region has been the most affected by recent exchanges of timberland among owners. More than 18 million acres of timberland have been sold over the past decade, with the primary sellers being traditional vertically integrated

⁶ Past periodic Forest Inventory and Analysis (FIA) surveys as summarized in Smith et al. (2004) may have lagged actual changes in ownership in some cases by several years. Forest Inventory and Analysis units have now moved to an annual survey basis to reduce such lags between data collection and reporting and current changes in timber resources and ownership.

forest products companies (Mendell et al., in press). The net purchasers of such timberlands include institutional investors and other tax-advantaged entities such as REITs or subchapter S corporations. In many cases, the timberland changing hands is managed similarly as under previous owners, and there appears to be no significant direct impact on the properties (Mendell et al., in press). Many of the timberland investments made on behalf of institutional clients are managed by TIMOs, who appear to be somewhat less inclined to invest in longer term silvicultural practices, on average, than the traditional forest products companies (Mendell et al., in press). Their interest in shorter term treatments includes midrotation fertilization. In some cases, as timberlands are sold, the “higher and better use” parcels are identified and sold separately into the real estate market. Monetizing real estate opportunities contributes to forest fragmentation on the urban-rural fringe.

Given growing cities and other urban areas, forest land development brings more people living closer to remaining forest lands. A Forest Inventory and Analysis (FIA) measure added in recent periodic surveys has been the identification of forest lands by rural-urban continuum class. Based on nationwide rural-urban continuum classes (Smith et al. 2004), 13 percent of U.S. forest land now is located in major metropolitan counties and 17 percent in intermediate and small metropolitan counties and large towns, together making up 30 percent of all U.S. forest land (Smith et al. 2004: 47). Between 1997 and 2002, the forest area in major metro areas increased by 5 percent, or more than 5 million acres, as the developed areas in the United States expanded.

Historical Trends in Forest Cover Areas

Forest cover type affects the forest’s role in wildlife habitat, timber supply, global climate change, water yield and quality, recreation, and other forest ecosystem goods and services. Land cover is the observed (bio)physical cover on the Earth’s surface, e.g., oak-hickory forest. Cover types are related to land use changes, but note that land use is the purpose to which land is put by humans, e.g., protected areas, forestry for timber products, plantations, row-crop agriculture, pastures, or human settlements. Examining historical trends of forest-land area by forest cover type help explain forest dynamics.

Since 1953, the largest three historical changes in U.S. forest cover have been in the East. Area of planted pine in the South has increased more than 10-fold since 1953, mostly on private lands. The growth in planted pine area illustrates that the largest recent impact on forest cover dynamics in the United States has been human influences, especially changes in land management objectives. In the last half of the 20th century, science has enabled increased productivity through more intensive

practices such as managed pine plantations. This has in some cases influenced the composition, structure, and ecological processes of forests. Some plantations represent reclamations from agricultural land uses, and others represent plantations that followed harvests of naturally regenerated timber stands. An example is conversion of naturally regenerated longleaf and slash pine stands (see “Species List” for scientific names) with loblolly pine plantations, resulting in a reduction of 50 percent in the area of the longleaf and slash pine type since 1953 (Smith et al. 2004).

Along with human-caused changes are the successional forces that led to a doubling of the area for maple-beech-birch type between 1953 and 2002 in the East. Two other hardwood types, oak-hickory and oak-pine, also increased in area more than 20 percent, gaining some area after timber harvests of other types. Although planted pine has increased in parts of the East, the hardwood types continue to dominate in terms of area in the region.

Softwood types dominate forest cover in the West, but the doubling of western hardwoods types is the largest increase (Smith et al. 2004). Within softwood types, Douglas-fir area has increased, sometimes at the expense of the western hemlock-Sitka spruce type. At higher elevations, the spruce-fir type has almost doubled its area since 1953, as successional forces have led to it replacing other species.

Area Projections by Region

The total area of U.S. timberland is projected to decrease about 3 percent between 2002 and 2050 (table 4). During the 1970s, a significant portion of the decline in forest area resulted from conversion of forest to cropland, particularly on Southern river bottoms and deltas. In the future, however, reduction in forest land area will mainly result from conversion to developed land uses such as urban expansion (Alig et al. 2003, 2004b; Alig and Butler 2004), highway and airport construction, surface mining, and reservoirs.

There is always uncertainty associated with projections of land use, and at present, the outlook for cropland seems especially uncertain. Part of the uncertainty associated with cropland projections is created by (1) ongoing technological developments (e.g., genetically modified crops) and the uncertain social acceptability of these innovations, and (2) major changes in agricultural policy over the last decade, eliminating some crop supports and land retirement programs and potentially leading to much wider swings in crop prices. Tens of millions of acres of agricultural land, primarily in the South, are suitable for afforestation (Alig et al. 1998). Future fluctuations in relative prices of agricultural and forestry commodities could lead to further cycles of shifts in these lands, alternating from forestry to agriculture and back. But because the baseline projections indicate only limited increases in timber

Forest land area is projected to decrease 3 percent between 2002 and 2050.

Table 4—Area of forest land and timberland in the United States by ownership and region, 1953–2002, with projections to 2050

Ownership and region	Historical						Projections				
	1953	1963	1977 ^a	1987 ^a	1997	2002	2010	2020	2030	2040	2050
<i>Million acres</i>											
Forest land:											
Region—											
North	160.8	165.7	164.2	165.5	170.3	169.7	172.1	171.0	168.6	166.2	163.8
South	226.0	228.4	217.0	211.1	214.1	214.6	213.2	212.6	211.8	211.2	210.5
Rocky Mountains ^b	141.6	140.4	138.2	139.6	143.2	144.3	144.3	144.2	143.8	143.2	142.5
Pacific Coast	227.8	227.4	224.2	221.5	219.3	220.3	216.3	213.9	211.6	209.4	207.1
Total U.S.:	756.2	761.9	743.6	737.8	747.0	748.9	745.9	741.7	735.9	729.9	723.8
Timberland:											
North—											
Public	29.1	28.4	28.6	30.0	32.2	32.5	32.5	32.5	32.5	32.5	32.5
Forest industry ^c	13.7	13.7	17.5	16.9	14.8	14.6	14.6	14.6	14.3	14.1	13.9
NIPF ^d	111.4	114.5	107.4	107.5	112.4	111.5	112.5	111.1	109.1	106.7	104.8
Total	154.3	156.6	153.4	154.4	159.4	158.7	159.6	158.2	155.9	153.3	151.2
South—											
Public	17.4	17.8	18.4	19.9	20.9	21.2	21.2	21.2	21.2	21.2	21.2
Forest industry ^c	31.8	33.6	36.9	38.0	37.0	35.9	36.8	36.6	36.4	36.3	36.3
NIPF ^d	155.3	157.3	144.3	139.4	143.2	145.5	142.6	142.1	142.0	141.4	140.7
Total	204.5	208.7	199.6	197.3	201.1	202.7	200.6	199.9	199.6	198.9	198.2
Rocky Mountains ^b —											
Public	46.5	47.0	40.6	41.4	49.9	50.3	50.3	50.3	50.3	50.3	50.3
Forest industry ^c	2.3	2.2	2.1	3.0	2.9	2.9	3.0	3.0	3.0	3.0	3.0
NIPF ^d	17.9	17.6	17.5	16.8	18.2	17.4	18.5	18.5	18.4	18.2	18.0
Total	66.6	66.9	60.2	61.1	71.0	70.6	71.8	71.8	71.7	71.5	71.3
Pacific Coast—											
Public	52.4	52.9	50.5	41.2	43.0	43.2	43.2	43.2	43.2	43.2	43.2
Forest industry ^c	11.2	11.9	12.5	12.5	12.1	12.1	12.0	12.0	11.9	11.9	11.8
NIPF ^d	19.8	18.1	16.0	19.9	17.1	16.2	15.9	15.3	14.9	14.6	14.5
Total	83.4	82.9	79.1	73.5	72.2	71.5	71.1	70.5	70.1	69.8	69.5
Total U.S.—											
Public	145.4	146.2	138.2	132.4	146.1	147.3	147.3	147.3	147.3	147.3	147.3
Forest industry ^c	59.0	61.4	68.9	70.3	66.9	65.6	66.4	66.1	65.6	65.2	64.9
NIPF ^d	304.4	307.5	285.3	283.6	290.8	290.7	289.6	287.0	284.4	281.0	278.1
Total	508.9	515.1	492.4	486.3	503.8	503.6	503.3	500.4	497.3	493.5	490.3

Data may not add to totals because of rounding.

Note: Data for 1953 and 1963 are as of December 31; all other years are as of January 1.

^a Data were revised after the 1989 RPA tables were developed.^b The Great Plains are included in the Rocky Mountains.^c Lands held by firms with commercial timber production objectives but no processing facilities (e.g., timberland investment organizations [TIMOs]) and real estate investment trusts [REITs] are included in both forest industry and nonindustrial private forest categories, depending on their classification in the starting (approximately 1995) inventory data. See text in chapter 2 “Projected Area Changes for Land Uses and Forest Management Cover Types” section for further discussion.^d Indian lands 1953–2050 are now included in nonindustrial private forest (NIPF); in past reports they were shown in public lands.

Source: Historical: Smith et al. 2004; Projections Alig et al. 2003; only private lands are modeled, and public timberland area is assumed to be constant in the future.

stumpage prices, little improvement is foreseen in existing market incentives for afforestation of agricultural land in the private sector. Thus, although some expansion in the area of timber plantations is expected, particularly in the South, the projections by no means approach the limits of afforestation in the United States.

North—

Projections for the North (table 4) show a slow declining trend in timberland area. The total timberland area in the North drops from about 159 million acres in 2002 to 151 million acres in 2050. The percentage drop is largest in the Northeastern States where substantial relative increases in population and economic activity are expected. Timberland area in the Lake States is also projected to decline, as conversions to urban and developed uses dominate natural reversions from former agricultural land. In most of the other states, the projected changes are small, and in some states the area of timberland is rising or essentially constant in the latter part of the period. In line with historical trends, converted timberland area is projected to come largely from NIPF lands, with a slight projected decrease in FI ownership.

Maple-beech-birch and aspen-birch will remain the most abundant forest cover types on private timberlands in the Lake States, and maple-beech-birch and oak-hickory in the Northeast. Projected area changes for hardwood forest cover types in the North are largely based on a continuation of recent trends, whereas softwood cover types are projected to diverge somewhat from historical trends.

South—

Projections of changes in southern timberland area (table 4) show a decline from about 203 million acres in 2002 to 198 million acres in 2050, with all the decline on private timberlands. Most of the projected net reduction is in the Southeast region, especially around large urban areas such as Atlanta. In some states, particularly in the east Gulf area, where substantial increases in population and economic activity are expected, the drop is also fairly large. In most of the other Southern States the projected changes are small, and in the mid-South the aggregate area of timberland is projected to increase slightly.

The projected net reduction in timberland area in the Southeast largely reflects the direct conversion of timberland to urban and developed uses. Some other timberland acres, in turn, may be converted to replace cropland lost to urban and developed uses. A small reduction in crop area is projected, whereas urban and related uses rise by nearly 35 percent. Pasture and range area is projected to drop. The projected increase in timberland area in the South Central region is due to conversion of agriculture land to forestry, given the assumption that real prices will be constant or fall for agricultural commodities (FAPRI 2003).

Between 1987 and 2002, the area of FI timberland declined, while the area of NIPF timberland increased. Some of that measured shift can be attributed to a restructuring of FI with the sale of their timberlands to private investment groups. This conversion of corporate timberlands is because of favorable tax treatments, attempts to improve corporate financial performance, low costs of capital, and the potential of timberlands to provide stable and attractive investor returns. This conversion is continuing unabated generating great interest both among the investment community (see Browning 2005) and the forestry community (see Random Lengths 2005, Wallinger 2005).

Other individual and corporate private owners have acquired many of the timberland acres that were once owned by farmers. The role of TIMOs and other corporate ownership is projected to increase in size. This is partly due to investment in southern pine timberland,⁷ but it is uncertain how all of these corporate lands will be managed in the future (USDA FS 1988, Zinkhan 1993). In this analysis, it was assumed that these corporate lands will continue to be managed largely as if they were industrial forest lands. That is, they will be managed for stable investor returns by producing efficient and expanded output of timber crops, primarily southern pine in the South. Individual owners, the other component of the NIPF group, are the largest ownership class. This diverse set of owners holds over one-third of the Southern timberland base—almost four times as much as corporate owners. Unlike the corporate owners, individuals in the NIPF owner group are projected to reduce their holdings of timberland in the future.

In 2002, FI owned about 36 million acres of timberland in the South, 4 million acres more than in 1953. However, the area of industrial ownership peaked in 1987, and declined by 2 million acres between 1987 and 2002 (Smith et al. 2004). The shift of industrial timberland to financial investors discussed above has been concentrated in the South (Mendell et al., in press). Several factors seem to be operating that reduce the attractiveness of industrial ownership of timberland. These include cashflow and tax considerations, other investment opportunities, refocusing of corporate priorities, opportunities for leasing land or long-term harvesting rights, and the increased substitution of more-intensive forestry practices in place of land acquisition. It was assumed that the total Southern area in FI ownership will slowly

⁷ A survey of TIMO ownership in the South by North Carolina State University researchers revealed that about 70 percent of their timberland is planted pine and that planned conversions to pine plantations will continue, although there is significant variation among TIMOs in level of timber management intensity. Total timberland holdings by TIMOs are still relatively low (less than 3 percent of total). Compared to forest industry and other private owners, however, they continue to display a strong growth potential (J. Siry, presentation at 2001 Southern Forest Economics Workers Conference, March 27–28, 2001, Atlanta, Georgia).

decrease from 2010 through 2050. This is particularly true for the Southeast, which generally has higher opportunity costs for timberland.

In 2002, the area of private timberlands of the Southern United States was dominated by upland hardwoods, followed by planted pine, natural pine, lowland hardwoods, and oak-pine forest types. The largest projected percentage change in net area is for planted pine, increasing by about 14 million acres by 2050, approximately a 50-percent increase. More than half of the additional plantations would be on FI lands. With management intensification on these lands, many harvested natural pine, mixed oak-pine, and hardwood stands are being artificially regenerated. Even with such projected change, hardwoods will continue to dominate the forested landscape of the South and will cover about one-half of the private timberland base in 2050. Naturally regenerated forests (of both softwood and hardwood types) are projected to compose three-fourths of the Southern private timberland in 2050.

In contrast, the area of natural pine on private lands is projected to decrease by 15 percent over the projection period. Many exchanges occur between forest cover types owing to natural succession and management (e.g., regeneration method after harvest). Causes of loss include an assumed continuation of trends in substantial hardwood encroachment after harvest of pine stands on NIPF lands. Sources of gain include reversions to timberland from abandoned agriculture land that seed in as pine in some cases, and some transitions from oak-pine to natural pine dominance in a stand.

The largest projected area decrease is for the upland hardwood type, with an 11-million-acre loss projected by 2050. The projection represents a change from long-term historical trends for the South. A combination of factors underlies the projected reduction: conversion to nontimberland uses (e.g., developed uses), conversion to pine plantations, and transitions to other types including oak-pine. The projected rate of reduction in upland hardwood area slows as market incentives for conversion to pine plantations lessen with stable softwood prices. Transitions between planted and naturally regenerated stands involve significant two-way flows, including substantial numbers of harvested pine plantations reverting to naturally regenerated forest types.

In addition to the area decreases, roughly 18 percent of upland hardwood timberland on NIPF lands was assumed to be unavailable for timber harvest in the future (Moffat et al. 1998a, 1998b). This estimate was developed from surveys of land managers and state foresters conducted in the South about management intentions on private timberlands. These surveys found that a significant number of owners did not intend to actively manage or harvest their timberland.

Rocky Mountains and Great Plains—

Total timberland area in the Rocky Mountains and Great Plains is projected to increase slightly from 70.6 million acres in 2002 to 71.8 million acres in 2020 and then slowly decrease through 2050. The projected decrease is largely on the NIPF ownership. Substantial areas of privately owned forests have been subdivided for home sites, particularly in the mountainous areas of Montana, Idaho, and Colorado. The projected net area changes reflect some initial gains from agriculture that are later reversed by direct conversion of timberland to urban and developed uses and other acres converted to replace cropland lost to urban and developed uses. The area of cropland is projected to drop by several million acres, while area of urban and related uses increases (Alig et al. 2004b). Pasture and range area is projected to have a downward long-term trend, especially later in the projection period when some Conservation Reserve Program (CRP) grasslands are converted to crop use. Only small changes in area of softwood and hardwood forest types are projected for this region by 2050.

Pacific Coast—

Total timberland area in the Pacific Coast region is projected to fall from 71.5 million acres in 2002 to 69.5 million acres by 2050. As in the Rocky Mountains, most of the projected reduction is for the NIPF ownership. Much of the current timberland in the Pacific Coast region is located on lands where forestry has a comparative advantage or is a residual use owing to topography, and projected changes are smaller than historical shifts. The projections reflect direct conversion of timberland to urban and developed uses (Alig et al. 2004b) and other acres converted to replace cropland lost to urban and developed uses.

Currently, FI owns approximately 17 percent of the Pacific Coast timberland, up from the 13 percent share in 1953. This share is projected to change little by 2050. Future area transfers between ownerships are expected to be much smaller than historical levels, with total timberland area on the NIPF ownership projected to drop 10 percent by 2050.

The largest cover type changes in the Pacific Coast region are projected to occur on FI lands, as more acres are planted to Douglas-fir. These changes are being spurred by the increased value of Douglas-fir. Conversely, hardwood area on this ownership is projected to decline. Projected timberland losses on NIPF lands are distributed across all forest types.

Timber Management and Investment in Private Land Management Intensity Classes

Future private timber growth and inventory were projected by means of the Aggregate Timberland Assessment (ATLAS) inventory model (see Haynes 2003, Mills and Kincaid 1992 for details). These projections depend critically on assumptions about future management investment. In ATLAS, the form and extent of management investment is characterized by a set of management intensity classes (MICs), each corresponding to a specific regime of silvicultural treatments. These MICs were developed from regionwide studies through the use of expert opinion and surveys targeting industrial managers and Southern state foresters (AF&PA 1999; Moffat et al. 1998a, 1998b; Siry 1998, 2002). Each MIC is associated with a regional average growth response or yield curve for a particular ownership, forest type, and site productivity class. Treatments or silvicultural regimes range from a low-investment, custodial land management approach to very intensive higher cost regimes. There is also a custodial class that is not harvested known as the unavailable class (see app. 2 for an expanded discussion on this category). For each owner-type-site combination, up to 12 regimes are employed in the South and 6 in the Pacific Northwest West. In regions outside the Pacific Northwest West and South a single, “average” management regime represents each owner-forest type combination.

At the start of the projection, land is allocated to MICs based on timberland inventory data derived from FIA plots.⁸ In the South and Pacific Northwest West, area shifts among MICs over time to simulate changing investment and management preferences. Mechanically, this process takes place in ATLAS after harvest as land area that is to be regenerated is allocated to the various MICs for the next rotation (land stays in a given MIC until harvested again in the future). Two methods were used to project area change by MIC in this 2005 update.

The first approach, employed in all past assessment studies, uses a preset future pattern of proportional MIC allocations. In this scheme, the proportions of regeneration area by MIC can differ from period to period (and by owner, region, forest cover type, and site productivity class), but these changes are determined at the

⁸The initial assignment of timberland acres to an MIC, including the management class considered unavailable for timber harvest, is an arbitrary process. Based on the ownership surveys we know what percentage, on a regional basis, of a particular forest condition should be in each MIC; however, the FIA field plot variables do not contain enough information to match the starting inventory to particular MICs. We therefore make the assumption that all acres within each owner, type, site, age class, stratification are equal in their availability for distribution to the representative set of MICs. From this common pool of timberland, we then assign area and volume to each MIC based on the desired target distribution.

start of the projection. As described in Haynes (2003), judgments about the forms of these time patterns have been derived from extensive consultation with owner groups and public agencies knowledgeable about the various regions and specific lands in question. Adjustments to the allocation rates were made by using an ad hoc price feedback approach over a series of projections, so as to “synchronize” the rate of investment with stumpage price trends. But the temporal pattern of allocations is developed specifically for the base case conditions. Simulations of alternative futures (as in chapter 4) could require modification of these MIC allocations, but no explicit mechanism is available (short of additional consultations with expert groups) to make these changes. As a result, the base allocations have generally been used for all projections.

A second method was developed for this 2005 update in which the allocation of regeneration areas to MICs depends on an explicit model of private management investment decisions (for details see app. 2). In this approach, owners are assumed to consider the potential investment returns from managing lands under the several MICs available (they compute the present worth of projected future net returns [present net worth]). When considering the allocation of regeneration land across MICs for a given future period, owners are assumed to adjust the proportions used in the previous period based in part on present net worth (MICs with higher present net worth get a higher allocation) differing by owner, region, site productivity, and forest cover type. Over time, more land tends to migrate into the MICs with higher present net worth. In the present application, however, there are no cases where all regeneration area is allocated only to the option with the highest investment return. The approach was calibrated for the South by using historical information on owner regeneration intentions. Judgment methods were used in the Pacific Northwest West. Because the estimated investment returns depend on prices from the projections, this approach—unlike the previous method—gives different MIC allocations for different scenarios. In this 2005 update, this second scheme is used for the base scenario. Its results are compared to the first (fixed-allocation) case as an alternative future.

Management Intensity Class Allocations

The following section compares the area allocated among the MICs under the fixed-allocation approach and the price-sensitive approach. Underlying both approaches is the general assumption that over time, private owners will increase the proportion of area under some form of noncustodial management. The results are summarized by broad categories of management by region and forest cover type for tables 5a and 5b. The fixed method, used in past assessments is presented first, followed

Table 5a—Proportions of timberland base by management intensity class (MIC) for Southern and Pacific Northwest West private owners, projected by using fixed-area allocation

Year and owner	South				Pacific Northwest West		
Forest industry:							
	Planted pine				All conifers		
	Low	Medium	High	Unavailable	Low	Medium	High
2000	0.25	0.48	0.26	0	0.29	0.33	0.38
2020	.03	.48	.49	0	.19	.33	.47
2050	.03	.47	.50	0	.18	.35	.47
	Natural pine and oak-pine						
	Partial cut	Low even-aged	High even-aged	Unavailable			
2000	.38	.37	.18	.08			
2020	.52	.24	.14	.10			
2050	.55	.20	.12	.13			
	Hardwoods						
	Partial cut	Low even-aged	High even-aged	Unavailable			
2000	.18	.68	.05	.08			
2020	.20	.60	.07	.13			
2050	.20	.41	.21	.17			
Other private:							
	Planted pine				All conifers		
	Low	Medium	High	Unavailable	Low	Medium	High
2000	.10	.58	.28	.03	.66	.19	.15
2020	.07	.47	.42	.04	.57	.25	.18
2050	.05	.43	.47	.05	.57	.26	.17
	Natural pine and oak-pine						
	Partial cut	Low even-aged	High even-aged	Unavailable			
2000	.43	.37	.14	.07			
2020	.34	.26	.29	.14			
2050	.35	.13	.36	.20			
	Hardwoods						
	Partial cut	Low even-aged	High even-aged	Unavailable			
2000	.53	.33	.04	.10			
2020	.53	.28	.05	.14			
2050	.57	.17	.08	.17			

Table 5b—Proportions of timberland base by management intensity class (MIC) for Southern and Pacific Northwest West private owners, projected by using price-sensitive allocation

Year and owner		South				Pacific Northwest West		
Forest industry:		Planted pine				All conifers		
		Low	Medium	High	Unavailable	Low	Medium	High
2000		0.25	0.48	0.26	0	0.29	0.33	0.38
2020		.02	.43	.55	0	.29	.28	.43
2050		.01	.41	.58	0	.50	.16	.34
		Natural pine and oak-pine						
		Partial cut	Low even-aged	High even-aged	Unavailable			
2000		.38	.37	.18	.08			
2020		.52	.15	.23	.10			
2050		.56	.06	.26	.13			
		Hardwoods						
		Partial cut	Low even-aged	High even-aged	Unavailable			
2000		.18	.68	.05	.08			
2020		.20	.60	.07	.13			
2050		.24	.45	.14	.17			
Other private:		Planted pine				All conifers		
		Low	Medium	High	Unavailable	Low	Medium	High
2000		.10	.58	.28	.03	.66	.19	.15
2020		.11	.39	.46	.04	.60	.22	.18
2050		.10	.33	.53	.05	.61	.18	.21
		Natural pine and oak-pine						
		Partial cut	Low even-aged	High even-aged	Unavailable			
2000		.45	.35	.14	.07			
2020		.38	.26	.24	.13			
2050		.38	.16	.28	.21			
		Hardwoods						
		Partial cut	Low even-aged	High even-aged	Unavailable			
2000		.55	.31	.04	.10			
2020		.58	.22	.07	.14			
2050		.60	.11	.10	.20			

by the price-sensitive projection used as the basis for this assessment. The MIC allocation method does not affect the projections of timberland area, so the area by owner, forest (management) type, and site class is the same for both approaches.

Pacific Northwest West—fixed allocation—

In the Pacific Northwest West region, only the Douglas-fir and western hemlock forest types were considered for various levels of active management. In 1990, these types supported nearly 95 percent of all forest industry softwood growing-stock volume and 83 percent of the softwood volume on nonindustrial private lands. The remaining softwood types are a mixture of conifers that often includes these species mixed with true fir, spruce, and cedar. Management classes represented broad regional averages and were tailored for each ownership. When stratified by site class and type, there were 21 management classes or categories available per ownership. To compare the projection outcomes in tables 5a and 5b, the individual classes were aggregated into three categories, high, medium, and low, where low represents a low investment or custodial approach to management and high represents a level of investment that might include site preparation, planting, commercial thinning, and fertilization. This comparison includes all softwood forest types; the mixed types not explicitly managed are assumed to remain in the “low” category.

The fixed-management allocation was originally calibrated for the 2000 assessment (Haynes 2003) when it was assumed that stumpage prices would fall in the short term and then increase to 2020 before falling again. The management response to rising prices was to invest money in regeneration and management. The biggest shifts in investment occur during this price rise as both types of owners move harvested lands under “modern” forms of management. Although both types of owners tend to increase intensive forms of management during this time, there is an apparent difference between their aggregate objectives.

By 2020, forest industry owners have increased the area under the highest management by 28 percent while the area under medium-intensity management stays relatively steady and the area in the lowest management class drops by nearly a third. This represents a shift “through” the medium classes as area is bumped up from low to medium investment levels, and the area in the medium class is bumped up to the high class. After 2020, the stumpage prices used to calibrate the MIC shifts fell more steeply and then slowly rose to 2050. During this time, little change in management strategy occurs, and the highest management class holds steady, accounting for 47 percent of all softwood timberland in the forest industry ownership.

The nonindustrial private ownership consists of a broad range of owners with diverse objectives for owning timberland. Initially, two-thirds of the ownership's timberland is under low investment or custodial forms of management. The investment trend is similar to industry's, but not nearly as aggressive. The medium management class makes the largest gain in area, increasing 27 percent by 2020, while the low management class shrinks by 13 percent. The highest management class increases by 16 percent and then declines slightly as prices fall and inventories begin to build. From 2020 to the end of the projection, 57 percent of all the non-industrial private softwood area remains under the lowest forms of management, and the projection ends with 17 percent in the highest class.

Pacific Northwest West—price-sensitive allocation—

As the projection proceeds using the price-sensitive management allocations, owners initially experience a rather large stumpage price drop, followed by a rebound that occurs between 2010 and 2020; then prices fall slightly, remain flat, and recover by 2050. Both industrial and nonindustrial owners increase their area under higher levels of investment during the price increase. By 2020, the shifts almost match the fixed-allocation projection, but overall prices are lower than the 2000 assessment and more area remains in the lowest investment class. The price decline after 2020 causes investment to slow further, then the projected MIC trajectories diverge. Prices continue to slide and do not begin a rebound until 2040, but by then the area in the medium levels of management has dropped significantly for both owners. This drop in the medium category is an indication that either less investment occurs or investment in aggressive management is preferable in times of flat prices. For nonindustrial owners, the proportion of area under the highest class of management actually increases by 2050. For industry it falls below the starting point, and about half of the industry softwoods move under the lowest form of management, a big change from the fixed projection's more aggressive approach, leaving just 18 percent in lower management.

South—fixed allocation—

The southern management intensity classes were developed for all forest types (or, forest management types as they are referred to in the South). In each Southern region, forest industry owners had inventory stratified among roughly 77 MICs, and the nonindustrial private owners had inventory spread among 67 MICs. For comparison here, these were grouped into the high, medium, and low categories.

In the year 2000, the planted pine forest type accounted for nearly 60 percent of the area occupied by forest industry softwood forest types, and this ratio increases

to 75 percent (a gain of 6.4 million acres) by 2050. Although the NIPF ownership began the projection with nearly as many acres of planted pine, the natural pine and oak-pine management types make up roughly three-quarters of nonindustrial private owners' softwood timberland. These forest owners are predicted to increase the area of planted pine by 6.0 million acres by 2050, and much of this increase will be a conversion of upland hardwood forests. In the end, two-thirds of the nonindustrial softwood area will remain in the natural pine and oak-pine types. Although both types of owners are projected to aggressively manage planted pine, investment within the forest industry ownership moves future stands out of the low category and into the medium and high levels of management where most stands receive at least one commercial thinning. The shift in NIPF planted pine is not as dramatic; as all classes gain area owing to the enrollment of area into planted pine, shifting occurs and the low and medium management intensity classes hold almost steady in total area. The high management class nearly doubles in area by 2020, and then by 2050 is up 143 percent. Although much smaller, the nonindustrial "unavailable" class gains more than a half-million acres, doubling in size by 2050. These are areas planted with pine for reasons other than timber production. Although management objectives for nonindustrial pine plantations may not be the same as objectives on forest industry lands, expansion of nonindustrial pine plantation area is promoted not only by market incentives but also by various state and federal forestry incentives, and by many local cooperative arrangements with industry.

Shifts in management among the remaining forest types can be seen in table 5a, where forest industry carries a much smaller relative share of the timberland area. Management regimes using partial cutting are increasingly applied in these types, especially in stands of natural pine and oak-pine. Between 2000 and 2050 there is a 33-percent net loss of area supporting these forest types (7 million acres). Similar to what happens on nonindustrial private lands, most of this change is not a loss of timberland but a conversion of harvested upland hardwood and natural pine stands to managed pine. As hardwood area declines, hardwood inventories drop and prices rise, and investment in hardwood management increases.

The largest upward shift in management of the remaining forest types occurs on the nonindustrial private ownership. The shift to managed stands outweighs the loss of area, as the total area enrolled under the higher regimes more than doubles. Of significance for this ownership is a 10-million acre increase in area of the unavailable class, where most of the increase occurs in the oak-pine type. In contrast, the industrial owners see a modest 450,000 acre increase in the unavailable class, occurring mostly in the bottomland hardwood forest type.

South—price-sensitive allocation—

Investment in the South is very similar under both MIC-shifting scenarios, although, in spite of flat or falling stumpage prices, the high-investment MICs of both ownerships are more attractive than the medium classes. Both owners profit by aggressively managing planted pine. The allocation results are most similar for the forest industry ownership, where investment moves nearly all future stands out of the low category and into the medium and high levels of management. The difference is that under the price-sensitive MIC shift scenario, more area is moved to the high level of investment, leaving the medium class with fewer acres than the fixed-allocation scenario. The shift in nonindustrial private planted pine is not quite as dramatic; greater area remains with little or no investment, while the high class gains the most area, eventually representing over half of planted pine type. The unavailable class gains in this scenario too, but because timber production is not the main objective of this class, a “fixed” method of moving area to this MIC was employed. In most cases, the area in this class is similar when using both techniques.

The price-sensitive shifts in management among the remaining forest types can be seen in table 5b. The same area changes apply as they do in the base projection, where there is a net loss of area in most forest types. The largest difference between the shifting techniques is the way natural pine and oak-pine are projected to be managed. Under the price-sensitive base projection, industrial owners put more emphasis on investment than they do under the fixed-allocation assumptions. This indicates the return on investment is positive, even when prices are soft. In this case, the area under partial cutting and higher management gain slightly, while a 3.4-million-acre loss occurs in the low-investment category. This seems reasonable that conversion to plantations or withdrawals for agriculture or development would occur where mixed softwood stands were providing lower financial returns. Meanwhile, the nonindustrial private allocation trend is similar, but is influenced not by conversion but shifts to the unavailable class. The total area in the natural and mixed softwood forest types remains fairly stable, while the unavailable class grows to represent 20 percent of the area by 2050, a 5.4-million-acre shift away from the other management categories. On a net basis, all of this growth in the unavailable class comes out of the lower management investment classes. Whereas industry saw little net change in the area of partial cutting and higher management class, under both allocation schemes, the nonindustrial private owners ramp up investment significantly while reducing the area of both partial cutting and low-intensity even-age management. Under the fixed-allocation scheme, the area

of higher management increases 111 percent (10.9 million acres), and under the price-sensitive scheme the area goes up by 72 percent.

The trends in hardwood management are similar between allocation schemes, but the magnitudes differ. An issue for forest industry is a 39-percent loss of hardwood area, most of which is converted to softwood species. Only a small amount of industrial hardwood stands see any investment in stocking control or other growth-enhancing operations. The conversion to pine seems to come out of the nonmanaged stands as the high-intensity class gains some area. This gain is bigger under the fixed-allocation scenario, where hardwood prices rose throughout the projection. Most of what remains is managed at low intensity. Perhaps, the most interesting result for industrial owners is a final allocation of between 17 and 21 percent of the hardwood area to become unavailable for harvest. This is about the same percentage as for the nonindustrial owners, although the actual area held in this class ranges from 13 to 15 million acres, more than 10 times the area considered unavailable for harvest on industry lands. The remainder of the nonindustrial hardwood management scenario looks about the same under both allocation methods. The price-responsive method adds more area in higher management, doubling in both cases, while partial cutting area drops slightly. The area in the lower forms of management plunges as stands are converted to planted pine or moved into the unavailable class. Overall, in spite of increased investment, the results indicate that most hardwood stands will not be actively managed.

Partial cutting, as shown in tables 5a and 5b was accounted for differently by owner group. As a harvest treatment it was considered a form of management and incorporated into several of the management intensity classes. For industrial owners, partial cutting took place in an MIC dedicated to partial cutting under a specific low-investment custodial-management regime. For nonindustrial owners, partial cutting was a harvest treatment option incorporated into both the low and higher investment regimes. The results show that for both owners, the type of MIC allocation did not significantly change the trends or area of stands treated by partial cutting.

Adjustments for Timber Removed From Inventories

The link between the wood volume equivalent of all forest products produced and the actual volume of timber removed from timber inventories is established by a set of assumptions on the sources and disposition of harvest. The actual volume of timber removed from inventory is called “removals from growing stock,” as shown in appendix 1, tables 20–23 and 31–34. Wood used to produce forest products, however, comes from both growing-stock and non-growing-stock sources. Additional

volumes are removed from the forest as logging residues and “other” removals. The largest fraction of wood used in products comes from the portion of the timber inventory defined as growing stock: live trees of commercial species meeting minimum standards of quality and vigor that are at least 5 inches in breast-height diameter. The remainder comes from non-growing-stock sources, such as dead timber or trees harvested from nonforest land such as urban areas. Other removals include noncommercial thinnings and other types of cutting in which the harvested stems are not used. Timber removals from growing stock are computed by subtracting the removals from non-growing-stock sources from projected total timber harvest, then adding the other components of removals—logging residues and other removals. Mathematically the link between removals and harvest is summarized in the following equation:

$$\text{Growing-stock removals} = \frac{\text{Timber harvest} \times (1 - \text{non-growing-stock fraction}) \times (1 + \text{other removals fraction})}{(1 - \text{logging residue fraction})}$$

where

non-growing-stock fraction is the fraction of harvest coming from non-growing-stock sources,

other removals fraction is the proportion of growing stock that is cut or killed from cultural operations or timberland clearing and left in the forest, and

logging residue fraction is the fraction of total removals left as logging residue in the forest.

The data for these three adjustments are derived from the timber product output tables given in Smith et al. (2001) and Smith et al. (2004). Projections were developed from trend relations for each region in the 2000 RPA timber assessment (shown in tables 6 and 7 of Haynes 2003). In general, past trends are expected to continue in all regions except in the North and West where aging timber inventories lead to higher proportions of harvest coming from non-growing-stock sources. Logging residues, on the other hand, have been declining and are expected to continue to decline as a percentage of the total. These declines largely reflect the effects of technological innovations that have made it economical to remove more of the lower quality material.

Finally, an additional class of “other removals” or reclassifications not reflected in these coefficients arises owing to changes in land use and cover type and the disposition of the timber on these lands at the time of the change. These volumes are recognized in the ATLAS inventory projection system through assumptions about the proportion of wood that is utilized from timberland that is projected to

change land use. In fact, land use change accounts for the majority of “other timber removals” given the size of projected losses from timber inventories resulting from the diversion of timberland to other uses such as crop or pasture land, roads, urban areas, parks, and wilderness.

Timber Harvests on Public Lands

National Forest Harvest Levels and Inventory Projections

Harvests from timberland within the national forests (NFs) decreased in the 1990s as the result of changing goals for federal land management. Under the base case assumption of continuation of current policies, national forests harvest is projected to remain at these lower levels for the next five decades.

There is an alternative that considers increased NF harvest as part of an effort to restore the health of Western forest lands. Projecting these lower harvest levels represents a continuation of the current impasse among commodity interests, communities, habitat conservation advocates, environmentalists, and other stakeholders. Harvests do rise slightly in some regions reflecting actions to maintain forest health consistent with current legislation and regulations. The inventory projections for NF were updated by using the most recent RPA database (Smith 2004) with assumptions about additional impacts of higher levels of fire, regeneration failure, and insects and diseases. A detailed description of these disturbances and their impacts for the national forest projections is given in Mills and Zhou (2003).

Historical and projected levels of total NF softwood harvest are shown in figure 5 and in appendix 1, table 20; hardwood harvest is shown in appendix 1, table 21. These inventory projections were developed by using the ATLAS model (Mills and Kincaid 1992) in a manner similar to that used for private timberlands. The approach applies three management regimes on NF lands based on current management directions. The first management regime allows regeneration removals; that is, the stands will undergo final harvest over a range of ages; the second regime allows partial cutting; the third management regime places stands in a reserved status where they are not available for harvest. Most area falls in this third regime.

Although the inventory change differs across regions, the total NF inventory is projected to increase 45 percent for softwoods and 65 percent for hardwoods under the current projected removal levels. Both softwoods and hardwoods on the NFs are expected to increase sharply in all regions ranging from 36 to 94 percent for softwoods, and 53 to 73 percent for hardwoods. As the inventory grows, more timberland area accumulates in older age classes. Figure 6 shows the area distribution of NF timberland (92.9 million acres) by age classes for the entire United States (except for Alaska) and for the West (71.7 million acres). In 2002, 17 percent of

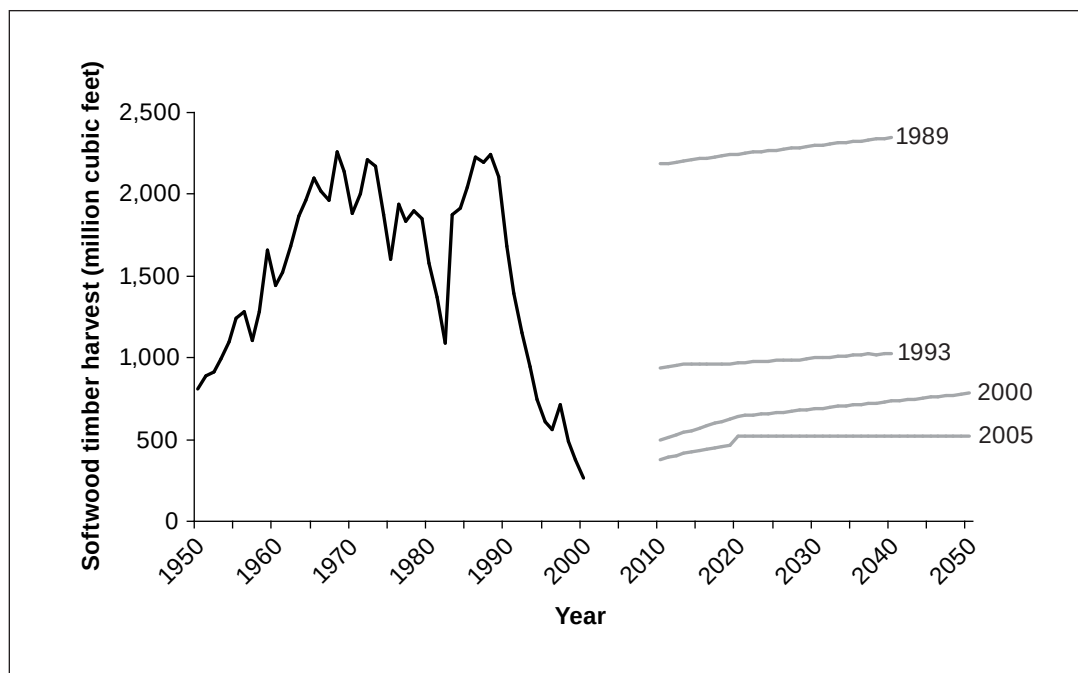


Figure 5—Actual national forest softwood timber harvest 1950–2002 with 1989, 1993, 2000, and 2005 national forest harvest assumptions.

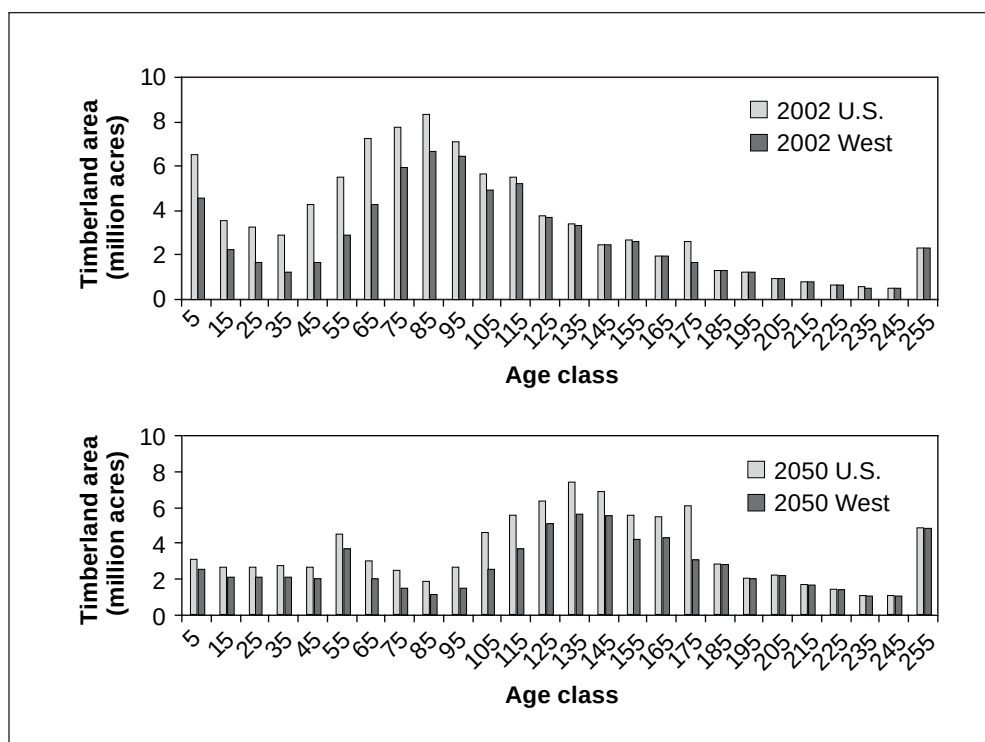


Figure 6—National forest timberland area by age showing the initial (2002) and the projection (2050) distributions.

the NF timberlands had trees older than 150 years. This is expected to increase to 37 percent by 2050. Currently, about 20 percent of NF timberland in the West has trees older than 150 years. This fraction is expected to double to 40 percent by 2050 under the current removal and disturbance assumptions.

Other Public Harvest Levels and Inventory Projections

Other public ownerships comprise a diverse collection of landowners, including the Department of Defense, State, local (county, municipal, etc.) and the Bureau of Land Management. For the first time, the inventory projections for other public are developed by using the updated ATLAS projection model (Mills and Kincaid 1992) in the same way as for private and national forest ownerships. The management regimes for the other public are the same as those for NF (Mills and Zhou 2003), that is, three management regimes were applied on other public timberland for inventory projections. The yields on other public timberland were developed by using the same procedure as that of NFs (Mills and Zhou 2003) based on the FIA plot information from this ownership.

The most recent RPA data (Miles et al. 2001) were used as starting conditions for other public inventory projections. Historical and projected harvest, net annual growth, and growing-stock inventories are shown in appendix 1, table 22 for softwoods and appendix 1, table 23 for hardwoods. Given the expected increases in inventory and assuming that many of these lands are managed in some type of trust for public funding (such as school common funds), harvest levels were allowed to increase in proportion to inventories. Softwood removal is projected to increase by 25 percent from 553 million cubic feet to 691 million cubic feet in 2050, and the hardwood removal will increase by 20 percent from 381 million cubic feet to 456 million cubic feet. However, the removal levels differ from region to region. Removals in some regions remain relatively stable, but removals in the Rocky Mountains and in the South are expected to increase significantly during the next five decades compared to the current levels.

Both softwood and hardwood inventories on other public lands are projected to increase over 60 percent during the projection period for the Nation. It ranges from -3 percent to 100 percent for softwood, and 15 percent to 89 percent for hardwood. Although all the regions are experiencing increases in inventory, the softwood inventory in the Pacific Northwest East will decrease until 2030 and then slowly increase owing to the lower softwood net growth in that region. The age structure of other public timberland in the West is more stable compared with NF timberland. However, the accumulation of inventory in the North contributes to an

increase in the older stands for the Nation. Figure 7 shows the area (45.0 million acres) distribution of other public timberland by age classes for the entire United States (except for Alaska) and for the West (12.1 million acres). In 2002, 6 percent of the other public timberlands had trees older than 150 years. This is expected to increase to 11 percent by 2050. Currently, about 8 percent of the other public timberland in the West has trees older than 150 years. This fraction is expected to increase to 12 percent by 2050 under the current removal and disturbance assumptions. Details of these projections are given in Zhou et al. (in press).

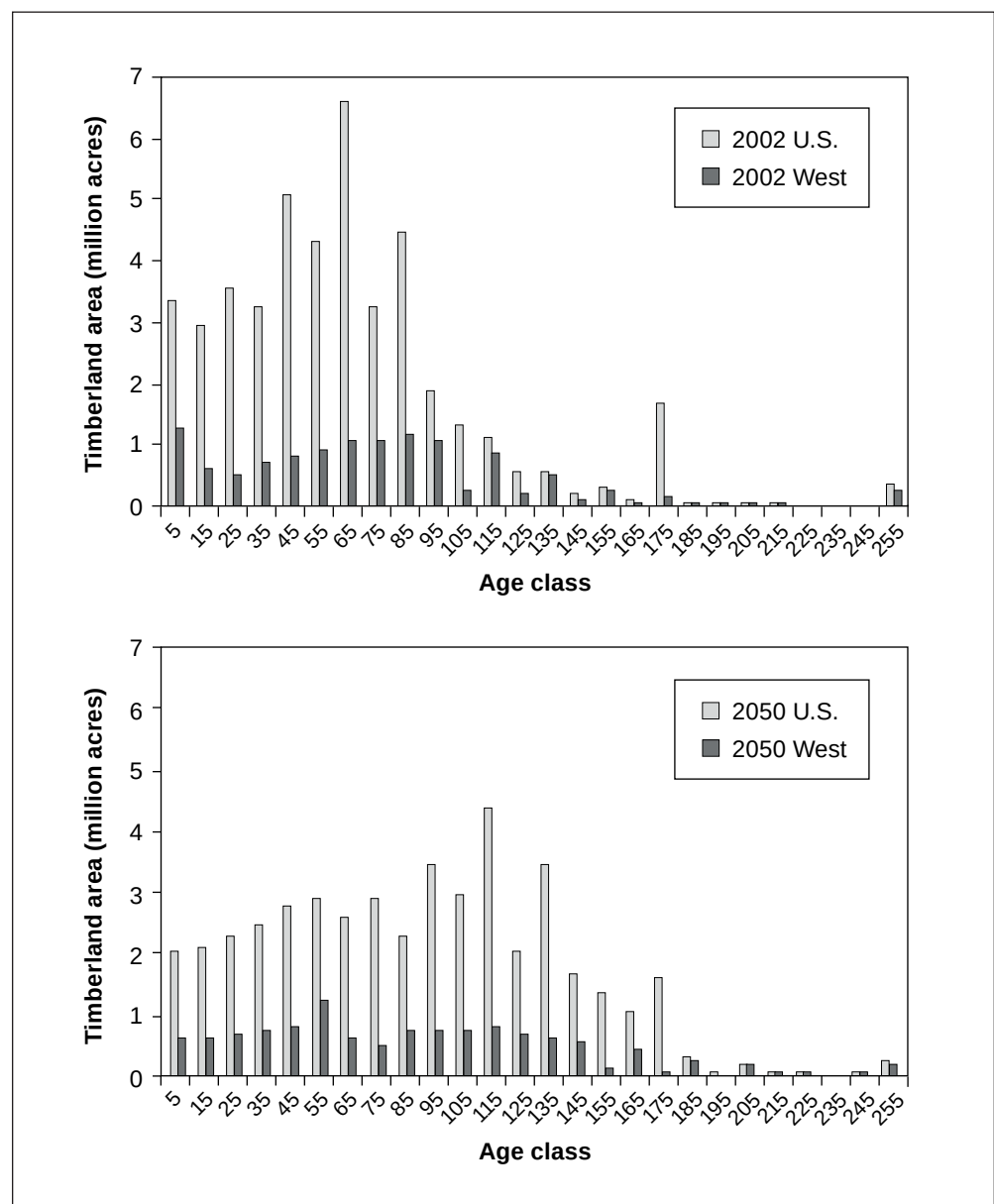


Figure 7—Other public timberland area by age showing the initial (2002) and the projection (2050) distributions.

Chapter 3: Timber Demand and Supply Relationships: Base Projection

Introduction

The 2005 update base projection was developed assuming a continuation of current public policies regulating management on both private and public forest lands and the projected population, macroeconomic, and resource conditions described in chapter 2. It provides one view of the future of the U.S. forest sector and serves as a datum for considering alternative scenarios on resource policies and other conditions that influence behavior in the sector. Comparisons of the base case and the several scenarios presented in chapter 4 provide a means of identifying both emerging problems and favorable developments that may present opportunities for timely policy action.

The base projection envisions continued growth in U.S. forest products consumption to 2050 but at somewhat slower rates than in the past five decades. The expected growth in harvests reverses a downward trend that started in the 1990s when harvest reductions on public lands led to lower total harvests, declining exports, and increased imports. Over the next 45 years, imports will supply a smaller portion of the growth in requirements, and domestic sources will supply a correspondingly larger share. The annual increment in future harvests from domestic forests alone,¹ at 0.11 billion cubic feet per year, will be close to the trend average over the past 50 years (0.12 billion cubic feet per year). At the same time, real product price growth will fall below long-term historical rates for nearly all products.

Over the 50 years from 1952 to 2002, U.S. consumption plus exports of all forest products rose by some 9.5 billion cubic feet. United States harvest increased by 6.0 billion cubic feet, while imports rose by 3.5 billion cubic feet over this same period (fig. 8).² Real prices of softwood lumber, hardwood lumber, and paper rose (annual compound rates of 0.8 percent, 0.4 percent, and 0.3 percent, respectively), while prices of softwood plywood, oriented strand board (OSB) (since 1976), and paperboard fell. In the update base projection, U.S. consumption plus exports increases over the 2002–2050 period by 8.6 billion cubic feet. Imports grow by 1.4 billion cubic feet, while harvest from both forests and SRWC plantations rises by 7.1 billion cubic feet.³ Prices of softwood lumber, hardwood lumber, and OSB rise slowly (annual compound rates of 0.2 percent, 0.3 percent, and 0.1 percent, respectively) while prices of softwood plywood, paper, and paperboard remain stable or fall.

¹This **excludes** hardwood agrifiber or short-rotation woody crops (SRWC).

²The details for these changes are summarized in Howard (2003).

³Harvest from domestic forests rises by 5.3 billion cubic feet and SRWC by 1.8 billion cubic feet.

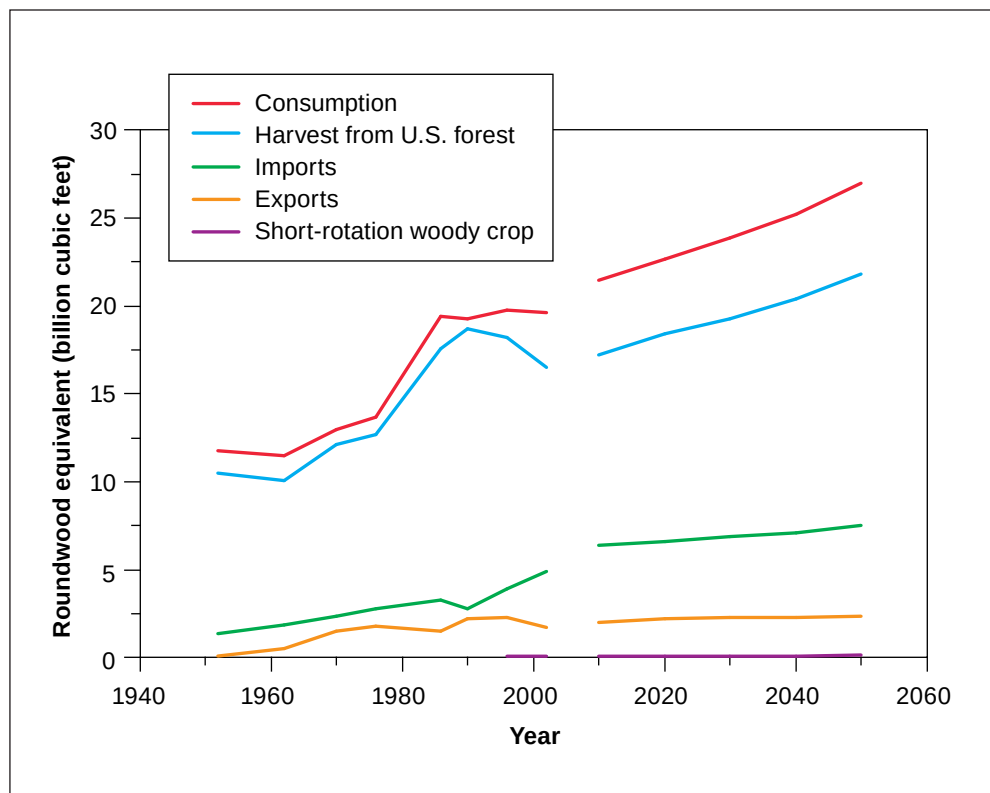


Figure 8—Total U.S. roundwood consumption, harvest, and trade, with projections to 2050.

Projected Consumption, Production, Trade, and Prices for Timber Products

The following sections give details of the update base outlook for major classes of forest products. Projected future trends differ markedly across products, driven by varying conditions of end-use demand, substitution from alternative products or imports, and the effects of changing timber supply conditions.

Solid Wood Products

Spurred by low interest rates and continued growth in disposable income, the key single-family component of new housing starts reached high levels during the early 2000s, creating strong demand and high levels of consumption for softwood lumber, plywood, and OSB. In the update macroeconomic outlook (chapter 2), single-family housing starts are expected to move back to long-term trend levels, and growth in single-family house size slows markedly, consistent with anticipated trends in future income and interest rates. Single-family starts do not move above the 2003 peak again until the final decade of the projection. Even so, the projection suggests robust demand conditions for housing construction materials, with the

average of single-family starts over the next 45 years expected to be close to the peak levels observed at the end of the 1990s. At the same time, real expenditures on residential upkeep and alteration are expected to resume their long-term growth trends after a period of near stability during the 1990s.

Softwood lumber—

For softwood lumber, this end-use demand outlook leads to limited growth in U.S. consumption in the near term as housing starts step down from their recent peaks. After 2015, however, the combination of slow growth in starts and trend growth in residential upkeep and alteration leads to steady demand expansion. By 2050, U.S. softwood lumber consumption rises above 70 billion board feet, nearly 28 percent higher than levels of the early 2000s (app. 1, table 25). As illustrated in appendix 1, table 24, the largest part of growth in total lumber consumption until 2050 derives from residential upkeep and alteration.

Over the past decade, populations of the mountain pine beetle (*Dendroctonus ponderosae*) have expanded to epidemic proportions in the lodgepole pine (see “Species List” for scientific names) forests of interior British Columbia (BC). The BC Ministry of Forests estimated that by the summer of 2004, some 17.3 million acres (7 million hectares) of forest had been affected. Beginning in the central interior, the infestation has now spread widely in the region. Pine mortality is expected to peak by 2007. In what the BC Ministry terms a “worst case” scenario, some 95 percent of the susceptible lodgepole pine in the interior could die from beetle attack by 2024 (BCMF 2005).

The base case assumes that beetle-killed salvage in interior BC continues to rise and that over the period 2005 to 2015 the average annual softwood sawtimber harvest in the Canadian Interior (CINT) region rises about 8 percent.⁴ Harvest peaks in 2010 and the expansion in sawlog supply ends in 2015. We assume that harvest then falls back gradually to lower levels by 2020 as allowable cuts contract. This is due partly to the depletion of stock during the epidemic and salvage process and partly due to expanding concerns for forest protection in provinces across Canada (see later discussion).

⁴This would correspond to about a 6 million cubic meter increase in interior BC annual allowable cut (AAC) (we assume the actual harvest rises by the same amount). This is slightly larger than the increments in AACs announced by the Provincial Chief Forester in September 2004 in the most heavily impacted management areas. The 2005 report *Provincial-Level Projection of the Current Mountain Pine Beetle Outbreak* (see BCMF 2005) refers to this particular harvest acceleration outlook as the “expedited harvest” option. It is but one of many possible future harvest trajectories. We obtain this harvest increment in the assessment projection model by shifting the supply of delivered saw logs to CINT sawmills.

Higher CINT sawlog supply (more volume at any given level of delivered log cost) will lead to increased lumber output, higher exports to the United States and other markets, lower prices in the North American softwood lumber market, and some displacement of production in U.S. regions. The speed and extent of CINT output growth will be heavily controlled by the rates of investment in new capacity in softwood lumber mills. We assume that capacity expands rapidly in the period to 2010 to fully absorb the sawlog increment. However, slower expansion is possible, given the uncertainties about the future course of the epidemic and salvage rates, and this would act to damp many of the market effects. We also assume that the lumber tariff structure remains at the early 2006 level of 10.8 percent until the peak of the output impact in 2010. At that point, we assume that concerns for rapidly rising imports to the United States lead to an increase to 15 percent.

In the face of expanded competition from Canadian and continued pressure from off-shore suppliers, softwood lumber output in the U.S. declines in the period to 2015 (fig. 9, see app. 1, table 25). In 2013, imports are expected to peak at 47 percent of U.S. consumption with offshore regions alone providing 10 percent (fig. 10). In later periods, as Canadian harvest falls under diminishing allowable cuts, the share of offshore suppliers rises at a faster rate and Canada's share drops.

In the period up to 2015, output falls in most softwood lumber producing regions. The Pacific Northwest West (PNWW) shows a relatively modest increase (fig. 11, see app. 1, table 26). Output in other Western regions continues the downward trend begun in the late 1980s. The South experiences a sharp decline from recent peak levels in the face of expanded import competition and near-term sawtimber inventory limitations (see discussion in a later section). After 2015, however, both the West and the South raise production, with Southern output exceeding 20 billion board feet by 2050 and the PNWW nearing 14 billion board feet. Although current timber harvest in the PNWW is only about two-thirds of its level prior to reductions in national forest harvest in the early 1990s, expansion in lumber output is possible based in part on continued shifting of sawlogs from plywood to lumber production and sharply reduced levels of log exports. Long-term output growth is possible because of improvements in lumber recovery, investments in timber management, maturation of large areas of young growth on industry lands in all regions, and in the South a steady rise in nonindustrial private (NIPF) harvests also based on maturation of younger timber stands.

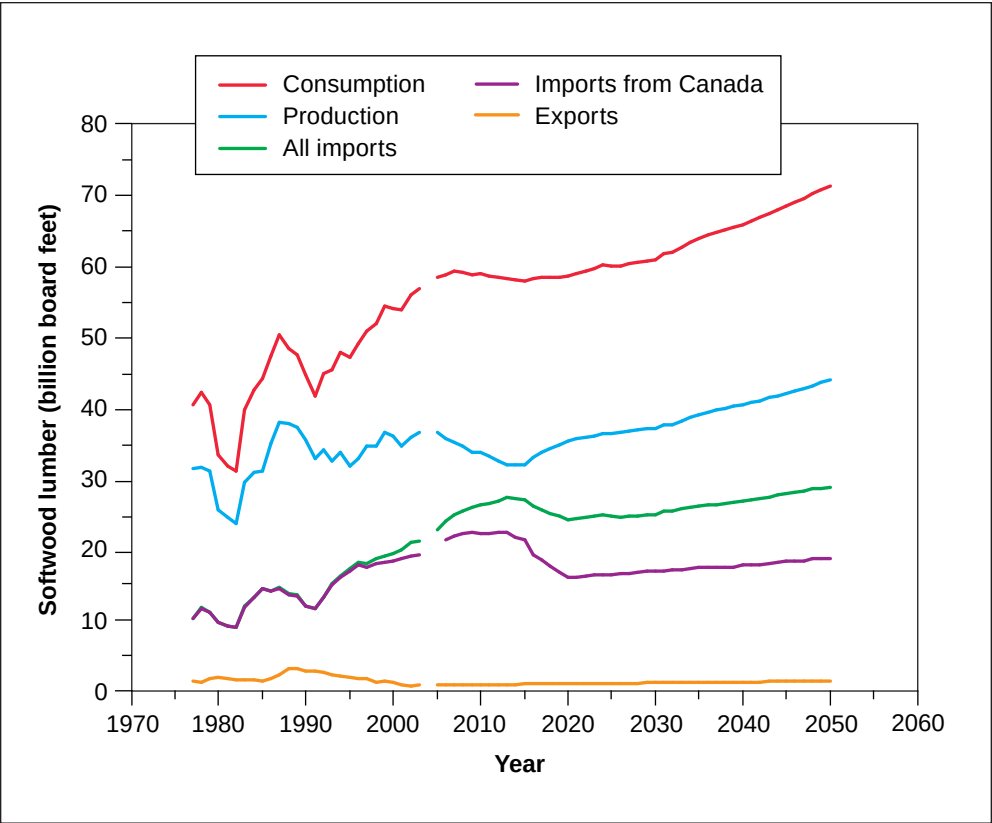


Figure 9—U.S. production, consumption, and trade of softwood lumber, with projections to 2050.

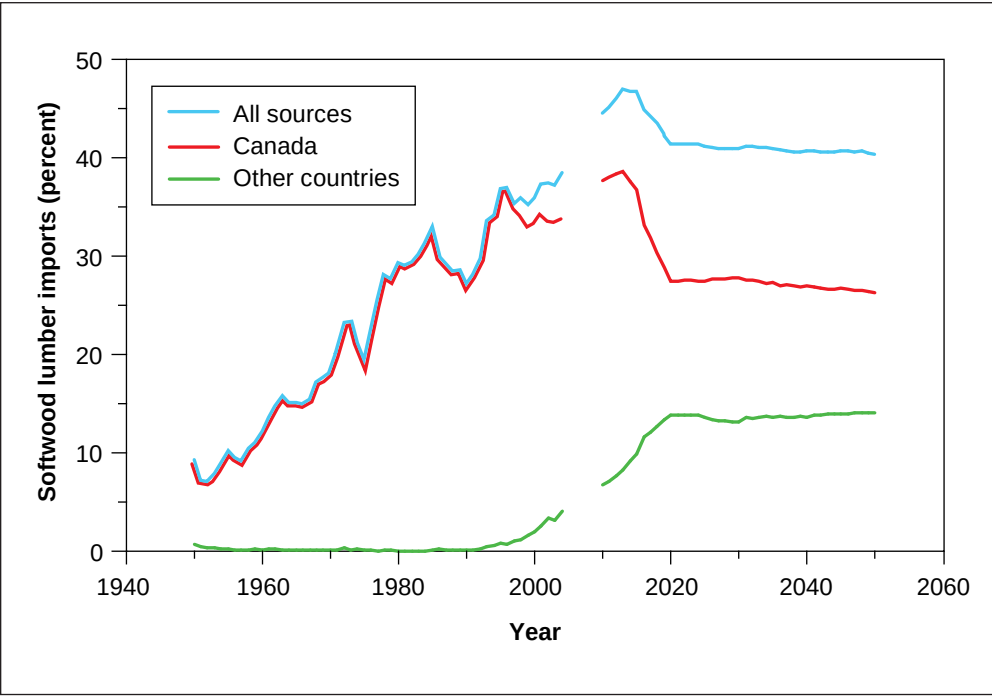


Figure 10—Softwood lumber imports by source as a percentage of U.S. consumption, with projections to 2050.

Hardwood lumber—

Consumption of hardwood lumber is concentrated in shipping (pallets) and manufacturing (furniture) end uses and, hence, is less sensitive to fluctuations in the construction sector than its softwood counterpart. Hardwood lumber use rose markedly during the 1980s with expansion in both new pallet and furniture production. Consumption growth slowed during the 1990s as use in manufacturing, flooring, millwork, and miscellaneous end uses stabilized. During the early 2000s, changes in pallet use that led to reduced requirements for new pallets (through recycling and rebuilding old pallets) and declining U.S. wood furniture output (with rising imports) further reduced U.S. hardwood lumber consumption growth.

The update projection envisions a continuation of slow consumption expansion (see fig. 12), reflecting limited growth in pallet output and further losses in furniture production, as offshore producers capture larger shares of the U.S. market. Between 1980 and 2000, annual U.S. pallet production rose from 258 million to 441 million. In the projection, pallet output reaches just 485 million units by 2020 as pallet recycling accelerates. Hardwood lumber use in all manufacturing (including furniture) falls from about 2.5 billion board feet in 2005 to roughly 2.0 billion board feet by 2050. In contrast, hardwood use in millwork and cabinets and miscellaneous applications (built-in joinery, signage, nonresidential upkeep, etc.) is expected to expand along long-term historical trends, offsetting losses in manufacturing.

The United States is a net exporter of hardwood lumber, mostly to Canada and Europe. Imports are a little more than half the volume of exports and involve specialty grades of lumber and nonnative species, mostly from Canada and Europe. This trade structure is expected to remain stable over the projection.

Virtually all hardwood lumber is produced in the Eastern States, with the South Central and Northeastern regions the largest producers. In the update projection, the Northeastern region becomes the largest producer by 2015, with output continuing to expand along the dramatic upward trend of the past three decades (fig. 13, see app. 1, table 26). South Central output is projected to continue its 15-year decline, falling below both Northern regions by 2050. Both the Southeast and North Central regions will experience modest output growth. Hardwood lumber production remains relatively stable in the West where the focus is on red alder.

Structural panels—

Structural panels have been one of the few categories of solid wood products showing major consumption growth. Between the late 1970s and early 2000s, U.S. consumption of structural panels rose by nearly 85 percent from 20 billion square feet, 3/8-inch basis to nearly 37 billion square feet. New housing and residential upkeep and alteration have been the primary areas of expansion (see app. 1, table 27).

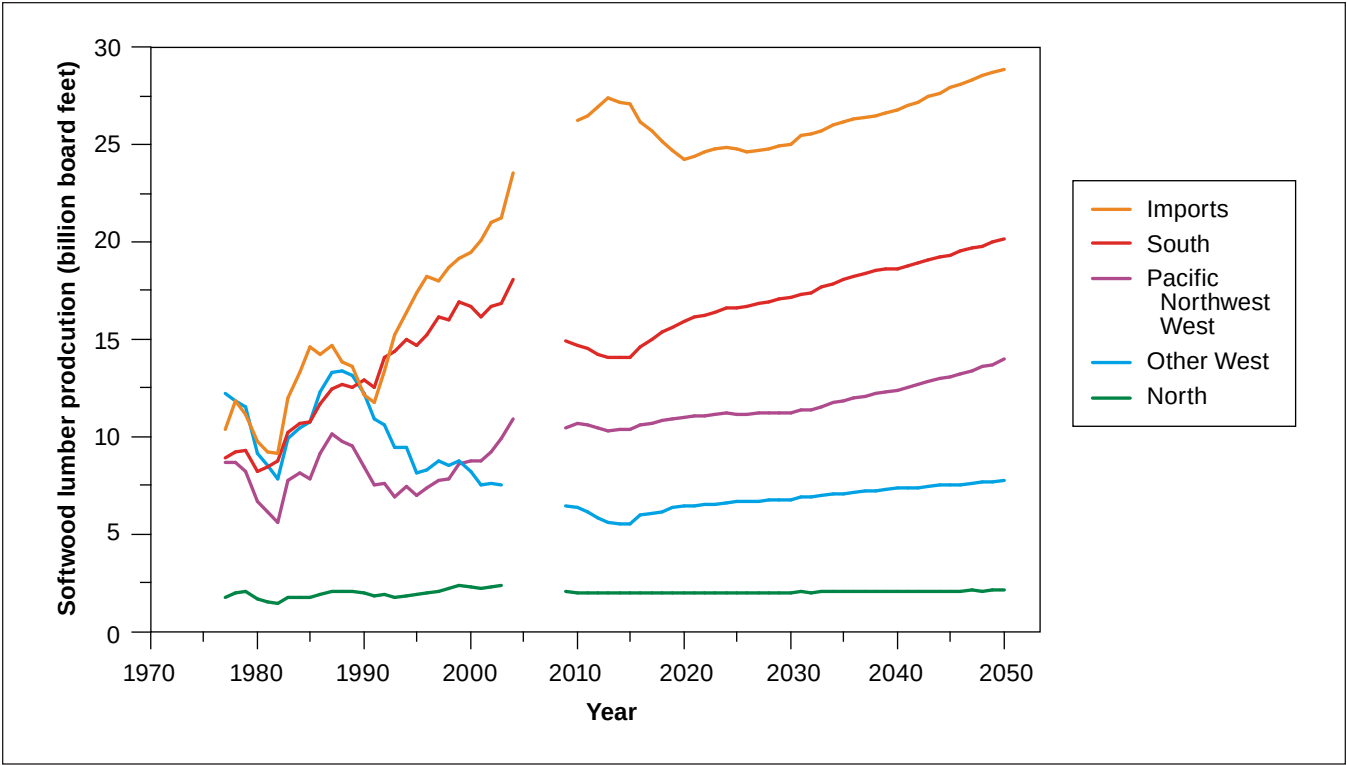


Figure 11—Softwood lumber production by U.S. region, with projections to 2050.

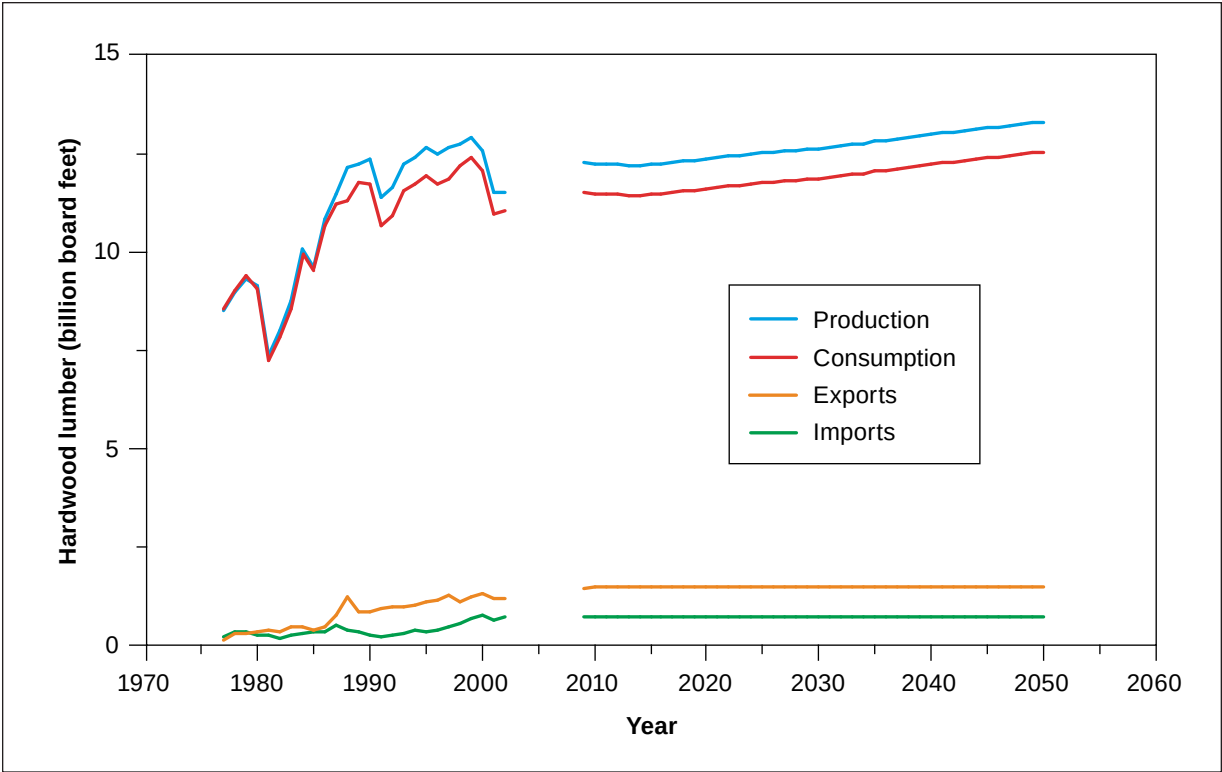


Figure 12—U.S. hardwood lumber production, consumption, and trade, with projections to 2050.

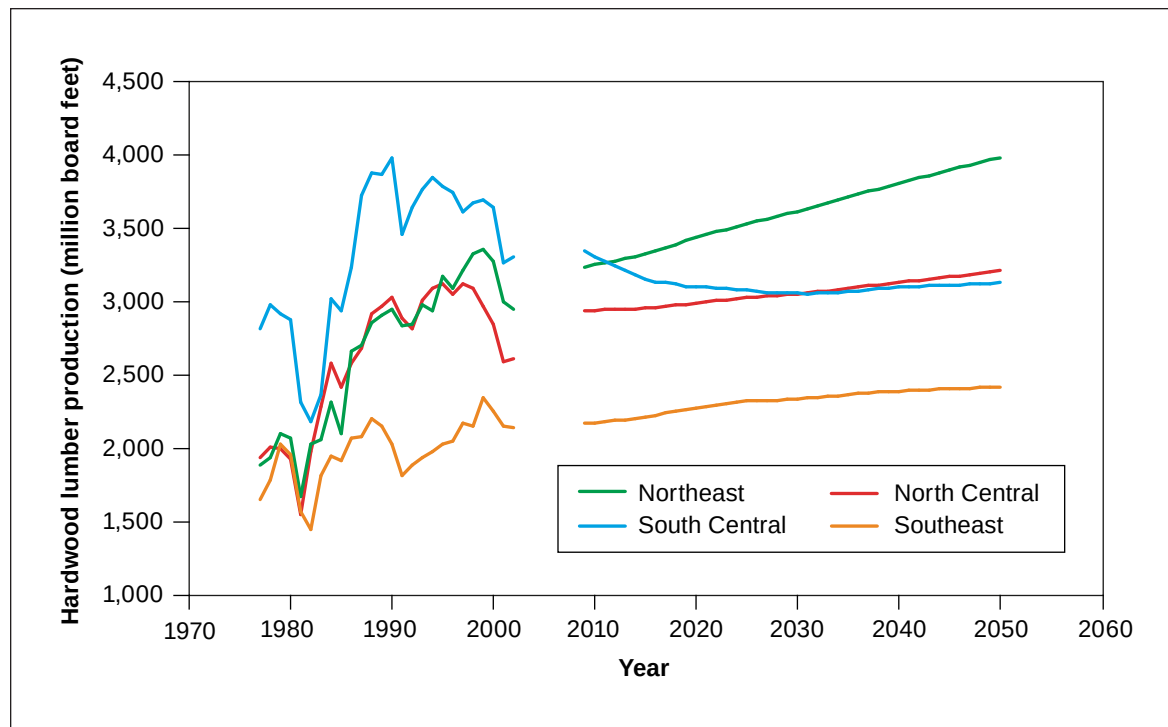


Figure 13—U.S. hardwood lumber production by major region, with projections to 2050.

Consumption trends for the two components of structural panels, softwood plywood and OSB, have been markedly different (see app. 1, table 28). Softwood plywood has lost market share to OSB across all major end uses, and plywood consumption has fallen steadily since the late 1980s. Consumption of OSB has grown and surpassed plywood in the late 1990s (fig. 14). Consumption of OSB is expected to continue to grow, although less rapidly than in the recent past, as its use per square foot of floor area in single-family units reaches a plateau. Future growth, as was the case for softwood lumber, will be heavily dependent on use in residential upkeep and alteration.

In the update projections, Canada continues as a major source of OSB supply to the United States, but future consumption growth will come largely from domestic regions (fig. 15). Southern regions have dominated U.S. OSB output since the mid-1990s and are expected to continue to do so until near the end of the projection period (fig. 16).

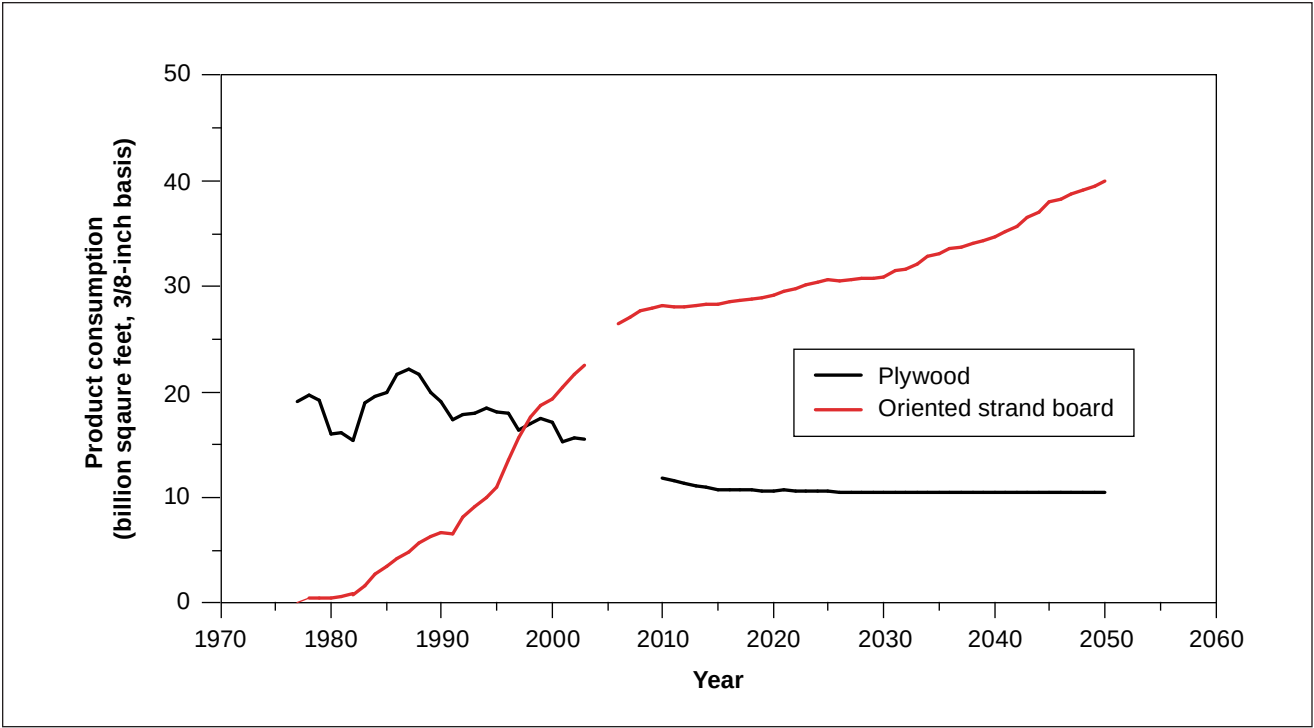


Figure 14—U.S. softwood plywood and oriented strand board (OSB) consumption, with projections to 2050.

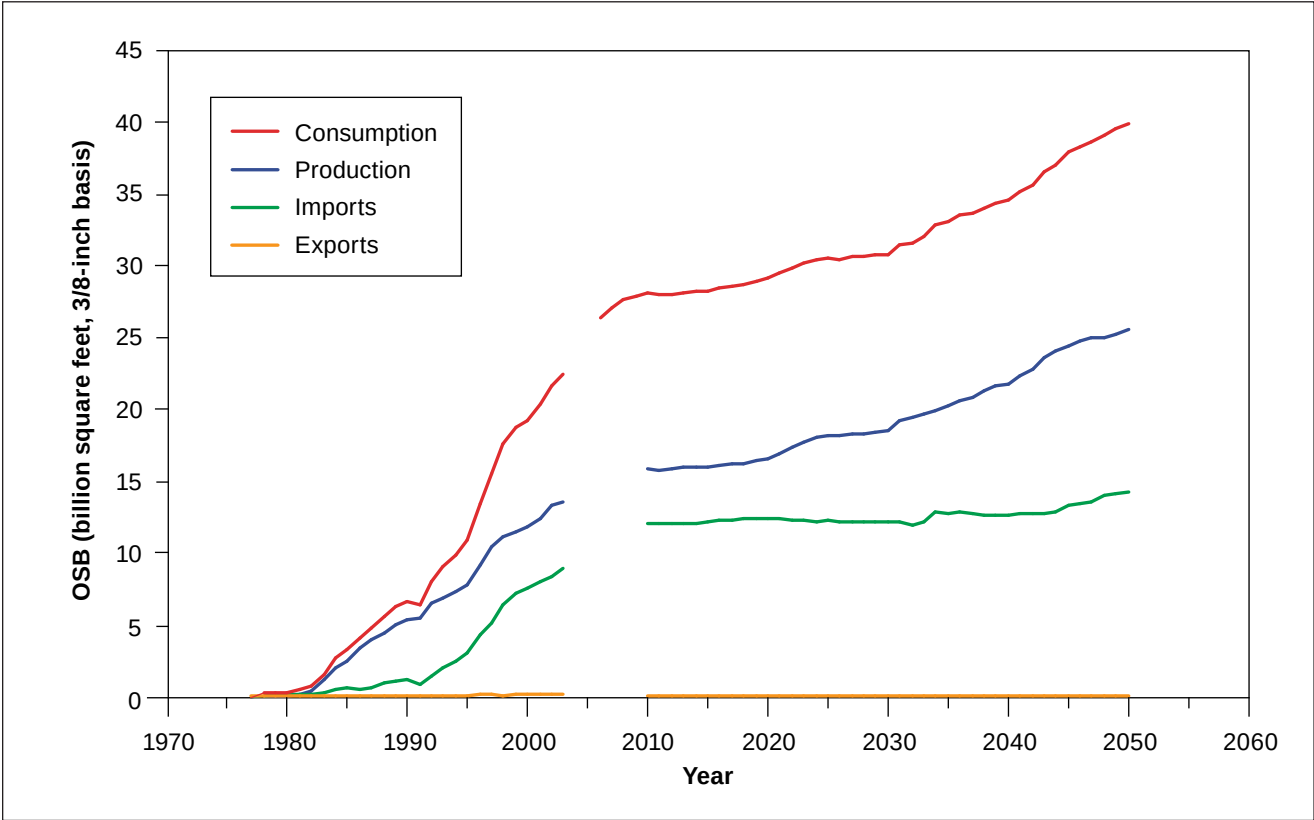


Figure 15—U.S. production, consumption, and trade of oriented strand board (OSB), with projections to 2050.

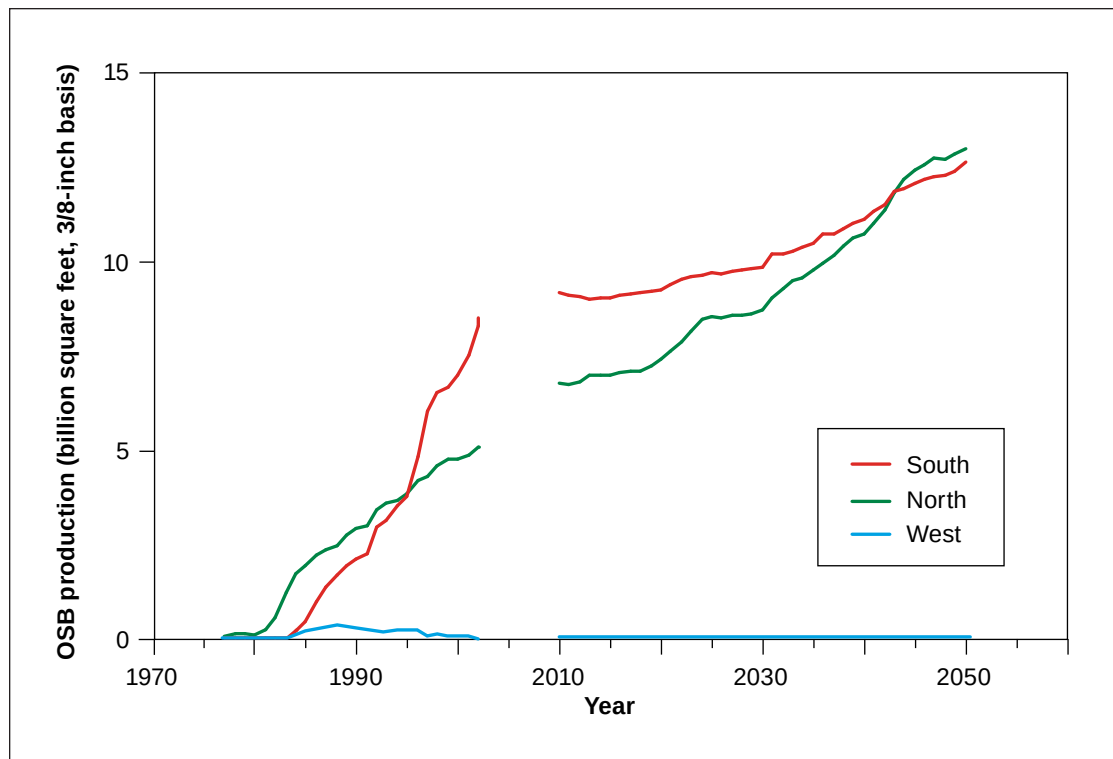


Figure 16—U.S. oriented strand board (OSB) production by region, with projections to 2050.

Softwood plywood will continue to lose markets to OSB, with a particularly rapid decline in consumption during the first decade of the projection. Consumption eventually stabilizes at about 10 billion square feet. Imports from the Southern Hemisphere and Europe are also expected to expand rapidly following recent trends. As a result, large production losses are projected in this period in both the PNWW and South. By the end of the projection, output in the PNWW, the region in which commercial-scale softwood plywood production began in the late 1940s, will have fallen to less than 1 billion square feet (fig. 17, and app. 1, table 29), concentrated mostly in the export and high-valued specialty grades.

Nonstructural panels—

Nonstructural panels comprise insulating board, hardboard, hardwood plywood, and medium density fiberboard (MDF)-particleboard. Consumption of these panels has been another growth area in solid wood products. Driven almost entirely by expanding use of MDF-particleboard in furniture, cabinetry, and underlayment, consumption rose by nearly 60 percent between the late 1970s and the early 2000s (fig. 18, see app. 1, table 30). An average of roughly 25 percent of U.S. consumption of nonstructural panels comes from imports, more than half for hardwood plywood (from Canada and Europe), and 20 to 30 percent for the other panel types.

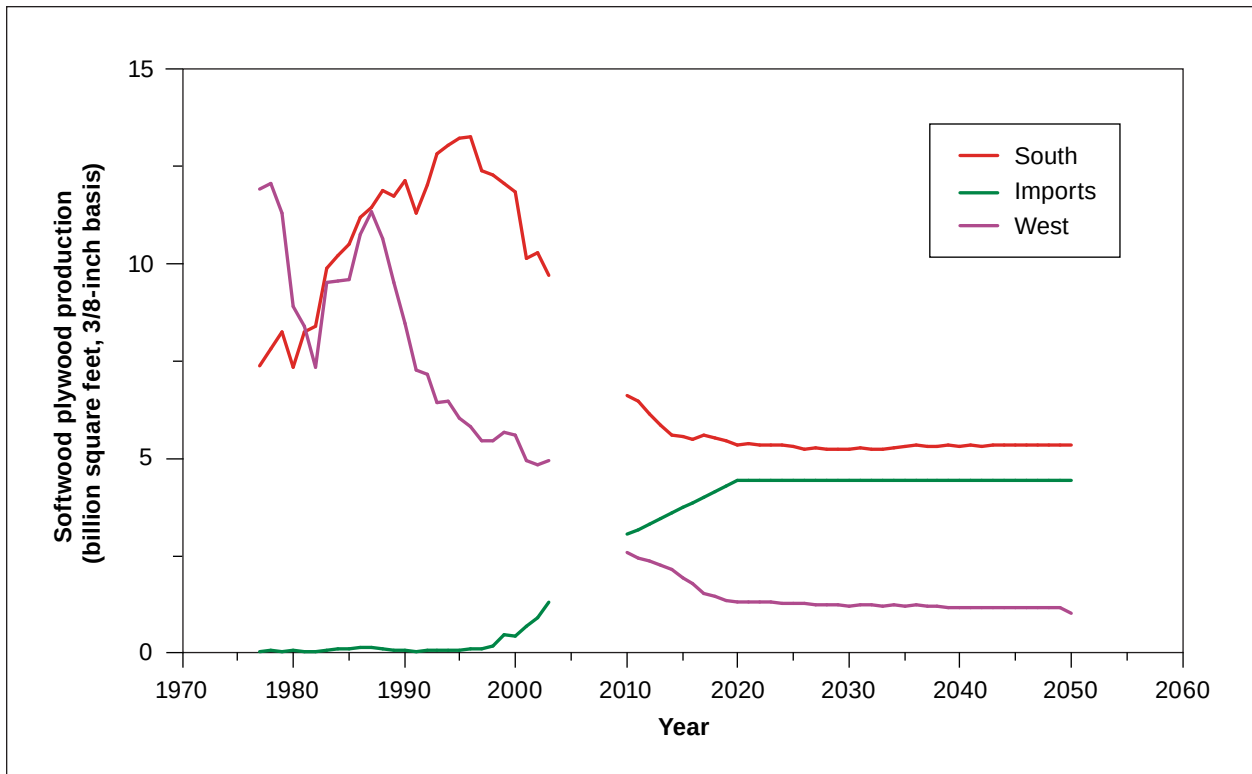


Figure 17—U.S. softwood plywood production by region, with projections to 2050.

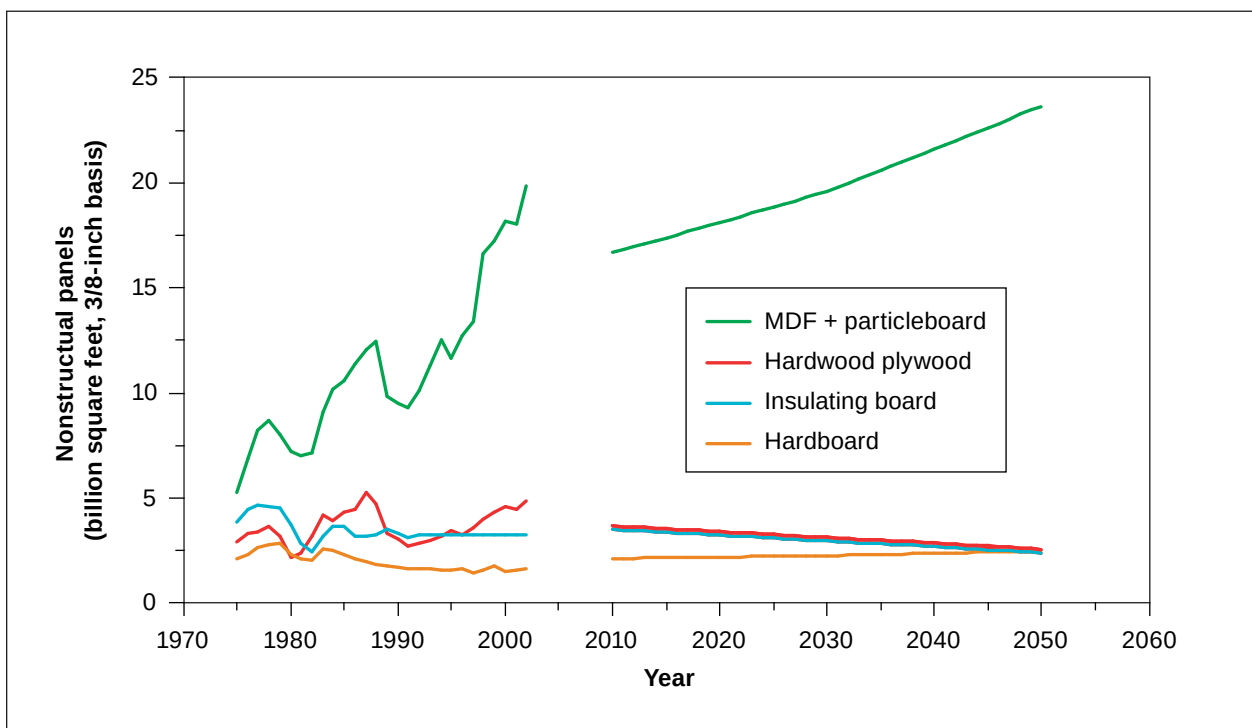


Figure 18—U.S. consumption of nonstructural panels by type, with projections to 2050. MDF = medium density fiberboard.

Because of different end-use markets and market trends, the outlooks for the four panel types differ. Used predominantly in residential construction where it faces major substitution from other materials, insulating board is expected to decrease in consumption steadily through 2050. Hardwood plywood, used in manufacturing and construction, is also expected to decline. Consumption of MDF-particleboard, however, paralleling output in cabinetry, underlayment in single-family residences, and furniture is expected to show continued growth after near-term market adjustments. And consumption of hardboard, with many of the same applications as well as siding and paneling, is also expected to rise slowly.

Paper and Paperboard

Boosted by a resumption of growth in U.S. industrial production, U.S. pulp, paper, and paperboard consumption is experiencing a gradual upturn following a historic downturn that began in the late 1990s. Principal end uses for paper and paperboard include shipping containers and packaging (49 percent of consumption), print media and advertising (42 percent), and household and sanitary products (7 percent). Packaging and advertising both experienced structural changes in demand directly connected to the downturn in U.S. industrial production from the late 1990s to 2002, and conversely both experienced a gradual rebound in demand along with resumed growth in industrial production since 2002.

Trends in industrial production (and demands for paper and paperboard in packaging and print advertising) are correlated with trends in the strength of the U.S. dollar relative to other world currencies. As the dollar gained strength in the period from the late 1990s to 2002, it offset U.S. industrial competitiveness and contributed to a decline in overall industrial production (as well as paper and paperboard demand) during that period. A weaker dollar since then (the dollar index settled back to its 30-year average in 2005) has contributed to a gradual rebound in industrial production and demand for paper and paperboard in packaging and print advertising, but structural changes in demand led to slower projected growth. Meanwhile, demand for household and sanitary paper products has remained relatively robust.

From 1960 to its recent peak (in 1999), the tonnage of U.S. paper and paperboard consumption climbed at an average annual rate of 2.8 percent. The 2005 update projection envisions a much slower growth rate for U.S. paper and paperboard consumption that averages just 0.7 percent per year over the period from 2005 to 2050, with a gradually declining rate of growth over that period. This projected growth, although positive, is nevertheless considerably slower than experienced in preceding decades, reflecting structural changes in demand

following the recent downturn and recovery in U.S. industrial production. Consequently, U.S. per capita consumption of paper and paperboard is projected to remain relatively flat at the current level of around 700 pounds per capita through the projection period, while U.S. consumption per million dollars of real gross domestic product (GDP) is projected to continue to decline. Figure 19 illustrates the historical and projected trends for U.S. consumption of paper and paperboard per capita and per million dollars of real GDP.

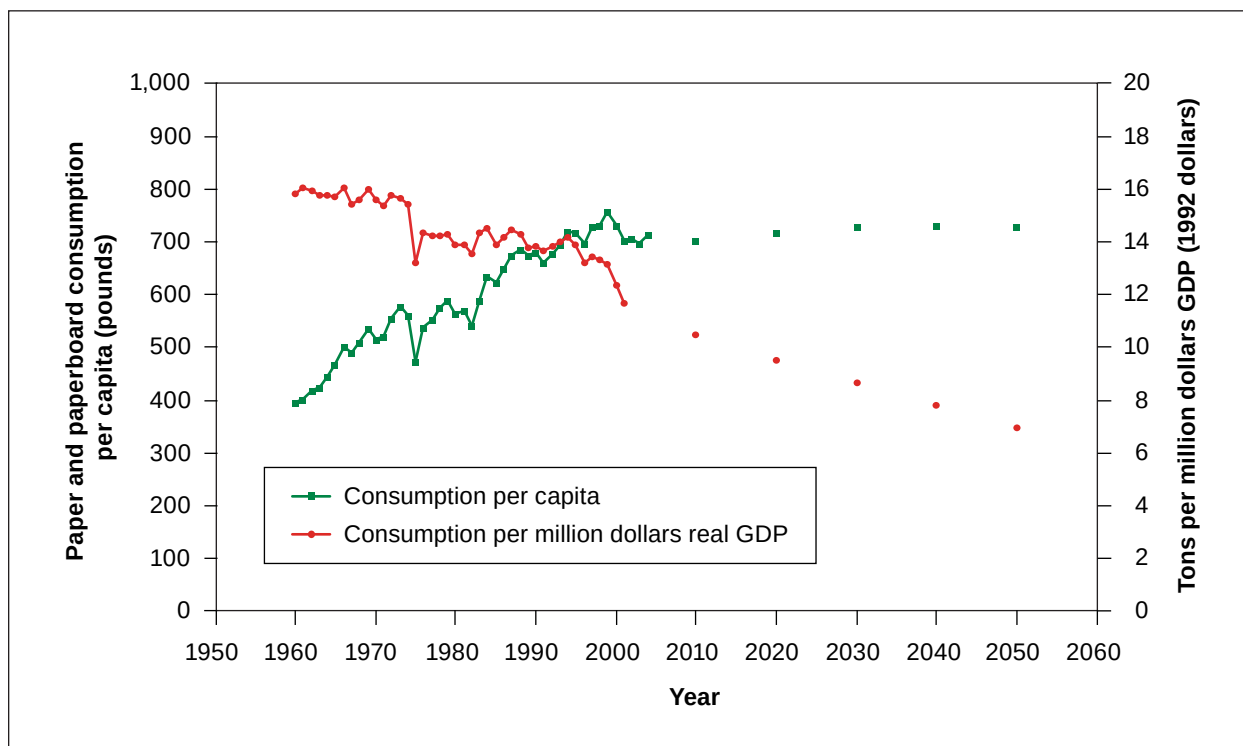


Figure 19—U.S. consumption of paper and paperboard per capita and per million dollars of real gross domestic product (GDP), with projections to 2050.

With slower growth in domestic demand and the presumption of a weaker dollar (following the dollar's moderation since 2000), net imports of pulp, paper, and paperboard are projected to increase at a more modest rate than in the recent past (when net imports of pulp, paper, and paperboard increased from around 1 million metric tons in 1996 to nearly 8 million metric tons in 2001). Exports are projected to gradually increase in the long run, but export growth expectations are tempered in the near term by expanding global capacity (in Asia, Latin America, and elsewhere). Figure 20 illustrates the historical and projected trends for U.S. consumption, production, and trade in paper and paperboard.

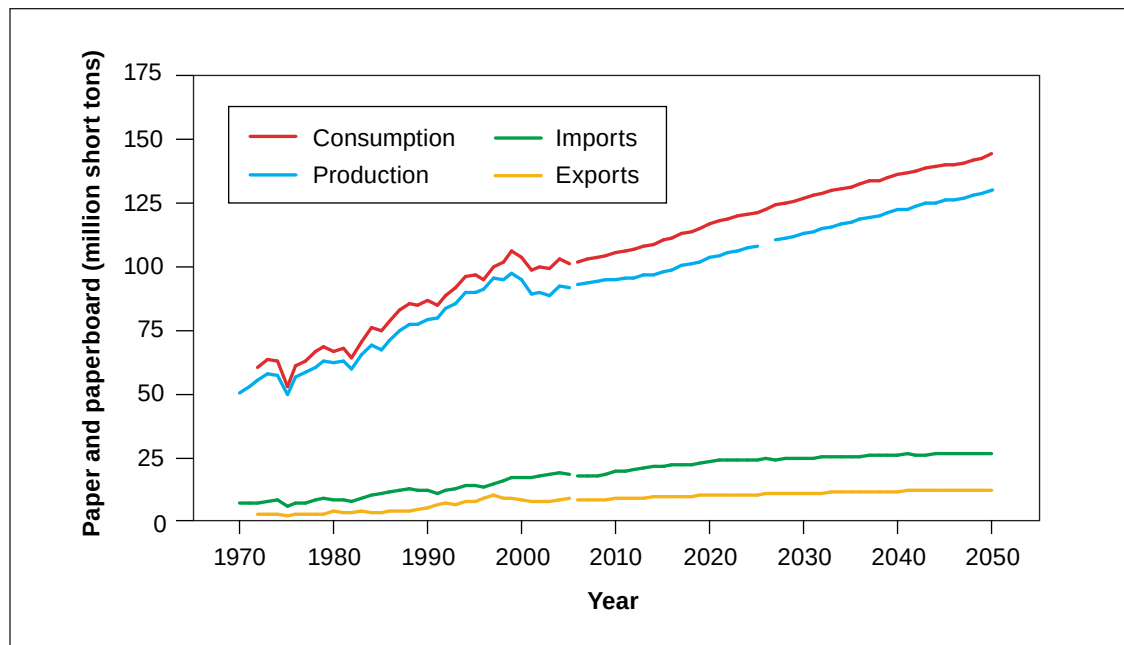


Figure 20—U.S. consumption, production, imports, and exports of paper and paperboard, with projections to 2050.

Structural changes in U.S. manufacturing and in the pulp and paper sector result in a significant adjustment in projected growth in pulp, paper, and paperboard relative to the trends of the late 20th century. Whereas U.S. paper and paperboard output increased at an average annual growth rate of 2.3 percent from 1970 to 1999, the current projections yield an average growth rate of only 0.8 percent (from 2001 to 2050), with very modest expansion in production capacity for at least the next decade.

United States wood pulp production is projected to increase at an average growth rate of 0.7 percent per year (2001 to 2050), slightly less than projected average annual growth for paper and paperboard production. Projected growth in wood pulp output derives from growth in paper and paperboard output and from slower expansion in pulp, paper, and paperboard imports. Growth in wood pulp output also derives from limited projected growth in domestic recycled fiber use. Paper recovery for recycling in the United States is projected to remain above the recovery rate of 50 percent (of consumption), but growth in exports (mainly to China) will account for a rapidly expanding share of recovered paper use.

The net effect of the pulp production and fiber use trends is projected growth in U.S. consumption of both softwood and hardwood pulpwood at U.S. wood pulp mills, although at generally slower rates of growth than in past decades. Figure 21 illustrates historical (AF&PA 1991–2001) and projected U.S. receipts of pulpwood at pulp mills by species group (hardwoods and softwoods).

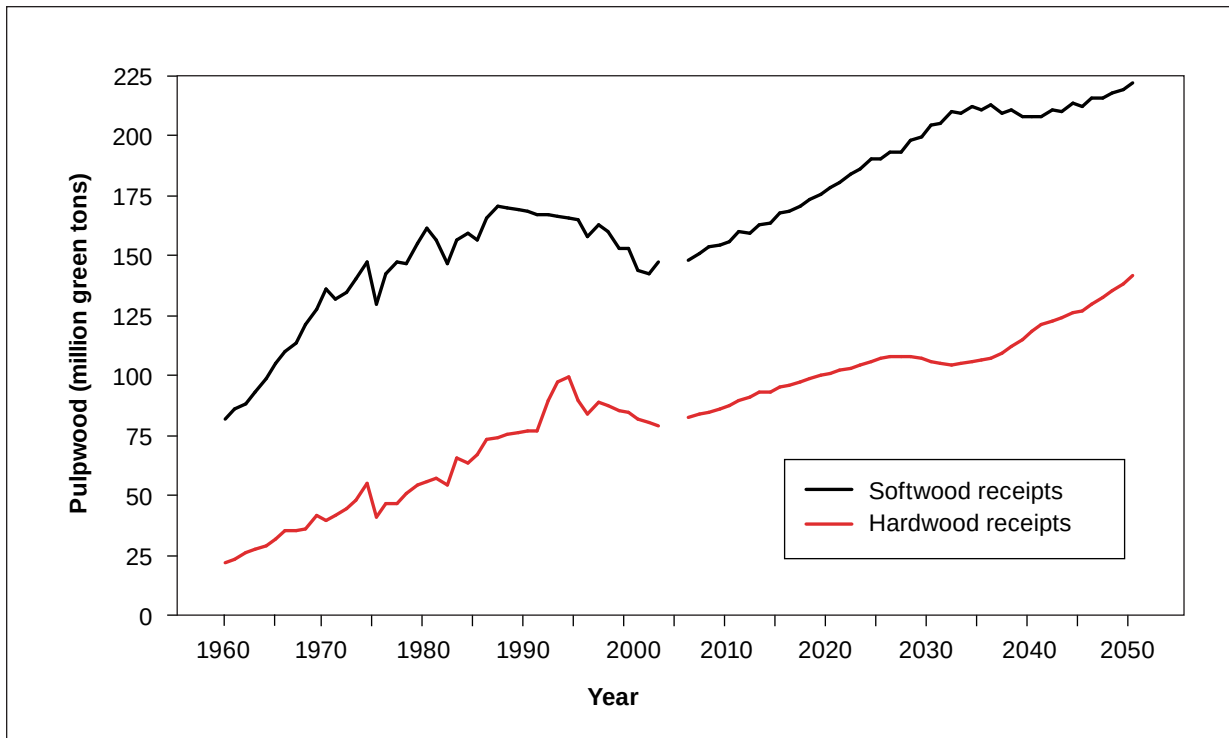


Figure 21—U.S. receipts of pulpwood at pulp mills by species group, with projections to 2050.

Receipts of softwood pulpwood at U.S. pulp mills are projected to increase at an average growth rate of 0.9 percent per year between 2006 and 2050, a rate that is well below the 1960–2003 average growth rate of 1.4 percent. Historically, increased rates of paper recycling from the mid-1980s to 1990s had a pronounced impact on growth in softwood pulpwood receipts at wood pulp mills (which peaked in the late 1980s, see fig. 21). Recycled fiber use expanded significantly in paper and paperboard products that traditionally used large proportions of softwood fiber (newsprint and containerboard). Both softwood and hardwood pulpwood receipts were altered by shifts toward economic globalization and the downturn in paper and paperboard output of the past decade. A projected leveling out of U.S. printing and writing paper production offsets projected growth in hardwood receipts more than growth in softwood receipts. Hardwood pulpwood receipts are projected to increase by only 0.4 percent per year (2006 to 2050).

Projected increases in hardwood pulpwood demand and prices are insufficient to stimulate rapid expansion in agricultural short-rotation woody crops (SRWC). The SRWC technology is a projected structural change, but it is expected to have small impacts on pulpwood supply until the last decade of the projection period (2040–2050), when hardwood SRWC supply gradually increases along with hardwood pulpwood prices.

Product Price Projections

The 2005 update base projection envisions only limited growth in real forest product prices, with growth rates at or below historical experience over the past 50 years for all major classes of products. Despite substantial projected increases in U.S. consumption of most products, supply expansion and substitution options combine to offset pressures for price growth. Specifically, slower price growth reflects (1) improved product recovery (input use efficiency); (2) competition from substitute products at the consumer level; (3) expanding supplies of lower cost imports (competition at the product supply level); (4) limited growth in domestic softwood stumpage prices as a result of rising harvests on private lands and maturation of productive softwood plantations; (5) regional capacity migration, shifting output to lower cost regions; and (6) shifts to lower cost fiber input sources (input mixes).

Projected product price growth rates are summarized in table 6 and price levels are given in table 7 and illustrated in figures 22 and 23. Among the solid wood products, only softwood and hardwood lumber show any continued growth trend. For hardwood lumber, this reflects further upward pressure from stumpage prices. Modest growth in softwood lumber price is due in part to our assumptions about future harvest trends in Canada. The softwood lumber price cycle between 2010 and 2030 (at first falling then rising) results from rising output with interior BC beetle salvage, subsequent reductions in annual allowable cut (AAC) across Canada (see the discussion on Canadian harvest later in this chapter) and eventual expansion in U.S. capacity and growth in offshore imports. Prices for OSB, which have been highly volatile in recent years, are projected to rise at only 0.1 percent per year, given limited growth in key pulpwood prices (softwoods in the South and hardwoods in the North) and continued options for expanding imports from Canada. Continued competition from OSB and losses of market share effectively stabilize projected softwood plywood prices. Historical paper and paperboard prices have shown limited growth despite dramatic expansion in U.S. consumption of these products over the past 5 decades. This has resulted from steady improvements in input productivity and shifts to alternative and less costly input mixes in these industries. These adaptations are expected to continue in the future, and deflated paper and paperboard prices are projected to decline slightly relative to 2000–2003 average levels.

Only limited growth is expected in real forest products prices.

Table 6—Historical and projected base case rates of product price change^a

Product	Historical ^a	Projection ^b
<i>Average annual percent change</i>		
Softwood lumber	0.8	0.2
Hardwood lumber	.4	.3
Softwood plywood	0 ^c	0
Oriented strand board	0 ^d	.1
All paper	.3	-.2
All paperboard	-.1	-.1

^aBased on simple trend regression from 1950 to 2003 except as noted.

^bBased on trend from average 2000–2003 value to average 2041–2050 value.

^cUses years 1965–2003.

^dUses years 1985–2003.

Table 7—Indices of deflated prices^a for selected timber products in the United States, by softwoods and hardwoods, 1952–2002, with projections to 2050

Product, unit, and species group	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Index of price per unit, 1982 = 100</i>												
Lumber:												
Softwoods	100.0	88.3	95.4	126.2	108.2	161.8	130.3	119.8	138.8	135.4	140.2	146.2
Hardwoods	104.4	103.5	118.4	109.8	118.0	136.4	136.0	138.6	148.8	153.4	157.3	159.5
Structural panels:												
Plywood	172.0	118.9	109.2	143.7	109.2	137.5	125.2	134.6	128.2	124.0	128.8	131.5
Structural panels:												
OSB-waferboard ^b	NA	NA	NA	NA	112.5	83.6	91.1	105.1	115.9	115.0	129.8	115.9
Nonstructural panels:												
Plywood	193.8	176.8	153.6	110.8	98.4	90.8	89.4 ^c	88.0	87.2	86.5	85.7	85.0
Other panels ^d	151.5	166.3	119.2	93.2	105.4	107.0	103.3 ^c	99.5	99.5	99.5	99.5	99.5
Paper and paperboard: ^e												
Paper	93.2	102.8	105.1	104.2	106.8	112.8	110.4	102.2	102.2	101.8	102.0	100.7
Paperboard	130.4	121.1	107.6	112.9	106.3	113.2	125.3	131.6	124.3	120.8	120.7	119.5

NA = not available.

^aAll price indexes deflated by the all-commodity producer price index.

^bOriented strand board (OSB) historical prices updated.

^c2002 data are estimated.

^dHardboard, particleboard, and fiberboard products.

^e1991 prices updated.

Source: Historical data from U.S. Bureau of Labor Statistics, Producer Prices and Price Indexes (USDI BLS 1958–2002); OSB from Random Lengths Yearbook 2002.

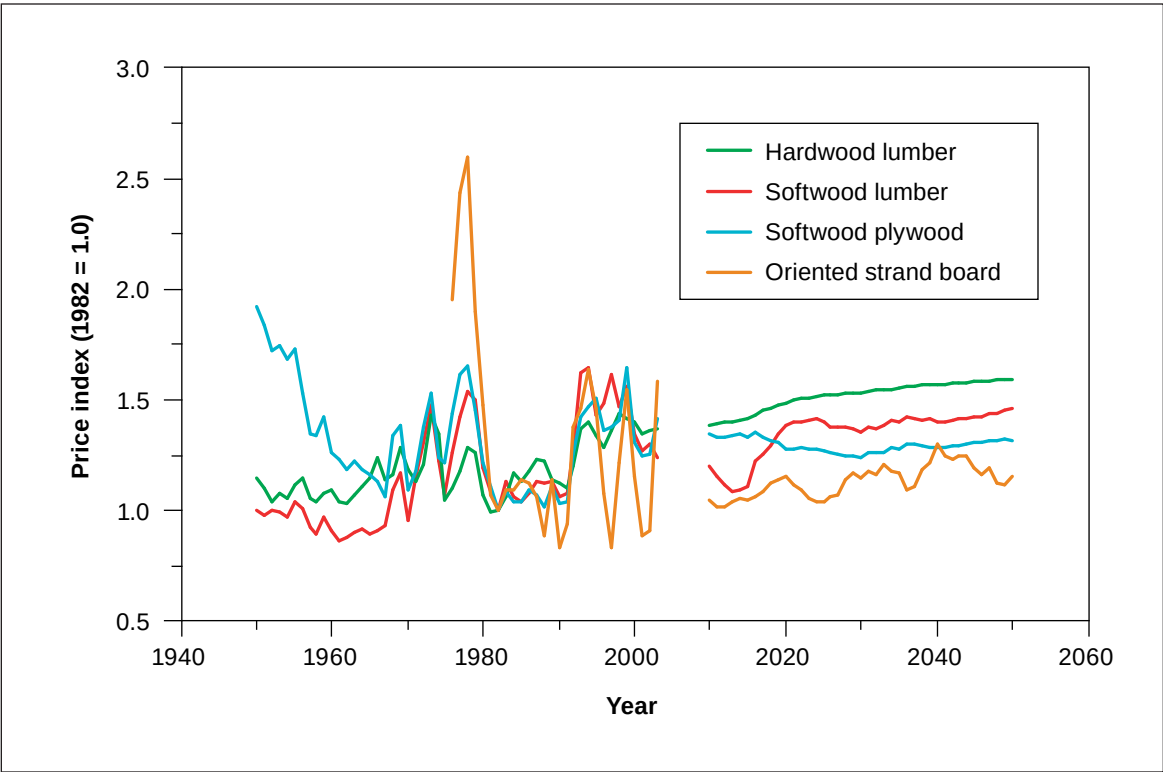


Figure 22—Real prices of solid wood products in the United States, with projections to 2050.

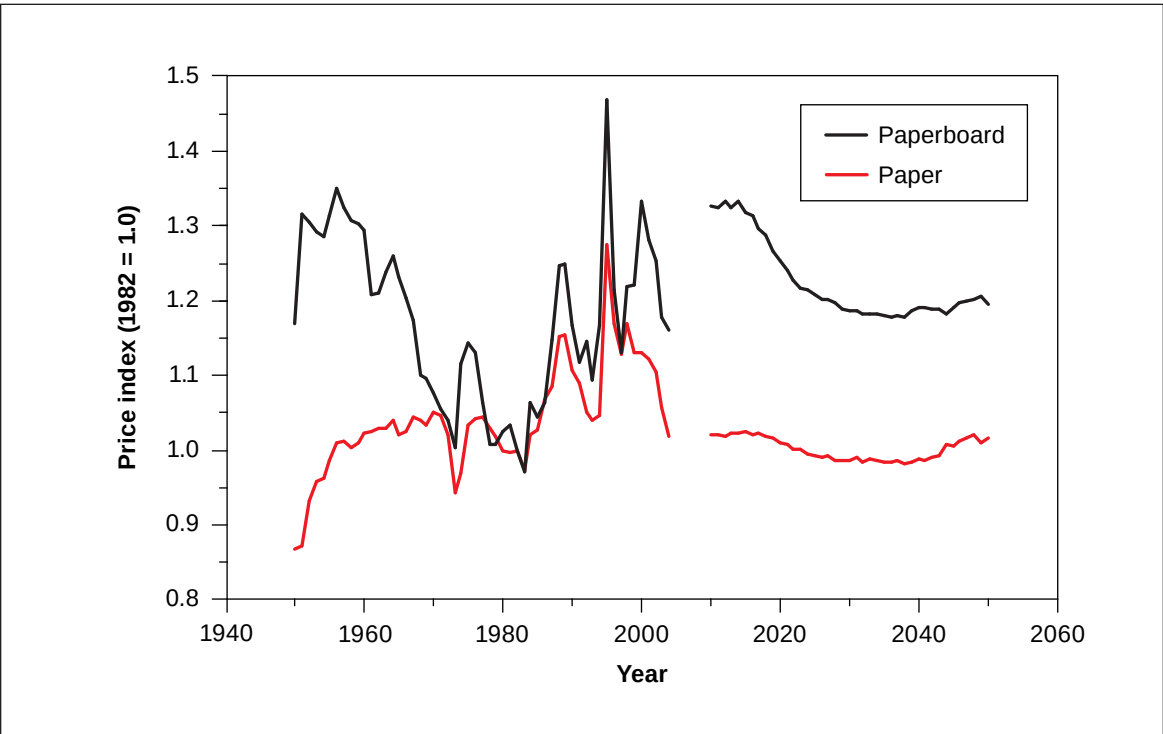


Figure 23—Real prices of paper and paperboard in the United States, with projections to 2050.

Shifts in U.S. Forest Products Production and Source Material

The solidwood equivalent of U.S. new supply⁵ of all wood and paper products is projected to increase over the next 50 years at just over half the rate of the last 50 years. Within this aggregate, paper products increase share from 28 percent to 36 percent (on a cubic volume of roundwood basis) while the share of lumber products falls from 52 percent to 40 percent. The share of composite products, such as OSB or particleboard rises from 4 percent to 6 percent.

About two-thirds of the increase in new supply is from increased U.S. roundwood harvest. The projected rate of growth in domestic harvest is only two-thirds of what it was in the last 50 years. But even with this slower rate of growth, domestic roundwood harvest per capita is projected to be roughly constant over the next 50 years. Harvest increases are mostly on nonindustrial private land in the South, mostly softwood, and all from nonsawtimber. Comparing levels in the 1990s with projected volumes in 2050, reveals that sawtimber harvest is expected to decrease by a small amount.

Roundwood consumption will grow 38 percent from 2002 to 2050.

Total Roundwood Use for Consumption, Production, and Trade

Table 8 displays total U.S. consumption by species for all classes of forest products. In this table the quantity of each product is converted to the equivalent volume of roundwood that would be required for its manufacture. In general, these quantities are similar to those reported in the 2000 assessment (Haynes 2003). Table 8 reveals that almost all the growth in consumption comes in the lower value nonsawtimber products. This continues the trend observed in the past two decades. The largest increase (2002 to 2050) for softwoods comes in pulpwood (which includes roundwood used for OSB), while the greatest roundwood use expansion for hardwoods is in fuelwood.

Table 9 shows estimates of domestic harvest, trade, and SRWC output. Similar to findings of the 2000 assessment, these projections show that an increasing portion of U.S. consumption is met from imports. By 2050, harvest from U.S. forests (excluding SRWC) is about 73 percent of U.S. consumption, down from 78 percent in 2002.

Table 9 also reveals the underlying trend in the origin of the forest products consumed in the United States. Prior to 1996, net trade in the United States had accounted for 7 to 8 percent of consumption. Trade's share more than doubled after

⁵“New supply” is the sum of domestic production plus imports. It is the total volume available for domestic consumption and exports.

1996 and was 16 percent in 2002 as the full effects of harvest reductions on Western federal timberlands worked their way through the forest sector. This reflects a structural shift in the U.S. forest sector, and a higher share of trade in total consumption is expected to persist throughout the projection period. There are some (Mayer et al. 2005) who point out that increasing domestic forest protection without decreasing demand for wood increases wood imports and negative impacts on forest biodiversity elsewhere.

Table 8—Apparent roundwood consumption in the United States, by species group and product, 1952–2002, with projections to 2050

Species group and product	Historical							Projections				
	1952	1962	1970	1976	1986	1996	2002	2010	2020	2030	2040	2050
<i>Billion cubic feet, roundwood equivalent</i>												
Softwoods:												
Sawlogs	5.0	4.8	5.7	5.6	7.1	7.1	8.1	8.0	7.8	7.9	8.3	8.7
Veneer logs	.2	.6	1.1	1.4	1.5	1.1	1.0	.6	.6	.6	.6	.6
Pulpwood ^a	2.3	2.6	3.6	2.9	3.3	3.6	3.6	3.8	4.8	5.4	5.9	6.6
Reconstituted panels ^b	0	0	0	0	0	.1	.1	.7	.7	.7	.8	.9
SRWC ^c	0	0	0	0	0	0	0	0	0	0	0	0
Miscellaneous products ^d	.3	.2	.4	.2	.3	.2	.3	.3	.3	.3	.3	.3
Fuelwood	.5	.2	.2	.2	.6	.3	.3	.6	.7	.7	.8	.8
Total	8.4	8.5	11.0	10.3	12.8	12.4	13.4	14.1	14.8	15.6	16.6	17.9
Hardwoods:												
Sawlogs	1.1	1.0	1.7	1.4	1.8	2.1	2.0	2.0	2.0	2.1	2.1	2.2
Veneer logs	.2	.2	.2	.2	.2	.2	.2	.3	.2	.2	.2	.2
Pulpwood ^a	.3	.7	1.2	1.2	2.1	2.6	2.7	2.6	2.9	3.1	3.1	3.2
Reconstituted panels ^b	0	0	0	0	0	.3	.1	.4	.4	.5	.6	.8
SRWC ^c	0	0	0	0	0	0	0	0	0	0	0	.1
Miscellaneous products ^d	.4	.2	.3	.1	.2	.2	0	0	0	0	0	0
Fuelwood	1.5	.9	1.0	1.0	2.9	1.6	1.2	2.1	2.2	2.3	2.5	2.6
Total	3.5	3.1	4.5	4.0	7.3	6.6	6.2	7.5	7.9	8.3	8.6	9.1
All species:												
Sawlogs	6.1	5.8	7.4	7.0	8.9	9.2	10.4	10.0	9.8	10.0	10.4	10.9
Veneer logs	.4	.8	1.3	1.6	1.8	1.3	1.2	.9	.8	.8	.8	.7
Pulpwood ^a	2.6	3.3	4.8	4.1	5.3	6.2	6.4	6.5	7.8	8.5	9.0	9.7
Reconstituted panels ^b	0	0	0	0	0	.3	.2	1.1	1.1	1.2	1.4	1.7
SRWC (hardwood) ^c	0	0	0	0	0	0	0	0	0	0	0	.1
Miscellaneous products ^d	.7	.4	.7	.4	.6	.7	.3	.3	.3	.3	.3	.3
Fuelwood	2.0	1.1	1.3	1.2	3.5	1.9	1.5	2.7	2.8	3.0	3.2	3.5
Total	11.9	11.6	15.5	14.3	20.1	18.9	19.6	21.5	22.7	23.9	25.2	27.0

Note: Historical data have been revised. Totals may not add because of rounding, all data converted by using national conversion factors.

^a Includes both pulpwood and the pulpwood equivalent of the net trade of chips, pulp, paper, and board.

^b Includes roundwood used in oriented strand board and particleboard manufacture.

^c SRWC = short-rotation woody crop; includes only hardwoods on agriculture lands.

^d Includes cooperage logs, poles, piling, fence posts, round mine timbers, box bolts, shingle bolts, and other miscellaneous items.

Source: Historical data: Ulrich 1989; 1970–1996 updated to reflect revisions in Howard 2003.

Table 9—Apparent roundwood consumption, exports, imports, and harvests in the United States, by species group, 1952–2002, with projections to 2050

Species group and product	Historical ^a							Projections				
	1952	1962	1970	1976	1986	1996	2002	2010	2020	2030	2040	2050
<i>Billion cubic feet</i>												
Softwoods:												
Total consumption ^b	8.4	8.5	11.0	10.3	12.8	12.4	13.4	14.1	14.8	15.6	16.6	17.9
Exports	.1	.4	.9	1.0	1.2	1.4	1.0	1.2	1.3	1.4	1.5	1.5
Imports	1.3	1.7	1.7	1.8	2.8	3.3	3.9	5.5	5.5	5.7	5.9	6.3
SRWC ^c	0	0	0	0	0	0	0	0	0	0	0	0
Harvest	7.2	7.2	10.2	9.5	11.2	10.5	10.5	9.8	10.7	11.3	12.1	13.1
Hardwoods:												
Total consumption ^b	3.5	3.1	4.5	4.0	7.3	6.6	6.2	7.5	7.9	8.3	8.6	9.1
Export	0	.1	.1	.1	.3	.9	.7	.8	.9	.9	.9	.9
Imports	.1	.2	.4	.4	.6	.7	1.0	.9	1.1	1.2	1.2	1.3
SRWC ^c	0	0	0	0	0	0	0	0	0	0	0	.1
Harvest	3.4	3.0	4.2	4.2	7.0	6.8	5.9	7.4	7.7	8.0	8.2	8.6
All species:												
Total consumption ^b	11.9	11.6	15.5	14.3	20.1	18.9	19.6	21.5	22.7	23.9	25.2	27.0
Exports	.1	.5	1.1	1.2	1.5	2.3	1.8	2.0	2.2	2.3	2.3	2.4
Imports	1.4	1.9	2.0	2.1	3.4	3.9	4.9	6.4	6.6	6.9	7.1	7.5
SRWC ^c	0	0	0	0	0	0	0	0	0	0	0	.1
Harvest	10.6	10.2	14.6	13.4	18.2	17.4	16.5	17.2	18.4	19.3	20.4	21.8

Note: Historical data have been revised. Totals may not add because of rounding.

^a Data are estimates of actual consumption and harvests; consequently, harvest data do not match similar data in table 10.

^b Total consumption of products converted to a roundwood equivalent basis by using national conversion factors.

^c SRWC = short-rotation woody crop.

Source: Historical data: Ulrich 1989; 1970–1996 updated to reflect revisions in Howard 2003.

Stumpage Markets

Timber harvest data and stumpage prices are summarized in tables 10 and 11. The growing-stock removals are summarized in tables 12 and 13. These projections reflect either limited growth in consumption or growth rates that are well within the potential of the resource base and increases in available timber inventories. In some cases, as for hardwoods in the North, considerable owner resistance to expansion of private harvest contributes to price increases.

The trends in timber harvest do not necessarily follow the trends in consumption (shown in table 8). For example, in this decade (through 2010) softwood timber harvests fall slightly, while softwood consumption increases. The difference is made up from increases in trade, especially for softwood lumber. After 2010, softwood harvest rises as harvests from managed private forests increase and Canadian supplies are restricted.

(text continues on page 71)

Table 10—Timber harvests^a from forest land in the contiguous states, by region, 1952–2002, with projections through 2050

Item	Historical							Projections				
	1952	1962	1970	1976	1986	1996	2002	2010	2020	2030	2040	2050
<i>Billion cubic feet</i>												
Softwoods:												
Northeast	0.48	0.37	0.39	0.43	0.57	0.62	0.58	0.58	0.53	0.51	0.50	0.51
North Central ^b	.17	.20	.17	.21	.23	.33	.26	.28	.30	.30	.30	.30
Southeast	1.65	1.40	1.67	1.70	2.23	2.63	2.92	2.67	3.17	3.41	3.70	4.06
South Central	1.21	1.16	2.01	2.26	2.68	3.48	3.69	3.21	3.64	4.00	4.39	4.79
Rocky Mountains—	.47	.61	.81	.84	.97	.85	.60	.69	.72	.76	.81	.83
North Rocky Mountains	.31	.44	.57	.60	.66	.57	.50	.44	.43	.44	.46	.46
South Rocky Mountains	.16	.17	.24	.24	.31	.28	.10	.25	.28	.32	.35	.36
Pacific Northwest ^c —												
Pacific Northwest West ^d	1.85	2.01	2.50	2.66	3.00	1.73	1.55	1.65	1.58	1.57	1.65	1.78
Pacific Northwest East ^d	.38	.50	.49	.53	.57	.39	.20	.24	.26	.29	.31	.34
Pacific Southwest ^e	.68	.86	.87	.77	.75	.66	.72	.46	.47	.47	.49	.49
Softwoods total harvests	6.90	7.10	8.90	9.40	11.00	10.70	10.51	9.77	10.67	11.31	12.15	13.11
Hardwoods:												
Northeast	.55	.55	.60	.59	1.50	1.42	1.29	1.51	1.55	1.59	1.73	1.87
North Central	.98	.80	.83	.92	1.91	1.62	1.42	1.43	1.47	1.51	1.53	1.65
Southeast	.77	.62	.70	.73	1.34	1.46	1.19	1.55	1.63	1.70	1.66	1.64
South Central	1.27	.96	.98	.96	1.56	2.45	1.84	2.28	2.44	2.58	2.70	2.86
West	.03	.07	.10	.10	.29	.55	.25	.63	.62	.62	.62	.62
Hardwoods total harvests	3.60	3.00	3.20	3.30	6.60	7.50	5.99	7.40	7.70	7.99	8.24	8.65

Note: Data may not add to totals because of rounding.

^a Harvest from all sources.

^b Includes the Great Plains States: Kansas, Nebraska, North Dakota, and eastern South Dakota.

^c Excludes Alaska.

^d Pacific Northwest West (western Oregon and western Washington) is also called the Douglas-fir subregion, and Pacific Northwest East (eastern Oregon and eastern Washington) is also called the ponderosa pine subregion.

^e Excludes Hawaii.

Sources: Historical data: 1952–96 from 2000 RPA timber assessment update (Haynes 2003).

Table 11—Deflated (1982) stumpage prices^a in the contiguous United States, by region, 1952–2002, with projections to 2050

Region	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Price (dollars) per thousand board feet, Scribner log rule</i>												
Sawtimber:												
Softwoods—												
North	89	62	53	51	37	108	106	98	108	117	128	140
South	130	82	120	142	119	228	209	250	246	228	226	228
Interior West ^b	47	31	55	95	64	108	137	121	136	131	122	118
Pacific Northwest West	55	63	104	155	99	299	208	161	235	215	216	228
<i>Price (dollars) per thousand board feet, International 1/4-inch scale</i>												
Hardwoods—												
North	NA	62	70	75	110	214	186	172	170	181	193	208
South	NA	32	45	49	43	86	99	83	91	99	108	118
<i>Price (dollars) per cord</i>												
Pulpwood:												
Softwoods—												
South	NA	18	17	15	13	21	12	18	15	10	12	13
Hardwoods—												
South	NA	5	5	4	3	13	11	7	5	10	17	20

NA = Not available.

^a All prices deflated by all-commodity producer price index.^b Interior West includes the Rocky Mountains, Pacific Southwest (California), and Pacific Northwest East (eastern Oregon and Washington).

Sources: Historical data for the North from Sendak (1994), all other regions from U.S. Department of Agriculture, Forest Service Timber Cut and Sold reports on national forests (On file at individual Forest Service regional offices); Timber Mart—South 1997–2002, Log Lines 1997–2002.

Table 12—Softwood and hardwood timber removals, harvest, growth, and inventory in the United States, by region, 1952–2002, with projections to 2050

Item	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Million cubic feet</i>												
North:												
Softwoods—												
Removals	622	528	583	692	725	673	643	690	660	632	618	624
Harvest	596	501	549	636	908	825	883	870	838	811	801	814
Net annual growth	973	1,212	1,336	1,558	1,288	1,175	1,183	1,192	1,158	1,115	1,059	1,011
Inventory	27,053	33,661	38,817	43,850	47,618	49,376	49,875	54,861	58,816	62,457	65,700	68,710
Hardwoods—												
Removals	1,279	1,391	1,722	1,801	1,982	2,120	2,051	2,180	2,238	2,299	2,404	2,569
Harvest	1,381	1,329	1,465	1,502	3,190	2,819	2,761	2,920	3,007	3,103	3,262	3,494
Net annual growth	2,743	3,213	3,593	3,790	4,223	4,169	4,235	4,135	4,126	4,036	3,915	3,781
Inventory	76,695	94,627	106,867	119,158	142,420	164,874	167,750	195,773	213,258	228,735	241,618	252,134
South:												
Softwoods—												
Removals	3,122	2,823	3,674	4,437	5,740	6,480	6,514	6,058	6,996	7,651	8,336	8,997
Harvest	3,036	2,707	3,527	4,251	5,317	6,157	5,700	5,837	6,776	7,419	8,089	8,738
Net annual growth	3,641	4,699	5,644	6,314	5,500	5,892	6,467	7,502	8,114	8,609	8,951	8,907
Inventory	60,462	75,087	89,156	101,208	105,613	104,847	108,020	115,830	132,030	144,007	152,892	155,045
Hardwoods—												
Removals	2,731	2,832	2,344	2,241	2,958	3,708	3,557	4,080	4,352	4,547	4,644	4,753
Harvest	1,933	1,662	1,840	1,707	2,931	3,438	3,846	3,824	4,066	4,251	4,364	4,492
Net annual growth	3,040	3,394	4,282	5,009	4,488	4,877	5,055	4,716	4,480	4,372	4,368	4,363
Inventory	88,008	98,985	109,271	122,165	139,027	151,516	159,950	155,980	158,343	156,544	154,041	150,542
Rocky Mountains: ^a												
Softwoods—												
Removals	534	739	889	842	839	517	511	532	584	610	649	664
Harvest	497	684	814	773	876	613	763	680	756	801	856	882
Net annual growth	1,100	1,256	1,446	1,594	1,956	2,026	1,901	1,579	1,475	1,396	1,362	1,344
Inventory	87,545	93,222	94,275	95,111	100,298	114,682	120,840	129,164	138,607	146,735	154,139	161,131
Hardwoods—												
Removals	34	30	27	24	28	30	24	67	74	81	88	89
Harvest	10	13	13	5	57	47	137	150	163	174	186	193
Net annual growth	87	99	119	139	169	483	222	171	164	171	166	153
Inventory	5,074	5,595	6,034	6,138	7,681	9,360	8,693	5,778	6,183	6,530	6,822	7,058
Pacific Coast:												
Softwoods—												
Removals	3,484	3,514	4,039	4,024	4,057	2,421	2,387	2,275	2,274	2,298	2,411	2,551
Harvest	3,393	3,429	3,805	3,850	4,190	2,506	2,726	2,394	2,382	2,411	2,527	2,673
Net annual growth	2,021	2,445	2,905	3,034	3,777	4,460	4,159	4,335	4,291	4,377	4,422	4,277
Inventory	256,729	247,785	237,754	226,787	199,382	214,933	212,961	230,209	248,054	272,529	293,894	312,628
Hardwoods—												
Removals	43	77	115	126	114	118	151	318	315	304	294	286
Harvest	37	62	87	102	145	172	468	483	472	455	442	437
Net annual growth	304	388	484	486	681	596	510	646	654	647	629	623
Inventory	14,093	16,413	19,197	18,437	23,220	25,805	27,598	32,380	36,384	40,610	44,613	48,625

Table 12—Softwood and hardwood timber removals, harvest, growth, and inventory in the United States, by region, 1952–2002, with projections to 2050 (continued)

Item	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Million cubic feet</i>												
United States:												
Softwoods—												
Removals	7,763	7,604	9,186	9,995	11,362	10,092	10,055	9,555	10,514	11,191	12,015	12,836
Harvest	7,522	7,321	8,695	9,510	11,290	10,101	10,072	9,781	10,752	11,441	12,273	13,108
Net annual growth	7,734	9,611	11,331	12,501	12,520	13,552	13,710	14,608	15,038	15,496	15,794	15,539
Inventory	431,789	449,755	460,002	466,956	452,911	483,838	491,699	530,064	577,507	625,728	666,626	697,514
Hardwoods—												
Removals	4,087	4,330	4,208	4,193	5,082	5,977	5,783	6,645	6,979	7,231	7,431	7,698
Harvest	3,361	3,066	3,405	3,316	6,324	6,475	7,213	7,377	7,707	7,983	8,253	8,619
Net annual growth	6,175	7,094	8,478	9,423	9,561	10,126	10,022	9,668	9,424	9,225	9,078	8,919
Inventory	183,870	215,620	241,369	265,898	312,348	351,555	363,991	389,910	414,167	432,417	447,093	458,358

Note: Historical harvest data are estimates of the trend level of harvests and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data show the average volume that would be harvested given the assumptions of the study. Inventory data for 1952 and 1962 are as of December 31. Inventory data for 1970 and the projection years are as of January 1. Inventory data shown under 1976, 1987, 1997, and 2002 are as of January 1 of following year. Historical data updated since 2000 report.

^a Great Plains states are included in the Rocky Mountains for historical data. For projections, western South Dakota is in the Rocky Mountains, and eastern South Dakota and other Great Plains states are in the North.

Source: For historical data, Powell et al. 1993; 1997 removals, growth, inventory data Smith et al. 2001; 2002 removals, growth, inventory from Smith et al. 2004; harvest data from Haynes 2003; 2002 harvest estimated from the assessment projections.

Table 13—Softwood and hardwood timber removals, harvest, growth, and inventory in the United States, by ownership, 1952–2002, with projections to 2050

Item	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Million cubic feet</i>												
National forest:												
Softwoods—												
Removals	1,028	1,728	2,082	1,986	2,061	630	250	384	506	510	510	510
Harvest	961	1,635	1,918	1,867	2,153	712	315	377	519	523	523	523
Net annual growth	1,664	1,999	2,367	2,468	2,783	3,431	3,349	2,852	2,621	2,389	2,218	2,077
Inventory	204,437	213,696	211,927	208,099	186,313	222,326	228,041	251,450	274,567	294,847	312,921	329,591
Hardwoods—												
Removals	117	126	146	130	160	198	91	70	81	83	85	85
Harvest	100	97	123	101	166	217	109	103	115	118	120	122
Net annual growth	396	508	573	658	617	674	637	568	540	490	440	399
Inventory	13,556	17,207	19,721	21,567	25,107	29,789	31,856	35,925	40,866	45,241	49,107	52,520
Other public:												
Softwoods—												
Removals	429	568	750	851	858	562	553	597	642	660	680	691
Harvest	403	562	702	822	814	577	600	612	655	674	693	702
Net annual growth	730	961	1,113	1,191	1,371	1,208	1,178	1,349	1,284	1,259	1,257	1,240
Inventory	55,184	55,720	57,521	59,039	57,255	51,089	51,837	59,400	66,341	72,401	78,196	83,749

Table 13—Softwood and hardwood timber removals, harvest, growth, and inventory in the United States, by ownership, 1952–2002, with projections to 2050 (continued)

Item	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Million cubic feet</i>												
Hardwoods—												
Removals	141	150	199	225	223	386	381	361	394	418	441	456
Harvest	122	130	170	199	276	445	451	479	507	524	544	561
Net annual growth	492	634	749	840	978	841	910	913	936	930	915	904
Inventory	16,417	20,621	23,894	26,365	31,256	36,524	38,798	43,017	48,476	53,696	58,536	63,108
Forest industry: ^a												
Softwoods—												
Removals	2,765	2,301	3,084	3,616	4,213	3,683	3,680	4,166	4,794	5,122	5,342	5,601
Harvest	2,796	2,289	2,896	3,417	4,222	3,623	4,207	4,234	4,806	5,110	5,308	5,553
Net annual growth	1,872	2,326	2,626	2,949	3,152	3,382	3,453	4,641	5,377	5,811	6,135	6,129
Inventory	77,439	76,094	75,433	74,526	72,753	66,261	65,857	64,972	69,881	80,970	89,080	95,607
Hardwoods—												
Removals	525	663	570	600	818	1,050	927	817	749	775	796	792
Harvest	421	434	488	473	1,025	1,069	996	901	834	867	893	900
Net annual growth	690	830	1,070	1,222	1,130	986	945	998	943	914	897	874
Inventory	20,373	25,425	29,381	32,313	35,311	33,526	33,214	32,251	33,680	34,838	35,816	36,594
Nonindustrial private forest: ^a												
Softwoods—												
Removals	3,541	3,007	3,270	3,543	4,230	5,217	5,572	4,408	4,572	4,899	5,482	6,033
Harvest	3,362	2,836	3,179	3,403	4,102	5,189	4,950	4,558	4,772	5,134	5,749	6,330
Net annual growth	3,468	4,325	5,225	5,893	5,214	5,532	5,730	5,767	5,757	6,037	6,184	6,093
Inventory	94,729	104,245	115,121	125,292	136,590	144,162	145,964	154,242	166,718	177,511	186,428	188,566
Hardwoods—												
Removals	3,305	3,392	3,293	3,237	3,881	4,342	4,374	5,397	5,756	5,956	6,109	6,366
Harvest	2,718	2,405	2,624	2,543	4,856	4,745	5,658	5,895	6,252	6,474	6,696	7,033
Net annual growth	4,597	5,122	6,086	6,704	6,836	7,625	7,530	7,189	7,005	6,892	6,827	6,743
Inventory	133,524	152,367	168,373	185,653	220,674	251,716	260,123	278,717	291,145	298,642	303,634	306,136
United States:												
Softwoods—												
Removals	7,763	7,604	9,186	9,995	11,362	10,092	10,055	9,555	10,514	11,191	12,015	12,836
Harvest	7,522	7,321	8,695	9,510	11,290	10,101	10,072	9,781	10,752	11,441	12,273	13,108
Net annual growth	7,734	9,611	11,331	12,501	12,520	13,552	13,710	14,608	15,038	15,496	15,794	15,539
Inventory	431,789	449,755	460,002	466,956	452,911	483,838	491,699	530,064	577,507	625,728	666,626	697,514
Hardwoods—												
Removals	4,087	4,330	4,208	4,193	5,082	5,977	5,783	6,645	6,979	7,231	7,431	7,698
Harvest	3,361	3,066	3,405	3,316	6,324	6,475	7,213	7,377	7,707	7,983	8,253	8,616
Net annual growth	6,175	7,094	8,478	9,423	9,561	10,126	10,022	9,668	9,424	9,225	9,078	8,919
Inventory	183,870	215,620	241,369	265,898	312,348	351,555	363,991	389,910	414,167	432,417	447,093	458,358

Note: Historical harvest data are estimates of harvest trends and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data show the average volume that would be harvested given the assumptions of the study. Inventory data for 1952 and 1962 are as of December 31. Inventory data for 1970 and the projection years are as of January 1. Inventory data shown under 1976, 1986, 1997, and 2002 are as of January 1 of following year. Historical data updated since 2000 report.

^a Lands held by firms with commercial timber production objectives but no processing facilities (e.g., timberland investment organizations [TIMOs] and real estate investment trusts [REITs]) are included in forest industry and nonindustrial private forest categories, depending on their classification in the starting (approximately 1995) inventory data. See text in chapter 2 “Projected Area Changes for Land Uses and Forest Management Cover Types” section for further discussion.

Source: For historical data, Powell et al. 1993; 1997 removals, growth, inventory data Smith et al. 2001; 2002 removals, growth, inventory from Smith et al. 2004; harvest data from Haynes 2003; 2002 harvest estimated from the assessment projections.

Softwoods

United States softwood harvests rise slowly over the projection at about 0.7 percent per year (2010–2050), driven entirely by expansion of pulpwood consumption (for OSB and wood pulp). Sawtimber cut for lumber, plywood, and other solid wood products declines slightly for the first decade of the projection (to 2015) then recovers to near current levels by 2050 (fig. 24). The decline to 2015 reflects a modest reduction in U.S. softwood lumber production and a steady fall in plywood output. After 2015, driven by expansion in residential upkeep and alteration (and by a resurgence in new housing after 2030), growth in softwood lumber consumption and in overall softwood sawtimber harvest resumes.

In contrast, U.S. paper and paperboard output and OSB production continue to expand throughout the projection, driving up pulpwood consumption and total softwood nonsawtimber harvest (fig. 24). Between 2010 and 2050, OSB production expands at 1.2 percent per year, and U.S. pulp production rises at 0.7 percent. During this period, roundwood pulpwood consumption (at OSB and wood pulp mills) is projected to grow annually at about 1.1 percent.

Projected softwood sawtimber and nonsawtimber harvests at the regional level are illustrated in figures 25 and 26. In part because of continuing improvements in recovery, further losses in lumber milling capacity, reductions in plywood production, and sawlog exports much lower than historical levels, sawtimber harvests in the West do not rise above recent levels by 2050. In the South, sawtimber cut grows more rapidly and exceeds recent levels in the last decade of the projection. Driven by the steady growth in U.S. and regional pulp production, Southern softwood nonsawtimber harvest rises sharply (fig. 26), with harvest more than doubling between 2003 and 2050.

For all regions, the private components of these projected softwood harvests are less than the anticipated forest growth, and private inventory volumes by 2050 are higher than in 2003 (fig. 27). Growth in excess of rising harvest is due in part to changes in the age class structure of private inventories, specifically the movement of large areas of young stands into the ages of very rapid volume accumulation. It also reflects the update projection of continued investment in more intensive management by private owners (see discussion in a later section of this chapter).

Softwood harvests will increase about 0.7 percent a year from 2010 to 2050.

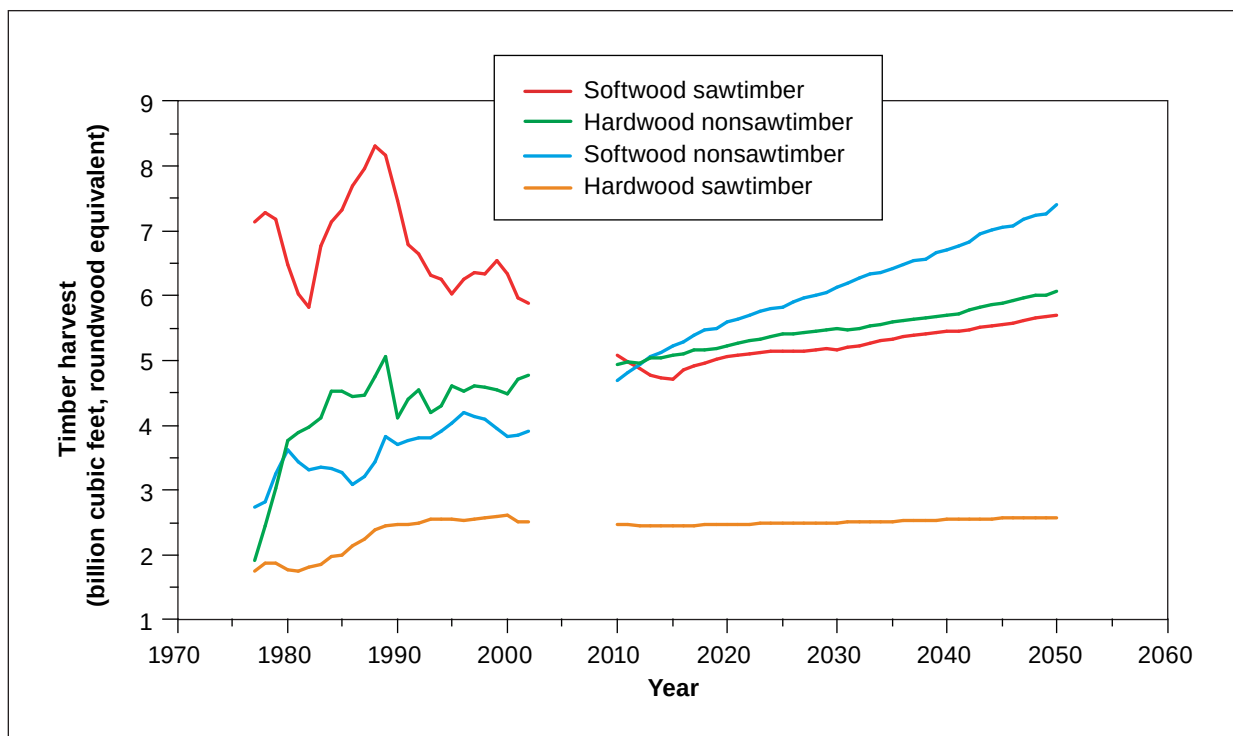


Figure 24—U.S. timber harvest by species and product category, with projections to 2050. Volumes include growing-stock and non-growing-stock sources. Sawtimber used for solid wood products; nonsawtimber includes pulpwood and fuelwood.

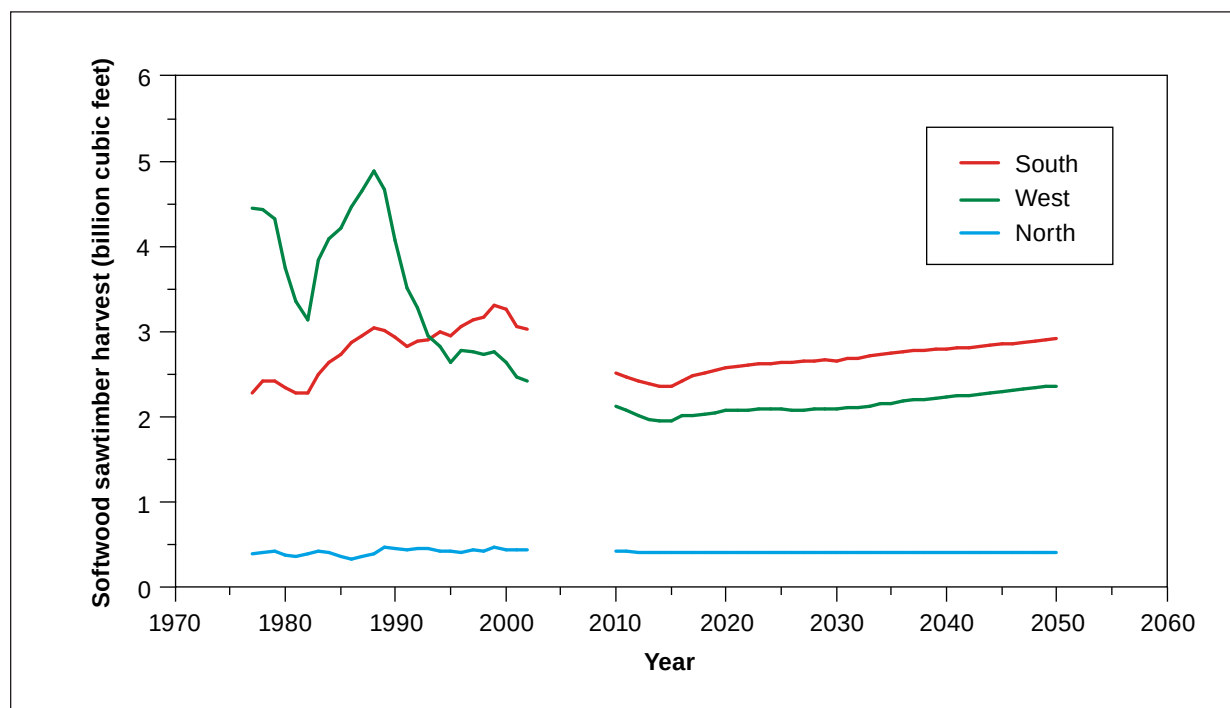


Figure 25—Softwood sawtimber harvest all owners, by region, with projections to 2050. Historical values are estimates.

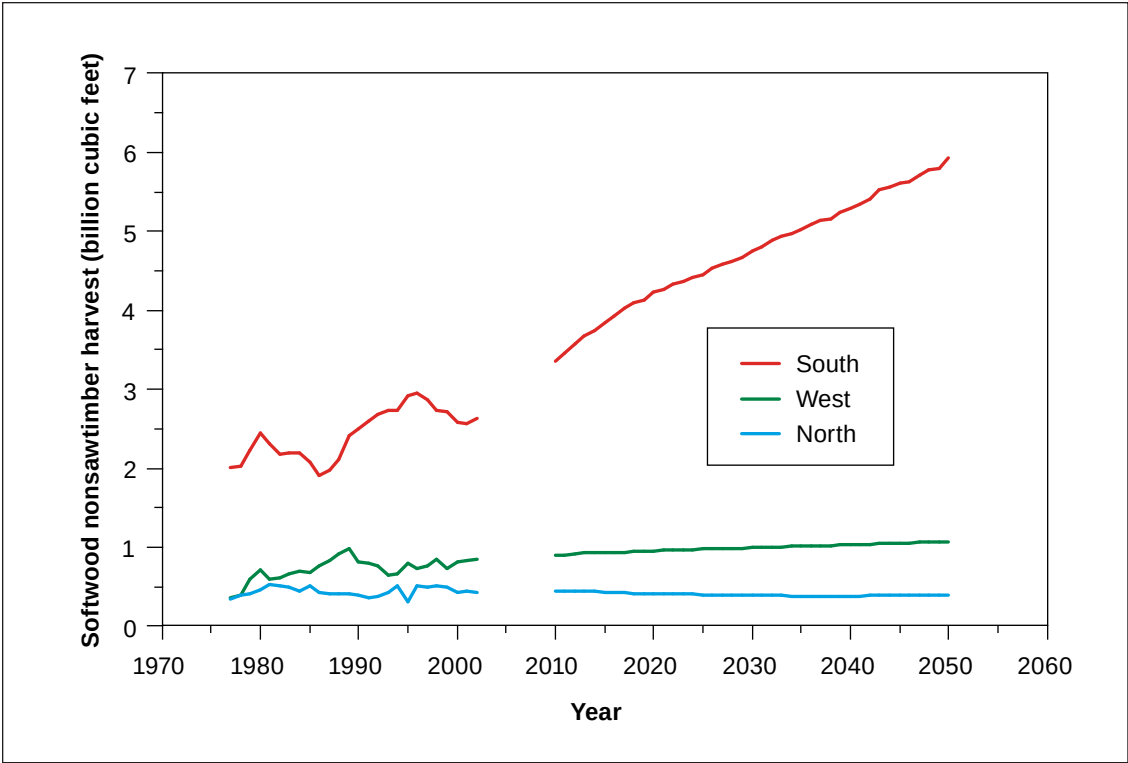


Figure 26—Softwood nonsawtimber harvest all owners, by region, with projections to 2050. Historical values are estimates.

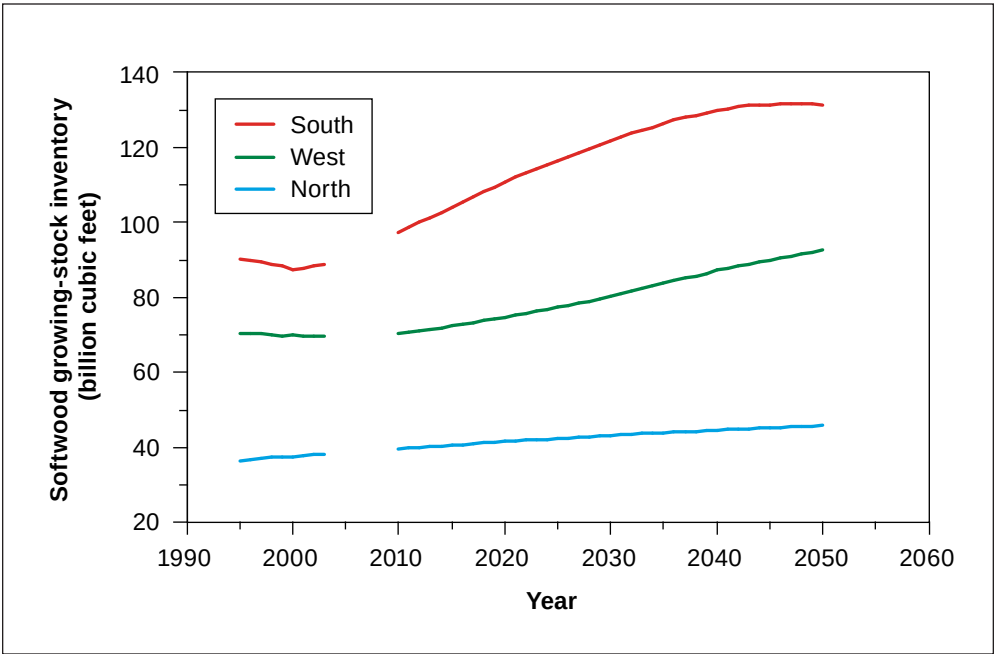


Figure 27—Private softwood growing-stock inventory, with projections to 2050. Historical values are estimates.

Hardwoods

Projected hardwood growing-stock removals on timberland rise steadily to 2025 then stabilize over the projection period. On average, hardwood harvests (excluding SRWC) are projected to increase at 0.4 percent per year from 2010 to 2050. As in the case of softwoods, the increase is due almost entirely to expansion of the pulpwood component of nonsawtimber harvest (fig. 24).

With increased wood pulp output, nonsawtimber consumption is projected to increase, but no gain is projected in the hardwood share of total nonsawtimber use. As illustrated in figure 28, hardwood harvests in the North and West are projected to be stable to slowly increasing, consistent with expected pulp output in those regions. In the South, hardwood harvest rises in line with the historical trend.

Total U.S. hardwood harvests for lumber, plywood, and other sawtimber products are relatively stable over the projection (fig. 24). This pattern is dictated by end-use consumption trends in hardwood lumber, where declining use for pallets and furniture offset growth in use for millwork and miscellaneous products. At the regional level, rising inventories and sawtimber stumpage prices in the North are expected to lead to some growth in hardwood harvest, particularly in the Northeast (fig. 29). Southern and Western hardwood sawtimber harvests, however, are expected to fall.

Growth rates of hardwood forests on private lands in the United States are smaller than those of softwood stands, and the hardwood growth rate has been declining over the past three decades.⁶ Yet, despite declining growth rates and rising harvests, private hardwood inventory in the North has grown steadily over the past five decades. This expansion, at a decreasing rate, is expected to continue in the update projection (fig. 30). In the South, however, future hardwood growth is projected to fall below harvests, yielding a declining private inventory.

Stumpage Prices

Projected growth in stumpage prices differs across regions, species, and between sawtimber and pulpwood (see table 11). Prices in the major producing regions of the West and South show limited growth (fig. 31). Cycles in PNWW, Interior West, and Southern prices between 2010 and 2030 reflect fluctuations in Canadian timber

⁶The average growth rate (current annual net growth as a percentage of inventory) on all private hardwood forests in the Eastern United States was 3.0 percent per year versus 11.5 percent per year for softwoods in 2002 (Smith et al. 2004). Between 1976 and 2002 the growth rate of private hardwood stands in the North fell from 3.1 percent to 2.6 percent per year, while in the South the rate declined from 4.2 percent in 1976 to 3.3 percent in 2002. Some of this loss is due to the declining proportions of hardwoods in softwood and mixed stands as levels of forest management intensify.

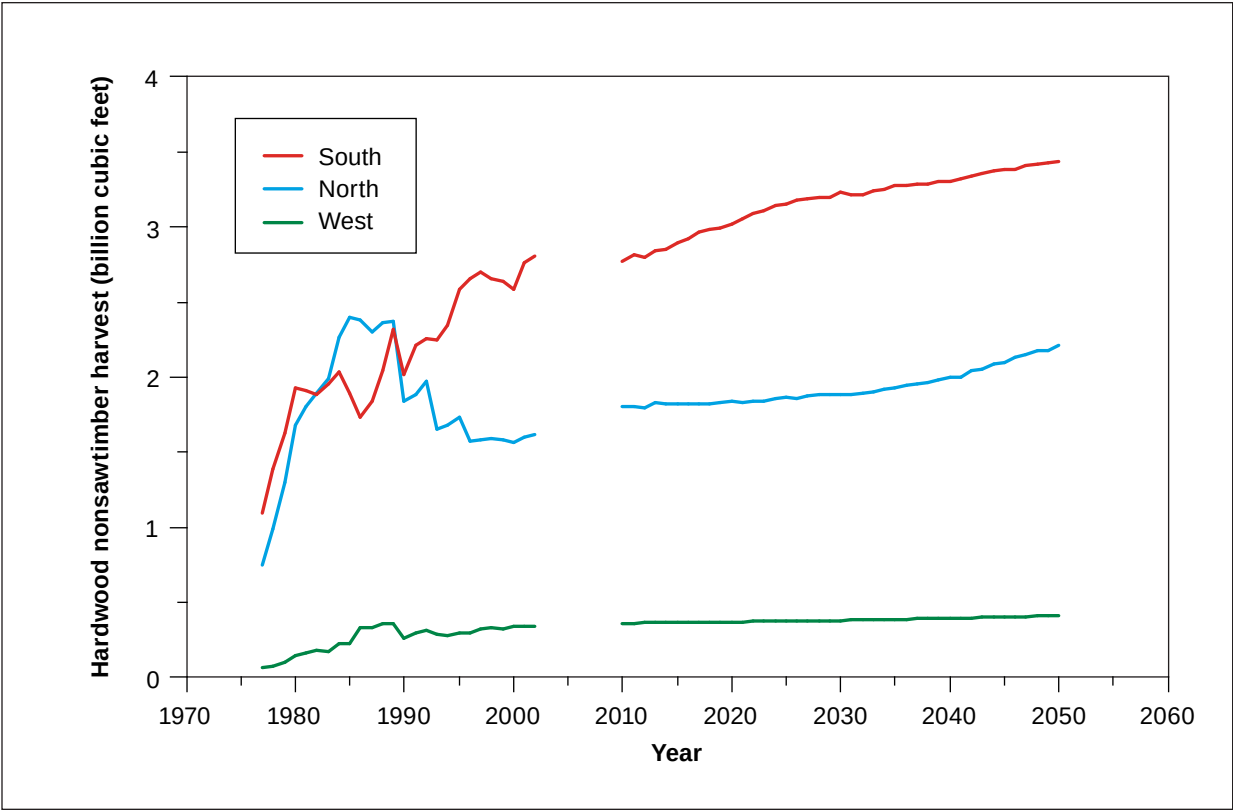


Figure 28—Hardwood nonsawtimber harvest all owners, by region, with projections to 2050. Historical values are estimates.

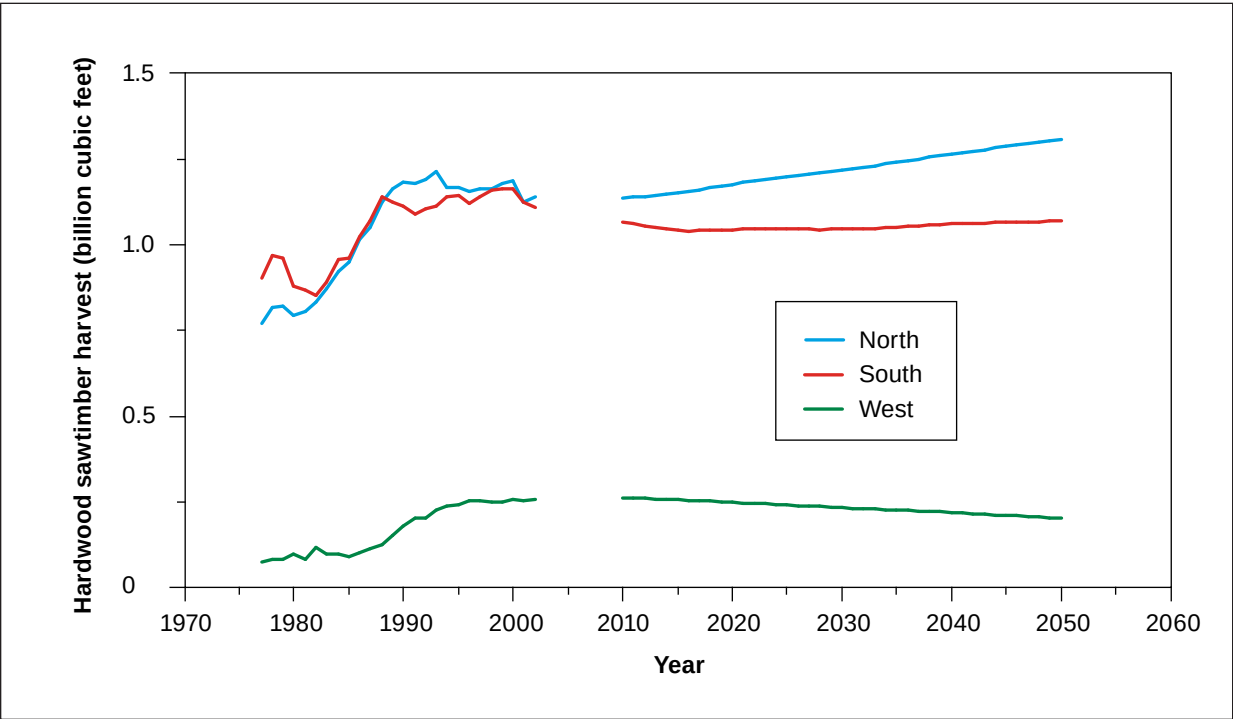


Figure 29—Hardwood sawtimber harvest all owners, by region, with projections to 2050. Historical values are estimates.

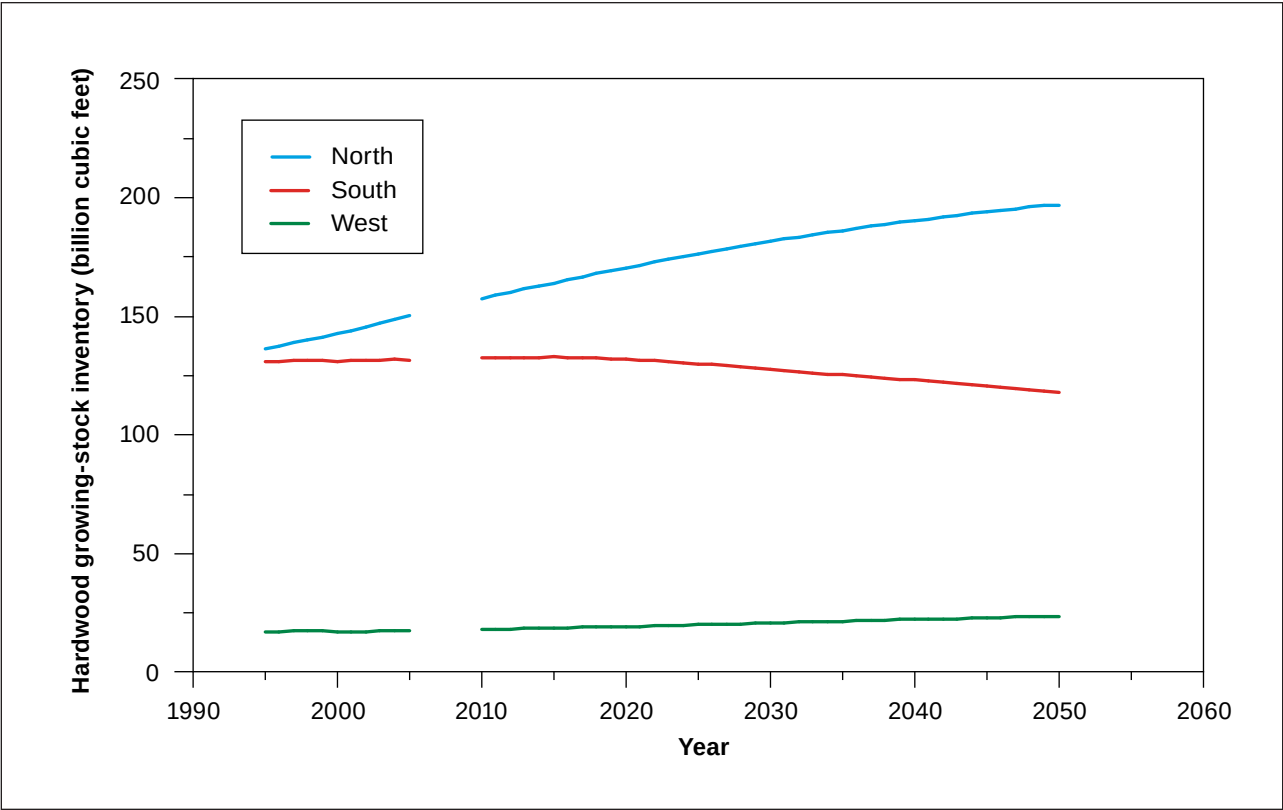


Figure 30—Private hardwood growing-stock inventory, with projections to 2050. Historical values are estimates.

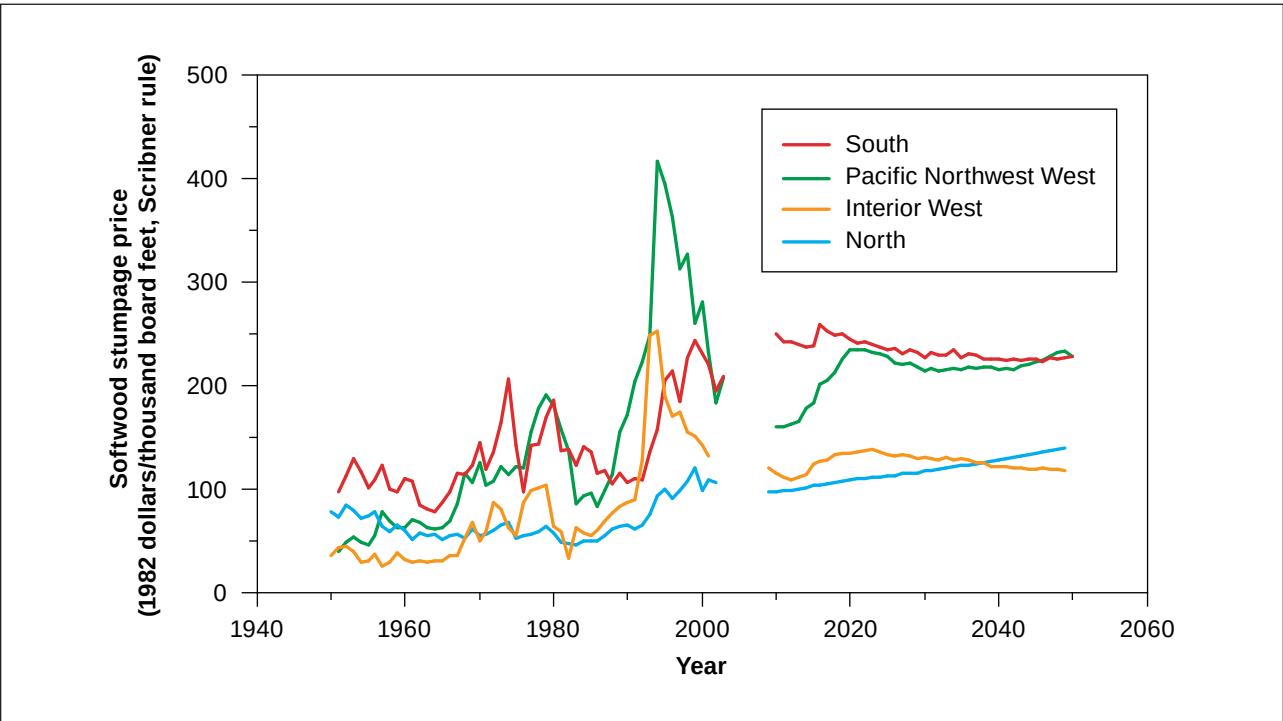


Figure 31—Real softwood sawtimber stumpage prices by U.S. region, with projections to 2050.

harvest (see later discussion) and their effects on competing lumber suppliers. Prices in the North continue to rise slowly in the projection, despite stable softwood sawtimber output and inventories. As the management objectives of nonindustrial ownership in this region continue to shift away from timber production, higher timber prices will be needed to induce continued harvesting.

Projected hardwood sawtimber prices, unlike their softwood counterparts, show continuation of the trends that have characterized the past 50 years (fig. 32). In the South this reflects a relatively stable hardwood sawtimber harvest but a steady decline in sawtimber inventory. In the North, hardwood sawtimber harvest rises in part because higher prices are needed to encourage private owners to expand cutting.

Pulpwood prices in the South have undergone significant changes in the recent past, with a major cycle in softwoods during the 1990s and an upward shift in hardwood prices to levels above softwoods for the first time (fig. 33). Both softwood and hardwood prices continue to cycle in the projections, driven by changes in the wood fiber mix in Southern pulp mills and in timber abundance on private lands. The cycles, roughly centered at 2015, derive from rapid projected growth in Southern softwood use (relative to hardwoods) over the next decade. After 2015, hardwood supply is more constrained, pushing up hardwood prices. Softwood use surges again after 2030 as hardwood prices move to higher levels.

Trends in Timber Removals, Inventory, Growth, and Private Management Investment

The update projection envisions continued growth in both softwood and hardwood removals, with the South remaining the primary regional source for both species groups (see table 12). Removals will rise, but growth will continue to exceed removals over the full projection period,⁷ leading to rising U.S. inventories. Viewed as an aggregate across all regions and owner groups, U.S. inventories are expected to rise by more than 41 percent for softwoods and more than 25 percent for hardwoods between 2002 and 2050. For private ownerships alone, softwood inventories are projected to rise by 34 percent and hardwoods by 17 percent. Softwoods are the larger category of removals and are projected to rise at roughly 28 percent, while hardwoods increase by nearly 33 percent between 2002 and 2050. Given current management policies, most removals (> 90 percent) come from private lands. In contrast to removals and inventory, trends in timber growth

United States timber inventories are expected to rise by more than 41 percent for softwoods and 25 percent for hardwoods.

⁷ Both net growth and removals are summarized in tables 12 and 13, and the ratio of growth to removals is summarized at the national level in table 17.

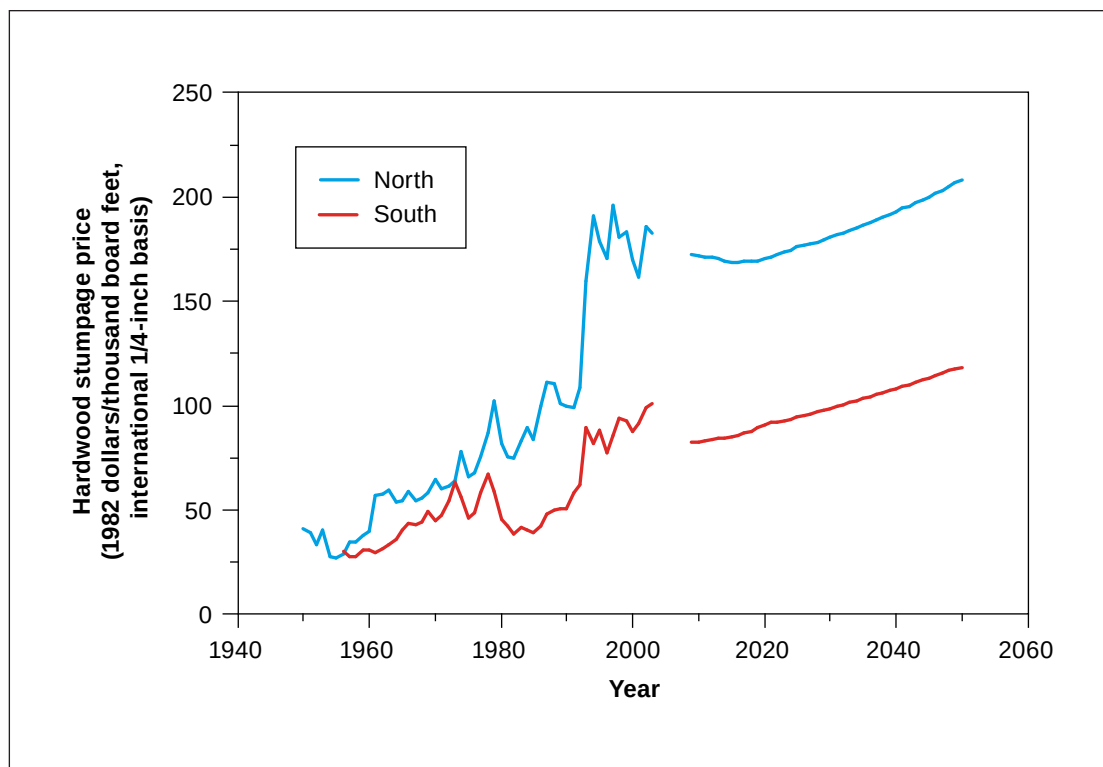


Figure 32—Real hardwood sawtimber stumpage prices by U.S. region, with projections to 2050.

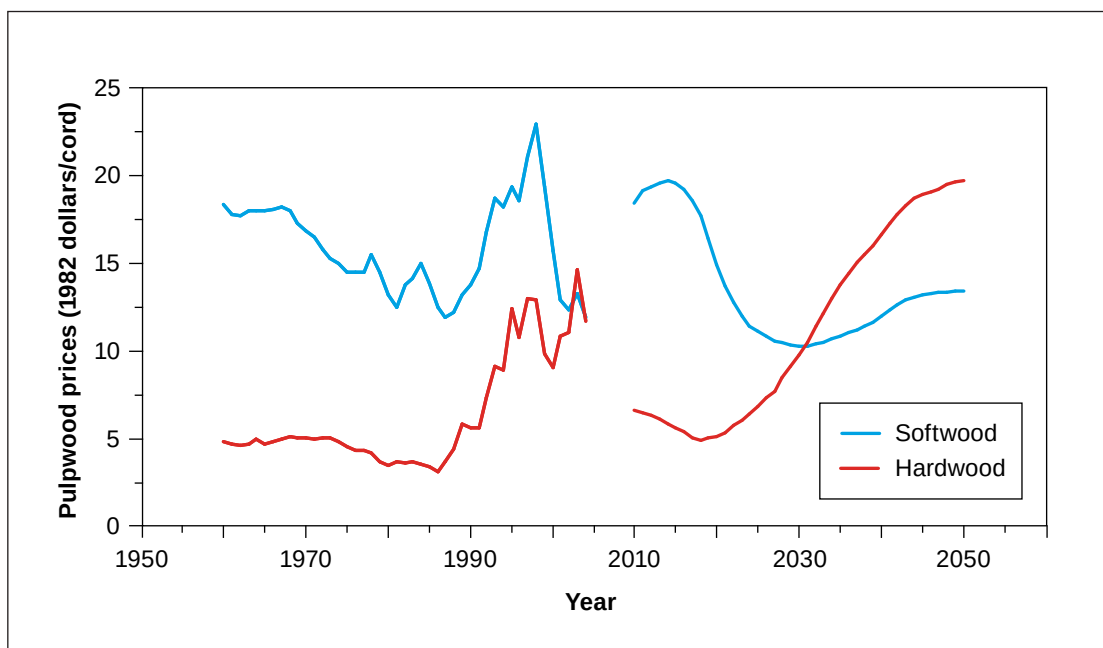


Figure 33—Real Southern softwood and hardwood pulpwood stumpage prices, with projections to 2050.

differ markedly by species. Softwood growth rises at a decreasing rate on both public and private lands, private lands contributing about 75 percent of the total. Hardwood growth on both public and private ownerships is projected to decline slowly as inventories age or as improved management reduces hardwood volumes in softwood stands. Private lands account for about 85 percent of the hardwood growth.

Details of the outlook by region and owner group can be found in tables 12 and 13 and in appendix 1, tables 31 through 34 for private owners, app. 1, tables 20 through 23 for public owners. Appendix 1, table 35 shows the trends in average diameter of trees harvested by region. The table suggests little projected change in the average harvest diameter relative to recent experience.

Softwoods

Growth, removals, and inventory relations are shown in figure 34 for three critical softwood supply groups, Southern forest industry, Southern other private, and PNWW forest industry, which jointly produce more than 70 percent of all U.S. softwood removals. The South becomes increasingly important as a softwood supplier over the projection. The region's share of total U.S. softwood removals rises from 63 percent in 2002 to 70 percent by 2050. Within this aggregate, Southern forest industry's share rises (22 percent to 32 percent) while the share of other private owners declines (40 percent to 35 percent).

Inventories, growth, and removals rise in all three cases, although trends in growth and the relation of growth to removals differ across regions. There are also wide differences in rates of inventory growth (growth/inventory) across the groups. Southern forest industry has the highest rates, ranging from 9.0 to 11.6 percent over the projection period. Southern other private growth rates cover a narrower range, from 4.7 to 5.6 percent, while PNWW forest industry rates range from 4.2 percent to 5.6 percent. Causes of the rising growth projections and differences in growth rates across the groups lie in three areas: (1) varying levels of management intensity over time, (2) shifts in the age class structure of the groups' inventories, and (3) gains and losses in the area of timberland and its allocation across forest cover types.

Figure 35 shows current and projected fractions of the timberland base allocated to various levels of management intensity for key inventory components of the same three region/owner groups. In the South, these charts exclude any lands reserved from management and areas allocated to extremely short-rotation fiber plantations. More intensive forms of management generally raise the absolute growth of stands at any age and the rates of growth on inventory (growth/inventory)

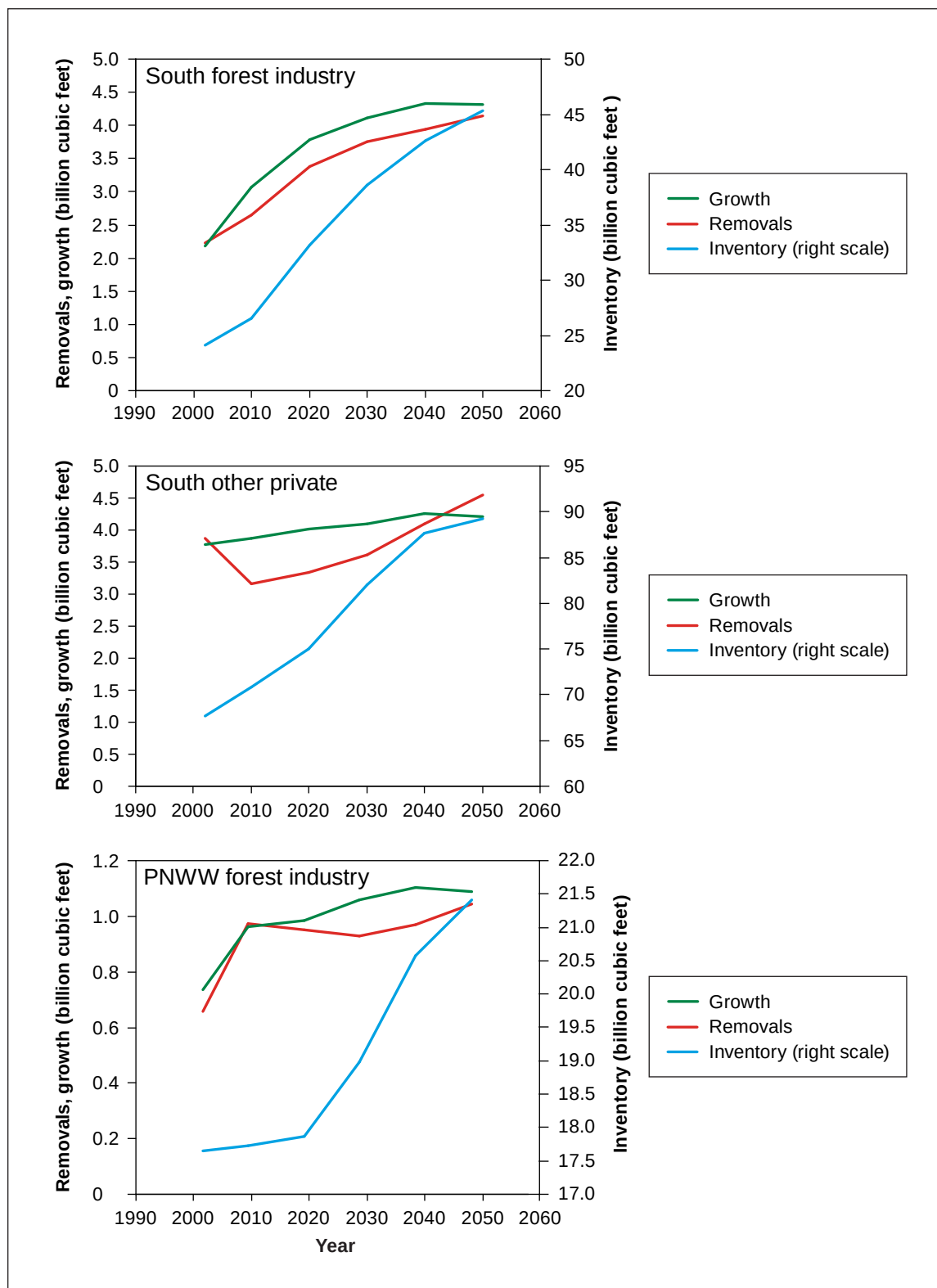


Figure 34—Softwood removals, growth, and inventory for Southern forest industry and other private and Pacific Northwest West (PNWW) forest industry lands, current and projections to 2050.

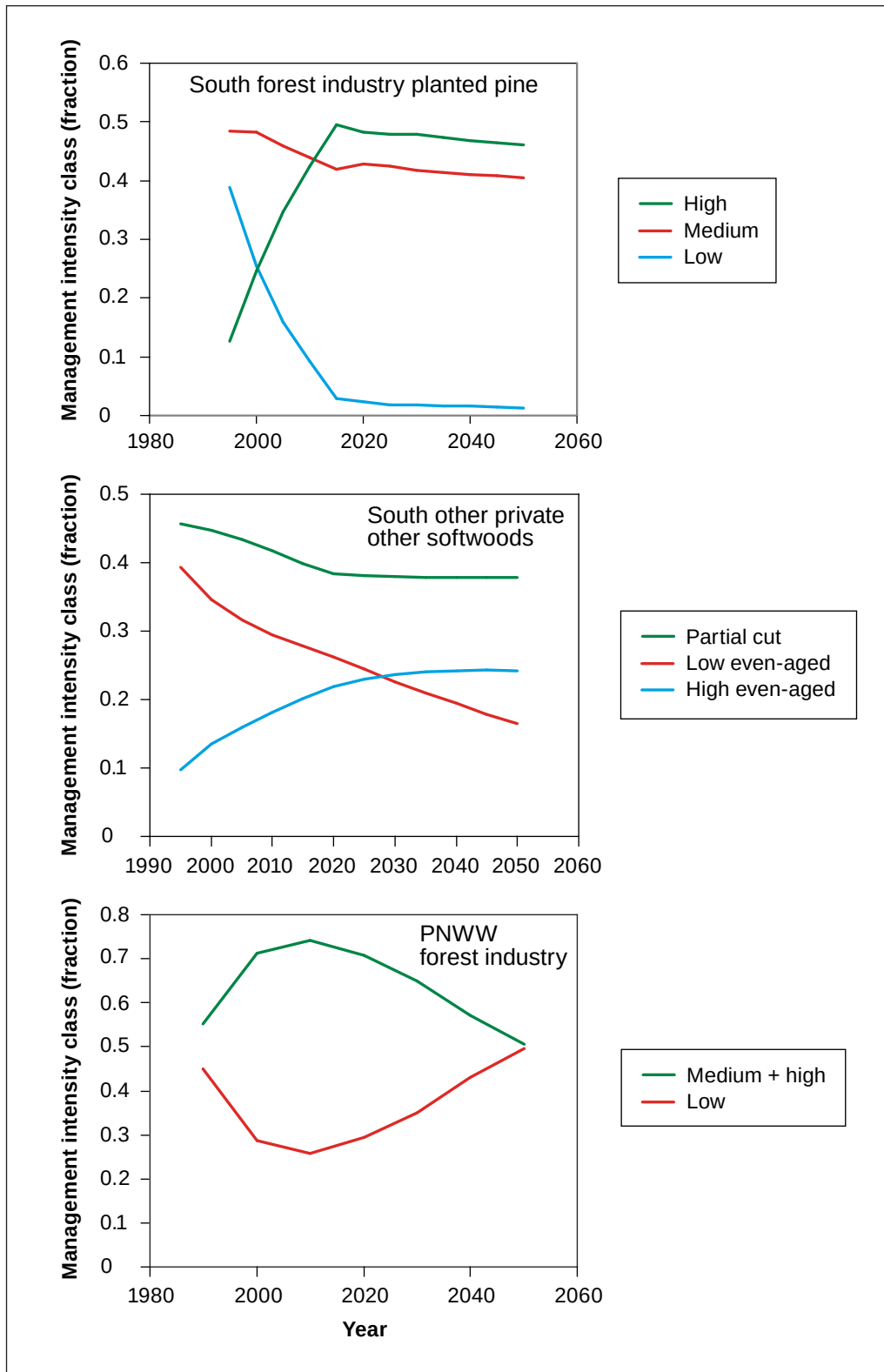


Figure 35—Fraction of softwood timberland area by management intensity groupings for Southern forest industry planted pine, Southern nonindustrial private other softwood types, and Pacific Northwest West (PNWW) forest industry, with projections to 2050.

as well. The shifts to more intensive forms of management are clear for the two Southern groups. In the PNWW forest industry case, however, the fraction of the land base in more intensive regimes rises at first then returns to proportions observed in the 1990s.

Shifts in the proportions of the softwood land base in various age classes can also influence growth. For most softwood species managed on an even-age basis, growth per unit area rises and reaches a peak in the early life of a stand, then declines as the stand continues to age. If larger portions of the land base are moved into these younger and higher growth age classes, overall growth of the inventory will rise while the inventory per unit area falls. Figure 36 (upper) shows the age class structures of the three key softwood region-owner groups in the year 2000 and at two points during the projection. Figure 36 (lower) shows changes in the projected age distributions relative to year 2000 and a representative growth increment curve for the group (medium site, medium-intensity plantations). This relation gives the periodic annual increment (PAI) of the representative stand—its average growth per acre per year for each age.

Again the effects are easiest to see for the South. For both industry and other private, proportions of the land base in older age classes fall while the area in ages near the growth peak of the yield curve rises. The growth effects of age class changes are more complex for the PNWW forest industry. By 2050, this inventory is more heavily concentrated in ages less than 65 years than it was in 2000. This raises overall growth (as shown in fig. 34) owing primarily to large increases in area near the peak PAI age (45 years)

Changes in the timberland base can influence growth directly by altering the area over which forest growth can occur and through changes in the mix of forest cover types, each of which has a distinct growth potential. Figure 37 shows timberland area by cover type for the three critical softwood region-owner groups. The most rapid softwood growth in the South is associated with planted pine types. As illustrated in figure 37, planted pine area increases on both Southern industry and other private lands, while natural pine area declines slightly. Timberland area losses are concentrated in the hardwood types. In the PNWW region, expanding area of the Douglas-fir type at the expense of hardwoods and “other softwoods” plays the same role. Total timberland area for PNWW forest industry is relatively stable over the projection.

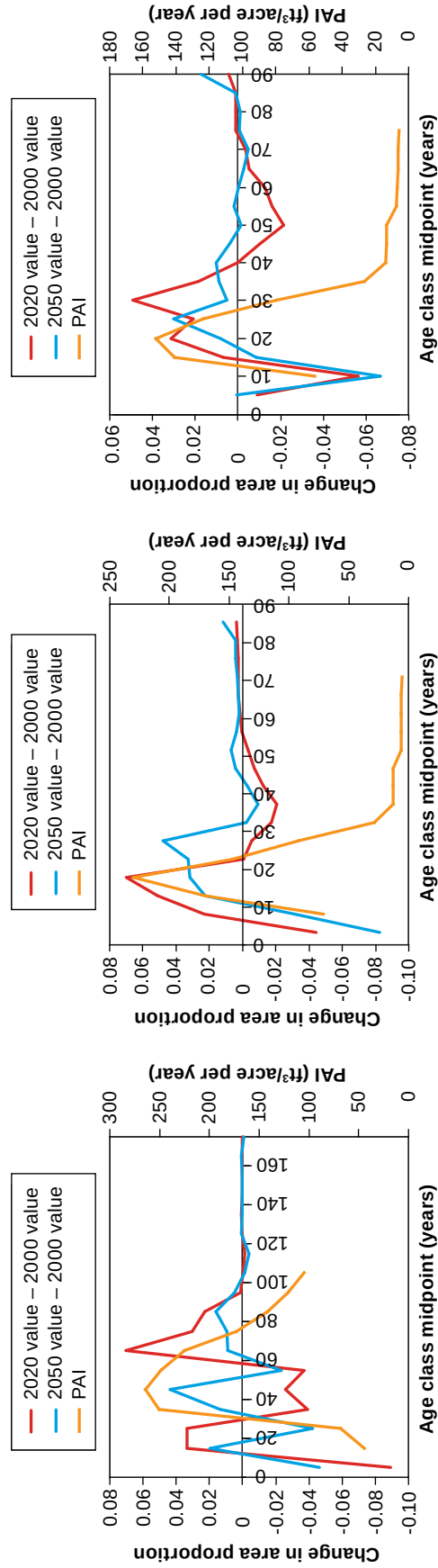
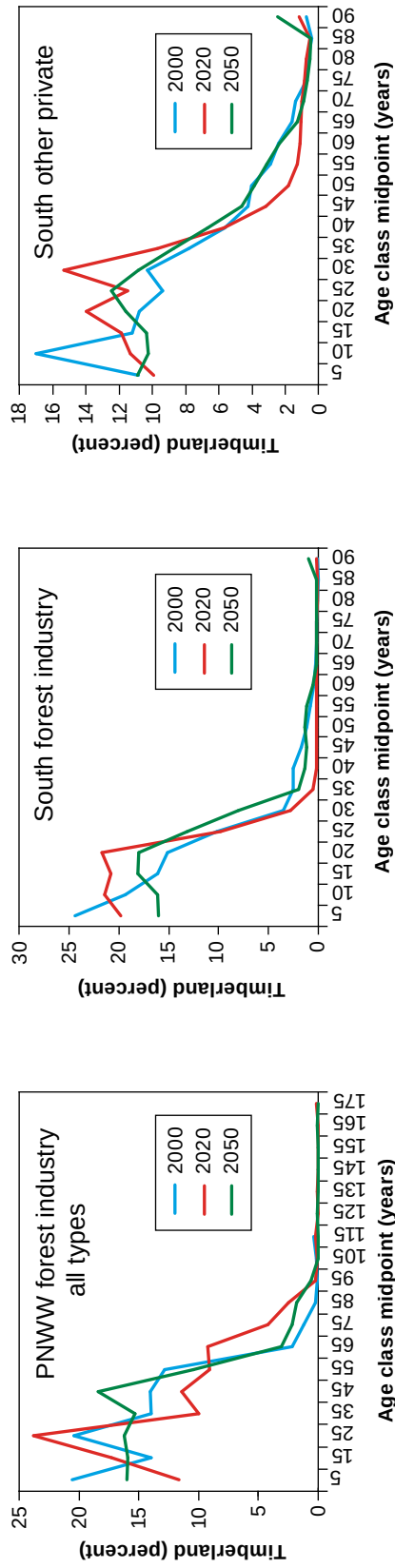


Figure 36—(upper) Percentage of area by age class for softwood types (all types for Pacific Northwest West [PNWW]) at three time points for three region/owner groups and (lower) change in area proportions between time points and periodic annual growth (PAI) from a typical even-age yield function for the region/owner group.

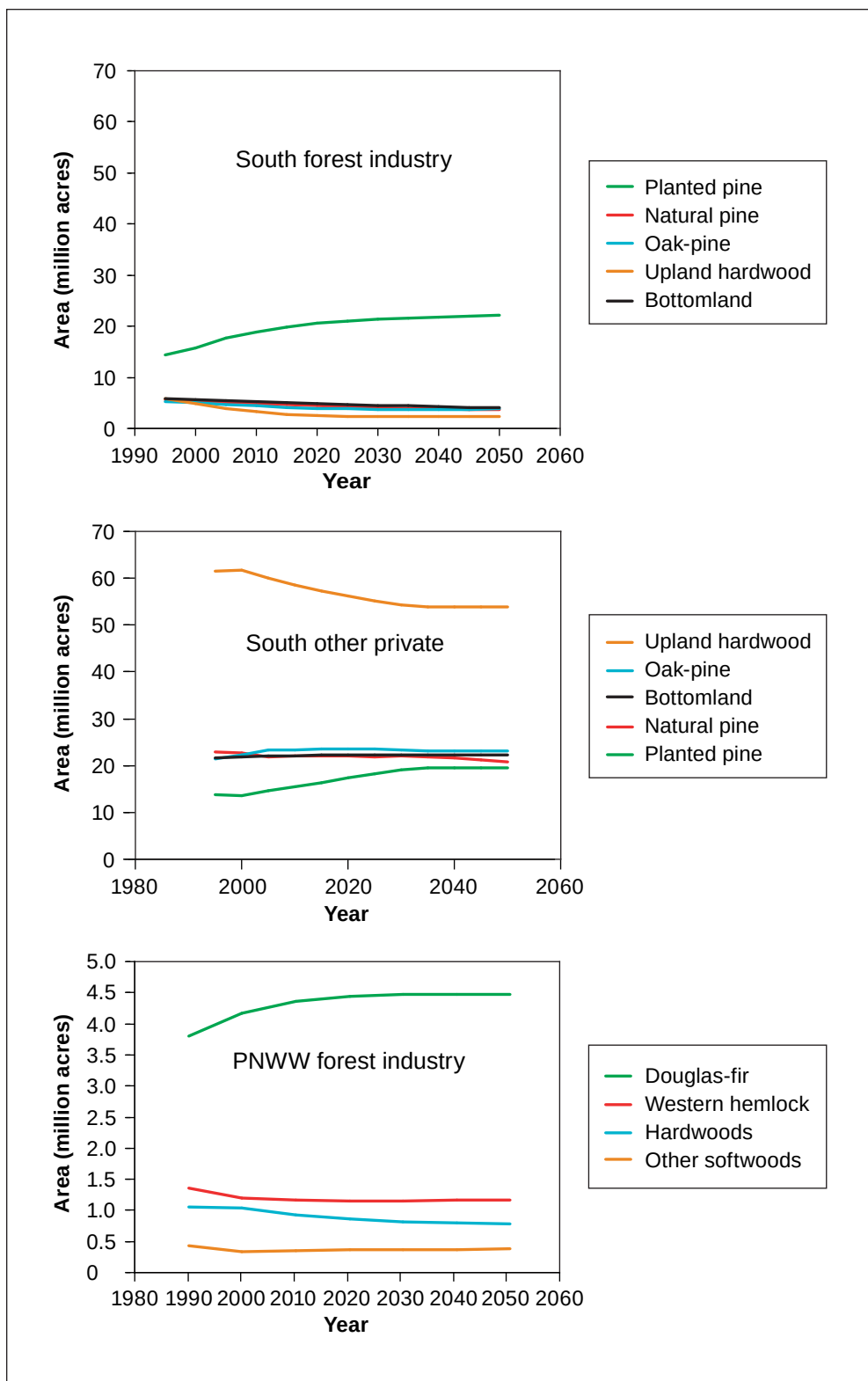


Figure 37—Area by forest cover type for three critical softwood supply groups, with projections to 2050.

Hardwoods

Other private ownerships in the Northern and Southern regions provide nearly three-quarters of annual U.S. hardwood removals. Growth, removal, and inventory relations for these groups are shown in figure 38. In contrast to softwoods, hardwood inventories are projected to rise in the North but fall in the South, and in both regions growth is expected to decline. Growth on hardwood lands is generally lower than that for softwoods both per unit area and as a percentage of inventory. On Northern other private lands, for example, hardwood growth rates (growth/inventory) decline from 2.6 percent in 2002 to 1.6 percent by 2050, whereas on Southern other private lands there is no trend, with rates lying in the 3.0 to 3.4 percent range.

Declining growth on these key components of U.S. hardwood timberland results from loss of timberland area and lack of any significant intensification of management. Falling hardwood timberland area on Southern other private ownerships is evident in figure 37. Between 2000 and 2050, the update projects a loss of nearly 10 percent of the hardwood area to softwood types or nonforest uses. The Northern other private hardwood base is projected to be relatively stable. Unlike softwood projections, the update projection for hardwoods envisions only limited areas of Southern hardwoods being moved into more intensive silvicultural regimes. At the same time, a sizable area of other private land is projected to shift into “reserved” status, which owners withhold from harvest and active management. The combination of land lost to reservations and to other uses and forest types far exceeds the area shifted to more intensive management, implying a net reduction in hardwood management intensity on Southern other private lands.

In the North, no change in the mix of other private hardwood management practices is foreseen. At the same time, the average stocking density (hardwood volume/acre) of Northern other private hardwood lands is expected to rise by nearly 40 percent between 2000 and 2050. As stand density rises to these higher levels, competition increases and growth gradually declines.

Projections of Canadian Harvest

Public lands in Canada, like their counterparts in the United States, face an array of pressures to broaden management objectives. To address these issues, Canada adopted a new National Forest Strategy in 2003.⁸ Among the eight strategic themes that are to guide future forest policy development are concerns for maintaining

⁸For a condensed description and links to detailed discussion see Natural Resources Canada 2003. *The State of Canada's Forests: 2002–2003* available at <http://www.nrcan.gc.ca/cfs-scf/national/what-quoi/sof/>. Use the menu to access the 2003 report, Special Articles, “Canada’s New National Forest Strategy.”

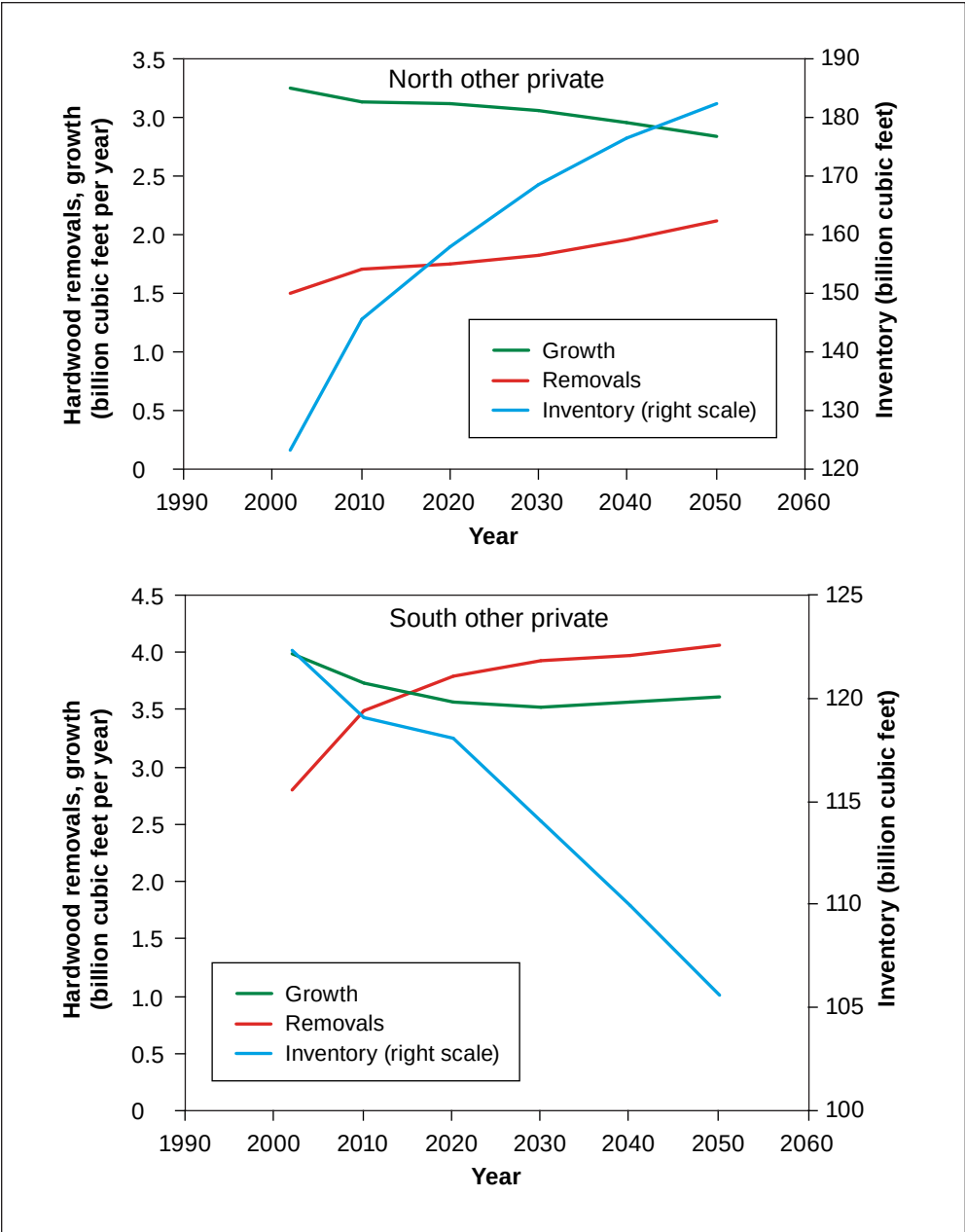


Figure 38—Hardwood inventory, growth, and removals for North and South other private ownerships, with projections to 2050.

biodiversity, approaching sustainable management, and recognizing the rights and participation of Aboriginal peoples. Addressing these concerns, some provinces have already begun to adjust their potential harvest levels downward (also called AAC).⁹

⁹ See http://nfdp.ccfm.org/compendium/harvest/index_e.php for a discussion of AAC and variation in its definition across provinces.

The 2005 update base case assumes that harvest restrictions through reductions in AACs will begin to significantly affect Canadian sawtimber cut beginning in 2010. Pulpwood harvest and harvests for use in OSB production are not limited in this process. For the BC coast region, we assume that allowable softwood harvest will be constrained to 400 million cubic feet per year, approximately the harvest level observed in the late 1990s. In the eastern Canada region, it was assumed that harvest would be allowed to rise no higher than 2.6 billion cubic feet by 2010 then fall back to 2.0 billion cubic feet per year by 2020. These levels and restrictions are analytical assumptions made in the update about future policy developments. Throughout most of Canada, actual policies and any AAC limitations have yet to be determined.

At the same time, the interior BC region faces a major expansion in harvest to salvage vast areas of lodgepole pine killed by the ongoing mountain pine beetle epidemic. The province has increased AACs in the most heavily impacted areas in an effort to salvage mortality and to remove susceptible live trees in advance of attack as a control measure.¹⁰ Between 2003 and 2004, the softwood AAC for all of BC rose by more than 9 percent,¹¹ and the actual 2004 softwood roundwood harvest from interior BC forests reached an all-time high of 58.1 million cubic meters. Given the anticipated trends of future beetle mortality, AACs and harvests could continue to rise in the near term, although the timing and extent are highly uncertain.

Part of this uncertainty arises from the difficulty of predicting the future course of the infestation. Rising beetle populations resulted, in part, from accumulating volumes of mature and slow-growing lodgepole pine (as a food source). This was augmented by a lengthy period of mild winters with low beetle mortality. A sequence of colder than normal winters over the next few years could act to slow the infestation, reducing mortality and hence the need for expanding salvage harvests. Trends in future salvage harvests will also be influenced by the time required to access dead trees, parts of which are in remote sections of the province, and the “holding time” of dead timber (the period over which dead timber remains merchantable). Both of these elements are not well understood at present. Accelerated harvest of mortality is also a political decision, subject to pressures from an array of groups, with attendant uncertainties.

¹⁰ See the BC Ministry of Forests Mountain Pine Beetle information Web site at (October 2005) http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/ particularly *British Columbia's Mountain Pine Beetle Action Plan for 2005–2010* and the link *Cut Level Increased in Response to Epidemic*.

¹¹ See the Canadian Forest Service's National Forestry Database Program at http://nfdp.ccfm.org/compendium/harvest/index_e.php.

In the update base case, we assume that beetle-kill salvage in interior BC continues to rise and that until 2015 the average annual softwood sawtimber harvest in the Canadian Interior (CINT) region rises about 8 percent (see footnote 4). Harvest peaks in 2010, and the expansion in sawlog supply ends in 2015. Harvest then falls back toward pre-epidemic levels. In light of the potential volumes of salvable sawlog material projected in *Provincial-Level Projection of the Current Mountain Pine Beetle Outbreak* (see BCMF 2005), this scenario lies in the lower portion of the range of possible harvest responses.

With the end of the beetle salvage in interior BC, we assume that AACs in that region will fall as a result of depleted inventories and that the overall cut in the other parts of the CINT region (Alberta and the Prairie provinces) will decline owing to the same types of pressures faced by other Canadian regions. In the base case, we limit interior Canadian harvest to 1.75 billion cubic feet per year by 2020 and for the remainder of the projection.

Historical harvest estimates for Canada by product category and base case projections are shown in figure 39 together with reported levels of AAC (see app. 1, table 36 for details). Projected sawtimber harvest falls after 2015 in the face of the assumed AAC restrictions. Pulpwood harvest (including use for OSB) is stable to declining over the projection consistent with the historical trend.

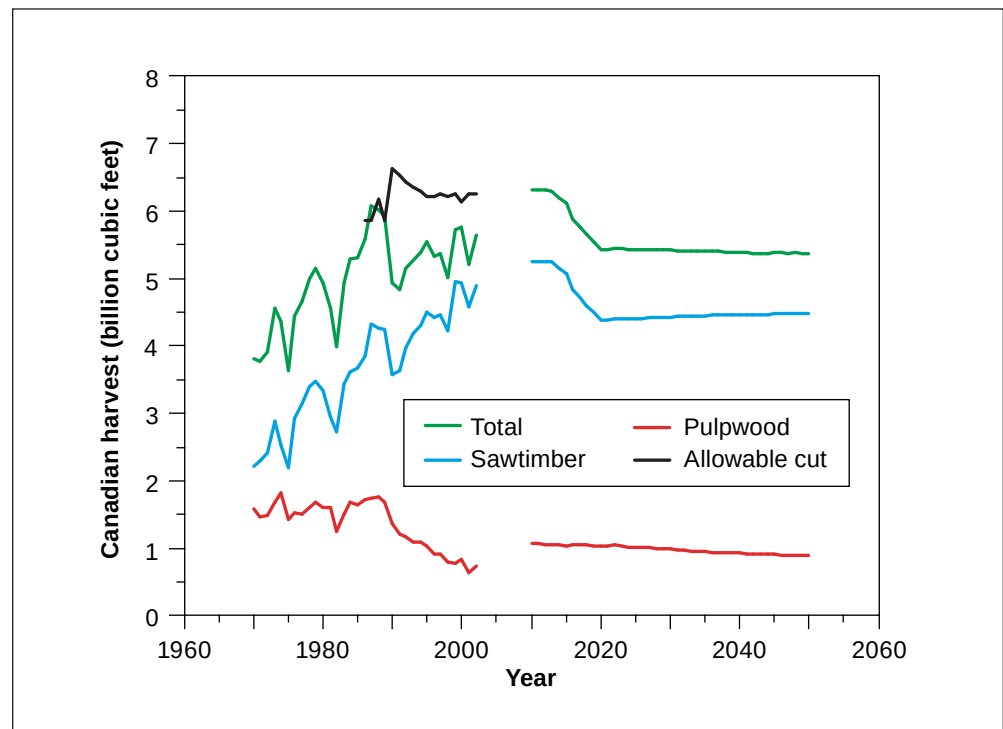


Figure 39—Canadian harvest by product category and total annual allowable cut for recent years, with projections to 2050.

Broad-Scale Trends in Forest Conditions

The base projections that are described in this chapter largely focus on timber markets and how harvest levels change forest resources. These projections also contain information about how forest conditions will change relative to recent conditions. In this section, we synthesize selected indicators into three determinants of broad-scale forest conditions. The first two are implications of the base projections for trends in diversity of forest types and structure. Both of these variables are cited as important components in broad-scale measures of ecosystem condition and change. The third is a composite measure that provides an overall descriptor of forest conditions.

This section is motivated by discussions about sustainable forest management and other approaches to broad-scale land management. These discussions represent a broadening of the goals for forest management and involve different types of information such as the expected changes in forest types, inventory structures, and composite measures of forest conditions.

These discussions all rely on developing various index measures. These indices serve the purpose of illustrating how an indicator changes over time. They are simply the ratio of one quantity to another quantity of the same indicator in a different period of time. These indices have no units, and the base year is selected to facilitate discussion (usually the first year of the data series for the indicator).

Trends in Structure

Concern about the structure of the inventory (the relative abundance of different size classes or seral stages) reflects the belief that there is value in maintaining a diverse range of different stages of forest development. Earlier results discussed in this chapter suggest we are seeing a progressive decline on private timberlands in older seral stages and an increase in the younger seral stages. The data for public and private lands are shown in appendix 1, tables 37 to 39 and summarized as diversity indices in tables 14 to 16. They reveal a more complex story but one much like that revealed in figures 40 to 42. For much of the country, we are seeing an aging of the forests and an accumulation of acres in the older seral stages as production shifts to managed forests that occupy only a small part of the timberland base. This is especially true in both the West and the North. In the South, however, there is a shift from older hardwood stands to younger softwood stands because of forest management decisions. From another perspective, the data in appendix 1, table 35 imply that much of the change in seral stage probably occurred before 1986 when the average diameter of harvested timber fell, especially in the West. From 1976 to

U.S. forests are getting older.

Table 14—Diversity indices^a for national forest timberlands

	Region									
		North Central							Pacific Northwest ^b	Pacific Northwest ^b
Year	Northeast	Lake States	Plains States	Southeast	South Central	Northern Rockies	Southern Rockies	Pacific Southwest		
Seral stage diversity										
2002	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2010	.832	.961	.981	1.010	.962	.992	.927	.991	.948	.987
2020	.852	.942	.954	1.015	.978	.972	.909	.992	.924	.980
2030	.800	.895	.877	1.046	.995	.979	.935	.990	.888	.972
2040	.828	.895	.908	1.113	.981	.988	.923	.945	.851	.975
2050	.771	.895	.904	1.058	1.121	.994	.894	.990	.824	.968
Type diversity										
2002	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2010	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2020	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2030	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2040	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2050	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Seral x type diversity										
2002	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2010	.918	.983	.990	1.016	.978	.996	.973	1.073	.974	.997
2020	.925	.980	.973	1.030	.993	.985	.967	1.025	.960	.994
2030	.899	.963	.934	1.056	1.025	.986	.967	1.018	.943	.991
2040	.912	.964	.949	1.058	1.023	.988	.972	1.025	.925	.992
2050	.892	.967	.945	1.028	1.076	.990	.958	1.018	.912	.990

^aThese were computed as Shannon and Weaver Diversity indices by using the proportion by seral stage. Changes in each region are computed relative to that region's value for 2002. Numbers less than 1 represent a loss of diversity and numbers greater than 1 a gain (relative to 2002) in diversity.

^bPacific Northwest West (western Oregon and western Washington) is also called the Douglas-fir subregion, and Pacific Northwest East (eastern Oregon and western Washington) the ponderosa pine subregion.

1986, the transition from naturally regenerated to managed stands occurred in both the South and PNWW, reducing the size of trees for final harvest. These trends are now expected (as shown in tables 14, 15, and 16) to be relatively stable.

Trends in Diversity

In addition to concerns about loss of older forests are concerns expressed about the lack of diversity associated with managed forests and that the spatial extent of managed forests will expand at the expense of existing natural forest types. The motivations for these concerns are rooted in the creation, during the last 50 years, of the planted forest type in the South that now covers approximately 30 million acres. The largest source from existing forest lands was the conversion of naturally regenerated pine after timber harvest, with a net area loss in pine types of about 15 million acres between 1953 and 2002. At the same time, upland hardwood area

Table 15—Diversity indices^a for other public timberlands

	Region									
	North Central								Pacific Northwest ^b	Pacific Northwest ^b
Year	Northeast	Lake States	Plains States	Southeast	South Central	Northern Rockies	Southern Rockies	Pacific Southwest		
Seral stage diversity										
2002	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2010	.933	.991	1.032	1.020	.814	1.070	.979	.925	.940	1.070
2020	.943	.987	1.003	1.119	.941	1.042	.947	.886	.969	1.049
2030	.826	.949	.989	1.152	1.127	1.090	.970	.893	.947	1.059
2040	.903	.936	.991	1.251	1.205	1.122	.977	.858	.924	1.035
2050	.834	.914	.990	1.389	1.356	1.150	.994	.898	.908	1.070
Type diversity										
2002	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2010	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2020	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2030	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2040	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2050	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Seral x type diversity										
2002	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2010	.971	1.002	1.026	1.013	.919	1.034	.999	.813	.978	1.058
2020	.970	1.001	1.009	1.054	.979	1.054	.991	.981	.975	1.036
2030	.922	.990	1.001	1.080	1.069	1.080	1.004	.976	.964	1.065
2040	.957	.981	.997	1.119	1.085	1.119	1.067	.976	.951	1.049
2050	.924	.976	.995	1.168	1.159	1.168	1.078	.979	.949	1.071

^aThese were computed as Shannon and Weaver Diversity indices by using the proportion by seral stage. Changes in each region are computed relative to that region's value for 2002. Numbers less than 1 represent a loss of diversity and numbers greater than 1 a gain (relative to 2002) in diversity.

^bPacific Northwest West (western Oregon and western Washington) is also called the Douglas-fir subregion, and Pacific Northwest East (eastern Oregon and western Washington) the ponderosa pine subregion.

increased, and in 2002, the area of private timberlands of the Southern United States was dominated by upland hardwoods, followed by planted pine, natural pine, lowland hardwoods, and oak-pine forest types. The largest projected percentage change in net area is for planted pine, increasing by about 14 million acres by 2050, approximately a 50-percent increase (Alig and Butler 2004). More than half of the additional plantations would be on forest industry lands. With management intensification on these lands, many harvested natural pine, mixed oak-pine, and hardwood stands are being artificially regenerated. Even with such projected changes, hardwoods will continue to dominate the forested landscape of the South and will cover about one-half of the southern private timberland base in 2050. Naturally regenerated forests are projected to compose three-fourths of the Southern private timberland in 2050.

Table 16—Diversity indices^a for private timberlands

	Region									
		North Central								
Year	Northeast	Lake States	Plains States	Southeast	South Central	Northern Rockies	Southern Rockies	Pacific Southwest	Pacific Northwest West ^b	Pacific Northwest East ^b
Seral stage diversity										
2002	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2010	.973	1.019	.997	.985	1.049	.929	.947	.982	.948	.941
2020	.987	1.007	.993	.954	1.031	.874	.954	.918	.939	.911
2030	1.004	1.011	1.001	.983	1.029	.878	.915	.957	.942	.961
2040	.959	1.023	1.006	.960	1.035	.916	.960	1.038	.987	1.018
2050	1.022	1.031	1.023	.944	1.033	.877	.991	1.064	1.005	1.037
Type diversity										
2002	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2010	.995	.994	.995	.993	1.029	.978	.990	.994	.979	.991
2020	.992	.990	.999	.991	1.044	.958	.980	1.000	.978	.986
2030	.985	.979	1.003	.987	1.052	.940	.972	.999	.981	.983
2040	.980	.981	1.006	.984	1.054	.918	.964	.999	.986	.989
2050	.975	.978	1.011	.983	1.054	.901	.956	.998	.988	.985
Seral x type diversity										
2002	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2010	.980	1.001	.993	.994	1.029	.953	.983	.995	.962	.976
2020	.986	.997	.993	.979	1.018	.913	.993	.960	.953	.956
2030	.985	.993	1.000	.997	1.032	.900	.927	.959	.943	.969
2040	.963	1.006	1.007	.984	1.045	.902	.956	1.009	.957	1.003
2050	.989	1.010	1.018	.985	1.047	.860	.966	1.006	.965	1.007

^aThese were computed as Shannon and Weaver Diversity indices by using the proportion by seral stage. Changes in each region are computed relative to that region's value for 2002. Numbers less than 1 represent a loss of diversity and numbers greater than 1 a gain (relative to 2002) in diversity.

^bPacific Northwest West (western Oregon and western Washington) is also called the Douglas-fir subregion, and Pacific Northwest East (eastern Oregon and western Washington) the ponderosa pine subregion.

U.S. forests will retain their current diversity.

Most U.S. regions are expected to maintain their current diversity of timber types (fig. 43) over the next five decades. The number of types and extent of diversity (based on number of types) differs by region. The highest diversity of types is in the Pacific Northwest East (PNWE). Some of the lowest relative diversity is for softwood and hardwood types in the PNWW, softwood types in the Great Plains, and for hardwood types in the South. Changes are expected in current levels of diversity of forest types for hardwood types in the South Central and softwood types in the Great Plains and northern Rocky Mountains. In these regions, timberland area lost or type conversions result in less abundance of some timber types in the future relative to the mid-1990s.

Diversity of forest type and seral stage can be combined and represented as a single index. These results are shown in the bottom part of tables 14, 15, and 16. In general, the results show remarkable stability in forest conditions for the

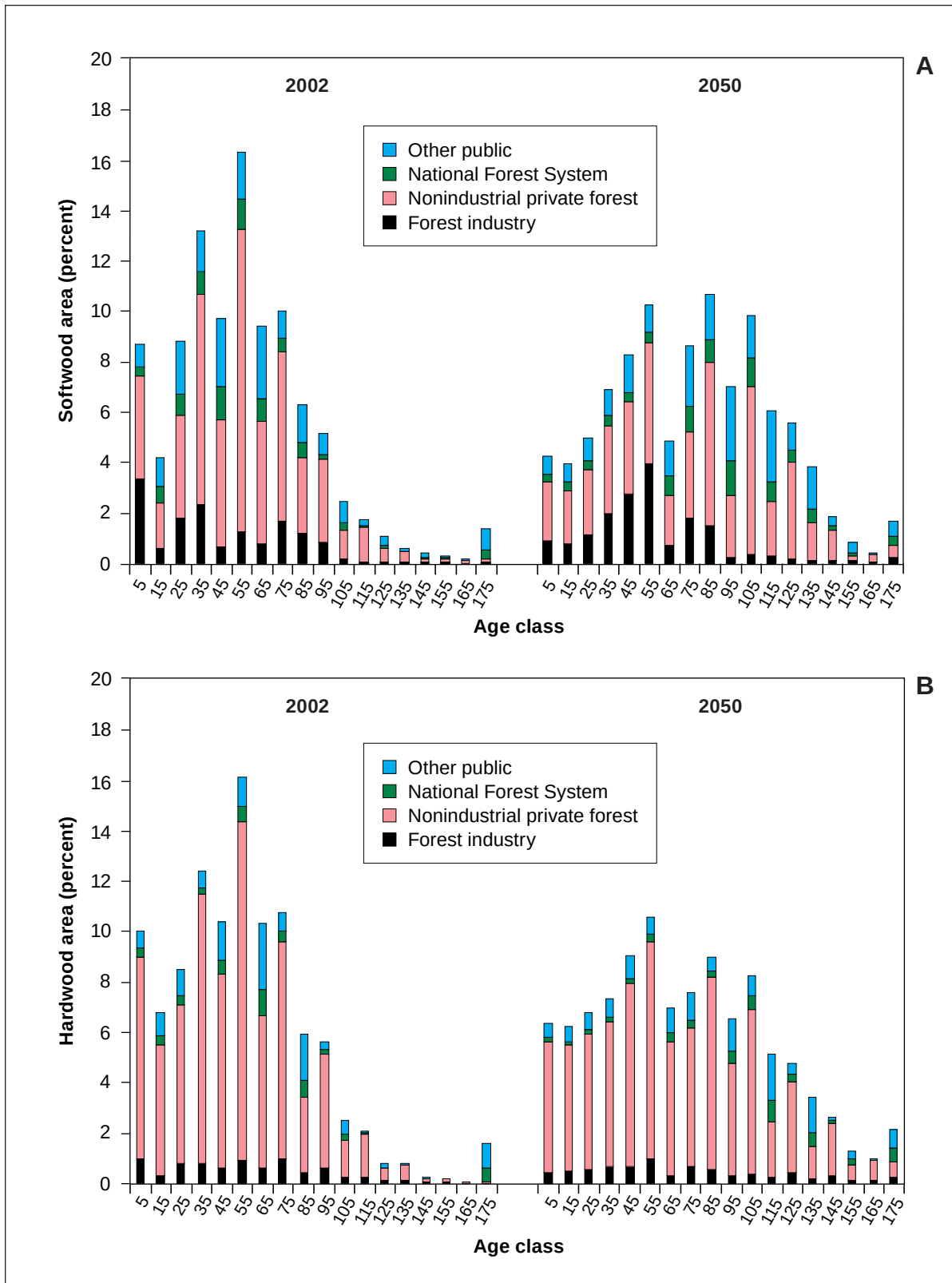


Figure 40—Age class distribution for all softwood (A) and hardwood (B) forest types on timberland area for the Northern United States, by ownership, with projections to 2050.

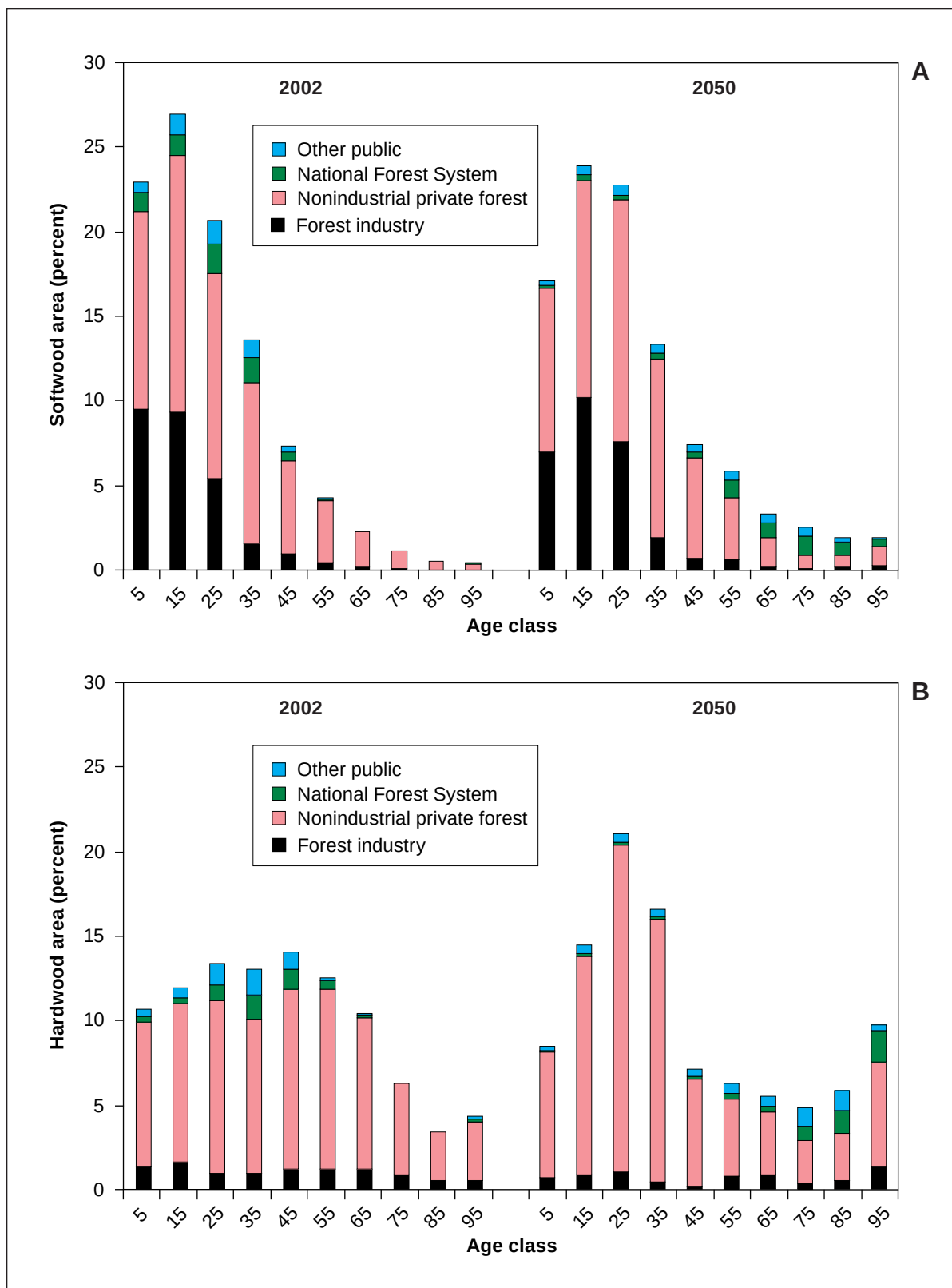


Figure 41—Age class distribution for all softwood (A) and hardwood (B) forest types on timberland area for the Southern United States, by ownership, with projections to 2050.

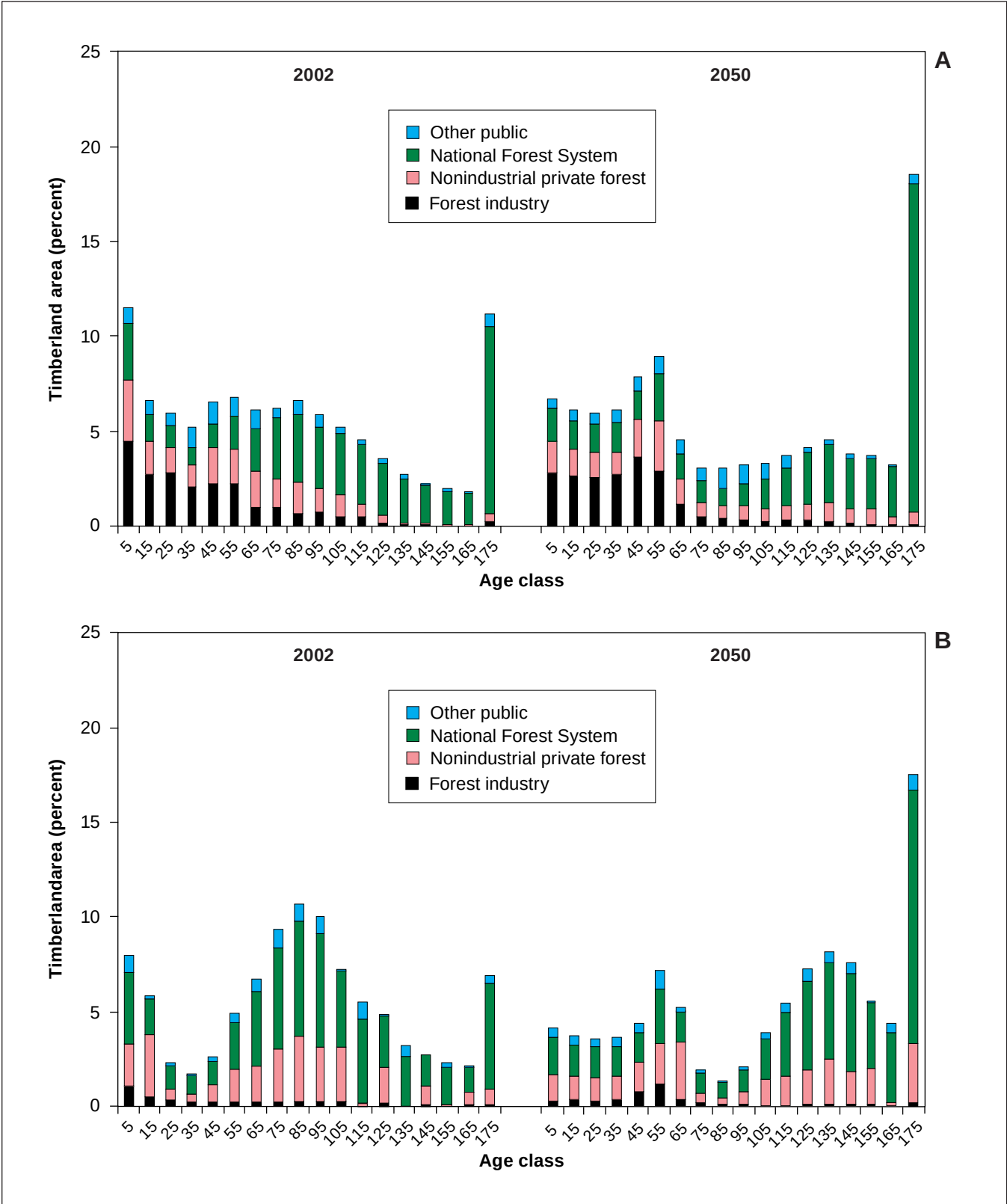


Figure 42—Age class distribution for all forest types on timberland area for the Pacific Coast (California, Oregon, and Washington) (A), and Rocky Mountains (B), by ownership, with projections to 2050.

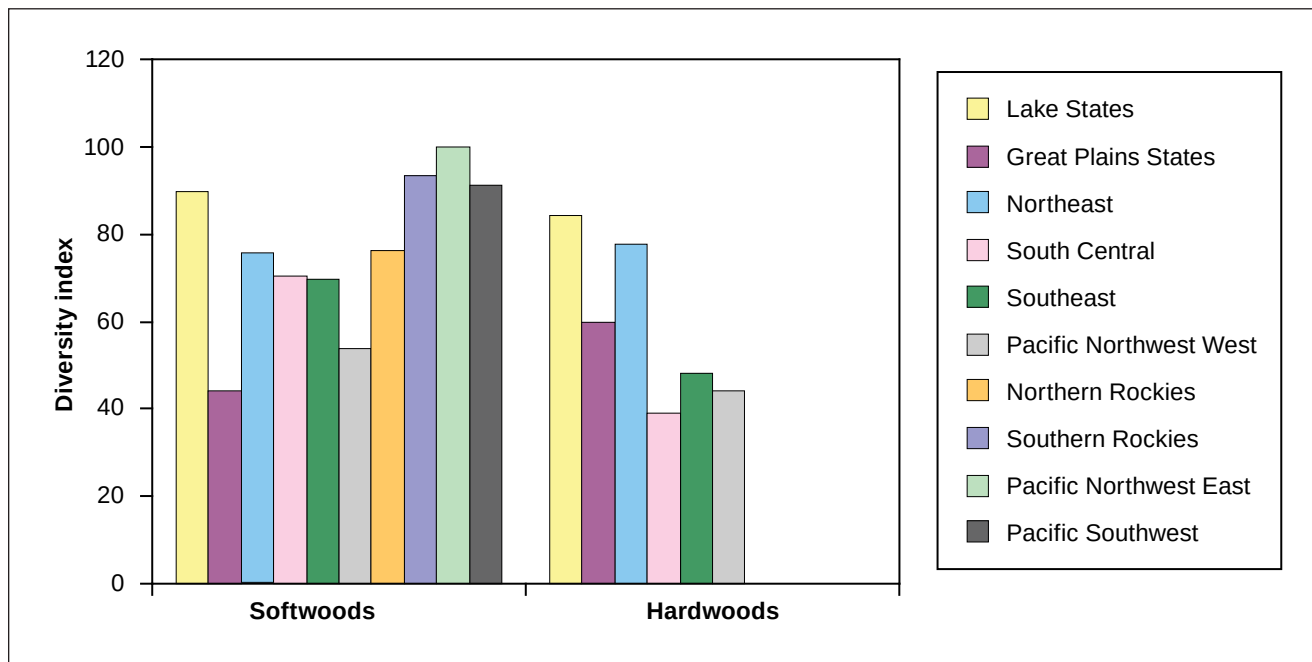


Figure 43—Diversity index for private lands by region and species for 2000. Note: PNWE 2000 is the base for the index.

next 50 years. In many ways this reflects the dynamic nature of forested ecosystems where regrowth, increasing productivity, and harvest all help balance ecosystem conditions.

Some of the biggest changes are expected to be on public timberlands. There, declines in the combined indices reflect shifts in seral stages toward older stands and a diminishment in the proportion of stands in young seral stages. For example, in the West, currently 24 percent of the area is in late-seral conditions, but by 2050 this proportion rises to 53 percent with most of the change coming from a reduction of acres in the younger and midseral stages (see app. 1, tables 37 through 39 for details).

These results have enormous implications for future forest policy discussions. Much of the current policy debate (such as management of hazardous fuels, sustainable forest management, and certification) is stimulated by the assertion that ecological conditions are in decline. Although those perceptions have been shaped by events of the past several decades, it seems unlikely that we will see changes of those magnitudes repeated in the next several decades. For example, the creation of a planted pine type in the South starting in the 1950s is a relatively recent event that created a new forest type primarily by converting timberland from three existing forest types (natural pine, oak-pine, and upland hardwoods). In the West, the attempts to regulate forest management on public timberlands starting in the 1950s changed age-class structures. Changes of these magnitudes and the associated ecological changes are not expected in the next 50 years.

A Composite Index to Describe Broad-Scale Trends in Forest Conditions

Composite measures have been used in forestry to describe broad-scale conditions (see Dorren et al. 2004, Haynes and Quigley 2001, Haynes et al. 2000, Heinz Center 2002, Noss 1999, US EPA 2003). In general, measures such as ecological integrity have proved useful in presenting assessments of broad-scale conditions to the public (Kay 1993), but the scientific community sees composite measures as oversimplifying complex relations and involving considerable measurement issues (NRC 2000).

A composite measure was developed from various individual indicators to describe forest conditions in the United States and the major RPA regions (see Haynes 2007 for more details). It is constructed from frequently cited variables such as area of timberland, proportion across all age classes, the proportion of the late-seral stage, fragmentation, total growing-stock inventories, proportion of softwood and hardwood types, and ratio of growth and harvest, which are used as indicators of broad-scale implications of forest management.¹² Data for most of these variables have been displayed in earlier tables and are summarized in table 17 in index form (where, except for the ratio of removals to growth, the value in each series has been divided by the 1952 value for that series). The use of indices removes the difficulties caused by different units. Area of timberland, total growing-stock inventories, proportion of softwood and hardwood types, and the ratio of growth and harvest can be used almost directly as indicators. Area disturbed by harvest is used as a proxy for fragmentation, and it is computed by dividing total harvest by average inventory per acre.¹³ The indicator for extent of area by successional stage is computed from an index that combined both the seral stage index with the proportional change since the base year in the oldest seral stage. This recognizes both the importance the public places on maintaining or improving the balance among age seral stages as well as on maintaining or expanding the proportion of the inventory in the oldest age class.

The indicators in table 17 are aggregated for the national level (the regional data are summarized in app. 1, table 40). Two of the indices are computed as the reciprocal of the original data because a drop relative to 1952 in those two indices

¹² All of these variables, except harvest, are included in some form among the indicators composing the first two criteria of the Montréal Process.

¹³ Fragmentation as used here does not include forest to nonforest changes. The approach used here probably overestimates fragmentation, as it does not recognize thinnings, partial harvest, or the differences between average volume per acre and the volume in mature stands typically clearcut, and treats all harvests as clearcuts.

Table 17—Indices of changes for selected indicators for the United States

Area	Old stands	Fragmentation	Area of timberland	Total growing-stock inventory	Softwood inventory	Growth/harvest	Composite index
	----- 1952 = 100 -----					Percent	
1952	100	100	100	100	100	128	105
1962	92	89	101	108	96	161	113
1970	87	97	99	114	94	164	112
1976	83	96	97	119	91	171	114
1986	78	124	95	124	84	125	104
1991	76	124	96	128	82	121	104
1997	78	111	99	136	83	143	111
2002	78	101	99	139	82	154	115
2010	81	104	99	149	82	141	115
2020	83	104	98	161	83	133	115
2030	87	101	98	172	84	127	117
2040	89	101	97	181	85	121	117
2050	94	102	96	188	86	113	117

Source: The data for all columns except old stands are given in tables 4 and 12. The indices were computed by dividing each value by the 1952 value for that series except the ratio of growth to harvest, which is used directly. See Haynes (2007) for computation details.

are seen as positive by various publics (see Shields et al. 2002 for a general discussion of the public values regarding forest lands). The composite index is constructed as a linear combination of individual indices for those indicators shown in table 17. This approach assigns equal weighting to the various indicators and is an average of all indicators reported for that year. Equal weighting was used here as a reasonable first estimate, but this is an area where further research is warranted.

The trends revealed in the indices by region and for the Nation can help shape perceptions about changes in forest conditions. For example, many believe that since the 1950s there has been a general decline in some of the indicators (see some of the indices in table 17) characterizing conservation of biological diversity and maintenance of productive capacity. Figure 44 suggests that offsetting changes among indices kept the composite index relatively stable to slightly increasing until the late 1970s or early 1980s when there were increased harvests, especially of hardwoods for pulpwood and fuelwood (see table 8). But in the 1990s, reduced public harvest, improving forest management, and increased productivity of private forest lands resulted in greater balance among the various indicators. For example, increases in growing-stock inventories have offset fragmentation and have slowed the shift from softwoods to hardwoods. Some of the greatest changes took place from 1976 to 1986 and involved increased harvests, especially of hardwoods for pulpwood and fuelwood (see table 8).

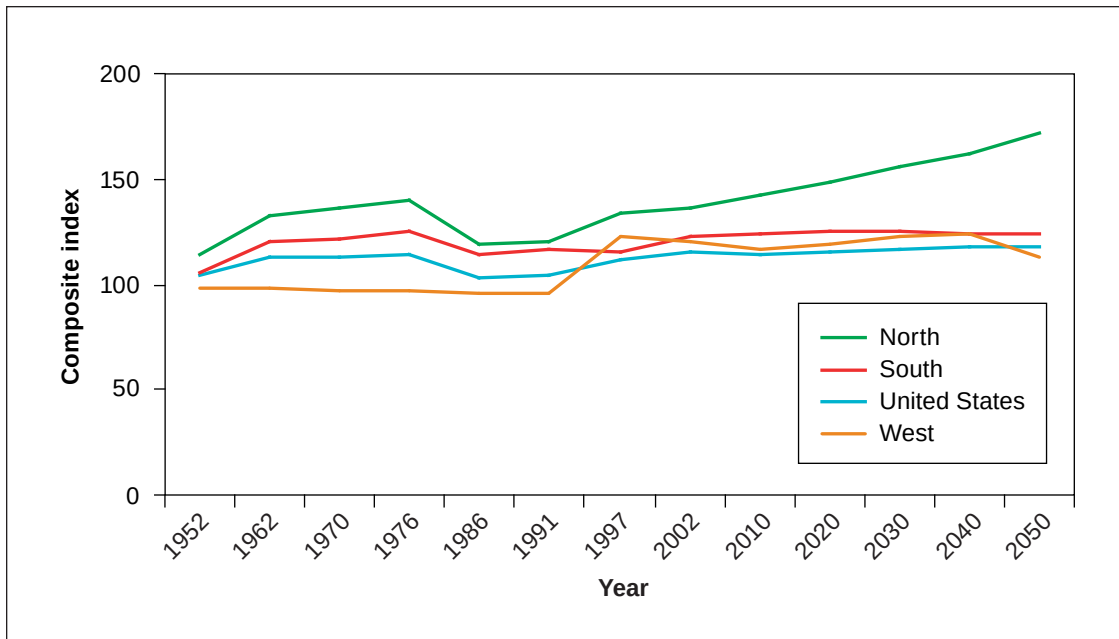


Figure 44—Total timberland integrity, with projections to 2050.

The results also show an apparent contradiction. That is, what causes inventory to increase when growth is about equal to or less than harvest? The answer lies in the proportion of the volume in trees less than 5 inches in diameter not included in the reported volume of inventory. There are periods when the proportion of southern softwood inventory less than 5 inches in diameter is relatively high (such as this decade and from 2030 to 2040). Not apparent in these national summaries are regional differences (shown in app. 1, table 40). For example, much of the increase in inventories and proportion of softwoods comes in western softwood species, whereas most of the increase in harvest comes from southern pines.

The indices also suggest that forests are aging as production shifts to fewer planted acres. Overall, seral stage conditions remain relatively stable after some initial shifts in the 1950s and 1960s (the same implications for the projections are shown in tables 14 to 16). The results also show that although fragmentation has emerged as a critical natural resource issue, its extent declines as the area harvested declines. However, its importance will not diminish as a land use issue.

The various changes in the composite index illustrated in figure 44 reflect shifts in the underlying index components. Some of these shifts reflect fundamental transitions in the U.S. forest sector. For example, there was a pronounced decline

Timberland integrity is expected to remain constant.

in the composite index during the 1980s that resulted from the beginnings of the transition from natural forests to more regulated and managed forests. Some of the factors contributing to these downward changes were increases in public lands reserved from timber production (13.8 million acres were protected in wilderness status between 1977 and 1987), rapid growth of timber harvest in the South, and the propensity of private land owners to manage for timber (USDA FS 1988). There was also a progressive increase in the demand for forest products, especially for fuelwood, pulp, and paper, which had a disproportionately large impact on the hardwood sector. The second set of events led to a stabilization of the index starting in the late 1990s and continuing into the future. Events contributing to this include growing inventory values (especially on public timberlands), stable growth/removals relations, rising proportion of older forests, and slower loss of timberland area.

Figure 44 also shows substantial differences among the regions of the United States. For example, much of the decline in timberland conditions observed in the 1970s and 1980s actually was concentrated in the East (the sum of the North and the South shown in app. 1, table 40), where it was associated with increases in hardwood harvests used as pulpwood and fuelwood (see table 8 for details). Figure 44 also shows a rapid increase in the West associated with the reductions of federal harvest and the timber industry that took place during the 1990s. Finally, it illustrates that the South, which provides the bulk of U.S. timber harvests, maintains relatively stable timberland conditions as the ratio of harvest and growth remain about constant. Figure 44 also reveals the advantage of looking across different spatial and temporal scales. Trends at the national level dampen trends at lower spatial (regional) scales. This raises questions about the desirability of, for example, being sustainable at the national level but seeing declines in timberland conditions for a region.

The trends shown in figures 43 and 44 are generally contrary to often-cited public concerns (reflecting societal values) that environmental conditions are in decline. These perceptions of decline have been shaped by many of the same events that led to declines in the composite index during the 1980s and, in some cases, changes in selected regions. This suggests that individual perceptions are slow to change, but the projected trends in the composite index offer hope that public values may change as perceptions of improving forest conditions become more widespread.

Disaggregating the Projections

Various aspects of these projections can be disaggregated and used to show the consequence of the set of assumptions when applied across the landscape. These disaggregated projections are shown in figures 45 to 47 (see Haynes 2003: 180–181 for a brief description of the disaggregation methods). These maps illustrate the spatial extent of forests in the United States and some of the differences and similarities between public and private timberlands. Figures 45 and 46 show the distribution of timber inventories by county for private and public timberlands. Comparing the two figures illustrates how public lands are concentrated in the West, the Lake States, and the Ozark and Appalachian Mountains. Private lands are concentrated in the East, but there are places in the West and Lake States where both private and public lands coexist and support diverse forests. Figure 47 shows the distribution of the average annual removals for the projection period. It reveals that the bulk of removals will come from a minority of counties located in the Pacific Northwest and in the Piedmont area of the South.

Inventory and timber product output information¹⁴ can be synthesized into a Timber Importance Index (TI_index) that measures the overall relative importance of private timberland in a county. The TI_index is shown in figure 48 and is being used in studies like the Forests at the Edge project (see Stein et al. 2005). It is a weighted index of the growth index, volume index, and timberland area index all adjusted by the production index. The indices were computed as the average value on all private timberland in a county relative to the average growing-stock growth on all timberland and counties. The timberland area index was weighted as being twice as important as the sum of the growth and volume indexes.

Figure 48 displays the distribution of these values for private lands for the Lower 48 States. In general it shows that 253 counties have the highest timber importance. These counties contain 20 percent of timberland and are concentrated in three areas of the United States: the PNWW, a crescent in the South from Texas to Virginia, and Maine. This is not to say that forests elsewhere are less important, only that forest production is concentrated in these relatively few counties. The relative locations of these counties in coastal or near coastal counties raises questions about the possible impacts of land conversions for residential development.

¹⁴This information is from the RPA database (Smith et al. 2004) and the Timber Product Output database maintained on the FIA Web site (http://ncrs2.fs.fed.us/4801/fiadb/rpa_table/2002_rpa_draft_tables.htm).

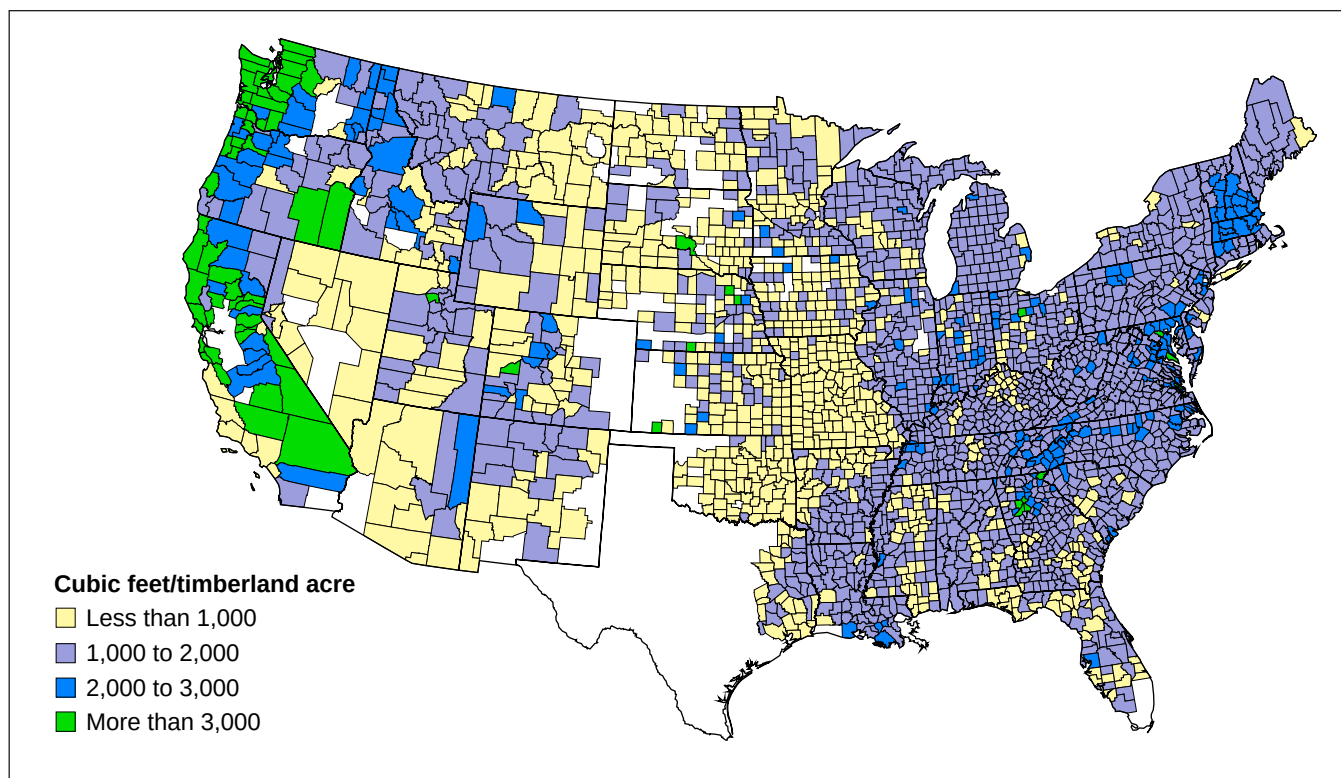


Figure 45—Distribution of timberland inventory on private timberland in 2002.

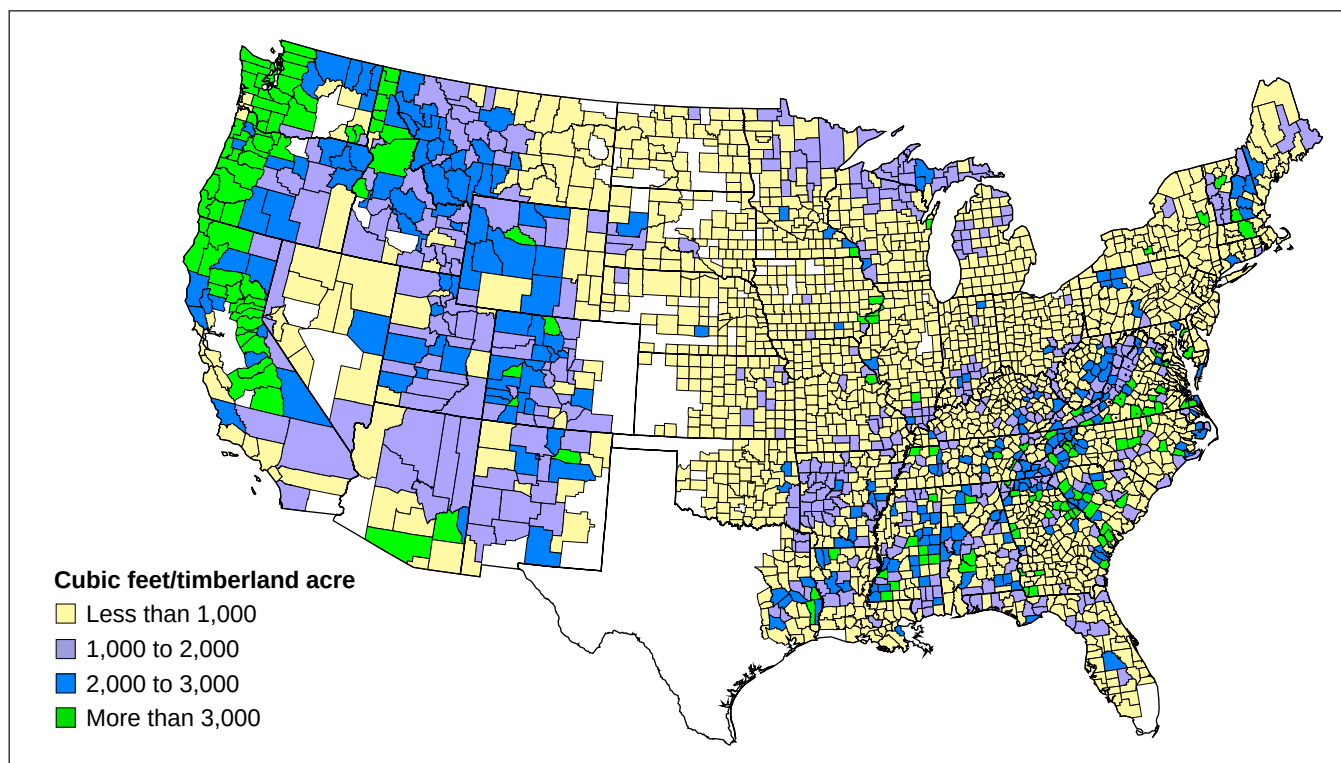


Figure 46—Distribution of timberland inventory on public timberland in 2002.

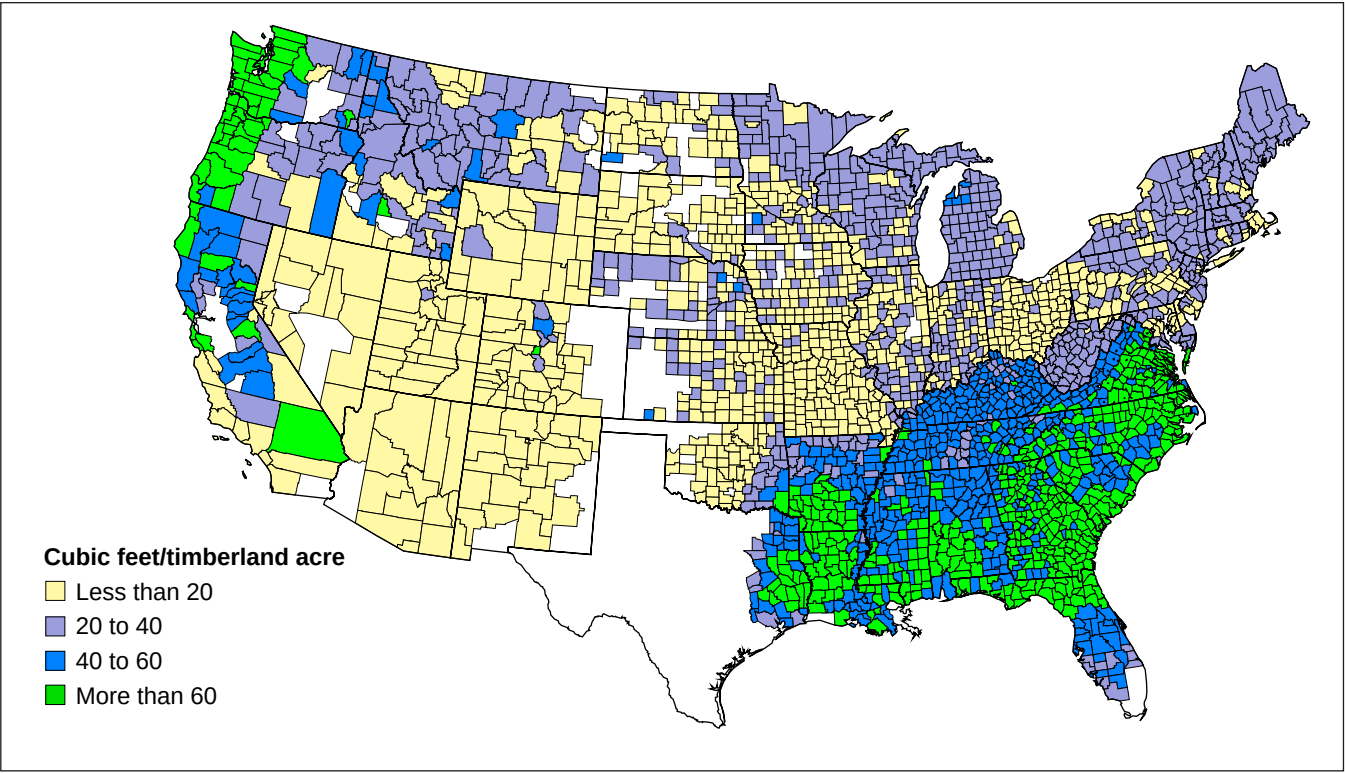


Figure 47—Average annual removals from private timberland (2000 to 2050).

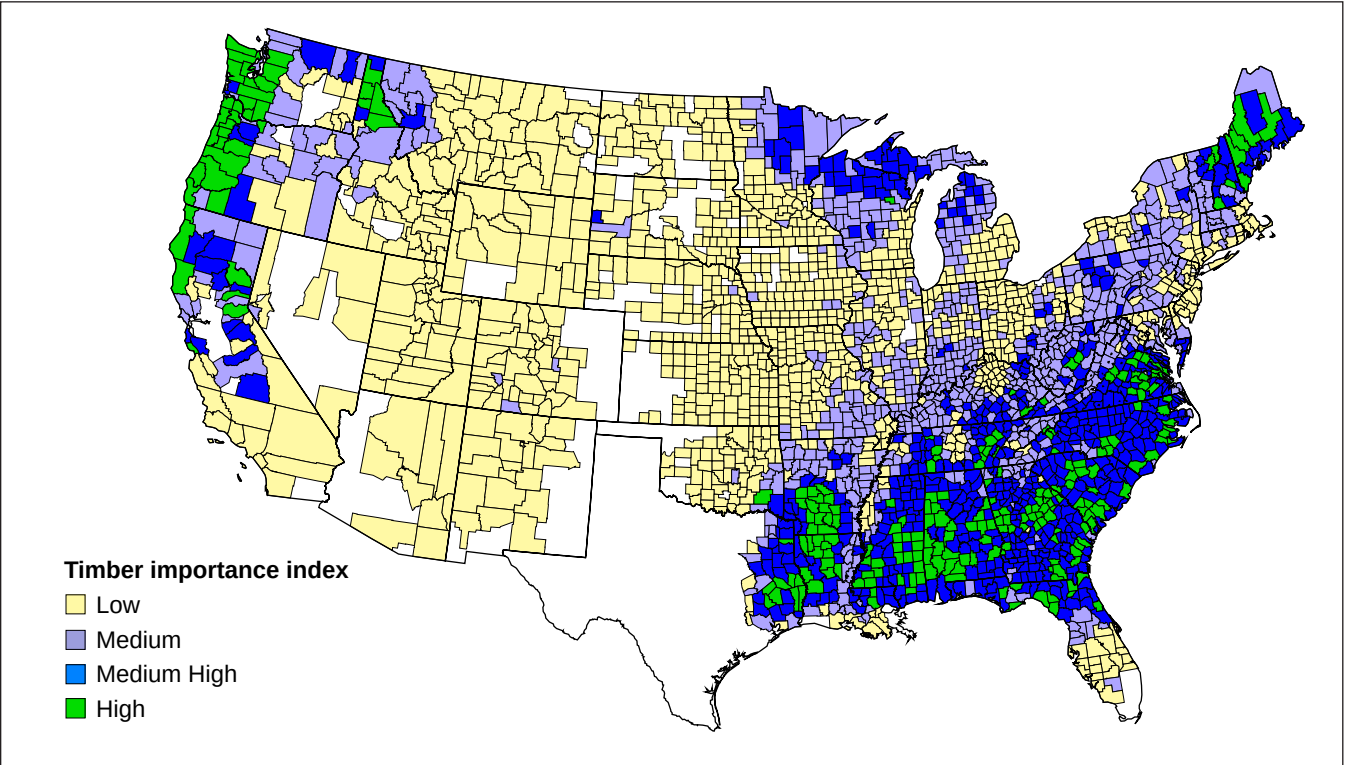


Figure 48—Timber importance index for all ownerships.

Chapter 4: Alternative Views of the Future

Introduction

The base case discussed in detail in chapter 3 provides one view of the possible future of the U.S. forest products sector. Projections are dependent on the many parameters and behavioral rules incorporated in the projection models. They are also dependent on the assumptions made about the economic and resource conditions that lie outside the model (e.g., population, national income, and land use trends as presented in chapter 2). The external assumptions used in the base case were drawn from an array of creditable sources to provide a consistent and “likely” outlook, but they still represent only one set of possible future conditions. By varying background assumptions and recasting the projection, it is possible to learn more about the sensitivity of outcomes to external conditions and to build some qualitative notions of the key uncertainties in the outlook.¹

This chapter examines an array of alternative futures that explore variations in some of the major background assumptions of the base case. Scenario planning has been a formal part of the timber assessments since the 1983 update (Haynes and Adams 1985). Timber assessments in the past two decades have included 46 alternative futures. Here we examine six that reflect both contemporary issues as well as several reflecting longstanding concerns such as the extent of reforestation and climate change. The scenarios and their rationales are tabulated below. Detailed results are summarized in app. 1, table 41.

¹ These alternative futures provide users of the RPA timber assessment with a basis for “scenario planning” by using classical sensitivity analysis, where a limited number of key exogenous and endogenous elements are varied in a projection, and key results are examined for differences. These differences allow the identification of emerging problems and provide a way to measure the effectiveness of possible solutions to those problems (Schwartz 1991).

Scenario name	Rationale for examination	What gets changed?
Reduction in other private timberland area	Other private ownerships are rapidly losing timberland area. What is the impact of this loss on future timber supplies?	Accelerate land loss from other private ownerships in all regions relative to the base case.
Climate change	What would differential shifts in timber growth rates across regions do to the U.S. forest sector outlook and regional positions?	(1) Adjust prospective timber growth rates in the ATLAS model for effects of both climate and elevated carbon dioxide. (2) Adjust prospective timber growth rates in the ATLAS model for effects of climate change only.
Restoration thinning on public lands in the West	A side effect of a program to restore the health of public forest lands in the West would be larger volumes of timber harvest. What would be the market effects of this expanded public harvest?	Raise public harvest in interior West regions consistent with one possible restoration thinning program.
Sequestration of carbon in plantations	What would be the impacts of a large program to expand U.S. forest carbon sequestration through afforestation of marginal agricultural lands? This case is the opposite of the other private land loss scenario.	Add plantations from hypothetical carbon sequestration program to timberland base.
Southern pine plantation establishment	How important is management intensification on private timberlands to the timber supply outlook of the South and the United States?	Reduce the rate of pine plantation establishment on private lands in the South to 10 percent below the base by 2020.

Reduction in Nonindustrial Private Timberland Area

In the base case, nonindustrial private forest (NIPF) timberland area was projected to decline by nearly 1 percent per decade in the Southeast (SE) and by 0.4 percent per decade in the Pacific Northwest West (PNWW) (largely as a result of losses to development) but to rise at about 0.2 percent per decade in the South Central (SC) (owing to agricultural land reversion to forest). These changes are consistent with historical multidecade trends in these regions. In the present scenario, we examine a case of NIPF timberland loss in all regions at rates substantially higher than the base. For the SE and PNWW, NIPF area declines by 5 percent each decade and for the SC region by 2 percent each decade from the year 2000 base level (see table 18). Accelerated area reductions for the SE and PNWW regions assume regionwide application of findings from recent Forest Inventory and Analysis (FIA) surveys for North Carolina (Brown 2004) and western Washington (Gray et al. 2005) that show 5-percent decadal reductions in the most recent remeasurements in those regions.

Table 18—Timberland area in nonindustrial private forest (NIPF) ownership by region, base case, and reduced NIPF timberland scenario

Scenario and area	2000	2010	2020	2030	2040	2050
Base—						
Southeast	60.739	60.116	59.470	59.097	58.385	57.614
South Central	82.285	82.525	82.752	82.909	83.037	83.130
Pacific Northwest West	4.751	4.725	4.705	4.687	4.671	4.658
Reduced NIPF area—						
Southeast	60.739	57.702	54.819	52.078	49.474	47.000
South Central	82.285	80.639	79.027	77.446	75.897	74.380
Pacific Northwest West	4.752	4.514	4.288	4.073	3.870	3.677

Note: Lands held by firms with commercial timber production objectives but no processing facilities (e.g., timberland investment organizations [TIMOs] and real estate investment trusts [REITs]) are included in both forest industry and nonindustrial private forest categories, depending on their classification in the starting (approximately 1995) inventory data. See text in chapter 2 “Projected Area Changes for Land Uses and Forest Management Cover Types” section for further discussion.

The SC region has a slight increase projected in the base case because of opportunities to afforest agricultural lands. Under the present scenario, these opportunities are assumed to be less extensively promoted by the next national farm bill and any regional environmental restoration efforts (e.g., bottomland hardwood ecosystem restoration). As a result, conversions to other uses dominate reversions to timberland over the projection period in the region.

In the simulation process, timberland area was reduced in proportion to current area by forest type. For the miscellaneous corporate portion of the NIPF class (which contains timber investment management organizations [TIMOs] and real estate investment trusts [REITs]), there has been a general increase in timberland area since 1990, while the “farmer and miscellaneous” component has declined. To reflect this ownership difference, we held the timberland area of the miscellaneous corporate component constant in the scenario.

As NIPF timberland area drops gradually below the base case in the South and PNWW, NIPF inventories in these regions fall, harvests decline, and stumpage prices rise. By the last decade of the projection (2041–2050), Southern NIPF softwood inventory is 12 percent below the base level and hardwood inventory is 10 percent smaller (see figs. 49 and 50). In the face of declining inventories, annual Southern NIPF softwood and hardwood removals fall in the area reduction alternative on average 2 percent over the 2020–2050 period (see fig. 51 for softwood removals). In the PNWW, NIPF softwood inventory falls by 11 percent from the base level in the final decade (see fig. 49) and average softwood removals drop by 5 percent in the 2020–2050 period.

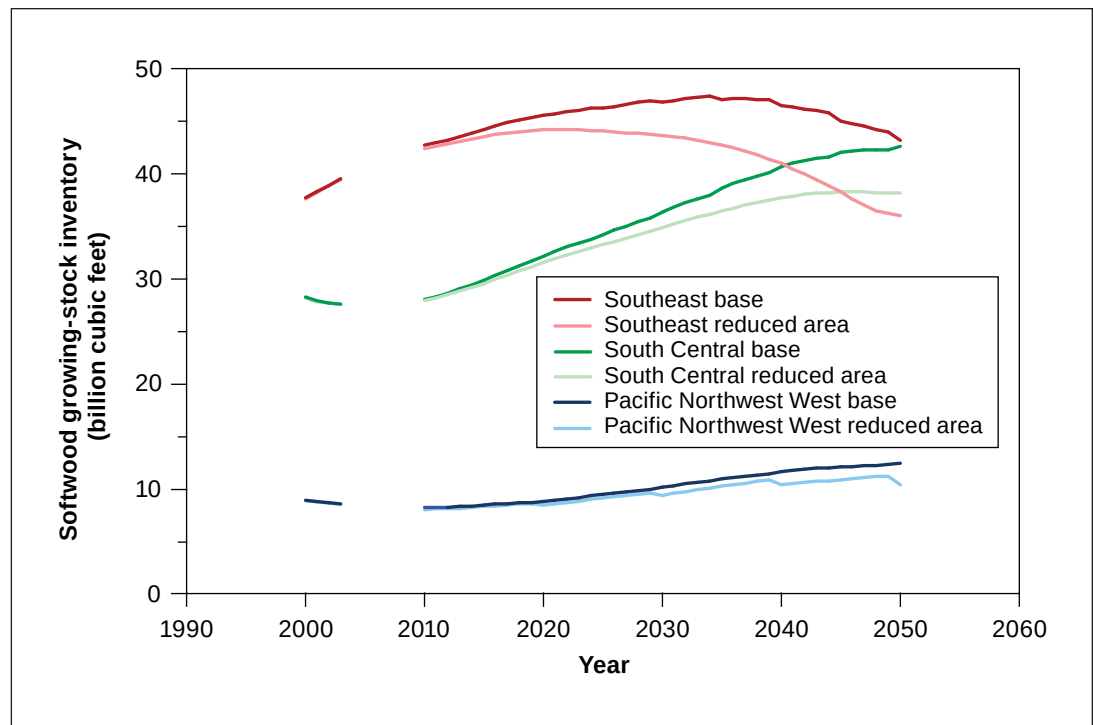


Figure 49—Softwood growing-stock inventory for base and reduced-NIPF-timberland-area scenario, for Pacific Northwest West and Southern nonindustrial private (NIPF) land.

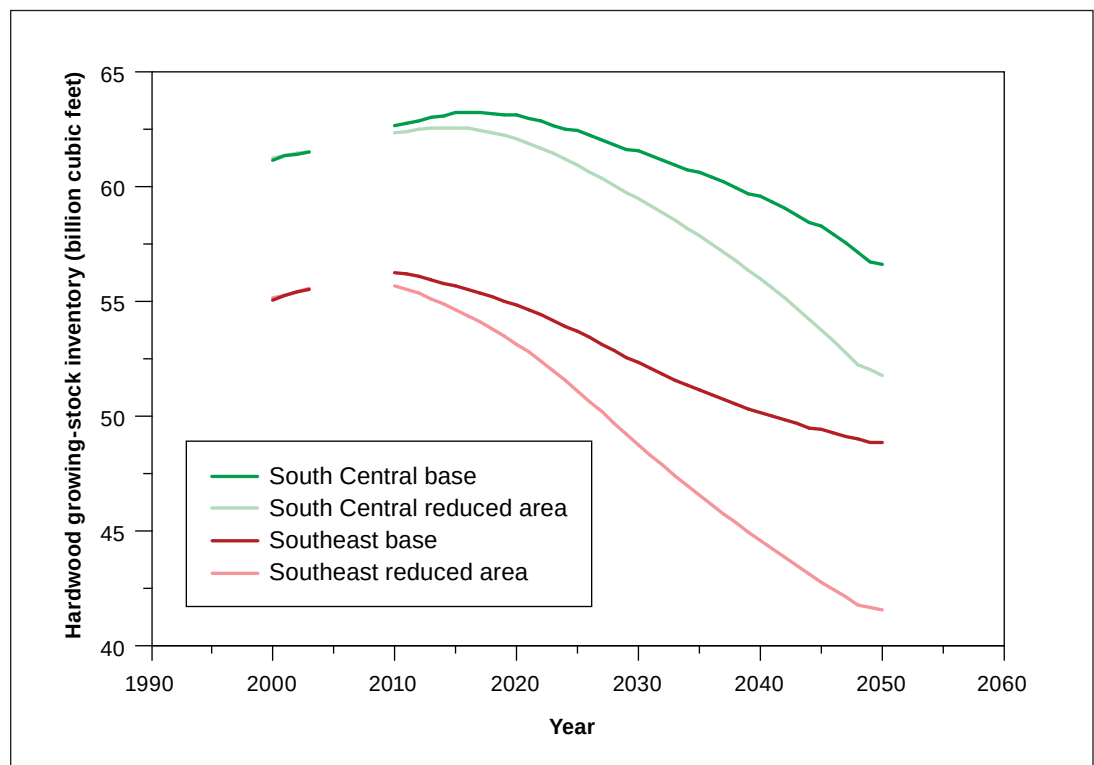


Figure 50—Hardwood growing-stock inventories for base and reduced-NIPF-timberland-area scenario, for Southern nonindustrial private (NIPF) land.

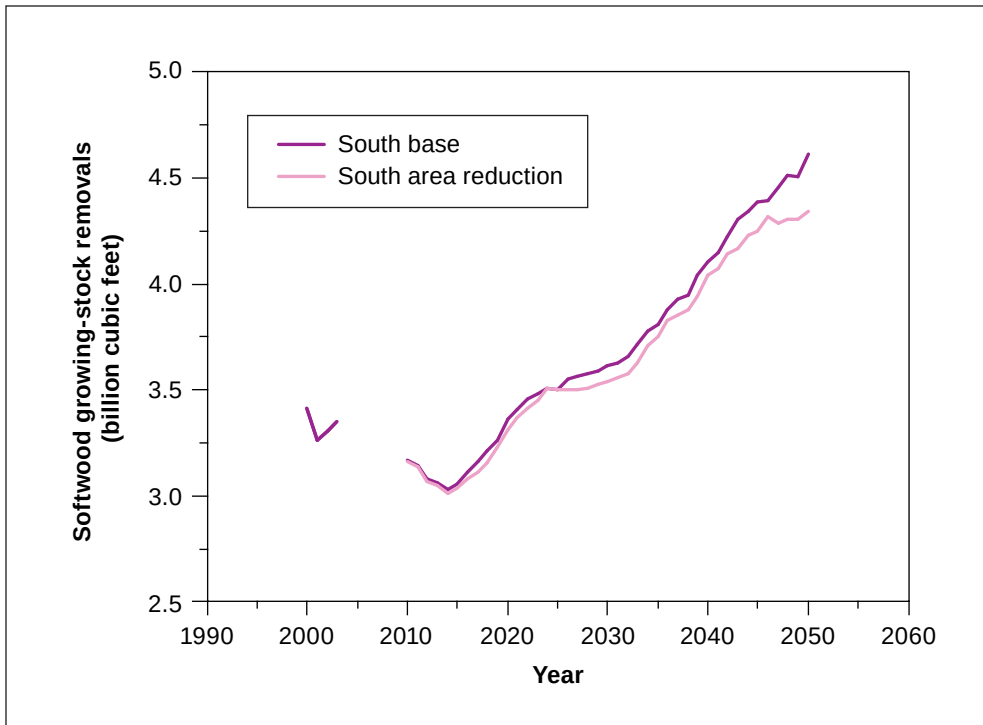


Figure 51—Softwood growing-stock removals for base and reduced-NIPF-timberland-area scenario, for Southern nonindustrial private (NIPF) land.

Although these inventory changes are sizable, the associated harvest shifts are smaller and have limited impacts on markets at the regional and national levels. Southern and PNWW softwood stumpage prices rise by 2 percent and 3 percent, respectively. Both Southern and PNWW lumber output decline by less than $\frac{1}{2}$ percent, national lumber prices rise by less than $\frac{1}{4}$ percent, and total U.S. lumber output falls by about 0.1 percent. The damping of regional and national impacts reflects, in part, substitution between owner groups within regions and across producing regions. In the South and PNWW, forest industry owners expand annual harvest by 1 and 2 percent, respectively, in the period from 2020 to 2050 in response to higher stumpage prices, offsetting the reductions on NIPF ownerships. Expanded output in other U.S. regions and in imports also counters the small reductions in PNWW and Southern softwood lumber output. Thus, despite the loss of more than 7 percent of the U.S. NIPF timberland base by 2050, the price and output impacts are heavily moderated.

Effects of Climate Change on U.S. Forests and Forest Products Markets

Global climate change may modify the growth rates and geographic distribution of forests in North America (National Assessment Synthesis Team 2000, Neilson et al. 1998). Forests are affected by changes in atmospheric carbon dioxide (CO₂) levels, annual and seasonal temperature patterns, and precipitation regimes (Norby et al. 2005). These changes influence physiological processes in trees, such as tree growth and, ultimately, the ability of trees to survive in various regions. The extent and geographic distribution of specific climatic and vegetation shifts remain uncertain. Research with climate models and ecological process models² presently yields fairly broad ranges of possible impacts, even for large regions. One contribution to this variation is the assumption about the influence of elevated atmospheric CO₂ on plant growth, the “fertilization” effect. Recent field research has suggested that this influence of the elevated atmospheric CO₂ on plant growth may be less than originally reported (Oren et al. 2001). For this report, we examine the potential impact of climate change with and without this assumption about fertilization on the productivity response in forests and the consequent changes in the forest sector.

Changes in forest growth and location will affect human use of forests. Accelerated growth and forest expansion in some regions would raise timber inventories and provide a basis for expanded harvest and wood products production. Reduced growth and the decline of forests in other regions would lead to a contraction in commercial use. Noncommodity services of forests would be affected as well, including recreation and amenity uses as described by Irland et al. (2001). Several past studies have examined the impacts of climate change on commodity output in the forest sector (Alig et al. 2002, 2004a; Joyce et al. 1995; McCarl et al. 2000; Perez-Garcia et al. 2002; Sohngen and Mendelsohn 1998).

In the present study, we use one projection of climate from the Hadley Centre in the United Kingdom that has been used in a number of recent ecological studies (National Assessment Synthesis Team 2000). The projected warming over the 21st century in the United States is approximately 5 °F. Regionally, the Hadley model scenario projects Eastern U.S. temperature increases of 3 to 5 °F by 2100 and greater increases in temperature (up to 7 °F) in the Western United States. The entire United States is projected to have increases in precipitation, except for the gulf coast and the Pacific Northwest. These increases vary regionally and

² So-called GCMs or global circulation models describe climate patterns as the chemistry of the atmosphere is projected to change with economic and population growth globally. Using these potential future climates, ecological models, in turn, estimate climate impacts on forest productivity and location.

seasonally. Under this climate scenario, atmospheric CO₂ continues to increase and influence plant growth. This scenario will be referred to as the “climate + CO₂” scenario. We examine a second scenario with the same climate scenario, but here we assume that the elevated carbon dioxide does not enhance plant growth, a “climate only” future.

In the “climate + CO₂” scenario, climate and elevated CO₂ act to augment growth in all regions. Both softwood and hardwood growth on private lands expand steadily (relative to the base), with particularly large percentage changes in the Western regions. In the “climate only” scenario, some regions continue to realize increases in timber growth (e.g., SE), while growth in other regions declines (e.g., SC). For the United States as a whole, however, both scenarios lead to overall increases in both softwood and hardwood inventories on private lands. Projections are shown in figure 52. Relative to the base, average private softwood inventory over the 2010–2050 period rises by 9.3 percent and hardwood inventory by 5.6 percent in the “climate + CO₂” scenario but by only 2.3 percent and 1.2 percent, respectively, in the “climate only” scenario. The “climate + CO₂” scenario influences tree growth and, consequently, softwood and hardwood inventories more positively than the “climate only” scenario. As in previous climate impact analyses, the regional impacts differ and can be quite different from the national average results, reflecting regional climate changes. The greatest relative increases in softwood inventories for both climate scenarios is in the South. And in contrast to the base, where Southern hardwood inventories declined, the volume of hardwood growing stock rises steadily throughout the “climate + CO₂” projection.

Because the inventory changes are gradual, their impacts on private timber harvest, timber prices, and ultimately on product markets and prices in both scenarios are relatively small and expand over the projection. For example, total U.S. softwood sawtimber harvest in 2050 increases by 0.9 percent in the “climate + CO₂” scenario and by only 0.3 percent in the “climate only” scenario. For the “climate only” scenario, the small aggregate increase reflects the mix of harvest expansion in some regions (PNWW, Pacific Southwest [PSW], and SE) and decline in others (Pacific Northwest East [PNWE], Southern Rockies [SR], North Central [NC], and SC). Regional stumpage prices are somewhat more sensitive, with 2050 softwood sawtimber prices falling by 18 percent in the PNWW and 11 percent in the South under the “climate + CO₂” scenario. In the “climate only” scenario, 2050 PNWW prices fall by 6 percent and by just 1 percent in the South.

Impacts in national product markets are further muted given extensive interregional and international substitution. By 2050 annual softwood lumber production in the United States rises by about 1.1 percent in “climate + CO₂” scenario, imports

The effects of climate change are gradual.

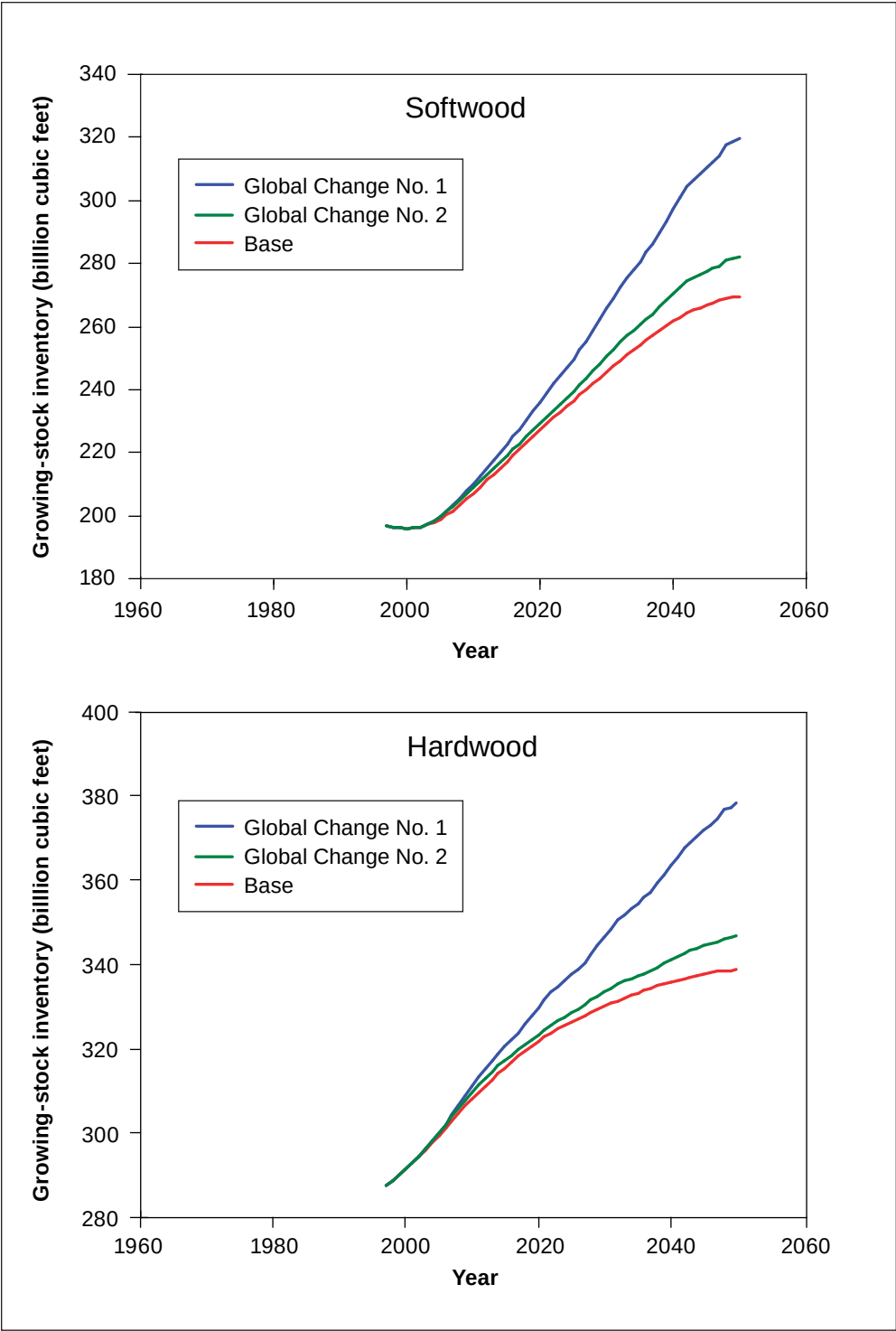


Figure 52—Total U.S. softwood and hardwood growing-stock inventory on private lands under the base, global change No. 1 (climate + CO₂) and global change No. 2 (climate only) scenarios.

fall by 1.1 percent, and consumption rises by about 0.2 percent. National market changes for the “climate only” scenario are half or less of the “climate + CO₂” case. Further details of changes are shown in app. 1, table 41.

Restoration Thinning on Public Lands in the West

Large areas of public forest land in the Western States support overly dense stands and abnormally high accumulations of fuels, partly as a result of decades of fire protection and cutting practices that emphasized ponderosa pine. As a result, forests in these areas have reduced growth rates, higher mortality, increased susceptibility to insect and disease outbreaks, and higher risk of catastrophic wildfires. Thinning in these stands to reduce fuels and mortality has been proposed as one approach to ecosystem restoration and improving forest health. The Healthy Forests Restoration Act of 2003 (PL 108-148) was enacted in part to facilitate stand treatments on federal lands with these objectives, but its provisions have yet to be made operational.

Implementation of a restoration thinning program would entail balancing an array of political, ecological, and economic considerations. Some of the major issues include, first, identifying stands and areas in need of treatment. Criteria might include the extent of fuel accumulation, departures from potential growth (e.g., as measured by an index of stand density), extent of species imbalance (e.g., unnaturally large numbers of fire-sensitive species), or some combined criterion such as the Fire Regime Current Condition Class (FRCCC) proposed by Schmidt et al. (2002), which estimates how far a stand has departed from natural wildfire conditions by integrating all these components.

The second issue is determining areas to be reserved from treatment. Portions of the public lands have been set aside for a wide array of purposes, including wilderness areas, natural areas, recreation areas, and habitat conservation or rehabilitation areas. It may be desirable to exclude some of these areas from thinning treatment to allow natural or other vegetation change processes to continue undisturbed.

The third issue is prescribing the form of the thinning treatment. The trees to be removed must be identified. Options generally involve the range of diameters that can be removed, starting with the smallest and moving up to some maximum. How many (and what sizes of) trees or how much basal area to remove depends on the objectives used in identifying the stands (in the first issue above) and relate to desired conditions in the postthinning stands.

The fourth issue is providing access to thinning areas. Large areas of forest in need of thinning (by a number of different criteria) lie far from road access. These areas may be eliminated from consideration unless decisions are made to construct roads.

The fifth issue is administering a treatment program and auditing costs. Even small-scale thinning programs could entail large numbers of treatment areas, requiring an expanded administrative structure within public forestry agencies to manage the thinning process, identify actual work areas on the ground, secure contractors or others to conduct the thinnings, and audit accomplishments and the costs of the program. Decisions are also required on the form and extent of any payments to be made by contractors for merchantable material removed, requirements for treatment of nonmerchantable material (small and dead wood), and whether subsidies will be offered to contractors for the treatment of areas with little or no merchantable material.

The areas to be thinned and the extent and quality of potential harvest volumes will be determined by the conditions noted above. At present, only small-scale projects (unrelated to the Healthy Forests Act) have been implemented in local areas under highly diverse circumstances, so no definitive guidelines on removal volumes are available. As a result, studies that have attempted to estimate potential thinning removals have done so under an array of assumptions about possible constraints. But even with fairly restrictive conditions on areas to be treated, limitations on access and maximum size of stems to be harvested, it is likely that a Westwide restoration thinning program would generate very large volumes of both merchantable sawtimber and biomass.³ Rummer et al. (2003), for example, attempted a broad-scale assessment of potential thinning harvest volumes in the Western States. In a case where they assumed that only material from the readily accessible and highest risk stands could be removed (FRCCC class 3) to reach lower stand-density targets, they found sufficient volume to provide wood for 25 percent of the current conventional wood products processing capacity in the Western States for the next 30 years.

The scenario examined here was based on this latter example. Rummer et al. (2003) estimated that 576.1 million bone dry tons of wood fiber could be removed from the highest-risk land class (FRCCC class 3) on all ownerships.⁴ Assuming that

³ See, for example, Fried et al. (2003) for a case that focuses on biomass generation in Oregon and California, and Adams and Latta (2005), which looks at sawtimber volumes that could be removed in thinning operations in eastern Oregon.

⁴ The silvicultural objective of this thinning is to reduce stand stocking, as measured by the stand density index, to a lower level allowing higher growth and reducing mortality. See Rummer et al. (2003).

roughly 60 percent of this aggregate estimate would come from public land, that only 60 percent of this public land is actually accessible with existing roads, and that about 70 percent of the removals would represent merchantable material, the total sawlog volume would amount to about 148 million bone dry tons or roughly 11.6 billion cubic feet. We assume that this volume is removed in a 30-year initial program (2006–2035) at 387 million cubic feet per year.⁵ If, as seems likely, a natural fire regime is not instituted in the region after the first thinning, continued thinnings would be required to maintain stand conditions. To emulate this process, we set removals at one-third their initial level for the remainder of the projection (2036–2050).

Thinning volumes enter the timber assessment projection model as a fixed expansion in Interior West public sawlog supply. This should reduce softwood stumpage prices in the region, stimulating expanded lumber output and expansion in processing capacity as the thinning program continues. This expansion takes place in those areas with an established industry (eastern Oregon, eastern Washington, and the northern Rockies). Higher lumber output at lower costs in the West will substitute for some production in Eastern regions and for imports. Softwood lumber prices would be expected to fall and U.S. consumption to rise. The speed and extent of these changes depend heavily on the rate at which softwood lumber and plywood processing capacity can be expected to expand in the Interior West region as a thinning program is initiated. Prior to 1990, public lands were the largest source of timber in the region. With the redirection of public lands management after 1990 and the associated reduction in public timber harvest, processing capacity has declined. We estimate that softwood lumber capacity fell by 40 to 50 percent for the region as a whole between 1989 and 2002, whereas for the SR region alone, the decline was closer to 75 percent. With low current capacity levels, large increments in public timber supply are likely to sharply depress stumpage prices at the outset of the program. This will provide some inducement to expand capacity, which in turn will act to move stumpage prices back toward base levels. Capacity changes in the assessment projection model are based largely on profitability measures, and this leads to fairly rapid capacity growth in the scenario results. Many other considerations are known to influence real-world capacity investment decisions, however, including perceived risk and stability of input supply—issues which could act to alter the capacity change projected by our model. Rates of capacity expansion

Falling lumber production in the Interior West complicates efforts to increase thinning.

⁵This is the total for all public lands in the Interior West region, which comprises the PNWE, Pacific Southwest, Northern Rockies, and Southern Rockies RPA assessment regions.

slower than those projected in the scenario would increase the regional stumpage price effect but reduce all of the production, consumption, and trade adjustments.

As illustrated in figure 53, annual softwood lumber production in the Interior West rises rapidly (under our capacity-expansion assumptions) to about 2.0 billion feet above the base case. As supply expands, U.S. softwood lumber price falls, on average about 4.0 percent over the 2010–2050 period. In response, annual softwood lumber production in other regions falls by 560 million board feet, yielding an increase in aggregate U.S. softwood lumber output of roughly 3.8 percent or about 1.4 billion board feet on an annual basis. Annual softwood lumber imports are also highly sensitive to price and fall by about 890 million board feet. As a result, the net increase in annual U.S. softwood lumber consumption is only some 560 million board feet, a bit more than one-quarter of the original production increment in the Interior West region.

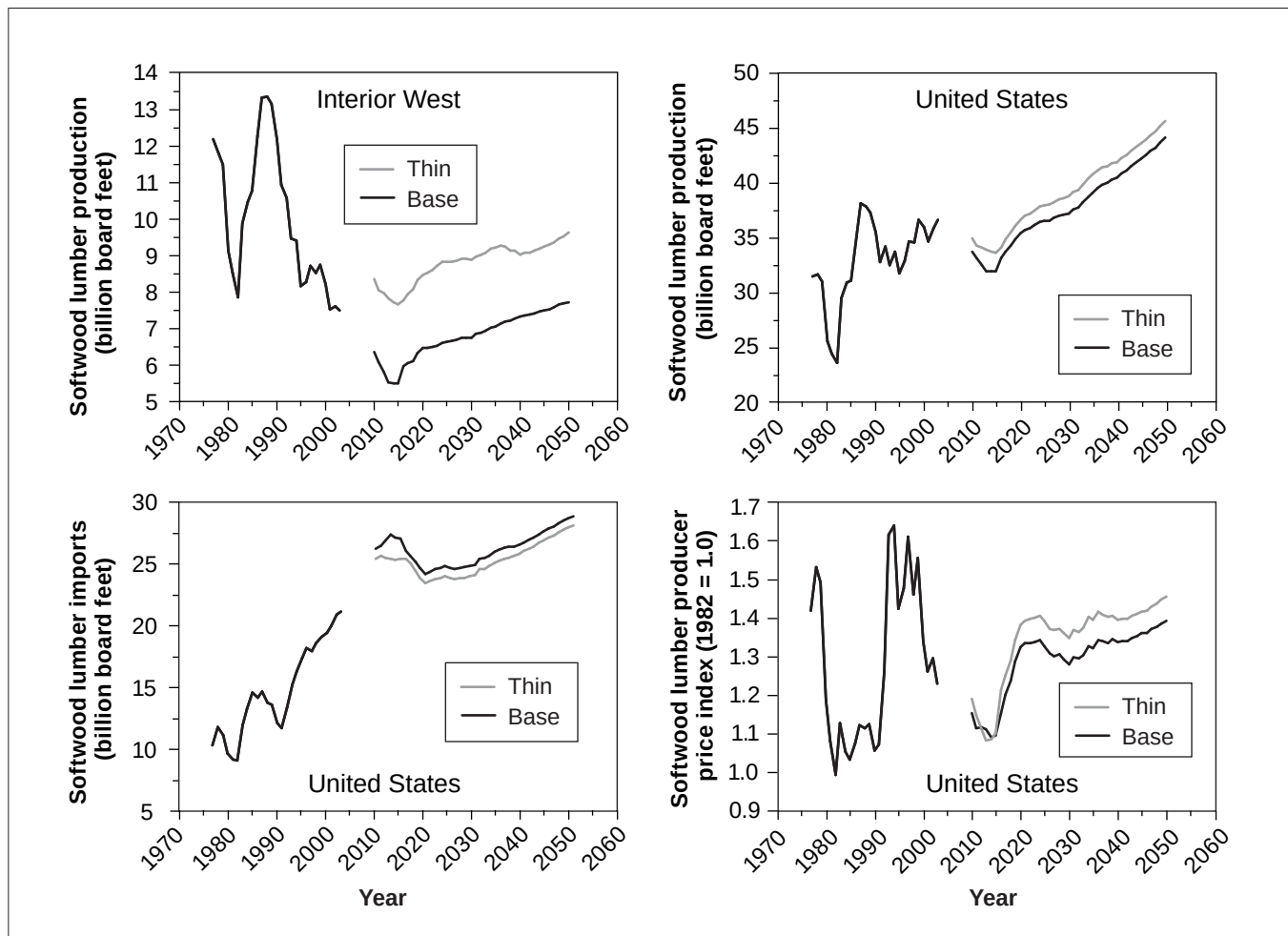


Figure 53—Softwood lumber market effects of a restoration thinning program in the Interior West region and United States projected to 2050.

Expanded public timber harvest reduces Interior West stumpage prices and the incentive to harvest timber on private lands in the region as shown in figure 54. This public-for-private harvest substitution yields a gradually accumulating “inventory savings” on private lands (see the lower graph in fig. 54). When public timber harvest drops back to lower levels and stumpage prices rise after 2035, private harvest expands above the base level to exploit this potential.

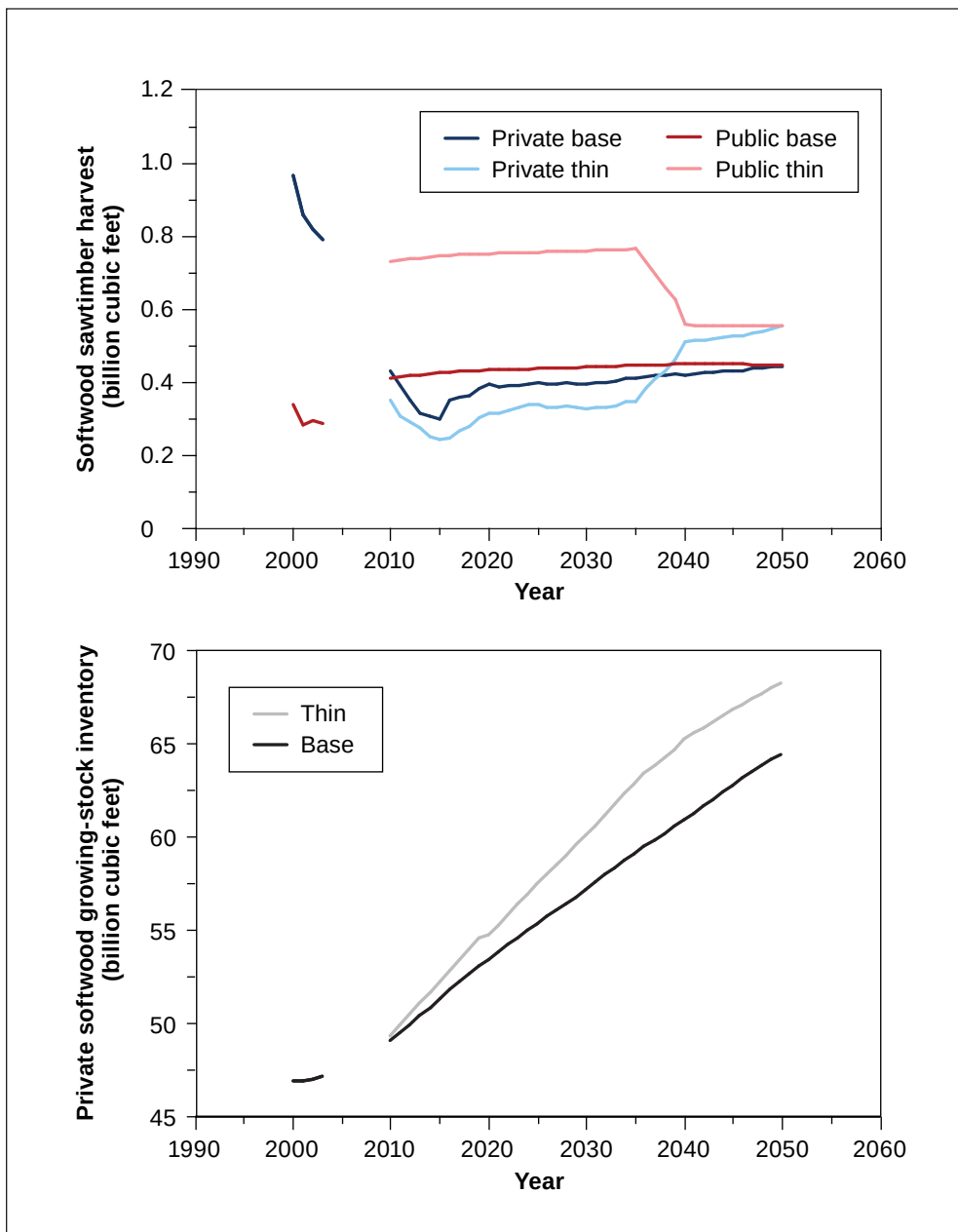


Figure 54—Interior West softwood sawtimber harvest by owner and private softwood growing stock for base and restoration thinning projected to 2050.

Sequestration of Atmospheric Carbon in Forest Plantations

Human activities have played a significant role in raising the atmospheric concentrations of greenhouse gases (including CO₂) through the combustion of fossil fuels, use of certain agricultural practices, and land-use changes (IPCC 2001). In the global carbon cycle, terrestrial ecosystems are important sources and sinks of atmospheric carbon. Roughly half of all carbon in terrestrial systems is stored in forest vegetation as biomass and as organic carbon in the soil and is subject to decrease or increase as a result of disturbance (including harvest), regrowth, or conversion to other uses (Watson et al. 2000, [table 1, pg. 4, in Policymaker Summary]). Historically, changes in land use have been major factors affecting terrestrial carbon sinks. During the period 1850–1998, cumulative CO₂ emissions from land-use change are estimated to have contributed 33 percent of total global emissions (Bolin and Sukumar 2000). In the United States, Houghton et al. (1999) estimated that changes in land use released about 25 Pg (25 billion metric tonnes) of carbon to the atmosphere over the period 1700–1990, largely from the conversion of forests to agricultural lands and from cultivation of prairie soils.

Expanding forest area through afforestation of economically marginal agricultural lands has been proposed as one approach to reduce net emissions of CO₂ in the United States and other countries. Several studies in the United States over the past decade have attempted to assess the extent of the area that might be suitable for such afforestation and the costs of the additional carbon sequestered. Results have shown a fairly broad range of cost and area estimates. Moulton and Richards (1990), for example, found that nearly 120 million acres of land might be afforested at carbon costs of \$20 per (short) ton or less, increasing carbon flux by roughly 250 million (short) tons per year. In contrast, Parks and Hardie (1995), using a different approach to cost estimation, found that almost no land could be afforested for carbon sequestration if forest carbon was worth only \$20 per ton. A recent survey by Stavins and Richards (2005) summarized a wide array of carbon cost studies, virtually all of which examined only afforestation as a means to increase forest carbon flux. Using what might be called the trend results from this set of studies, they found that at a carbon value of \$20 per ton, perhaps as much 80 million tons per year of additional carbon might be sequestered through afforestation. Based on afforestation area and carbon flux estimates from Stavins and Richards, an 80-million-ton annual program could require as much as 42 million acres of agricultural land.⁶

⁶Based on simple proportioning from area and sequestration rate estimates presented by Stavins and Richards (2005: p 33).

In this scenario, we examine the market and resource impacts of a relatively modest 6-million-acre expansion in U.S. forested area through afforestation of agricultural land. Such a program could yield roughly a 7-million-short-ton annual increment in U.S. forest carbon flux and would be roughly consistent with a carbon value of just less than \$10 per ton.⁷ Following patterns observed in previous programs of agricultural land diversion (e.g., the Soil Bank and Conservation Reserve Programs), 90 percent of the afforestation was assumed to occur in the South, roughly 7 percent in the West, and 3 percent in the North. These lands would be part of existing farming/ranching operations and hence were classed with the NIPF owner group. For the South, the area change amounts to a 2.7 percent increase in total regional timberland. For the United States as a whole, 6 million acres represents about a 1.7-percent increase in the private timberland base.

In the South and West, all plantations were assumed to be in softwood types (again similar to experience in earlier programs), whereas in the North, a small fraction (20 percent) was planted to the oak-hickory type. The land was classed as medium-site forest land. The plantations were assumed to be given low to medium management treatment beyond initial stand establishment and were treated as available for commercial timber harvest once they passed minimum merchantability thresholds.

Given the relatively modest size of the timberland area increment, the aggregate resource and market impacts of this scenario are limited. As the afforested areas mature, NIPF softwood inventories rise above the base as shown in figure 55. Because the largest portion of the new timberland is in the South and given the rapid early growth rates of Southern planted pine, the inventory increments are observable relatively early in this region. Inventory differences have roughly stabilized by 2040, when Southern NIPF softwood inventories are about 11 percent above the base. Changes are smaller in the West and North and discernable in figure 55 only near the end of the projection. Increased inventory stimulates some additional timber removals in the South, as shown in figure 56, but the change is significant only after 2035 and averages less than 0.5 percent in the last 15 years of the projection. Changes in the North and West are too small to be visible in the figure. As a result, impacts on regional stumpage prices and national product markets and prices are also small.

⁷The land area estimate was derived by using the same proportioning approach as in footnote 4, and the approximate carbon value was derived from figure 6 in Stavins and Richards (2005).

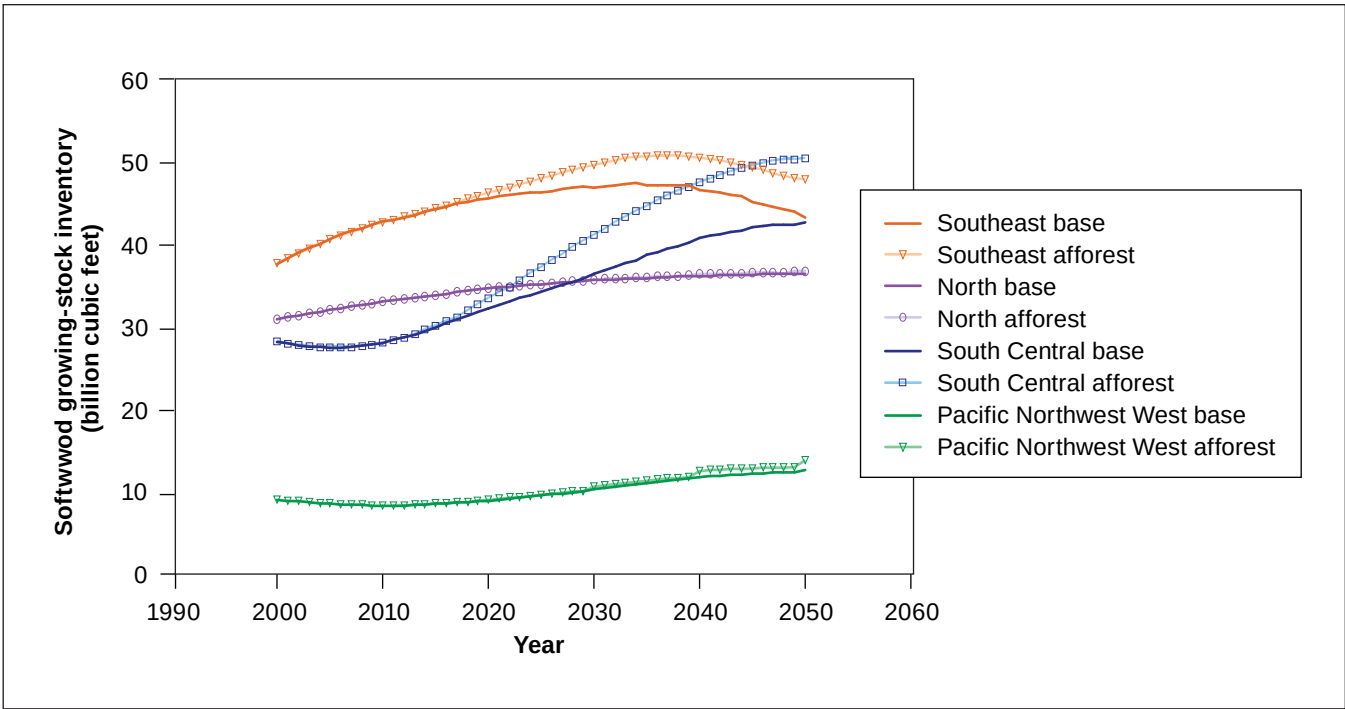


Figure 55—Softwood growing-stock inventory for nonindustrial private owners in selected regions under base and increased afforestation cases projected to 2050.

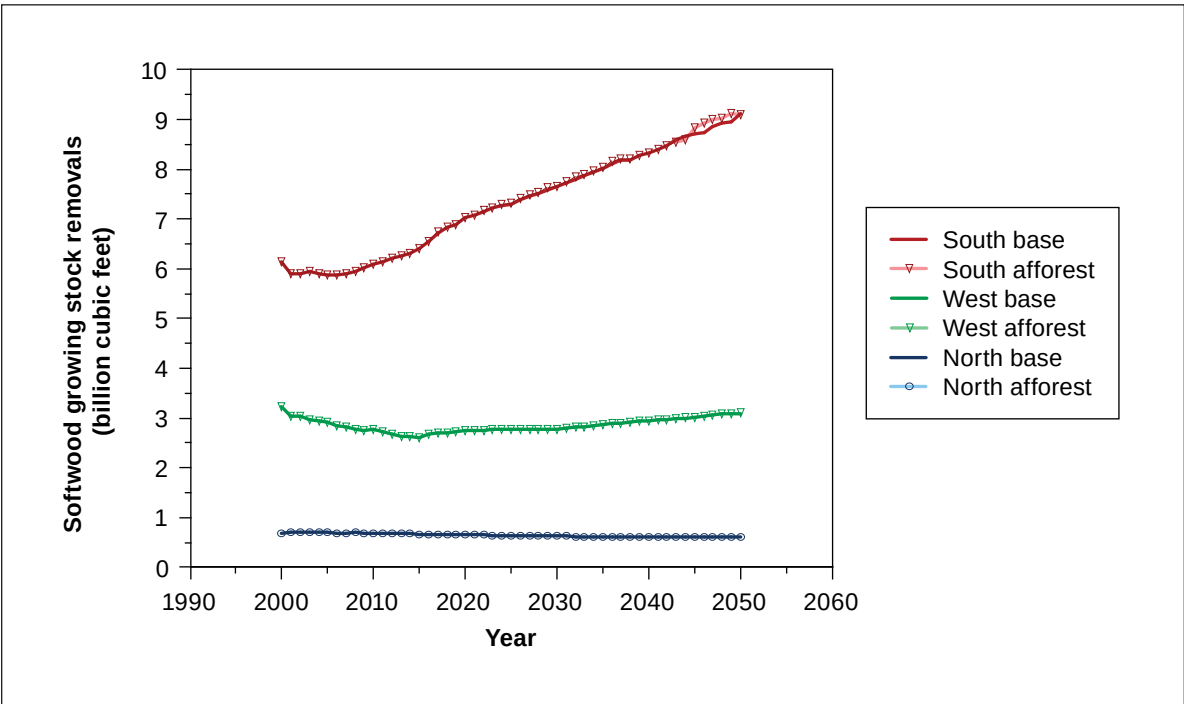


Figure 56—Softwood growing-stock removals (all owners) by major region under base and increased afforestation cases projected to 2050.

Reduced Southern Pine Plantation Establishment

In the base case, the area of planted pine on private lands in the South grows steadily through the projection, rising by 12.4 million acres between 2000 and 2050. Southern planted pine area rises from 16 percent of the private timberland base in 2000 to 24 percent by 2050. How important is this increase in plantation area to the softwood (and hardwood) supply potential of the South and the United States? This scenario examines a gradual reduction in Southern planted pine area, falling to 10 percent below the base case by 2020 (see table 19), a total reduction of some 4.2 million acres by 2050. Planted pine area was reduced in the projection on all private ownerships and all sites and was redistributed proportionally across the other forest cover types, both softwood and hardwood. As a result, the total projected timberland area (summed across all forest cover types) remains the same as the base.

Table 19—Southern private timberland area by cover type for base and reduced planted pine area scenarios

Year	Base		Reduced planted pine area	
	Planted pine	Other types	Planted pine	Other types
	<i>Million acres</i>		<i>Percent change from base</i>	
2000	29.257	149.457	0	0
2005	32.401	146.212	-2.50	0.55
2010	34.487	143.813	-5.00	1.18
2015	36.289	141.616	-7.50	1.90
2020	37.881	139.701	-10.00	2.67
2025	39.363	137.983	-10.00	2.81
2030	40.496	136.631	-10.00	2.92
2035	41.122	135.674	-10.00	2.98
2040	41.445	134.936	-10.00	3.02
2045	41.521	134.469	-10.00	3.04
2050	41.608	134.010	-10.00	3.05

Pine plantations have more rapid growth and higher yields than other cover types. Less plantation area would be expected to lower future timber inventories, reduce timber harvests, raise stumpage prices relative to the base, and lower product output. As illustrated in figure 57, the private inventory reduction is substantial, and aggregate Southern private inventory expansion after 2020 is sharply curtailed. By the last decade of the projection, Southern private softwood inventory is 11 percent below the base. Transmission of inventory changes to timber harvest and product output, however, is strongly attenuated. Average annual (2010–2050) Southern softwood growing-stock removals fall by only 1.1 percent relative to the base (fig. 58). Private owners continue harvesting at just below base rates despite the large difference in inventory. This is due in part to increases in Southern softwood sawtimber stumpage prices that reach nearly 10 percent above the base by 2050 (fig. 59).

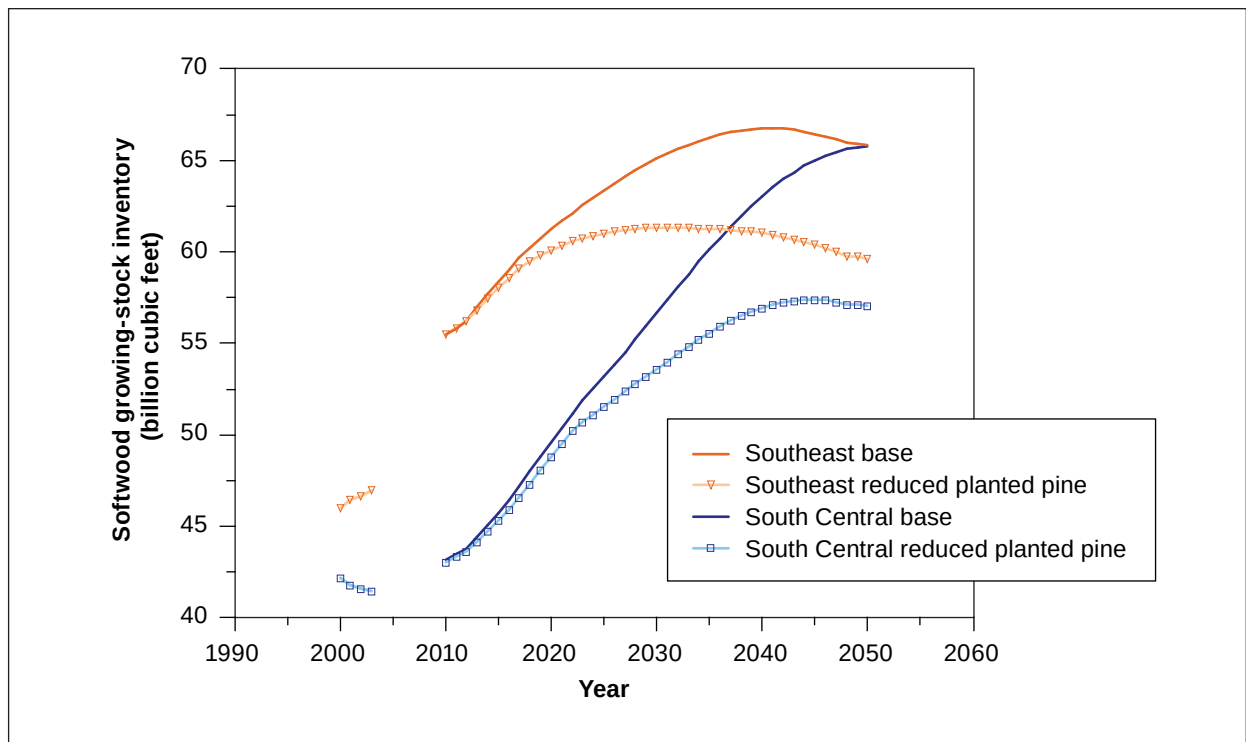


Figure 57—Private softwood growing-stock inventory in Southern regions for base and reduced-planted-pine scenarios projected to 2050.

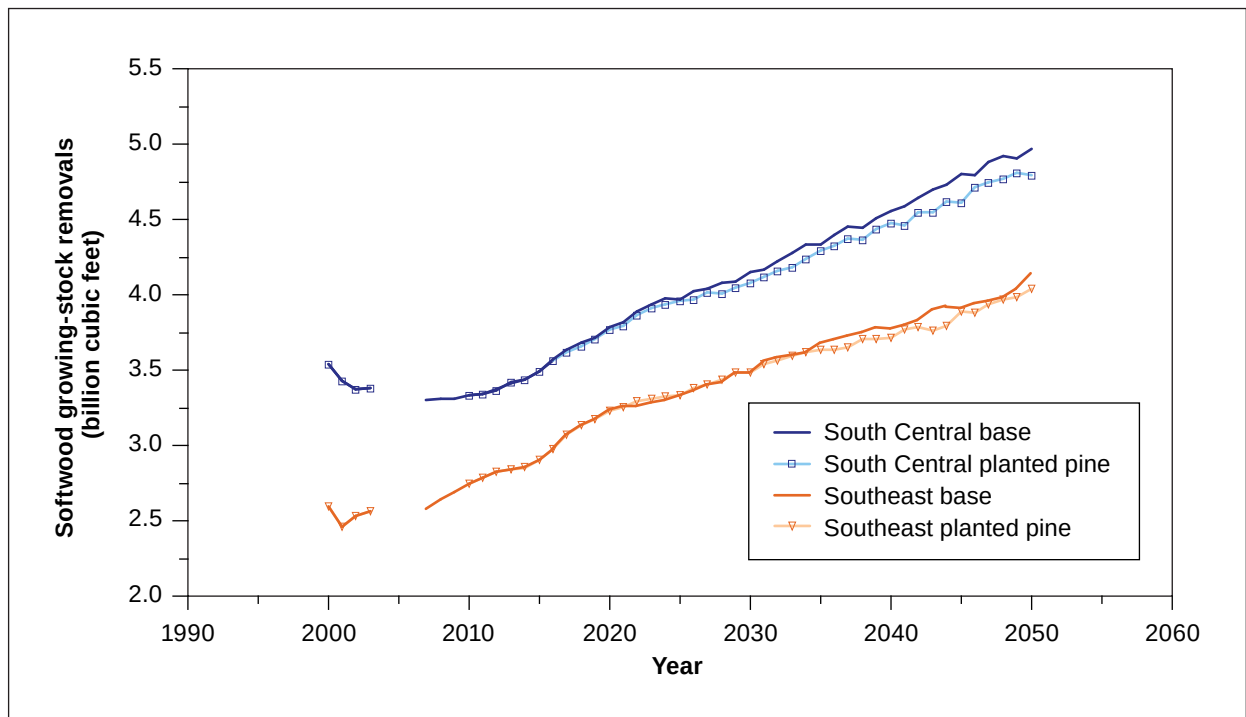


Figure 58—Softwood growing-stock removals for Southern regions for base and reduced-planted-pine scenarios projected to 2050.

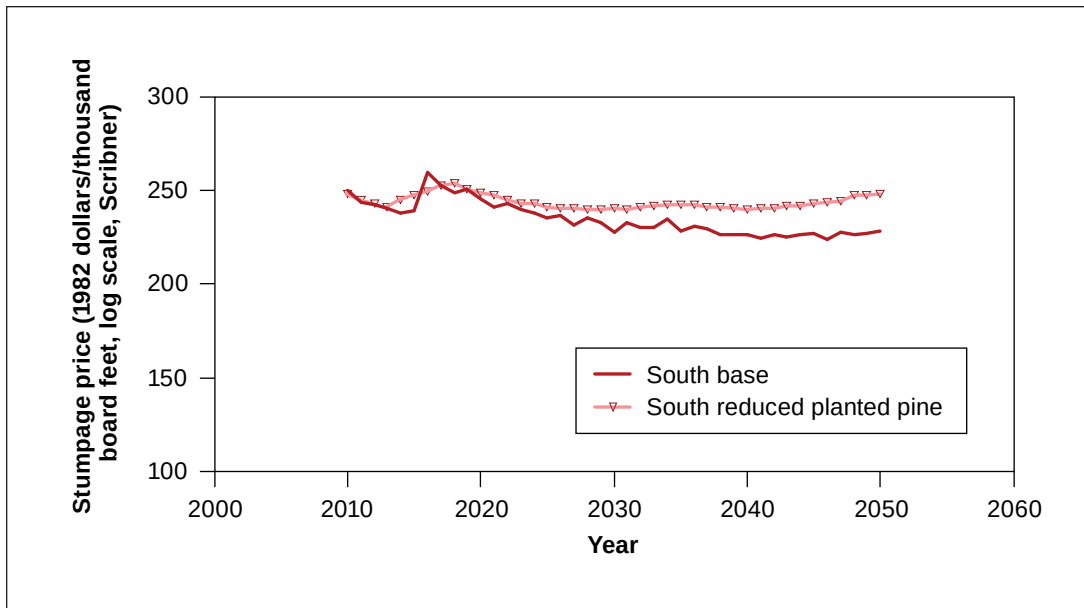


Figure 59—Softwood sawtimber stumpage price for Southern region, base and reduced-planted-pine scenarios projected to 2050.

Outside of the SC region, impacts in product markets are still smaller as a result of substitution between suppliers. Average (2010–2050) annual softwood lumber production outside of the South rises by about 1 percent while southern production falls by about 0.4 percent. At the national level, average annual U.S. softwood lumber production falls by 0.1 percent, imports rise by 0.1 percent, and U.S. consumption declines by less than 0.05 percent. Changes for other solid wood products are even smaller. Thus, as seen in several preceding scenarios, price response and substitution—in this case between regions—act to dilute the impacts of large regional changes in broader market areas.

These alternative views of the future illustrate the sensitivity of outcomes to external conditions and provide some qualitative notions of the key uncertainties in the outlook. Alternative futures have been a formal part of the past six RPA timber assessments. These past analyses, and the new scenarios examined here (such as restoration thinning on public lands and the possible climate change impacts on forest growth), focus on a range of contemporary resource issues and, in some cases, the effectiveness of various programs to mitigate possible impacts. Results from the scenarios may also be useful in drawing inferences about trends in other resources, such as wildlife habitat, environmental services, or amenity values, in that changes

in major timberland attributes (e.g., timber inventory and structure) can broadly affect prospective conditions for a number of forest-based goods and services.⁸

Examining differences and similarities across the alternative futures can help to identify some general characteristics of responses as projected by the models used in the assessment. One general observation is that land, timber, capital, and wood product markets will likely adjust and adapt to external conditions in ways that act to limit economic effects. Many changes are possible across the large timberland base, including shifts among owners and regions in timber production and harvests and in timber processing technology. However, adjustments across regions, including international responses, may at times involve lags, depending on resource conditions (e.g., age class distributions) or processing capacity. Several forms of adaptation may be used in the forest sector, including changes in (a) land use and forest cover types, (b) timber management intensity, (c) hardwood/softwood species mix of timber harvest, (d) timber harvesting patterns within and between regions, (e) timber rotation ages, and (f) use of wood versus other products (i.e., substitution of nonwood products in consumption based on relative price).

The scenarios also illustrate the temporal differences between types of activities or actions and their associated economic effects. In our climate change scenarios, timber inventories respond gradually to climate change, and their impacts on private harvest, prices, and ultimately on product markets and prices are relatively small. Timber harvest rises because of increased timber inventories, as both softwood and hardwood growth on private timberlands expands steadily relative to the base. The directions of change are consistent with earlier studies, including the regional variation, e.g., growth increases in Western regions but reductions in parts of the South. The timing of impacts in the restoration thinning case is much more immediate, with most of the shifts in solid wood markets evident by 2010. In addition, even though the timber supply changes from the restoration thinning scenario are concentrated in the West and involve primarily sawtimber, the market-related impacts are felt nationally and affect both the solid wood and pulp and paper portions of the forest sector.

The temporal scale for adjustments or responses is often related to whether the activity or issue acts initially on the market for forest products (and hence on existing timber stocks) or on forest management options for new or existing forests.

⁸Treatment of other resource conditions is outside the scope of this timber assessment, but for example, see Adams et al. (1992) projection of wildlife habitat indices as part of a forest resource assessment or Nalle et al.'s (2004) modeling of joint production of wildlife and timber. There is a growing interest in environmental markets and payments for ecosystem services to promote forest management that "results in better biodiversity and sustains local economies" (see Clarren 2006 for more details).

The public lands restoration thinning scenario, for example, has major effects on near-term markets for forest products and influences private timber management decisions only indirectly through changes in expected future prices. The carbon sequestration or pine plantation scenarios, in contrast, relate primarily to future forests and, hence, the impacts occur gradually in the future.

Consideration of broader geographic scales acts to mitigate how some changes play out in local, regional, national, and international markets. For example, although the South may face reductions in forest growth relative to the base under the second climate change scenario, the region has potential to add timberland, especially high-yielding pine plantations. However, as with the expanded carbon sequestration scenario, timber and product price response and substitution act to reduce the impacts of large regional changes in broader market areas.

The scenario of using forest-based activities in climate change mitigation indicates how timber markets may react to activities designed for nontimber purposes. Expanding afforestation on 6 million acres of marginal agricultural lands in the SC region could result in a 7-million-short-ton annual increment in U.S. forest carbon flux, or about 0.5 percent of annual U.S. emissions. Given the relatively modest size of the timberland area increment and the several decades required for maturation of the plantations, aggregate market impacts are limited. However, the other scenario of a reduction in NIPF timberland area indicates that deforestation could potentially more than offset the gain in inventory from the climate change mitigation scenario, in that both private softwood and hardwood growing-stock inventories are projected to be 13 percent lower than the base in the South by 2050 if that deforestation occurs. Consideration of deforestation owing to changes in land demand manifested through land markets raises the possibility of leakage for climate change mitigation programs; the net impact on timberland area can be less than the original area increment because of countervailing timberland transfers to agriculture or developed uses as land markets adjust (see Alig et al. 1997 for a more complete discussion).

Another market-based adjustment that can affect both timber supplies and climate change mitigation costs is the possibility of a reduced rate of establishment of a key ingredient in future timber supplies, pine plantations in the South. For both regions, establishment rates of pine plantations may fall below base projections if landowners perceive lower financial returns relative to the base. As with the expanded carbon sequestration scenario, timber and product price response and substitution would act to reduce the impacts of large regional changes in broader market areas.

Information gleaned from the bioeconomic modeling systems applied in examining different scenarios in large-scale assessments, even though some scenarios are not directly designed or intended as climate change scenarios, can aid policy-makers in identifying implications for possible policy options in view of the joint production of timber and standing forest carbon. For example, the reduced NIPF timberland area scenario with the reduction in private softwood growing-stock inventory by 2050, owing to reduced pine plantation establishment would roughly offset the projected increase in the carbon sequestration scenario.

Key in this last point is how the base run can be interpreted as a baseline for expected environmental services such as carbon storage. Interpreting the base as a baseline illustrates several critical issues where there is not consensus in the scientific community such as defining a baseline that combines both biophysical and economic components. Here the base includes expected market impacts including increased harvests to meet future expected timber consumption and future timberland area losses. It includes assumptions about changes in the mix, location, and efficiency of processing facilities. It includes increases in forest resource conditions reflecting changes in timberland extent and improved forest management. The comparisons of the base with scenarios can be used to measure the incremental effects (referred to as additionality) of various changes, a key component in many of the discussions of environmental services.

Results from the restoration thinning scenario point to the importance of capacity adjustments and investment capital flows. New capacity will be located in areas with the ability to compete cost-effectively in domestic commodity lumber markets. This reflects expanding opportunities for adjustment as the projection advances and demand shifts resulting from substitution. For example, in the restoration thinning case, lumber price differences decline relative to the base as demand expands. During the early periods of this scenario, lower stumpage prices encourage expansion of domestic lumber production and capacity in the Interior West. This new capacity absorbs the additional timber made available near processing facilities; as a result, stumpage prices stabilize and then gradually approach prices in the base. In a similar fashion, initial reductions in lumber prices increase the quantities of lumber demanded. As prices remain lower than the base, consumers continue to shift away from substitutes, and lumber consumption rises further above the base.

Similar processes of substitution by consumers and lagged adjustments in production take place in other sawtimber/solid wood supply scenarios, producing a characteristic pattern of prices and volumes. This is similar to the adjustments described by Haynes (2003) for an expanded national forest timber harvest scenario

in the 2000 timber assessment. In the present update, the lumber orientation of the Western U.S. restoration thinning scenario means that sawlog markets are primarily affected.

The Western U.S. restoration thinning scenario reveals the importance of lumber imports from Canada for the aggregate timber supply outlook. With Canada as the United States's largest trading partner for forest products, lumber imports from Canada are affected both by changes in Canadian timber harvest levels and U.S. harvest levels. In the scenario, U.S. lumber production rises while Canadian imports drop, and there are ripple effects in other regions. Producers in Canada and the U.S. South are the most cost-effective suppliers of softwood lumber, and when the design of a scenario reduces or alters softwood lumber consumption or production, the various adjustments are borne by producers in less cost-effective regions, mostly in the Western United States.

Finally, the climate change scenarios have higher domestic timber harvests than the base. However, because timber inventory changes are gradual as climate change alters stand growth, their impacts on private timber harvest, stumpage prices, and ultimately on product markets and prices are relatively small. Timber harvest increases are due to increased timber inventories as both softwood and hardwood growth on private timberlands expands steadily relative to the base. The directions of change are consistent with some earlier studies, including regional impacts that differ geographically, e.g., growth increases in Western regions, growth reduction in the SC region.

In general, results across the scenarios suggest that changes in supply and demand interact, both regionally and nationally, and associated adjustments will result in national impacts that are relatively small by 2050 compared to some regional or short-term impacts. This insensitivity results from a large timberland base, flexible capital flows, numerous possibilities for substitution in resource and product markets, technological changes, investments in timber growing and processing, and other adaptation options. The ability of the forest sector to continue to adapt to both market and resource changes depends on deliberate policy deliberations that attempt to anticipate emerging issues and to evaluate the effectiveness of various means to seek solutions.

Differences in scenario outcomes demonstrate the adaptability of the forest sector.

Chapter 5: Summary and Discussion

Findings in the eight¹ timber assessments from 1953 to 2000 trace a gradual evolution in the number and complexity of forestry issues in the United States. A persistent concern in all these studies, however, has been how to expand timber production and utilization from a contracting forest land base to meet growing and evolving public needs and expectations for a variety of forest goods and services. Past assessments provide evidence of a substantial expansion in the productive capability of America's forests. Since 1953, U.S. timberland area has fallen by about 1 percent while softwood inventories have risen by 14 percent and hardwood stocks have nearly doubled. Softwood growth rose by more than 75 percent and hardwood growth expanded by nearly two-thirds. At the same time, softwood harvest has increased by a third until recently and hardwood use has nearly doubled. The result is that in America's forests today, growth is 2½ times removals and the density of stocking (timber volume) per acre is 40 percent higher than it was 50 years ago. Of course there are regional and ownership variations in these trends, but in the aggregate the improvement in timber productivity potential has been dramatic.

In this last chapter, we summarize the main themes that emerge from the 2005 update and offer some observations about developments that may influence the future of American forest management.

Future Trends and Conditions

Expected Market Changes

The 2005 update base projection envisions continued strong growth in total U.S. forest products requirements (domestic consumption plus exports) to 2050. Although imports will rise, they will actually provide a smaller portion of the **growth** in total wood requirements between 2002 and 2050 (and domestic sources a correspondingly larger share) than was the case during the last five decades. Future harvests from domestic forests alone² are expected to grow each year by 0.13 billion cubic feet (bcf), slightly greater than the trend over the past 50 years of 0.12 bcf/year (fig. 8). At the same time, real product price growth will fall below long-term historical rates for nearly all products.

Over the 50 years from 1952 to 2002, U.S. consumption plus exports of all forest products (our total need for wood) rose by some 9.5 bcf. The U.S. timber harvest increased by 6.0 bcf, and imports rose by 3.5 bcf over this same period (fig. 8). Real prices of softwood lumber, hardwood lumber, and paper rose (compound rates of

The essential question is how to expand timber production from a contracting forest land base.

¹ Prior to the five RPA timber assessments there were assessments published in 1958, 1965, and 1974 (USDA FS 1958, 1965, 1974).

² **Excluding** agricultural short-rotation woody crops (SRWC).

0.8, 0.4, and 0.3 percent, respectively), while prices of softwood plywood, oriented strand board (OSB) (since 1976), and paperboard fell. In the 2005 update base projection, U.S. consumption plus exports increase over the 2002–2050 period by 8.0 bcf. Imports grow by 2.6 bcf, while harvest from both forests and SRWC plantations rises by 5.4 bcf.³ Prices of softwood lumber, hardwood lumber, and OSB rise slowly (0.2, 0.3, and 0.1 percent, respectively); in contrast, prices of softwood plywood, paper, and paperboard remain stable or fall.

Timberland Area and Forest Management Types

Between 1953 and 2002, U.S. timberland area declined by 5 million acres, or about 1 percent, to 503.5 million acres. The 2005 update base case projects a further decline of about 3 percent by 2050. The major cause of deforestation will be conversion to developed uses (e.g., residential and commercial building sites) with population growth as a major factor, rather than conversion to agriculture, which was the dominant competing use in earlier decades.

Several significant recent trends in private timberland ownership are expected to continue. The result will be a smaller private timberland base and a more numerous and diverse set of owners with smaller parcels closer to urban areas.

- Land held by the forest industry group (firms integrated to processing) will continue to decline through sales to institutional and other financial investors (timberland investment organization [TIMOs] and real estate investment trusts [REITs]). These groups manage for appreciation in the value of the forest land asset but do not operate timber processing facilities.
- The land base of nonindustrial ownerships is also projected to decline by more than 12 million acres or about 4 percent by 2050, continuing the trend of the past 50 years. At the same time, the number of nonindustrial landowners is expected to continue to grow and the average parcel size fall.
- Between 1997 and 2002, the forest area in major metropolitan regions increased by 5 percent. Future urban development will bring still more urban forests and more people living closer to the remaining forest lands.
- The area of planted pine in the South will continue to expand as U.S. timber production is concentrated on fewer acres. Even so, hardwood types will continue to dominate the forest land base in the South and throughout the Eastern United States.

³ Domestic forest harvest rises by 5.3 billion cubic feet and SRWC by 0.1 billion cubic feet.

Softwood Harvest

The U.S. softwood growing-stock removals rise slowly over the projection at about 0.7 percent per year (2002–2050), driven entirely by expansion of pulpwood consumption (for OSB and wood pulp). Sawtimber cut for lumber, plywood, and other solid wood products declines slightly for the first decade of the projection (to 2015) then recovers to near current levels by 2050 (fig. 24). The decline to 2015 reflects a modest reduction in U.S. softwood lumber production and a steady fall in plywood output. Housing starts are projected to move back to levels of the late 1990s, and the recent rapid growth in housing unit size will come to an end. This slowing in end-use activity is reflected in reduced softwood lumber consumption. At the same time, softwood lumber imports, both from Canada in response to the interior British Columbia (BC) mountain pine beetle (*Dendroctonus ponderosae*) epidemic and from off-shore sources, continue to out-compete domestic products. Thus, in the period to 2015, imports grow while U.S. output slowly declines. After 2015, driven by expansion in residential upkeep and alteration (and by a resurgence in new housing after 2030), growth in softwood lumber consumption and overall sawtimber harvest resumes. Softwood plywood consumption and output fall steadily through 2030, as substitution by OSB in all major markets continues.

In contrast, U.S. paper and paperboard output and OSB production continue to expand throughout the projection, driving up pulpwood consumption and total softwood nonsawtimber harvest (fig. 24). Between 2006 and 2050, total U.S. pulpwood consumption (at OSB and wood pulp mills) is projected to grow at an average annual rate of 0.8 percent, while roundwood pulpwood consumption (including export) is projected to grow annually at about 1.1 percent and wood residue pulpwood consumption declines by 0.7 percent per year. Over the projection period, wood use in OSB production expands at 1.2 percent per year and U.S. wood pulp production expands at 0.7 percent. Consumption of OSB rises steadily, both because it continues to capture market share from softwood plywood and because it accounts for essentially all of the future growth in structural panel consumption. The projected growth in U.S. wood pulp production is less than half the historical growth rate from 1970 to 1999 (1.5 percent).

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

In 2004, U.S. output of paper and paperboard increased by 4 percent, reflecting the general recovery in U.S. industrial production, but paper and paperboard production dropped by 1 percent in 2005. In the decades ahead, production and consumption are projected to gradually increase along with projected increases in U.S. population and overall economic growth. However, U.S. per-capita consumption of paper and paperboard is projected to remain essentially flat in the decades ahead (at around 700 pounds per capita) while consumption per unit of gross domestic product (GDP) is projected to decline (fig. 19). Thus, the current growth outlook for U.S. production and consumption of paper, paperboard, and wood pulp is much lower than historical growth rates of the late 20th century (fig. 20). Whereas U.S. paper and paperboard output increased at an average annual rate of 2.3 percent from 1970 to 1999, the projections from 2001 to 2050 represent an average annual rate of only 0.8 percent, with very modest projected expansion in production capacity (future capacity expansion is likely to be met entirely by incremental expansions or upgrades at existing mills rather than construction of new mills).

The U.S. wood pulp production is projected to increase at an average annual rate of just 0.7 percent (from 2001 to 2050), which is less than half the historical growth rate from 1970 to 1999 (1.5 percent, fig. 60). Projected growth in wood pulp output derives from modest projected growth in paper and paperboard output and limited projected growth in domestic recycled fiber use. Paper recovery for recycling is projected to continue increasing in the United States, and the recovery rate

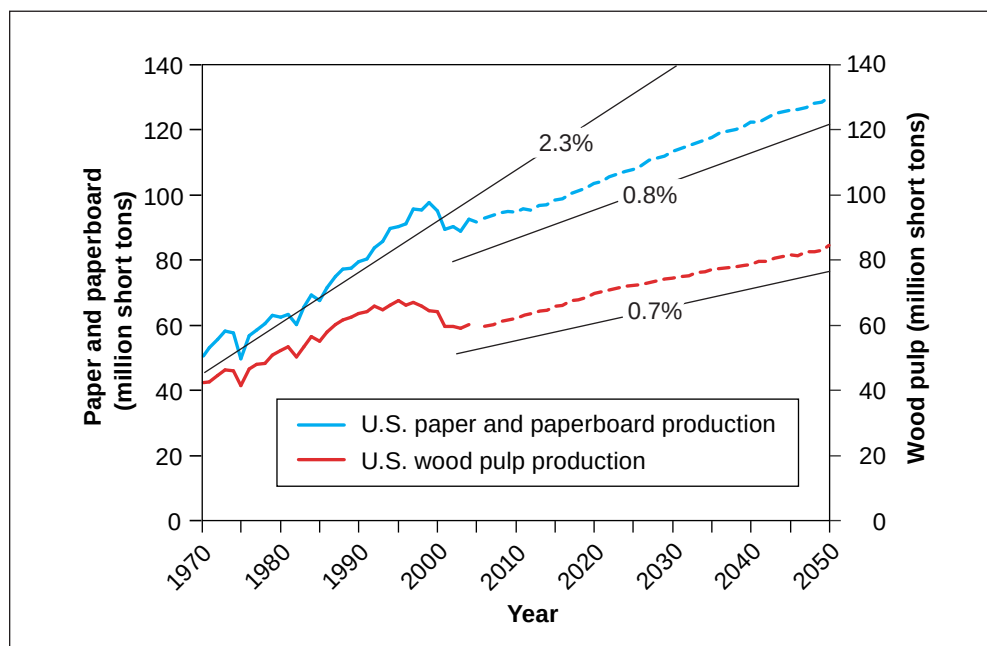


Figure 60—U.S. paper, paperboard, and pulp production projected to 2050. Paper and paperboard = paper + paperboard + building paper. Wood pulp includes estimated dissolving pulp production.

is projected to remain above 50 percent, but growth in exports (mainly to China) accounts for the largest share of projected expansion in paper recovery. United States municipalities are shifting toward single-stream recycling (commingled curbside collection) to reduce collection costs, resulting in higher downstream costs for recovered paper sorting and separation. This favors shipment of recovered paper to countries such as China, where labor for hand sorting is cheap and paper-recycling capacity is rapidly expanding. United States recovered paper exports doubled in the past decade, with China the leading export destination, and exports are projected to increase from 16 million tons in 2005 to 25 million tons by 2050.

This analysis also took into account projected shifts in product output by principal grade of paper, paperboard, and wood pulp, and their effects on pulpwood use, both hardwood and softwood. For example, U.S. newsprint production and consumption is projected to continue declining in the future, while kraft linerboard (for corrugated containers) is projected to continue increasing. Both newsprint and kraft linerboard are heavy consumers of softwood pulpwood, and thus the decline in softwood consumption in newsprint is offset by projected gains in linerboard. Printing and writing paper grades are heavy consumers of hardwood fiber, but little growth is projected in U.S. printing and writing paper output.

The net effect of projected trends in fiber use and production is a relatively stable distribution of hardwood and softwood in projected U.S. pulpwood consumption (pulpwood receipts at wood pulp mills), with a gradually increasing share for softwood and gradually declining share for hardwood (fig. 21). The projections contrast with trends of preceding decades when the hardwood share was increasing. Overall pulpwood receipts at pulp mills are projected to gradually increase (at 0.7 percent per year between 2006 and 2050), following the projected growth in wood pulp production, but the projected trend in hardwood pulpwood receipts is relatively flat, at just 0.4 percent per year (fig. 21). Projected growth in U.S. softwood pulpwood receipts, at 0.9 percent per year, is well below the 1960-2003 trend rate of 1.4 percent. However, softwood accounts for the largest share of projected gains in pulpwood receipts. The projected gains in U.S. softwood pulpwood receipts are supplied primarily by southern pine plantations.

Hardwood Harvest

Projected hardwood harvest on timberland rises steadily over the projection. On average, hardwood harvest is projected to increase at 0.7 percent per year from 2005 to 2050. As in the case of softwoods, the increase is due in large part to expansion of the pulpwood component of nonsawtimber harvest (fig. 24).

In contrast, hardwood harvests for sawtimber products are relatively stable over the projection (fig. 24). This pattern is dictated by end-use consumption trends in hardwood lumber, where declining use for pallets and furniture offset growth in use for millwork and miscellaneous products.

Private Inventories

For the United States as a whole, and for all regions and private owner groups, projected softwood inventory in 2050 is higher than estimated levels in 2000 (major regions are illustrated in fig. 61). Growth exceeds harvest in all cases despite rising removals over the projection. Aggregate U.S. private hardwood inventories also rise sharply by 2050, with continued expansion in the North offsetting modest reductions in the South.

One of the key determinants of long-term forest growth is private investment in silvicultural activities. For the South, the 2005 update base case projects continued shifts of private timberland in softwood types toward the more intensive forms of

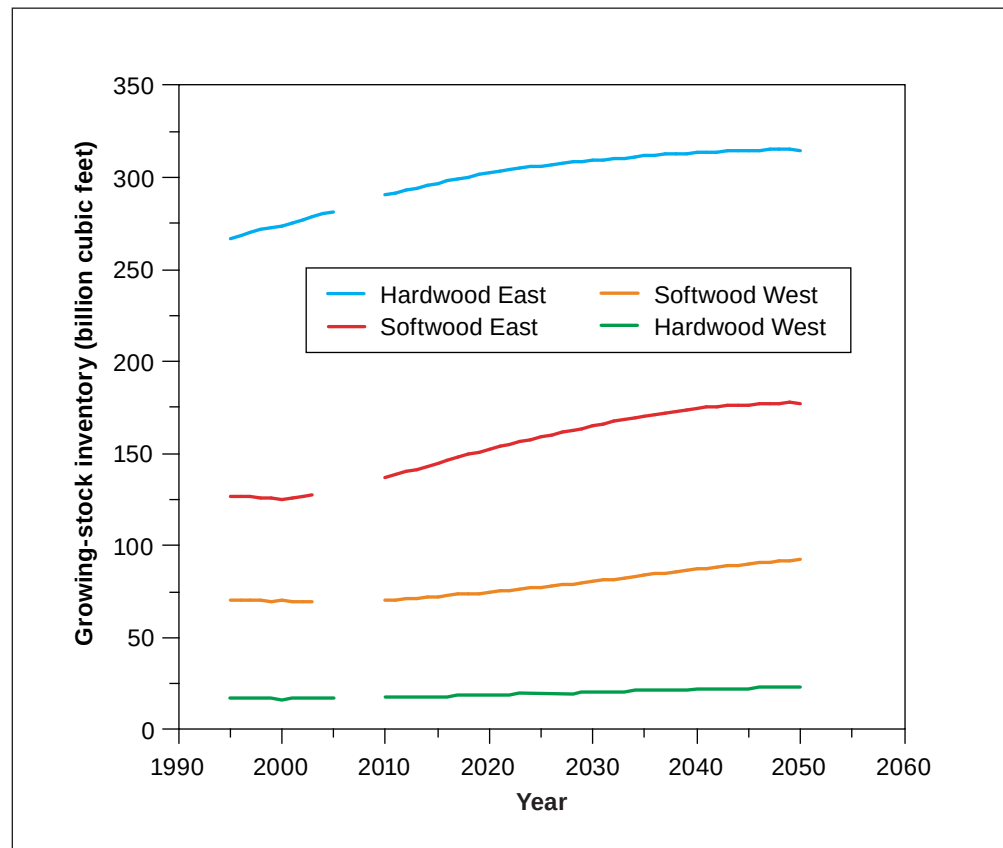


Figure 61—U.S. private growing-stock inventory by region and species group projected to 2050.

management for both industrial and nonindustrial ownerships.⁴ This is illustrated in figure 35 for the two largest groups of Southern softwood timberland, industrial planted pine and other private “other softwoods” (natural pine, and oak-pine). In the Pacific Northwest West (PNWW), industrial ownerships continue to shift lands toward more intensive silvicultural regimes until the 2010 decade (2010–2019), but by the end of the projection, the structure of management intensities has returned to the mix observed in the 1990s.

Prices

The 2005 update projects a very moderate future for growth in real forest products prices. Solid wood products prices are expected to rise, but at rates that are small in absolute terms (0.3 percent per year or less) and well below those of the past five decades (fig. 22). Prices for the large aggregates of paper and paperboard are expected to decline in real terms (fig. 23).

Limited product price growth derives from continued improvements in input use efficiency in domestic production, competition from substitute products, and continued pressure from lower cost imports across the whole array of product classes.

Slow product price growth is reflected in many categories of stumpage prices (figs. 31, 32, 33). Sawtimber stumpage prices in the South and Interior West decline slowly after 2010, while those in the PNWW and North rise at about 0.2 percent and 0.6 percent per year. Southern hardwood pulpwood prices rise steadily in the projection as hardwood inventories contract. Southern softwood pulpwood prices oscillate in response to the changing fiber mix, ending the projection near recent levels.

Main Results From the Projections

- **Growing consumption.** Total U.S. forest products consumption is projected to continue to rise, reaching 27.0 bcf annually by 2050, a 38-percent increase relative to 2002 levels (see tables 8 and 9). Both softwoods and hardwoods share in this growth. Per capita wood use, which has shown wide variation over the past 50 years, will trend slightly downward below the average level of the past five decades (see fig. 62). Solid wood products consumption per capita will continue to fall and pulp products use will rise.

The decisions of numerous private landowners have changed available forest resources.

⁴ Management intensity shifts occur at time of regeneration in the update model. They are based, in part, on the anticipated soil expectation values of the several investment options.

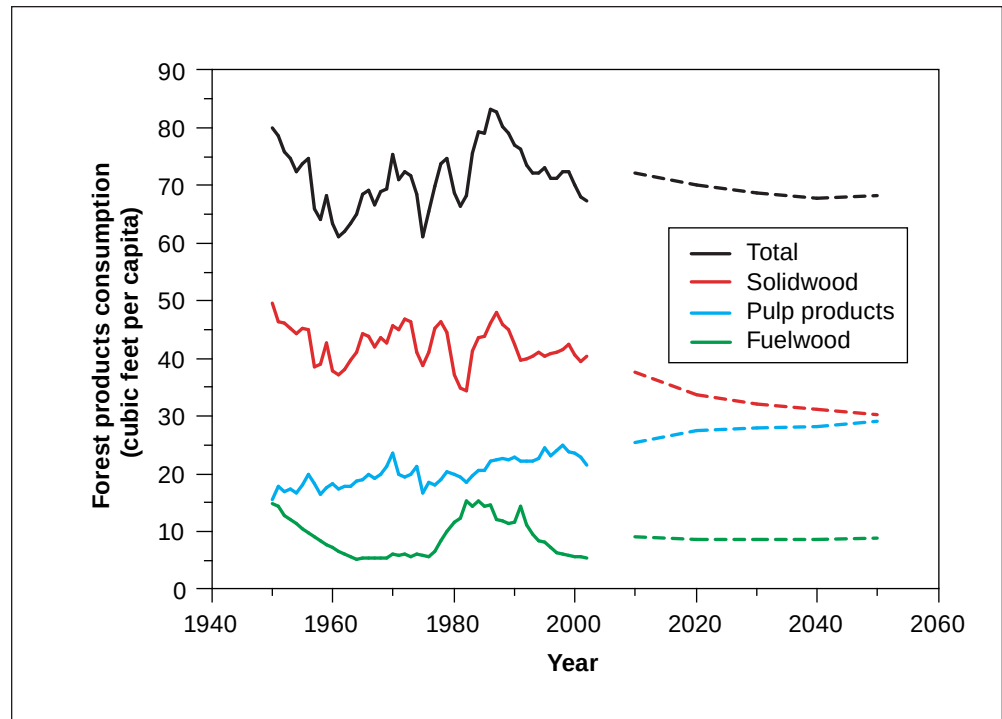


Figure 62—U.S. forest products consumption per capita by type of product (dashed lines are historical trend from regression), projected to 2050.

**The United States
is increasing its
dependency on
imports of forest
products.**

- Rising imports and import dependency.** The United States' relative import dependence⁵ nearly doubled between 1952 and 2002, rising from 12 to 23 percent, while the absolute level of imports more than tripled (fig. 8). Over the period to 2050, U.S. imports will continue to rise (by 53 percent 2002–2050) and at a somewhat faster rate than domestic wood supply. As a result, import dependence is projected to rise to about 27 percent in 2010, then decline slowly to just below 26 percent by 2050. Growth of imports' share results from continued expansion in off-shore (non-Canadian) imports of all product types and rapid near-term growth in Canadian softwood lumber imports arising from timber salvaged in the interior BC pine beetle epidemic. As a result, the United States will have reason for continued interest in the forest resource and forest industry policies of trading partners and all nations.

⁵ Import dependence is computed here as the ratio of imports to the sum of domestic consumption plus exports.

- **Slow changes in domestic resource conditions.** Large or dramatic changes in U.S. forest conditions are not expected over the next 50 years, even as harvest rises. Adjustments will continue in the extent of certain forest types (expanding in some regions and contracting in others), shifts in age-class structures (some continuous and some transitory), an accumulation of older stands on public lands in the West, and an array of other variations, but most are expected to be gradual and not large relative to historical experience over the past 50 years. This does not suggest that debates on issues of forest protection, stewardship, and the adequacy of forest-based environmental services are moot, only that these deliberations need not proceed in an atmosphere of impending crisis based on concerns for fiber scarcity or large-scale ecological change.
- **Growing role of South in wood supply.** The South is the largest single wood-supplying region in the United States, and its importance is expected to rise over the next 5 decades. The South's share of total U.S. harvest rose from 46 percent in the early 1950s to nearly 56 percent in 2002. The region's share is projected to rise to 61 percent of total harvest by 2050. The absolute levels of both softwood and hardwood harvest are projected to rise. The South's share of U.S. softwood harvest increases from 63 percent to 68 percent between 2002 and 2050, and its hardwood share rises from 51 percent to 52 percent.
- **Hardwood inventories decline in the South, rise in the North.** The base projection shows a markedly different picture of future hardwood inventory development in the North and South. Across all forest types in the South, hardwoods have the lowest rates of timber growth, the least intensive forms of management, and the greatest expected future reductions in the area available for timber production. Knowledge of intensive Southern hardwood culture is limited, and silvicultural activities in hardwood stands are complex owing to the diversity of species. To date, silvicultural research has emphasized softwood stand management. In addition, many of the Southern hardwood forests are in small parcels held by nonindustrial private owners with diverse objectives. Finally, the area of hardwood types is expected to decline 7 percent (15.4 million acres) over the projection through conversion to other types (predominantly softwoods), losses to urban and developed uses, and reservations for nontimber purposes. Reflecting these conditions, and continued growth in harvest, Southern hardwood inventories are expected to decline by about 6 percent between 2002 and 2050.

Northern hardwood forests are characterized by low growth rates compared to the hardwoods in the South, they are managed under similar limitations on silvicultural research, they have a roughly similar parcelization structure, and they contained nearly equivalent volumes of growing-stock inventory in 2002 (168 bcf in the North versus 160 bcf in the South). They face a lower rate of harvest, however, given the limited and historically declining nature of the forest industry in the Northern States. Further, despite a projected decline in the aggregate area of timberland in the North (5 percent over all owners between 2002 and 2050), the area of hardwood types is expected to increase (by 2 percent) as softwood types are allowed to revert to hardwoods on nonindustrial private forest (NIPF) ownerships. The result is a projected increase of nearly 50 percent in the Northern hardwood inventory by 2050.

- **Intensification of management on a portion of private timberlands.** The update base projection assumes a continuation of current policies on public timberlands. As a consequence, private lands supply virtually all future increases in harvest in the United States, and public lands make a relatively limited contribution. It is expected that a larger portion of private timberland will be shifted into more intensive management as a result. Even so, more than three-fourths of the private land base will remain in natural forest types with little or no active management. Our projection envisions the development of a mixed pattern of management on private lands. Some areas are projected to be used intensively for wood production, while most of the land base is used at a lower level of intensity for timber production or for provision of nonwood outputs and services.⁶

⁶This concentration of intensive management on a portion of the private land base has been advocated by some as a goal for domestic forest policy (see, for example, Binkley 1999, Sample 2001, and Victor and Ausubel 2000).

Observations

This section highlights some of the broader outcomes of the base and scenario projections that may have implications for forest management decisions and forest policy development in the 21st century.

The Importance of Rising Prices to Forest Management and Retention of Forest Cover

Many private, and a few public, timberland owners give some consideration to potential financial returns in determining how intensively they will manage their timber and the ages at which stands will be cut. Upward trends in prices over long periods effectively augment any reductions in costs of timber production and the financial rates of return from a timber investment (see fig. 63 for example). Rising timber prices make more intensive, and more expensive, forms of management

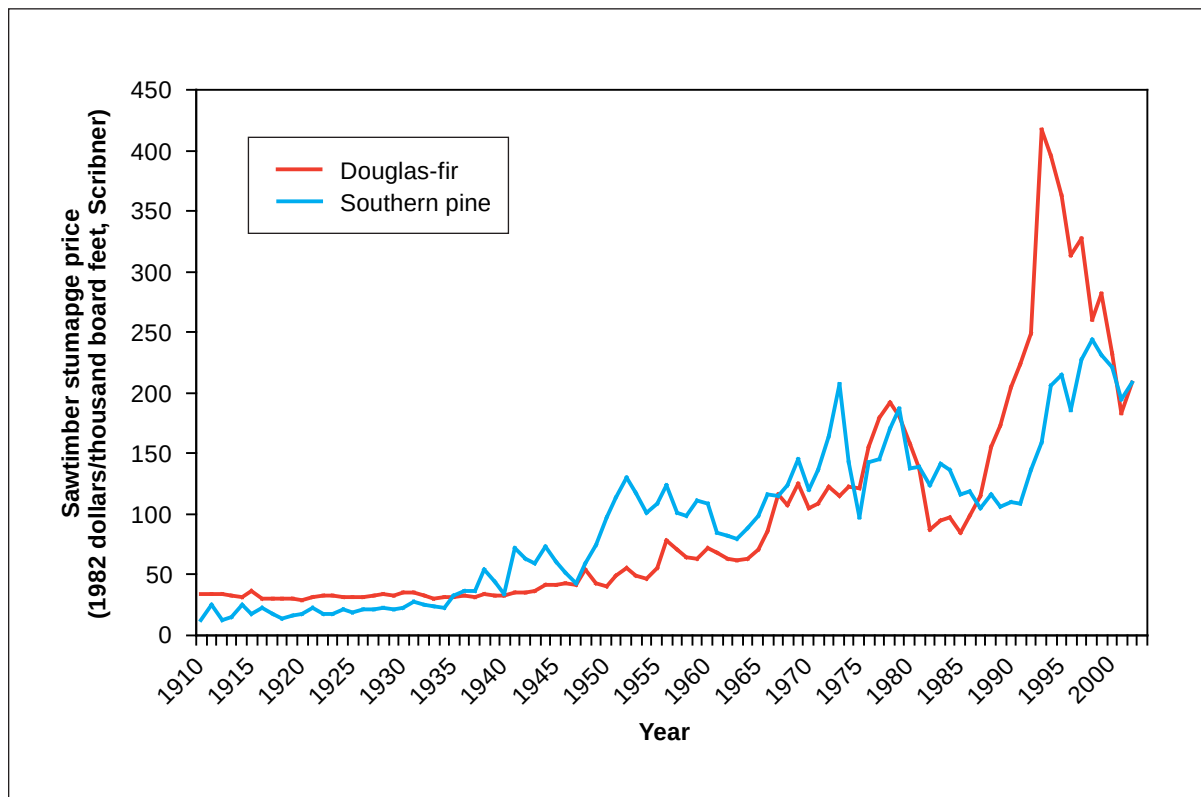


Figure 63—Stumpage prices for Douglas-fir and southern pine sawtimber.

Market incentives for forest management are declining.

look more attractive (net returns are higher).⁷ In older assessment reports (see, for example, Haynes 1990, Haynes et al. 1995, USDA FS 1982) timber prices were projected to rise over most of the projection period. In the 2000 assessment (Haynes 2003) and this 2005 update, however, product substitution, competition from imported sources of products, and rising domestic timber output potential in the South combine to largely eliminate timber price growth in the projections.

Many types of silvicultural investments in many regions promise reasonable rates of return without timber price growth.⁸ However, there is wide variation in acceptable rates of return and attitudes toward risk among private forest owners and potential forestry investors. As a consequence, the absence of prospective timber price inflation (and hence lower potential returns) may adversely influence the attractiveness of timber investments to some owners, reducing the intensity of management on private lands, and lowering long-term timber output potential. The methods used in the 2005 update to simulate owner decisions about the management intensity classes (MICs) adopted at regeneration include consideration of prospective rates of return (see app. 2). Thus, management intensity in the base and other projections are, in part, sensitive to future price trends. These methods are only approximations, however, and cannot include the full array of considerations influencing private investment decisions.

Intensification of forest management is sometimes viewed as the adoption of a complex regime of practices such as site preparation, planting, competition control, precommercial thinning, and so on. In practice, however, intensive management may involve nothing more than insuring prompt and adequate regeneration after harvest or adjusting the form of partial removals to favor more rapid growth of residual trees. The effect of more intensive management, whatever its specific form, is to raise rates of forest growth and expand inventories on the available timberland base. Other ecosystem services that are related to the rate of growth and extent of inventory (e.g., carbon dioxide uptake, certain types of wildlife habitat, or visual amenities) may be enhanced as well. Absent the inducement of rising prices, both the direct and indirect effects of intensification may be reduced in U.S. forests.

⁷ In this discussion, we are concerned with prices that rise over multiple rotations or cutting cycles. Prices of timber may also rise over the life a timber stand owing to quality improvements in the timber as it gets older and larger, but we do not consider these so-called quality-premium issues here. See McConnell et al. (1983) for an analysis of the rotation-age effects of continually changing prices in a general context. Continually rising prices do not necessarily lead to longer even-age rotations as is generally the case with quality-premium effects.

⁸ For an example in the U.S. South, see Siry et al. 2001.

Continually rising timber prices act to increase the value of land in forest uses, making forest use relatively more attractive for some lands than alternatives such as agriculture or development. A stable timber price outlook affects the balance between returns from alternative uses and, in the update projections, leads to higher rates of forest land loss than would be the case under rising prices (see Alig and Butler 2004, for discussion of the modeling methods). These land area shifts augment the long-term timber supply reductions resulting from less intensive management.

Urbanization and Rural Development Affecting America's Forests

Concerns about reduction in the area of U.S. forest lands are of long standing. Some of the earliest efforts in forest conservation were inspired by rapid loss of forests to agriculture and logging, the desire to protect timber and water resources, and the desire to preserve lands of extraordinary beauty and uniqueness. In earlier sections of this study, we saw that land base changes can affect the South's ability to continue its growing role in softwood timber supply and constitute one of the key reasons for the projected decline in southern hardwood timber inventory. Recent forest inventory and analysis (FIA) surveys (e.g., Brown 2004, Gray et al. 2005) and the USDA NRCS national resource inventory (2001) suggest that loss of timberland to urbanization is accelerating in key timber supply regions. For example, expansion of developed area and urban sprawl in the South has been described as a major issue for future natural resource management, especially for the region's forests (Seelye 2001, Wear and Greis 2002). The national net loss of timberland over the past five decades was about 1 percent on all ownerships and about 2 percent on private lands alone. The base projection anticipates nearly a 3-percent loss in the next 50 years from all ownerships and 3.7 percent from private holdings. Shifts to urban and other developed uses promise to be the largest causes of these reductions (Alig et al. 2004b).

Urbanization and developments in rural areas can result not only in direct conversion of forest land but can also involve fragmentation, parcelization, ownership changes, and land value changes.⁹ Development pressures can also add to uncertainty about how forest land will be managed and its ultimate environmental conditions if owners anticipate higher economic returns in an alternative use. Forest

⁹ Forest fragmentation is the creation of smaller forested blocks owing to conversion of forest to nonforest use. Forest parcelization is the creation of smaller forest ownership tracts owing to an increase in the number of owners, although the original amount of forest area may remain the same, in contrast to forest fragmentation. See Alig 2000, Alig and Plantinga 2004, Alig et al. 2005, Butler and Leatherberry 2004, and Butler et al. 2004 for further discussion of these issues.

landowners face increasing pressures (through existing and proposed public regulations) to produce multiple forest-based goods and services from their forest lands. This often occurs in circumstances where the economic incentives to shift land uses to urban and other developed uses are rising as well, with increased demand due to projected increases in population and personal incomes (Alig et al. 2004b). Forest land prices capture information regarding current as well as potential uses of land. As a result, they anticipate future development of forest land near urbanizing areas, casting what Wear and Newman (2004) call a “speculative shadow” over timberland values and owners’ decisions.

Increased housing development in America’s private forests also has implications for the condition and management of the forests and the watersheds in which they occur, including reduced fish and wildlife habitat, altered water flows and water quality, and increased area of forest-residential interface that affects forest fire suppression costs and risks (Stein et al. 2005, Stewart et al. 2003). Some 44 million acres or 11 percent of private forests—particularly in the East—are projected to undergo increased housing development over the next three decades. About half of this development would involve shifts from rural (16 or fewer housing units per square mile) or exurban (forests with 16 to 64 housing units per square mile) use to urban use by 2030, with the remainder being forest land experiencing a higher density of houses than at present (Stein et al. 2005). The number of forested acres per capita in the United States has been shrinking, and conditions of the remaining forested acres have been altered over time. A shared desire to protect open spaces and the associated goods and services (that many consider to be public goods) as populations increase and the remaining forest land is shared among more people has motivated an emerging alliance between forest owners and conservation advocates (Kline et al. 2004).¹⁰ With increased public demand for open space preservation, a frequently cited strategy is to increase the economic attractiveness of current land uses by compensating private landowners for their contributions to broad-scale conservation goals (e.g., Best 2002, Best and Wayburn 2001).

¹⁰ An example in 2001 was the New England Forestry Foundation purchasing a conservation easement on more than 760,000 acres of privately owned forest land in northern Maine. An example of a working forest conservation easement is the Pacific Forest Trust’s alliance with the Bascom Pacific’s Pondosa Tree Farm Project (near Mount Shasta, California) to conserve habitat for multiple fish species and protect wet meadows and aspen groves (Web site for the 2005 California Forest Futures conference at <http://nature.berkeley.edu>).

Substitution Regulates Impacts of Market and Resource Changes

The economic process of substitution, stimulated by changes in the relative prices of competing goods or of comparable goods from different suppliers, is a dominant characteristic of the markets for forest products. Consumers of forest products, such as homebuilders that use lumber or merchants that use paper-based packaging, can substitute nonwood products such as steel studs or plastic wrapping if wood-based products become relatively more costly. They can also shift to different types of wood-based products, for example, wooden I-joists rather than solid lumber, or purchase the same products from lower priced sellers in different regions or countries. The availability of many types of substitutable products and many sources of supply for any given forest product act to reduce the price impacts of supply shifts in forest products markets. In effect, the demand faced by any single supplier is made very sensitive to price as a result of having many competitors. A small increase in a single supplier's price will quickly send buyers to other sources, reducing output and costs. A small price reduction quickly attracts more buyers, pushing the single supplier's output toward capacity and raising costs. In both cases, the overall impact on market price is reduced.

The effects of supply-side substitution are reflected in the results of the scenario analyses in chapter 4. All the scenarios can be interpreted as some form of supply shift: restoration thinning on public lands in the Western United States increases that region's lumber output, reductions in pine plantation or NIPF timberland area in the South reduces that region's timber supply, and so on. The timing of the impacts differs from case to case, e.g., the restoration thinning effects are immediate, whereas the impacts of the Southern land area reductions take many decades, but they all lead to some form of supply change. The effects of substitution in moderating price impacts can be seen at several levels. For example, increased public harvest in the West under a restoration thinning program raises western softwood lumber output but reduces production in the South and lowers the volume of lumber imports. Thus, despite increases in output of interior West softwood lumber approaching 30 percent (2 billion board feet), national product prices fall by 3 to 5 percent and consumption rises by about 0.5 billion board feet (1.1 percent at the peak year). Fully 75 percent of the Western lumber increment is offset by substitution across regional suppliers (domestic and foreign).

Substitution (and the lack of it) also regulates adjustment to supply shifts within a region. For example, in the case of reduced timberland areas in NIPF ownership

in the South, stumpage prices rise. In the context of the timber assessment projection model, only forest industry lands provide an alternative price-sensitive timber source. The stumpage price shift is not large but would be far larger if there were no price responsive substitutes at all.

The State of Overall Forest Conditions

Society's concerns for environmental health and forest-land conditions have raised interest in understanding the overall state of forest conditions. A variety of issues motivate these concerns. In the international arena, debates about forest management often deal with different suggestions for how to supplement market-determined actions with processes that endeavor to find an equilibrium among interests advocating environmental protection, employment that contributes to economic prosperity, public access, and social justice (see Andersson et al. 2004 for a variety of perspectives on these issues). In the United States, there is a growing awareness of the threats that land use changes pose to the ability of forests to produce a broad array of ecosystem goods and services. Finally, there is the longstanding concern about the nature and extent of the tradeoff in forest conditions between timber harvests as an economic activity and environmental conditions.

Some of these concerns can be examined in the context of overall forest conditions by using a timberland integrity index such as the one discussed in chapter 3. This composite index provides a description of timberland conditions and can be used to illustrate how the relation between environmental and commodity outputs

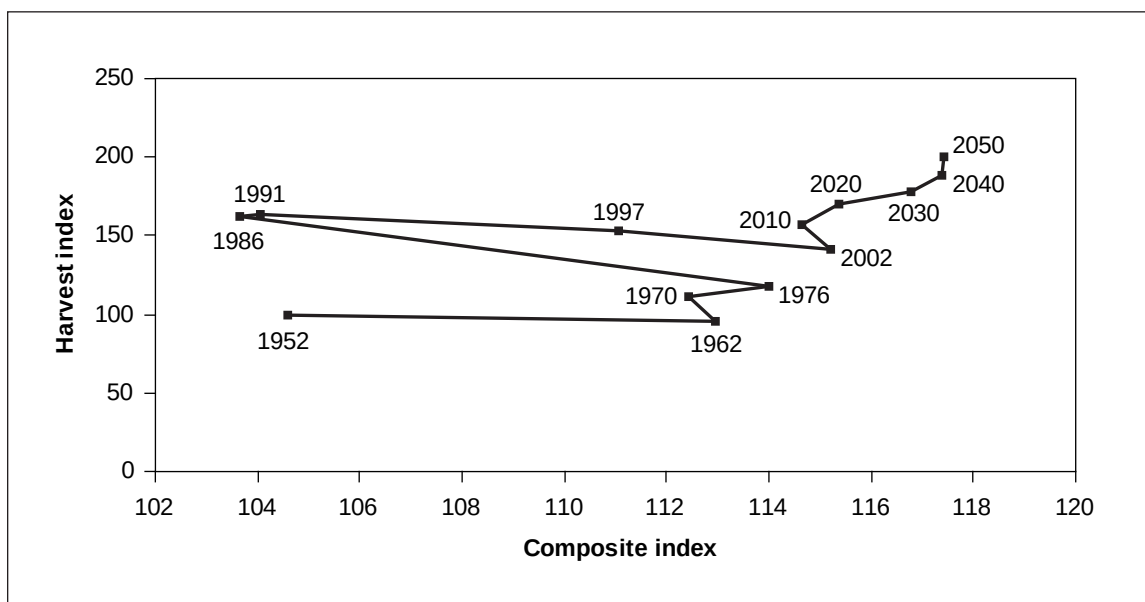


Figure 64—Composite index and total harvest index, 1952–2002 and projections to 2050.

of the forest changes over time. This latter use might provide a means for assessing the state of overall resource conditions or progress toward forest planning goals such as sustainable forest management.

The relation between the biophysical/environmental and commodity dimensions of forest production have framed much of the contemporary forest management debate (see Monserud et al. 2003 for discussion). Figure 64 shows the relationship between composite forest conditions (as described by the timberland integrity index) and timber harvests for roughly a 50-year historical period and the update projection to 2050. The direction and slope of changes over time suggest the extent and nature of tradeoffs or compatibility among these two broad-scale measures. For example, movements between consecutive years upward and to the left indicate that harvest increased at the expense of ecological conditions. This happened between 1962 and 1970, 1976 and 1986, and it is expected to happen through this decade. Movements to the right and downward suggest gains in the composite index while harvest levels have been stable or falling (such as between 1991 and 2002). Otherwise the movements have been mostly upward and to the right, where there has been an expansion in both timber harvest and timberland integrity, suggesting compatible changes between commodity output uses and ecological conditions.

The general upward (to the right) trend after 1986 has resulted in part from the use of forest management methods that enabled improvements in both timber harvest levels and timberland conditions. Figure 64 could be viewed as evidence that the United States is making progress toward the goals, embedded in sustainable forest management, of simultaneously improving economic prosperity and environmental conditions. But much of the rhetoric of the current debate about sustainability suggests that it is less about the physical notions of sustainability (given that the United States will sustain increases in timber inventories, gross forest conditions, and timber harvest levels) than about competing goals for public and private land management that involve other societal values (e.g., conservation of biodiversity) for forests [for examples of analyses informing these types of discussions see Heinz Center (2002) and USDA FS (2004)].

Although the United States has no formal mechanism for strategic forest policy discussions, a de facto policy has evolved from the decisions made for the management of public lands, state and local forest practice regulations, and the collective decisions of private timberland owners. For federal timberlands, this forest policy includes goals that assign forests to some type of reserved status or management in a passive fashion with limited timber harvest. For private timberlands, the result has been management of the majority of the forest area in a custodial fashion at a very

The U.S. forest conditions are expected to improve while harvest levels increase.

low intensity (but available for wood production) with only a small fraction managed more intensively. The trends in figure 64 suggest that this policy has allowed improvements in both timber harvest and forest conditions.

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Equivalents

When you know	Multiply by:	To find:
Inches	2.54	Centimeters
Feet	.305	Meters
Square feet	.09	Square meters
Cubic feet (hardwood) ^a	40	Pounds
Cubic feet (softwood) ^a	35	Pounds
Cubic feet ^b	.2	Board feet
Cubic feet	.028	Cubic meters
Acres	0.41	Hectares
Cubic feet per acre	.07	Cubic meters per hectare
Pounds	.454	Kilograms
Tons	.907	Metric tonnes
Degrees Fahrenheit (°F)	.556(F - 32)	Degrees Celsius
Dollars (1982)	1.602	Dollars (2005)

^a Timber weights are air dry.

^b For the purposes of this report, we use five board feet per cubic foot (log scale) for harvested timber but the actual value differs by region, depending on the type of log scale used and the physical characteristics of the timber (diameter, length, taper, defect).

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Glossary

The terms in this glossary were taken from several sources including the *Forest Ecosystem Management Assessment Team Report* (1993), *The Dictionary of Forestry* (Helms 1998), the *Forest Resources of the United States*, 1992 (Powell et al. 1993), and the *Forest Resources of the United States*, 1997 (Smith et al. 2001).

afforestation—The establishment of a forest or stand in an area where the preceding vegetation or land use was not forest.

age class—An interval into which the age range of trees is divided for classification or use. Ten-year intervals are used most commonly except in the South where 5-year intervals are used.

chain weighted—A form of adjusting gross domestic product (GDP) for inflation that accounts for both changes in quantities and prices from year to year. The GDP series not adjusted for inflation are referred to as being in unchained dollars.

chemical wood—Trees used as a source of various chemicals such as acetic acid, methanol, and wood alcohol. Usually, timber that is not of sufficient size and/or quality to make lumber or plywood.

cord—A traditional measure of wood volume defined as the amount of round wood that can be stacked in a 4- by 4- by 8-foot space, equivalent to roughly 75 to 80 cubic feet of solid wood volume inside the bark for pulpwood, or about 500 board feet, log scale.

cropland—Land used for the production of adapted crops for harvest, including row crops, small grain crops, hay crops, nursery crops, orchard crops, and other specialty crops. The land may be used continuously for these crops, or they may be grown in rotation with grasses and legumes.

cull tree—A live tree, 5.0-inches in diameter at breast height (d.b.h.) or larger, that is unmerchantable for sawlogs now or prospectively because of rot, roughness, or species. (See definitions for rotten and rough trees).

diameter class—A classification of trees based on diameter outside bark measured at breast height (4 1/2 feet above ground). The common abbreviation for “diameter at breast height” is d.b.h. For 2-inch diameter classes, the 6-inch class, for example, includes trees 5.0 through 6.9 inches d.b.h.

Douglas-fir subregion—The area in the states of Oregon and Washington that is west of the crest of the Cascade Range (also called Pacific Northwest West).

Doyle rule—A log rule or formula for estimating the board-foot volume of logs. The formula is:

$$V = [(D-4)^2/4]L$$

where D is diameter inside bark at the small end in inches and L is length in feet.

dry weight—The weight of wood and bark, oven-dry basis (excluding all moisture).

engineered wood products—Composite wood products designed to substitute directly for dimension lumber in many building and structural applications. Includes prefabricated wood I-joists, glued laminated timber, and structural composite lumber (laminated veneer lumber, parallel strand lumber, and oriented strand lumber).

prefabricated wood I-joists (wood I-joists)—Structural, load-carrying members designed for roof and floor joist applications, offering long lengths with low material weights. The I-joist flange is typically dimension lumber or structural composite lumber; the web material is oriented strand board.

glued laminated timber (glulam)—Engineered, stress-rated product created by adhesively bonding individual pieces of lumber having a thickness of 2 inches or less. It is versatile and can be shaped into forms ranging from straight to complex curved beams. Uses include headers, girders, purlins, beams, and arches.

structural composite lumber (SCL)—Composite products designed to be dimension lumber substitutes. Includes laminated veneer lumber, parallel strand lumber, and oriented strand lumber.

laminated veneer lumber (LVL)—A structural composite lumber product made by adhesively bonding thin sheets of wood veneer into a large billet. The grain of the veneers are all parallel in the “long” direction. The billet is then sawn to desired dimensions. Uses include headers, beams, rafters, scaffold planking, and flanges for prefabricated wood I-joists.

parallel strand lumber (PSL)—A structural composite lumber product made by adhesively bonding veneer that has been chopped into strands to take out knots and other imperfections. A billet is formed with the grain of the strands in the long direction and then sawn. Uses include beams and garage door headers.

oriented strand lumber (OSL)—A structural composite lumber product made from flaked wood strands that have a high length-to-thickness ratio. The strands are oriented with the grain in the long direction into a billet and then sawn to desired dimension. Uses include millwork parts, studs, and flanges for prefabricated wood I-joists.

farmer-owned lands—Lands owned by a person who operates a farm, either doing the work themselves or directly supervising the work.

fiber products—Products made with largely intact plant fibers (or wood fibers) derived primarily from pulpwood, pulpwood chips, and recovered paper, such as wood pulp, paper or paperboard products, and also (in this publication) products made primarily from pulpwood roundwood, such as oriented strand board, but not including other panel products made primarily from fine wood residues, sawdust, or bark.

fine materials—Wood residues not well suited for chipping or for use in fiber products because of small particle size and a large proportion of fibers that are cut or broken, such as planer shavings and sawdust (used in panel board products such as particleboard, but not in oriented strand board, and seldom used for pulpwood because of poor fiber quality).

forest industry (FI)—A diverse group of manufacturers that harvest, process, and use timber products in their final products. Activities include the harvesting of the timber resource; conversion of logs to primary timber products, such as lumber, plywood, and wood pulp; and the conversion of primary timber products to secondary or final products, such as pallets, furniture, and paper products.

forest land—Land at least 10 percent stocked by forest trees of any size, including land that formerly had such tree cover and that will be naturally or artificially regenerated. Forest land includes transition zones, such as areas between heavily forested and nonforested lands that are at least 10 percent stocked with forest trees, and forest areas adjacent to urban and built-up lands. Also included are pinyon-juniper and chaparral areas in the West, and afforested areas. The minimum area for classification of forest land is 1 acre. Roadside, streamside, and shelterbelt strips of timber must have a minimum crown width of 120 feet to qualify as forest land. Unimproved roads and trails, streams, and clearings in forest areas are classified as forest if less than 120 feet in width.

forest management type—A classification of timberland based on the species and source of trees forming a plurality of live trees present.

forest inventory types—A classification of forest land based on the species forming a plurality of the live-tree stocking. Major forest type groups recognized in the timber assessment include:

white-red-jack pine—Forests in which eastern white pine, red pine, or jack pine, singly or in combination compose a plurality of the stocking. Common associates include hemlock, aspen, birch, and maple.

spruce-fir—Forests in which spruce or true firs, singly or in combination compose a plurality of the stocking. Common associates include white cedar, tamarack, maple, birch, and hemlock.

natural pine—A Southern management type representing stands that (a) have not been artificially regenerated, (b) are classed as a pine or other softwood forest type, and in which 50 percent or more of the naturally established stand is loblolly pine, slash pine, shortleaf pine, longleaf pine, or other southern pines singly or in combination. Common associates include oak, hickory, and gum.

planted pine—A Southern management type representing forests in which 50 percent or more of the stand is loblolly pine, slash pine, shortleaf pine, longleaf pine, or other southern pines that have been established by planting or direct seeding.

lowland hardwood—A Southern management type composed of forests in which 50 percent or more of the stand is tupelo, blackgum, sweetgum, oak, and southern cypress, singly or in combination, and southern pine makes up less than 25 percent. Common associates include cottonwood, willow, oak, elm, hackberry, and maple. This type is found on the alluvial flood plains of the Mississippi and other southern rivers. May also be called bottomland hardwood.

oak-pine—A Southern management type composed of forests in which 50 percent or more of the stand is hardwood, usually upland oaks, and southern pines make up 25 to 49 percent of the stocking. Common associates include upland oak-shortleaf pine in the foothills and plateaus; mixed hardwood-loblolly pine on moist sites; and scrub oak-longleaf pine in the sand hills of the Carolinas, Georgia, and Florida. Other associates include gum, hickory, and yellow-poplar. May also be called mixed pine-hardwood.

oak-gum-cypress—Bottomland forests in which tupelo, blackgum, sweetgum, oaks, or southern cypress, singly or in combination compose a plurality of the stocking except where pines make up 25 to 50 percent, in which case the stand would be classified as oak-pine. Common associates include cottonwood, willow, ash, elm, hackberry, and maple.

elm-ash-cottonwood—Forests in which elm, ash, or cottonwood, singly or in combination compose a plurality of the stocking. Common associates include willow, sycamore, beech, and maple.

maple-beech-birch—Forests in which maple, beech, or yellow birch, singly or in combination compose a plurality of the stocking. Common associates include hemlock, elm, basswood, and white pine.

aspen-birch—Forests in which aspen, balsam poplar, paper birch, or gray birch, singly or in combination compose a plurality of the stocking. Common associates include maple and balsam fir.

Douglas-fir—Forests in which Douglas-fir composes a plurality of the stocking. Common associates include western hemlock, western redcedar, the true firs, redwood, ponderosa pine, and larch.

hemlock-Sitka spruce—Forests in which western hemlock, Sitka spruce, or both compose a plurality of the stocking. Common associates include Douglas-fir, silver fir, and western redcedar.

redwood—Forests in which redwood composes a plurality of the stocking. Common associates include Douglas-fir, grand fir, and tanoak.

ponderosa pine—Forests in which ponderosa pine composes a plurality of the stocking. Common associates include Jeffrey pine, sugar pine, limber pine, Arizona pine, Apache pine, Chihuahua pine, Douglas-fir, incense cedar, and white fir.

western white pine—Forests in which western white pine composes a plurality of the stocking. Common associates include western redcedar, larch, white fir, Douglas-fir, lodgepole pine, and Engelmann spruce.

lodgepole pine—Forests in which lodgepole pine composes a plurality of the stocking. Common associates include alpine fir, western white pine, Engelmann spruce, aspen, and larch.

larch—Forests in which western larch composes a plurality of the stocking. Common associates include Douglas-fir, grand fir, western redcedar, and western white pine.

fir-spruce—Forests in which true firs, Engelmann spruce, or Colorado blue spruce, singly or in combination compose a plurality of the stocking. Common associates include mountain hemlock and lodgepole pine.

western hardwoods—Forests in which aspen, red alder, or other western hardwoods, singly or in combination compose a plurality of the stocking.

pinyon-juniper—Forests in which pinyon pine and juniper singly or in combination compose a plurality of the stocking.

upland hardwoods—A Southern management type composed of stands that have at least 10 percent stocking and classed as an oak-hickory or maple-beech-birch forest type. Common associates include yellow-poplar, elm, maple, and black walnut.

fuelwood—Wood used by conversion to some form of energy, primarily residential use.

green ton—Weight measure for pulpwood roundwood or pulpwood chips that are freshly cut and have not had enough time to age or lose free moisture, generally assumed to be the weight of wood at 50-percent moisture content on a total weight basis (2.0 green tons = 1 bone dry ton).

growing stock—A classification of timber inventory that includes live trees of commercial species meeting specified standards of quality or vigor. Cull trees are excluded. When associated with volume, includes only trees 5.0 inches d.b.h. and larger.

hardwood—A dicotyledonous (nonconiferous) tree, usually broad leaved and deciduous.

harvest—(a) An intermediate or final cutting that extracts salable trees. (b) The volume of roundwood harvested from both growing-stock and non-growing-stock sources that is extracted from harvest sites.

highly erodible cropland—All cropland in land capability classes (classifications used by the Soil Conservation Service to rate the suitability of soils for agricultural production) 3e, 4e, 6e, and 7e.

industrial wood—All commercial roundwood products except fuelwood.

international 1/4-inch rule—A log rule, or formula, for estimating the board-foot volume of logs. The mathematical formula is:

$$V = (0.22D^2 - 0.17D)(0.904762),$$

for 4-foot sections, where D = diameter inside bark at the small end of the section.

land area—(a) Bureau of the Census: the area of dry land and land temporarily or partly covered by water, such as marshes, swamps, and river flood plains; streams, sloughs, estuaries, and canals less than 1/8 statute mile wide; and lakes, reservoirs, and ponds less than 40 acres in area. (b) Forest Inventory and Analysis: same as (a) except that the minimum width of streams, etc., is 120 feet, and the minimum size of lakes, etc., is 1 acre. This latter definition is the one used in this publication.

live cull—A classification that includes live, cull trees. When associated with volume, it is the net volume in live, cull trees that are 5.0 inches d.b.h. and larger.

log scale—The volume contents of individual trees or logs prior to processing. In the United States the most common rules for measuring board-foot volumes for sawtimber are the Scribner log rule, international 1/4-inch log rule, and the Doyle log scale.

logging residues—The unused portions of growing-stock trees cut or killed by logging and left in the woods.

managed plantations—Stands of trees established by artificial means (e.g., planting or direct seeding) composed primarily of single or related species, treated to have uniform structure and age class, and projected to receive at least minimal treatment for growth enhancement.

management intensities—Growth and yield categories developed for the aggregate timberland assessment system (ATLAS) to represent the development of stands under various improved management practices (i.e., genetic improvement, stocking control, fertilization, commercial thins, etc.).

marginal cropland and pasture—Cropland and pasture that would yield higher rates of return to the owner if planted to pine.

market pulp—Mostly bleached kraft or sulfite pulp produced for sale to pulp customers.

net annual growth—The average annual net increase in the volume of trees during the period between inventories. Components include the increment in net volume of trees at the beginning of the specific year surviving to its end, plus the net volume of trees reaching the minimum size class during the year, minus the volume of trees that died during the year, and minus the net volume of trees that became cull trees during the year.

net volume in cubic feet—The gross volume in cubic feet less deductions for rot, roughness, and poor form. Volume is computed for the central stem from a 1-foot tall stump to a minimum 4.0-inch top diameter outside bark, or to the point where the central stem breaks into limbs.

nonforest land—Land that has never supported forests and lands formerly forested where use of timber management is precluded by development for other uses. (Note: Includes area used for crops, improved pasture, residential areas, city parks, improved roads of any width and adjoining clearings, powerline clearings of any width, and 1- to 40-acre areas of water classified by the Bureau of the Census as land. If intermingled in forest areas, unimproved roads and nonforest strips must be more than 120 feet wide, and clearings, etc., more than 1 acre in size, to qualify as nonforest land).

non-growing-stock—A classification of inventory that includes all trees not meeting the standards for growing stock.

nonindustrial private forest (NIPF)—An ownership class of private forest lands whose owner does not primarily operate wood-using plants (distinguished from land owned by forest industry).

nonsawtimber—Timber that is not used by sawmills or veneer mills, but is used in the manufacture of pulp, paper, oriented strand board (OSB), various nonstructural panels, or used for fuelwood.

nonstocked areas—Timberland less than 10 percent stocked with growing-stock trees.

oriented strand board (OSB)—An engineered structural-use panel made from wood strands that are cut longitudinally from small-diameter logs or pulpwood roundwood. The strands have a high length-to-thickness ratio and are bonded together with waterproof resin under heat and pressure. The strands are oriented along the length or width of the panel in alternating layers to take advantage of the inherent longitudinal fiber strength of wood. The panels are used in construction for roof, wall, and floor sheathing and for the web for prefabricated wood I-joists.

other forest land—Forest land other than timberland and productive reserved forest land. It includes reserved forest land, and available land that is incapable of producing annually 20 cubic feet per acre of industrial wood under natural conditions because of adverse site conditions such as sterile soils, dry climate, poor drainage, high elevation, steepness, or rockiness. Urban forest land is also included that, owing to its location, is considered unavailable for sustained timber harvesting.

other industrial timber products—Also called a miscellaneous products category of roundwood products that includes such items as poles; piling; posts; round mine timbers; hewn ties; bolts used for shingles; handles, and woodturnings; cooperage logs; chemical wood; and miscellaneous items.

other land—Nonforest land less the area in streams, sloughs, estuaries, and canals between 120 and 660 feet and lakes, reservoirs, and ponds between 1 and 40 acres in area (i.e., nonforest land less non-census water area).

other removals—Unutilized wood volume from cut or otherwise killed growing stock, from cultural operations such as precommercial thinnings, or from timberland clearing. Does not include volume removed from inventory through reclassification of timberland to productive reserved timberland.

other sources—Sources of roundwood products that are non-growing-stock. These include salvable dead trees, rough and rotten trees, trees of noncommercial species, trees less than 5.0 inches d.b.h., tops, and roundwood harvested from nonforest land (e.g., fence rows).

other white oaks—A group of species in the oak genus that includes overcup, chestnut, and post.

overrun—The difference between the greater volume actually sawn over the lessor estimated log scale volume.

ownership—Categories of property owners: a combination of persons; a legal entity such as a corporation, partnership, club, or trust; or a public agency. All parcels of land in the United States are assigned to one of the categories of ownership.

plantation—See managed plantation.

plant byproducts—Wood material (such as slabs, edgings, trimmings, miscuts, sawdust shavings, veneer cores and clippings, and pulp screenings) from primary manufacturing plants used for pulp, particleboard, fuelwood, and other products.

poletimber—Live trees at least 5.0 inches in diameter, but smaller than sawtimber trees (9.0 inches or greater).

ponderosa pine subregion—The area in the states of Oregon and Washington that is east of the crest of the Cascade Range, (also called Pacific Northwest East).

primary wood-using mill—A mill that converts roundwood products into other wood products. Common examples are sawmills that convert sawlogs into lumber and pulp mills that convert pulpwood roundwood into wood pulp.

private ownerships:

forest industry (FI)—An ownership class of private lands owned by companies that grow timber for industrial use and own wood processing facilities.

nonindustrial private forest (NIPF)—An ownership class of private lands where the owner does not operate wood-use plants. This includes lands owned by operators of farms, lands owned by private individuals, and lands owned by private corporations.

Native American—(a) Lands held in trust by the United States or states for Native American tribes or individual Native Americans. (b) Lands owned in fee by Native American tribes whether subject to federal or state restrictions against alienation or not. Since 1990, these lands are grouped with other private lands in the NIPF ownership group.

productivity class—A classification of forest land in terms of potential annual cubic-foot volume growth per acre at culmination of mean annual increment in fully stocked natural stands.

public ownerships:

federal—An ownership class of public lands owned by the U.S. Government.

national forest—An ownership class of federal lands, designated by Executive order or statute as national forests or purchase units, and other lands under the administration of the Forest Service including experimental areas and Bankhead-Jones Title III lands.

Bureau of Land Management (BLM)—An ownership class of federal lands administered by the Bureau of Land Management, U.S. Department of the Interior.

county and municipal—An ownership class of public lands owned by counties or local public agencies, or lands leased by these governmental units for more than 50 years.

other public—An ownership class that includes all public lands except national forest. This category generally includes federal, state, county, and municipal ownerships.

state—An ownership classification of public lands owned by states or lands leased by states for more than 50 years.

pulpwood—Roundwood, wood chips, or wood residues that are the wood raw materials used for the production of wood pulp or (in this publication) the roundwood inputs for reconstituted panels (such as oriented strand board). In this publication, pulpwood does not include wood residues used for reconstituted panels.

reconstituted panels—The entire family of wood panel products that are reconstituted from small wood particles, fibers, or strands, including oriented strand board, insulating board, hardboard, particleboard, and medium density fiberboard (MDF), but excluding plywood

recovered paper—Paper that is recovered after commercial or consumer use for recycling back into products, primarily into recycled paper or paperboard products.

reserved timberland—Forest land withdrawn from timber use through statute, administrative regulation, or designation without regard to protective status.

residues—Bark and woody materials that are generated in primary wood-using mills when roundwood products are converted to other products. Examples are slabs, edgings, trimmings, miscuts, sawdust, shavings, veneer cores and clippings, and pulp screenings. Includes bark residues and wood residues (both coarse and fine materials) but excludes logging residues.

removals—The net volume of growing-stock trees removed from the inventory by harvesting; cultural operations, such as timber stand improvement or land clearing; or changes in land use.

rotten tree—A live tree of commercial species that does not contain a sawlog now or prospectively, primarily because of rot (i.e., when rot accounts for more than 50 percent of the total cull volume).

rough tree—(a) A live tree of commercial species that does not contain a sawlog now or prospectively, primarily because of roughness (i.e., a sound tree that is culled because of such factors as poor form, splits, or cracks affecting more than 50 percent of its total cull volume); or (b) a live tree of noncommercial species.

roundwood—Logs, bolts, or other round sections cut from growing-stock and non-growing-stock sources such as trees smaller than 5.0 inches d.b.h.; stumps, tops, and limbs of growing-stock trees; rough and rotten trees; dead trees; and trees that grow on land other than timberland.

roundwood equivalent—The volume of logs or other round products required to produce given quantities of lumber, plywood, wood pulp, paper, or other similar products, after deducting the proportion of wood raw material input that is obtained not from logs or roundwood but from plant byproducts or recycled wood fiber (from recovered paper).

salvable dead tree—A standing or down dead tree that is considered currently or potentially merchantable by regional standards.

sawlog—A log meeting minimum standards of diameter, length, and defect, including logs at least 8 feet long, sound and straight, and with a minimum diameter inside bark of 6 inches for softwoods and 8 inches for hardwoods, or meeting other combinations of size and defect specified by regional standards. A log usually used in the manufacture of lumber and plywood.

sawtimber—Stands at least 10 percent occupied with growing-stock trees, with half or more of total stocking in sawtimber or poletimber trees, and with sawtimber stocking at least equal to poletimber stocking.

sawtimber trees—Live trees containing at least one 12-foot saw log or two noncontiguous 8-foot logs, and meeting regional specifications for freedom from defect. Softwood trees must be at least 9.0 inches d.b.h., and hardwood trees must be at least 11.0 inches d.b.h.

seral stage—A stage or recognizable condition of a plant community that occurs during its development from bare ground to climax. Forests are assumed to progress through five recognized stages: seedling; poles and saplings; young; mature; and old mature. These stages are represented by grouping age classes. The age-class groupings differ by broad regions reflecting successional differences among various timber types.

seedling stage—The stand establishment stage. Includes the first age class (average age of 5 years) in all regions for both hardwood and softwood types, except for softwood types in the North where it includes the first two (5 and 15) age classes. Grass, herbs, or brush are plentiful.

poles and sapling stage—Young stands. Crown closure occurs early in this stage; as stand density increases, grass, herbs, or brush rapidly decrease. Usually considered not to be merchantable, although both precommercial and commercial thinning can occur depending on market conditions.

	Age classes	
	Hardwood	Softwood
North	15 to 35	25 to 35
South	10 to 20	10 to 15
West	15 to 35	15 to 35

young stage—Young stands where the crown differentiation is starting to occur. These stands contain a mix of sawtimber and nonsawtimber size trees and little understory vegetation. For many private landowners, these stands are often considered to reflect typical rotation lengths.

	Age classes	
	Hardwood	Softwood
North	45 to 65	45 to 65
South	25 to 55	20 to 35
West	45 to 55	45 to 75

mature stage—Stands composed mostly of sawtimber. For softwoods, often thought to be at or just over the age where net annual growth has peaked. For hardwoods, these stands are often considered merchantable. In some types there is gradually increasing stand diversity, hiding cover, and forage.

	Age classes	
	Hardwood	Softwood
North	75 to 135	75 to 135
South	60 to 75	40 to 75
West	65 to 135	85 to 135

old mature—Stands considered to be overmature. Stand ages are past the point where net annual growth has peaked. For some types, stands represent the potential plant community capable of existing on a site given the frequency of natural disturbance events.

	Age classes	
	Hardwood	Softwood
North	≥\$145	≥\$145
South	≥\$80	≥\$80
West	≥\$145	≥\$145

Scribner rule—A diagram log rule that assumes 1-inch boards, is based on diameter at the small end of the log, disregards taper, and does not provide for overrun.

site productivity class—A classification of forest lands in terms of inherent capacity to grow crops of industrial wood. The class identifies the average potential growth in cubic feet per acre per year and is based on the culmination of mean annual increment of fully stocked natural stands.

high sites—Land capable of growing at least 85 cubic feet of wood per acre per year.

medium sites—Land capable of growing 50 to 85 cubic feet of wood per acre per year.

low sites—Land capable of growing 20 to 49 cubic feet of wood per acre per year.

softwood—A coniferous tree, usually evergreen, having needles or scalelike leaves.

southern pine—This is not a forest type but a common name for stands that are composed of loblolly, slash, shortleaf, longleaf pine, or other pines grown in the South; also called southern yellow pine.

sound dead—The net volume in salable dead trees.

stocking—The degree of occupancy of land by trees, measured by basal area or number of trees by size and spacing, or both, compared to a stocking standard; i.e., the basal area or number of trees, or both, required to fully use the growth potential of the land.

stumpage—Standing timber (trees) in the forest.

stumpage price—The price paid for standing timber (trees) in the forest. Usually expressed as dollars per thousand board feet, log scale.

succession—A series of dynamic changes by which one community succeeds another through stages leading to potential natural community or climax. The sequence of communities is called a sere, or seral stage.

timber supplies—The volumes of roundwood actually harvested, range of volume available for harvest at varying price levels, or future volumes estimated to be harvested at market equilibrium. Includes roundwood from growing-stock and non-growing-stock sources.

timberland—Forest land that is producing or is capable of producing crops of industrial wood and not withdrawn from timber use by statute or administrative regulation. Areas qualifying as timberland have the capability of producing in excess of 20 cubic feet per acre per year of industrial wood in natural stands. Currently inaccessible and inoperable areas are included.

tops—The wood of a tree above the merchantable height (or above the point on the stem 4.0-inches diameter outside bark [dob]). It includes the usable material in the uppermost stem and branches.

unreserved forest land—Forest land (timberland and woodland) that is not withdrawn from use by statute or administrative regulation. Includes forest lands that are not capable of producing in excess of 20 cubic feet per year of industrial wood in natural stands.

urban and other areas—Areas within the legal boundaries of cities and towns; suburban areas developed for residential, industrial, or recreational purposes; school yards; cemeteries; roads and railroads; airports; beaches, power lines, and other rights-of-way; or other nonforest land not included in any other specified land use class.

veneer logs—The logs used in the manufacture of veneer. A roundwood product from which veneer is sliced or sawn and that usually meets certain standards of minimum diameter and length and maximum defect.

wood pulp—A fibrous raw material made from plant fiber (chiefly wood fiber in the United States) and used primarily to make paper and paperboard products.

Species List

Common name	Scientific name
Alpine fir (subalpine fir)	<i>Abies lasiocarpa</i> (Hook.) Nutt.
Apache pine	<i>Pinus engelmannii</i> Carr.
Arizona pine	<i>Pinus ponderosa</i> var. <i>arizonica</i> (Engelm.) Shaw
Ash	<i>Fraxinus</i> spp.
Aspen	<i>Populus</i> spp.
Balsam fir	<i>Abies balsamea</i> (L.) Mill.
Balsam poplar	<i>Populus balsamifera</i> L.
Basswood	<i>Tilia</i> spp.
Beech	<i>Fagus</i> spp.
Birch	<i>Betula</i> spp.
Blackgum (Black tupelo)	<i>Nyssa sylvatica</i> Marsh. var. <i>sylvatica</i>
Black walnut	<i>Juglans nigra</i> L.
Chestnut oak	<i>Quercus prinus</i> L.
Chihuahua pine	<i>Pinus</i> (associates with Apache pine)
Colorado blue spruce	<i>Picea pungens</i> Engelm.
Cottonwood	<i>Populus</i> spp.
Cypress	<i>Taxodium</i> spp.
Douglas-fir	<i>Pseudotsuga menziesii</i> (Mirb.) Franco
Eastern white pine	<i>Pinus strobus</i> L.
Elm	<i>Ulmus</i> spp.
Engelmann spruce	<i>Picea engelmannii</i> Parry ex Engelm.
Eucalyptus	<i>Eucalyptus</i> spp.
Grand fir	<i>Abies grandis</i> (Dougl. ex D. Don) Lindl.
Gray birch (yellow birch)	<i>Betula alleghaniensis</i> Britton
Gum	<i>Liquidambar</i> spp.
Hackberry	<i>Celtis occidentalis</i> L.
Hemlock	<i>Tsuga</i> spp.
Hickory	<i>Carya</i> spp.
Incense-cedar	<i>Libocedrus decurrens</i> Torr.
Jack pine	<i>Pinus banksiana</i> Lamb.
Jeffrey pine	<i>Pinus jeffreyi</i> Grev. & Balf.
Juniper	<i>Juniperus</i> spp.
Larch	<i>Larix</i> spp.
Limber pine	<i>Pinus flexilis</i> James
Loblolly pine	<i>Pinus taeda</i> L.
Lodgepole pine	<i>Pinus contorta</i> Dougl. ex Loud.
Longleaf pine	<i>Pinus palustris</i> Mill.
Maple	<i>Acer</i> spp.
Mountain hemlock	<i>Tsuga mertensiana</i> (Bong.) Carr.
Oak	<i>Quercus</i> spp.
Overcup oak	<i>Quercus lyrata</i> Walt.
Paper birch	<i>Betula papyrifera</i> Marsh.
Pinyon	<i>Pinus edulis</i> Engelm.
Ponderosa pine	<i>Pinus ponderosa</i> Dougl. ex Laws
Post oak	<i>Quercus stellata</i> Wangenh.
Red alder	<i>Alnus rubra</i> Bong.
Red pine	<i>Pinus resinosa</i> Ait.
Redwood	<i>Sequoia sempervirens</i> (D. Don) Endl.

Common name	Scientific name
Scrub oak	<i>Quercus berberidifolia</i> Liebm.
Shortleaf pine	<i>Pinus echinata</i> Mill.
Silver fir (Pacific silver fir)	<i>Abies amabilis</i> Dougl. ex Forbes
Sitka spruce	<i>Picea sitchensis</i> (Bong.) Carr.
Slash pine	<i>Pinus elliottii</i> Engelm.
Sugar pine	<i>Pinus lambertiana</i> Dougl.
Sweetgum	<i>Liquidambar styraciflua</i> L.
Sycamore	<i>Platanus occidentalis</i> L.
Tamarack	<i>Larix laricina</i> (Du Roi) K. Koch
Tanoak	<i>Lithocarpus densiflorus</i> (Hook. & Arn.) Rehd.
True firs	<i>Abies</i> spp.
Tupelo	<i>Nyssa</i> spp.
Western hemlock	<i>Tsuga heterophylla</i> (Raf.) Sarg.
Western redcedar	<i>Thuja plicata</i> Donn ex D. Don
Western white pine	<i>Pinus monticola</i> Dougl. ex D. Don
White-cedar	<i>Chamaecyparis thyoides</i> (L.) B.S.P.
White fir	<i>Abies concolor</i> (Gord. & Glend.) Lindl. ex Hildebr.
White pine	See western white pine
Willow	<i>Salix</i> spp.
Yellow-poplar	<i>Liriodendron tulipifera</i> L.

Source: Burns and Honkala 1990a, 1990b.

Appendix 1: Background Tables

Table 20—Softwood removals, harvest, growth, and inventory for the national forest timberlands, 1952–2002, with projections to 2050

Region and item	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Million cubic feet</i>												
Northeast:												
Removals	3	3	3	3	6	5	1	3	4	4	4	4
Harvest	3	3	3	2	6	6	4	4	6	6	6	6
Net annual growth	13	15	16	18	19	14	15	14	12	11	10	9
Inventory	459	532	637	636	678	782	838	953	1,041	1,112	1,174	1,226
North Central:												
Removals	22	30	28	34	26	25	14	18	24	24	24	24
Harvest	24	28	34	32	29	28	19	20	26	26	26	26
Net annual growth	57	73	75	98	118	94	94	64	67	64	61	59
Inventory	1,336	1,988	2,170	2,542	3,270	3,578	3,499	3,958	4,400	4,808	5,191	5,548
Southeast:												
Removals	15	28	35	67	74	47	10	19	27	27	27	27
Harvest	14	27	33	61	59	45	15	18	26	26	26	26
Net annual growth	80	90	129	137	94	57	79	110	73	62	60	56
Inventory	2,074	2,243	2,705	2,946	2,848	2,991	2,971	3,968	4,701	5,098	5,440	5,757
South Central:												
Removals	145	94	156	181	174	139	37	63	76	76	76	76
Harvest	141	90	147	174	163	132	35	46	72	72	72	72
Net annual growth	211	336	314	245	231	192	205	192	144	117	116	117
Inventory	3,123	4,874	4,952	5,670	6,466	6,396	6,498	6,660	7,718	8,283	8,675	9,087
Rocky Mountains: ^a												
Removals	229	412	524	463	468	130	79	104	133	133	133	133
Harvest	218	387	480	426	465	186	102	116	148	148	148	148
Net annual growth	689	776	905	1,044	1,296	1,274	1,160	893	832	746	675	618
Inventory	58,013	62,979	63,825	65,081	70,832	84,993	90,815	98,791	106,262	112,778	118,511	123,621
Pacific Southwest: ^b												
Removals	117	263	378	306	334	96	42	75	104	104	104	104
Harvest	89	216	346	286	347	117	64	79	108	108	108	108
Net annual growth	162	186	338	364	422	616	658	431	406	384	363	343
Inventory	29,590	29,391	28,694	28,073	27,213	29,539	28,723	32,427	35,568	38,477	41,171	43,659
Pacific Northwest West: ^c												
Removals	364	567	530	525	538	66	24	22	38	40	40	40
Harvest	361	586	489	511	659	73	19	22	39	41	41	41
Net annual growth	180	197	240	227	320	778	768	801	754	694	640	597
Inventory	47,584	47,704	45,478	44,088	33,607	51,399	50,718	58,711	66,139	73,014	79,216	85,002
Pacific Northwest East: ^c												
Removals	121	256	314	313	387	72	29	51	71	73	73	73
Harvest	100	232	286	292	378	83	45	52	74	76	76	76
Net annual growth	261	310	329	312	269	320	317	294	280	258	240	225
Inventory	23,408	25,757	25,911	23,649	17,331	23,915	24,222	26,692	28,891	30,837	32,582	34,173

Table 20—Softwood removals, harvest, growth, and inventory for the national forest timberlands, 1952–2002, with projections to 2050 (continued)

Region and item	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Million cubic feet</i>												
Alaska:												
Removals	13	75	114	95	54	51	14	29	29	29	29	29
Harvest	11	66	100	83	47	43	12	20	20	20	20	20
Net annual growth	10	16	20	23	15	85	53	53	53	53	53	53
Inventory	38,850	38,228	37,555	35,414	24,068	18,733	19,757	19,290	19,847	20,404	20,961	21,518
United States:												
Removals	1,028	1,728	2,082	1,986	2,061	630	250	384	506	510	510	510
Harvest	961	1,635	1,918	1,867	2,153	712	315	377	519	523	523	523
Net annual growth	1,664	1,999	2,367	2,468	2,783	3,431	3,349	2,852	2,621	2,389	2,218	2,077
Inventory	204,437	213,696	211,927	208,099	186,313	222,326	228,041	251,450	274,567	294,847	312,921	329,591

^a Rocky Mountains region historical data include the Great Plains States. For projections, western South Dakota is in Rocky Mountains; eastern South Dakota and other Great Plains States are in the North Central region.

^b Pacific Southwest excludes Hawaii.

^c Pacific Northwest West (western Oregon and western Washington) is also called the Douglas-fir subregion, and Pacific Northwest East (eastern Oregon and eastern Washington) is also called the ponderosa pine subregion.

Source: For historical data, Powell et al. 1993; 1997 removals, growth, inventory data Smith et al. 2001; 2002 removals, growth, inventory from Smith et al. 2004; harvest data from Haynes 2003; 2002 harvest estimated from the assessment projections; projections from Mills and Zhou 2003.

Table 21—Hardwood removals, harvest, growth, and inventory for the national forest timberlands, 1952–2002, with projections to 2050

Region and item	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Million cubic feet</i>												
Northeast:												
Removals	10	11	19	29	13	16	7	5	6	6	6	6
Harvest	9	9	15	21	26	19	10	8	9	9	9	9
Net annual growth	69	88	105	117	131	68	68	75	67	59	53	47
Inventory	1,983	2,580	3,007	3,749	4,074	3,696	3,959	4,700	5,356	5,917	6,416	6,848
North Central:												
Removals	28	35	47	49	53	64	49	39	43	44	45	46
Harvest	32	34	40	43	76	68	52	53	57	59	60	61
Net annual growth	112	141	140	159	154	139	145	118	121	116	112	109
Inventory	2,482	3,491	3,994	4,483	5,470	6,281	6,249	6,991	7,796	8,538	9,223	9,875
Southeast:												
Removals	12	18	26	21	14	51	14	9	11	11	11	10
Harvest	9	11	17	15	14	47	10	8	10	10	10	10
Net annual growth	73	86	122	141	139	105	108	87	79	71	56	42
Inventory	2,784	3,335	3,511	4,679	5,503	5,773	5,776	6,415	7,172	7,842	8,414	8,831
South Central:												
Removals	61	52	36	26	34	56	17	11	13	13	13	13
Harvest	41	29	32	18	35	52	12	11	12	12	12	12
Net annual growth	67	111	122	144	135	144	155	127	115	98	82	67
Inventory	1,785	2,793	3,947	3,576	4,502	5,249	5,699	6,251	7,419	8,390	9,201	9,855
West: ^a												
Removals	6	11	19	5	45	11	4	7	8	9	10	10
Harvest	9	14	19	4	16	32	25	23	27	28	29	30
Net annual growth	74	82	85	97	58	218	160	161	158	146	137	134
Inventory	4,522	5,008	5,262	5,080	5,558	8,790	10,173	11,568	13,123	14,554	15,853	17,111
United States:												
Removals	117	126	146	130	160	198	91	70	81	83	85	85
Harvest	100	97	123	101	166	217	109	103	115	118	120	122
Net annual growth	396	508	573	658	617	674	637	568	540	490	440	399
Inventory	13,556	17,207	19,721	21,567	25,107	29,789	31,856	35,925	40,866	45,241	49,107	52,520

^a West excludes Hawaii and Alaska. The 1997 increase in inventory data is due to changes in inventory procedures in the Rocky Mountains.

Source: For historical data, Powell et al. 1993; 1997 removals, growth, inventory data Smith et al. 2001; 2002 removals, growth, inventory from Smith et al. 2004; harvest data from Haynes 2003; 2002 harvest estimated from the assessment projections; projections from Mills and Zhou 2003.

Table 22—Softwood removals, harvest, growth, and inventory for other public timberlands, 1952–2002, with projections to 2050

Region and item	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Million cubic feet</i>												
Northeast:												
Removals	7	6	9	14	16	13	14	12	12	11	10	10
Harvest	7	5	7	13	18	20	18	17	18	17	16	16
Net annual growth	27	32	37	49	54	61	63	47	50	49	47	45
Inventory	885	1,044	1,275	1,555	2,496	2,797	3,111	3,414	3,798	4,185	4,564	4,923
North Central:												
Removals	35	39	43	48	33	71	59	59	57	57	56	56
Harvest	33	35	38	41	43	74	65	64	61	61	61	61
Net annual growth	92	120	126	142	168	141	141	164	165	164	161	158
Inventory	2,162	2,943	3,237	3,728	4,840	5,272	5,275	6,320	7,415	8,488	9,560	10,586
Southeast:												
Removals	52	45	71	80	120	114	112	101	108	115	123	128
Harvest	51	43	69	88	100	109	95	97	104	110	117	122
Net annual growth	70	84	126	149	148	145	155	174	124	127	137	138
Inventory	1,584	2,089	2,278	2,770	3,639	4,452	4,577	5,677	6,154	6,217	6,291	6,385
South Central:												
Removals	43	32	38	51	74	61	63	60	67	70	75	78
Harvest	30	30	32	51	64	57	55	58	63	67	72	74
Net annual growth	56	58	78	71	55	66	81	92	81	78	80	83
Inventory	780	824	1,225	1,340	1,458	1,951	2,179	2,210	2,431	2,517	2,550	2,579
Rocky Mountains: ^a												
Removals	79	86	86	93	76	49	51	92	112	125	139	145
Harvest	72	78	78	85	79	54	90	97	118	131	144	150
Net annual growth	119	141	162	162	220	168	169	211	190	174	164	157
Inventory	9,923	10,147	10,399	10,429	11,094	8,427	8,503	9,777	10,661	11,208	11,503	11,646
Pacific Southwest: ^b												
Removals	5	18	27	24	15	23	23	9	11	11	11	11
Harvest	3	16	26	22	12	24	9	9	11	12	12	11
Net annual growth	14	14	14	14	25	29	29	20	22	21	21	20
Inventory	1,892	1,435	1,150	1,108	1,245	1,320	1,320	1,412	1,517	1,622	1,719	1,811
Pacific Northwest West: ^c												
Removals	155	274	359	439	419	159	159	210	222	222	221	221
Harvest	158	290	343	428	418	163	213	215	226	226	226	226
Net annual growth	193	316	356	371	495	491	459	545	556	550	551	542
Inventory	20,085	19,787	19,610	19,161	19,576	19,243	19,243	22,495	25,835	29,172	32,505	35,766
Pacific Northwest East: ^c												
Removals	52	64	103	96	102	67	67	49	48	44	40	37
Harvest	48	61	97	89	77	73	52	51	50	46	41	38
Net annual growth	66	88	91	96	139	67	27	42	42	42	42	43
Inventory	7,792	6,536	6,483	6,748	7,027	2,537	2,539	2,458	2,401	2,371	2,392	2,449
Alaska:												
Removals	1	4	14	6	3	5	5	5	5	5	5	5
Harvest	1	4	12	5	3	3	4	4	4	4	4	4
Net annual growth	93	108	123	137	67	40	54	54	54	54	54	54
Inventory	10,081	10,915	11,864	12,200	5,880	5,090	5,090	5,637	6,129	6,621	7,112	7,604

Table 22—Softwood removals, harvest, growth, and inventory for other public timberlands, 1952–2002, with projections to 2050 (continued)

Region and item	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Million cubic feet</i>												
United States:												
Removals	429	568	750	851	858	562	553	597	642	660	680	691
Harvest	403	562	702	822	814	577	600	612	655	674	693	702
Net annual growth	730	961	1,113	1,191	1,371	1,208	1,178	1,349	1,284	1,259	1,257	1,240
Inventory	55,184	55,720	57,521	59,039	57,255	51,089	51,837	59,400	66,341	72,401	78,196	83,749

Note: Data for 1952–1986 contain Indian lands; in 1991 Indian lands were transferred to nonindustrial private forest.

Note: Historical harvest data are estimates of harvest trends and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data show the average volume that would be harvested given the assumptions of the study. Inventory data for 1952 and 1962 are as of December 31. Inventory data for 1970 and the projection years are as of January 1. Inventory data shown under 1976, 1986, 1997, and 2002 are as of January 1 of following year. 1997 data updated since 2000 report.

^a Rocky Mountains region historical data (excluding harvest) includes the Great Plains States. For projections, western South Dakota is in the Rocky Mountains region; eastern South Dakota and other Great Plains States are in North Central region.

^b Pacific Southwest excludes Hawaii.

^c Pacific Northwest West (western Oregon and western Washington) is also called the Douglas-fir subregion, and Pacific Northwest East (eastern Oregon and eastern Washington) is also called the ponderosa pine subregion.

Source: For historical data, Powell et al. 1993; 1997 removals, growth, inventory data Smith et al. 2001; 2002 removals, growth, inventory from Smith et al. 2004; harvest data from Haynes 2003; 2002 harvest estimated from the assessment projections; projections from Zhou et al. (in press).

Table 23—Hardwood removals, harvest, growth, and inventory for other public timberlands, 1952–2002, with projections to 2050

Region and item	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Million cubic feet</i>												
Northeast:												
Removals	24	30	37	30	28	45	51	50	54	54	55	55
Harvest	23	26	28	23	23	92	76	78	83	82	81	81
Net annual growth	142	182	210	238	265	151	194	138	150	154	151	150
Inventory	3,803	4,838	5,697	6,478	9,110	10,158	11,018	11,838	12,747	13,761	14,735	15,693
North Central:												
Removals	44	55	77	87	74	231	189	172	180	181	180	179
Harvest	45	51	70	72	81	249	229	232	240	240	240	240
Net annual growth	213	270	278	304	341	237	305	369	375	369	370	371
Inventory	4,583	6,619	7,649	8,343	10,112	11,430	11,538	13,561	15,546	17,446	19,326	21,255
Southeast:												
Removals	15	16	29	34	36	39	54	52	58	67	76	81
Harvest	12	10	20	31	62	34	46	48	53	61	70	76
Net annual growth	27	32	55	71	86	100	106	75	76	77	78	78
Inventory	845	1,155	1,547	1,992	3,006	4,062	4,262	4,418	4,595	4,680	4,695	4,664
South Central:												
Removals	50	40	35	52	62	53	51	54	67	79	92	101
Harvest	33	36	36	53	66	49	47	57	63	73	85	95
Net annual growth	55	71	90	109	101	181	146	165	161	153	141	133
Inventory	1,365	1,750	2,106	2,401	3,307	4,956	5,728	6,095	7,110	7,909	8,499	8,859

Table 23—Hardwood removals, harvest, growth, and inventory for other public timberlands, 1952–2002, with projections to 2050 (continued)

Region and item	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Million cubic feet</i>												
Rocky Mountains: ^a												
Removals	2	4	3	2	2	2	1	3	3	3	3	3
Harvest	2	2	1	1	1	4	7	8	9	8	7	7
Net annual growth	8	9	10	11	27	45	18	13	15	15	15	14
Inventory	566	624	670	682	974	823	827	746	866	985	1,099	1,222
Pacific Southwest: ^b												
Removals	1	2	2	2	1	1	1	1	1	1	1	1
Harvest	1	1	1	2	1	1	1	11	11	11	10	10
Net annual growth	6	5	7	7	16	5	5	4	5	5	4	4
Inventory	218	190	263	283	554	319	319	332	384	433	478	512
Pacific Northwest												
Removals	5	3	13	15	15	13	33	27	29	31	32	34
Harvest	6	4	10	13	36	14	42	43	46	47	49	50
Net annual growth	34	58	92	93	88	74	64	77	82	85	84	82
Inventory	1,135	1,584	2,089	2,322	2,442	2,846	2,846	3,331	3,828	4,377	4,894	5,389
Alaska:												
Removals	—	—	3	3	5	1	1	1	1	1	1	1
Harvest	—	—	4	4	6	2	1	2	2	2	2	2
Net annual growth	7	7	7	7	55	49	72	72	72	72	72	72
Inventory	3,902	3,861	3,873	3,864	1,751	1,930	2,260	2,696	3,400	4,105	4,810	5,514
United States:												
Removals	141	150	199	225	223	386	381	361	394	418	441	456
Harvest	122	130	170	199	276	445	451	479	507	524	544	561
Net annual growth	492	634	749	840	978	841	910	913	936	930	915	904
Inventory	16,417	20,621	23,894	26,365	31,256	36,524	38,798	43,017	48,476	53,696	58,536	63,108

Note: Data for 1952–86 contain Indian lands; in 1991 Indian lands were transferred to nonindustrial private forest.

Note: Historical harvest data are estimates of harvest trends and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data show the average volume that would be harvested given the assumptions of the study. Inventory data for 1952 and 1962 are as of December 31. Inventory data for 1970 and the projection years are as of January 1. Inventory data shown under 1976, 1986, 1997, and 2002 are as of January 1 of following year.

— = less than 0.5 million cubic feet.

^a Rocky Mountains region historical data (excluding harvest) includes the Great Plains States. For projections, western South Dakota is in the Rocky Mountains; eastern South Dakota and other Great Plains States are in the North Central region. The 1997 increase in growth data is due to changes in inventory procedures.

^b Pacific Southwest excludes Hawaii.

Source: For historical data, Powell et al. 1993; 1997 removals, growth, inventory data Smith et al. 2001; 2002 removals, growth, inventory from Smith et al. 2004; harvest data from Haynes 2003; 2002 harvest estimated from the assessment projections; projections from Zhou et al. (in press).

Table 24—Population and lumber consumption in the United States, per capita and by end use, 1962–2002, with projections to 2050

Year	Population	Per capita use	End use						Total use
			New housing	Residential upkeep and improvements	New nonresidential construction	Manufacturing	Packaging and shipping	All other	
	<i>Millions</i>	<i>Board feet</i>	<i>Billion board feet</i>						
1962 ^a	186.5	209	14.1	4.3	4.2	4.5	4.5	7.3	39.1
1970	205.1	199	14.0	5.0	4.7	4.7	5.7	6.7	40.7
1976	218.0	202	18.3	6.3	4.5	4.9	5.9	4.3	44.1
1986	240.7	238	20.8	15.4	5.3	6.1	5.9	3.8	54.7
1996	265.5	231	19.8	15.3	4.9	7.9	6.4	7.0	61.3
1998	270.3	238	22.2	14.1	5.4	8.4	7.2	7.1	64.4
2002	287.5	235	23.3	17.3	4.5	8.0	7.1	7.6	67.7
2010	298.0	236	20.2	20.4	6.0	7.8	7.3	8.7	70.4
2020	323.0	217	18.6	21.4	6.2	7.9	7.3	8.7	70.1
2030	347.2	210	18.4	22.6	6.6	8.1	7.4	9.6	72.8
2040	370.3	211	20.3	24.3	7.0	8.2	7.5	10.7	78.0
2050	394.2	213	22.4	26.1	7.3	8.5	7.6	12.0	83.9

Note: Data may not add to totals because of rounding.

^a Historical data 1962–86 updated to reflect revisions in new housing and residential repair and alterations.

Source: Historical data McKeever 2002.

Table 25—Lumber consumption, imports, exports, and production in the United States, 1962–2002, with projections to 2050

Year	Consumption			Imports			Exports			Production		
	Softwood lumber	Hardwood lumber	Total	Softwood lumber ^a	Hardwood lumber	Total	Softwood lumber ^a	Hardwood lumber	Total	Softwood lumber	Hardwood lumber	Total
	<i>Billion board feet</i>											
1962 ^b	30.8	8.3	39.1	4.6	0.3	4.9	0.6	0.1	0.8	26.8	8.1	34.9
1970	32.2	8.5	40.7	5.8	.3	6.1	1.1	.1	1.2	27.5	8.3	35.9
1976	36.0	8.0	44.1	8.0	.3	8.2	1.6	.2	1.8	29.7	8.0	37.7
1986	47.1	10.2	57.4	13.8	.3	14.0	1.9	.5	2.4	35.3	10.5	45.7
1996	49.5	11.8	61.3	18.0	.4	18.4	1.8	1.1	2.9	33.3	12.5	45.8
1998	52.0	12.2	64.2	18.5	.5	19.0	1.1	1.1	2.2	34.7	12.7	47.4
2002	56.0	11.1	67.7	21.0	.7	21.7	.8	1.2	2.0	35.8	11.5	47.4
2010	59.0	11.4	70.4	26.3	.7	27.0	1.0	1.5	2.5	33.7	12.2	45.9
2020	58.5	11.6	70.1	24.2	.7	24.9	1.1	1.5	2.6	35.4	12.4	47.8
2030	60.9	11.9	72.8	25.0	.7	25.7	1.3	1.5	2.8	37.2	12.7	49.8
2040	65.8	12.2	78.0	26.8	.7	27.5	1.4	1.5	2.9	40.4	13.0	53.4
2050	71.4	12.5	83.9	28.9	.7	29.6	1.5	1.5	3.0	44.0	13.3	57.3

Note: Data may not add to totals because of rounding.

^a Includes small volumes of mixed species not classified as softwood or hardwood.

^b Historical data 1962–86 updated to reflect revisions in new housing and residential repair and alterations.

Source: Historical data McKeever 2002.

Table 26—Lumber production in the contiguous United States, by softwoods and hardwoods and region, 1952–2002, with projections to 2050

Species group and region	Historical							Projections				
	1952	1962	1970	1976	1986	1996	2002	2010	2020	2030	2040	2050
<i>Billion board feet, lumber tally</i>												
Softwoods:												
Northeast	1.3	0.8	0.6	0.8	1.4	1.4	1.5	1.4	1.3	1.3	1.4	1.4
North Central ^a	.4	.3	.3	.4	.3	.5	.8	.6	.7	.7	.7	.7
Southeast	5.2	2.7	2.9	3.4	5.3	6.7	7.3	5.9	6.4	6.5	6.7	7.0
South Central	3.6	3.2	4.3	4.6	6.2	8.7	9.4	8.8	9.6	10.7	11.9	13.1
Rocky Mountains—	2.5	3.6	4.3	4.5	4.6	3.6	3.4	3.2	3.3	3.4	3.7	3.8
Northern Rockies	1.6	2.8	3.0	3.1	3.4	3.1	3.0	2.7	2.7	2.8	3.0	3.1
Southern Rockies	.9	1.0	1.2	1.2	1.3	.5	.4	.4	.5	.6	.7	.8
Pacific Northwest ^b —												
West ^c	10.3	8.6	7.6	8.5	9.3	7.4	9.2	10.7	11.0	11.2	12.4	14.0
East ^c	2.3	2.4	2.4	2.7	2.8	1.5	1.6	1.4	1.6	1.9	2.2	2.5
Pacific Southwest ^d	4.6	5.0	5.2	4.8	5.2	3.4	2.6	1.8	1.6	1.5	1.4	1.4
Total U.S. softwoods	30.2	26.8	27.5	29.7	35.3	33.3	35.8	33.7	35.4	37.2	40.4	44.0
Hardwoods:												
Northeast	.9	1.3	1.6	1.9	2.3	3.1	3.0	3.3	3.4	3.6	3.8	4.0
North Central ^a	2.4	1.5	1.7	2.6	3.2	3.1	2.6	2.9	3.0	3.1	3.1	3.2
Southeast	1.6	1.9	2.0	1.4	2.0	2.2	2.1	2.2	2.3	2.3	2.4	2.4
South Central	2.3	3.3	2.9	1.8	2.7	3.5	3.3	3.3	3.1	3.1	3.1	3.1
West	0	.1	.1	.2	.2	.5	.5	.5	.5	.5	.4	.5
Total U.S. hardwoods	7.2	8.1	8.3	8.0	10.5	12.5	11.5	12.2	12.4	12.6	13.0	13.3

Note: Data may not add to totals because of rounding.

^a Includes Great Plains.

^b Excludes Alaska.

^c Pacific Northwest West (western Oregon and western Washington) is also called the Douglas-fir subregion, and Pacific Northwest East (eastern Oregon and eastern Washington) is also called the ponderosa pine subregion.

^d Excludes Hawaii.

Source: Historical data for softwoods WHPA (annual issues), AF&PA (annual issues); USDC (annual issues); for hardwoods USDC (annual issues), Luppold and Dempsey 1989.

Table 27—Population and structural panel consumption in the United States, per capita and by end use, 1962–2002, with projections to 2050

Year	Population	Per capita use	Panel type		End use						Total
			Softwood plywood	OSB/ wafer-board	New housing	Residential upkeep and improvements	New nonresidential construction	Manu- facturing	Packaging and shipping	All other	
Millions		Square feet	----- Billion square feet (3/8-inch basis) -----								
1962	186.5	51	9.5	—	3.9	1.7	1.7	0.7	0.2	1.3	9.5
1970	205.1	69	14.3	—	5.9	2.3	1.9	.9	.3	3.0	14.3
1976	218.0	82	17.7	—	8.7	3.2	1.9	1.1	.3	2.6	17.8
1986	240.7	107	21.6	4.2	11.8	7.0	3.1	1.8	.4	1.7	25.7
1996	265.5	119	18.0	13.6	17.0	7.5	2.5	3.2	.5	.8	31.6
1998	270.3	129	17.2	17.6	19.4	7.3	2.9	3.7	.6	.9	34.8
2002	287.5	130	15.7	21.7	20.8	6.0	3.0	3.8	.7	3.2	37.4
2010	298.0	134	11.8	28.2	22.2	8.0	3.0	3.6	1.3	1.8	40.0
2020	323.0	123	10.7	29.2	20.3	8.4	3.3	4.0	1.9	1.9	39.9
2030	347.2	119	10.4	30.9	19.5	8.9	3.8	4.5	2.7	1.9	41.3
2040	370.3	122	10.5	34.6	20.7	9.7	4.2	5.0	3.7	1.9	45.1
2050	394.2	128	10.5	40.0	22.0	10.5	4.5	5.7	4.9	2.7	50.5

Note: Data may not add to totals because of rounding.

— = Less than 50 million square feet.

Source: Historical data Howard 2003.

Table 28—Structural panel consumption, imports, exports, and production in the United States, 1962–2002, with projections to 2050

Year	Consumption			Imports			Exports			Production		
	Softwood plywood	OSB/wafer-board	Total	Softwood plywood	OSB/wafer-board	Total	Softwood plywood	OSB/wafer-board	Total	Softwood plywood ^a	OSB/wafer-board	Total
	<i>----- Billion square feet (3/8-inch basis) -----</i>											
1962	9.5	—	9.5	—	—	—	—	—	—	9.5	—	9.5
1970	14.2	—	14.2	—	—	—	0.1	—	0.1	14.3	—	14.3
1976	17.7	0.1	17.8	—	—	—	.7	—	.7	18.4	0.1	18.5
1986	21.6	4.2	25.7	0.1	0.7	0.8	.6	—	.6	22.0	3.5	25.6
1996	18.0	13.6	31.6	.1	4.4	4.5	1.2	.2	1.4	19.2	9.3	28.5
1998	17.2	17.6	34.8	.2	6.5	6.7	.8	.1	.9	17.8	11.2	29.0
2002	15.7	21.7	37.4	.9	8.5	9.4	.4	.2	.6	15.2	13.4	28.6
2010	11.8	28.2	40.0	3.0	12.2	15.2	.5	—	.5	9.3	16.0	25.3
2020	10.7	29.2	39.9	4.4	12.5	17.0	.5	—	.5	6.7	16.7	23.4
2030	10.4	30.9	41.3	4.4	12.2	16.7	.5	—	.5	6.5	18.6	25.1
2040	10.5	34.7	45.1	4.4	12.8	17.2	.5	—	.5	6.5	21.9	28.4
2050	10.5	40.0	50.5	4.4	14.3	18.7	.3	—	.3	6.4	25.6	32.0

Note: Data may not add to totals because of rounding.

— = Less than 50 million square feet.

OSB = oriented strand board.

^aIncludes production from both domestic and imported species.

Source: Historical data Howard 2003.

Table 29—Structural panel production in the contiguous United States, by region, 1962–2002, with projections to 2050

Species group and region	Historical						Projections				
	1962	1970	1976	1986	1996	2002	2010	2020	2030	2040	2050
<i>Billion square feet (3/8-inch basis)</i>											
Softwoods:											
Northeast	0	0	0.1	0.6	1.3	1.6	2.6	3.0	3.8	5.0	6.4
North Central ^a	0	0	.1	1.7	3.0	3.5	4.2	4.4	4.9	5.7	6.6
Southeast	0	.9	1.7	3.5	6.2	6.6	6.6	5.5	5.8	6.5	7.2
South Central	0	2.4	5.1	8.7	11.9	12.1	9.2	9.2	9.3	10.0	10.7
Rocky Mountains	.2	.9	1.2	1.4	1.3	.9	.6	.5	.4	.4	.4
Pacific Northwest ^{b c}											
West	8.0	8.7	8.8	8.6	3.8	3.5	1.5	.4	.4	.4	.2
East	.1	.6	.9	.9	1.0	.5	.5	.5	.4	.4	.5
Pacific Southwest ^d	1.2	.8	.6	.1	0	0	0	0	0	0	0
United States	9.5	14.3	18.5	25.6	28.5	28.6	25.3	23.4	25.1	28.4	32.0

Note: Data may not add to totals because of rounding.

^a The Great Plains are included in the North Central region.

^b Excludes Alaska.

^c Pacific Northwest West (western Oregon and western Washington) is also called the Douglas-fir subregion, and Pacific Northwest East (eastern Oregon and eastern Washington) is also called the ponderosa pine subregion.

^d Excludes Hawaii.

Source: Historical data: Adams et al. 1988, American Plywood Association 1996–2002.

Table 30—Nonstructural panel consumption, imports, exports, and production in the United States by type, 1962–2002, with projections to 2050

Year	Consumption					Imports				
	Hardwood plywood	Insulating board	Hardboard	Particle board ^a	Total	Hardwood plywood	Insulating board	Hardboard	Particle board ^a	Total
<i>Billion square feet (3/8 inch basis)</i>										
1962	2.0	1.0	1.0	4.0	7.9	1.0	0	0	0	1.0
1970	3.8	3.2	4.8	3.7	13.6	2.0	0.1	0.4	0	2.5
1976	3.4	3.4	7.1	6.9	17.3	2.4	0	.5	0.1	3.0
1986	4.5	2.4	6.5	11.4	21.5	3.2	.3	.8	2.8	7.1
1990	3.0	2.5	5.2	9.5	17.8	1.6	.3	.7	.7	3.3
1997	3.6	2.5	4.5	13.4	22.5	2.0	.3	1.3	1.9	5.5
2002	4.9	2.5	4.9	19.8	31.4	2.9	.3	2.7	8.2	14.1
2010	3.5	3.5	2.1	16.7	25.8	1.7	.4	.6	3.1	5.8
2020	3.2	3.3	2.2	18.1	26.8	1.7	.4	.6	3.5	6.2
2030	3.0	3.0	2.3	19.6	27.8	1.7	.5	.7	3.8	6.6
2040	2.7	2.7	2.4	21.6	29.4	1.7	.5	.7	4.2	7.1
2050	2.4	2.4	2.5	23.6	30.9	1.7	.5	.7	4.5	7.5

Year	Exports					Production				
	Hardwood plywood	Insulating board	Hardboard	Particle board ^a	Total	Hardwood plywood	Insulating board	Hardboard	Particle board ^a	Total
<i>Billion square feet (3/8 inch basis)</i>										
1962	0	0	0	0	0	1.5	0.8	0.8	3.8	6.9
1970	.1	.1	0	0	.2	1.8	4.3	1.5	3.7	11.4
1976	.1	.1	.1	.2	.5	1.1	4.5	2.3	6.9	14.8
1986	.1	.2	.1	.2	.6	1.4	2.9	1.9	8.8	15.0
1990	.2	.2	.2	.7	1.3	1.5	3.1	1.7	9.5	15.8
1997	.3	.2	.4	.4	1.3	1.9	3.1	1.5	11.8	18.3
2002	.2	.2	.2	.4	1.0	2.1	3.1	1.0	12.1	18.3
2010	.3	.3	.3	.8	1.7	2.1	3.4	1.8	14.4	21.7
2020	.3	.3	.3	.8	1.7	1.9	3.1	1.9	15.5	22.3
2030	.3	.3	.3	.8	1.8	1.6	2.8	1.9	16.6	22.9
2040	.4	.3	.3	.9	1.8	1.4	2.5	2.0	18.3	24.2
2050	.4	.3	.3	.9	1.9	1.1	2.2	2.1	20.0	25.3

Note: Data may not add to totals because of rounding.

^aIncludes medium-density fiberboard.

Source: Historical data Howard 2003.

Table 31—Softwood removals, harvest, growth, and inventory on forest industry^a timberlands in the contiguous United States, 1952–2002, with projections to 2050

Region and item	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Million cubic feet</i>												
Northeast:												
Removals	105	92	138	182	273	118	118	156	113	95	86	83
Harvest	99	87	128	168	356	144	247	222	167	142	130	125
Net annual growth	179	236	339	377	188	65	66	140	140	140	140	137
Inventory	5,246	6,427	9,753	10,824	9,191	5,803	5,722	4,858	4,870	5,195	5,655	6,150
North Central: ^b												
Removals	34	23	28	33	37	32	25	9	11	10	9	8
Harvest	30	22	25	28	41	34	13	9	11	9	8	8
Net annual growth	43	44	63	55	50	35	35	45	48	50	49	50
Inventory	917	1,314	1,521	1,690	1,653	1,426	1,426	1,831	2,141	2,518	2,888	3,285
Southeast:												
Removals	325	262	458	518	821	961	928	1,059	1,451	1,600	1,584	1,668
Harvest	318	252	430	473	740	923	1,014	1,035	1,426	1,571	1,550	1,630
Net annual growth	375	411	558	688	725	890	966	1,435	1,670	1,759	1,828	1,796
Inventory	6,803	7,809	8,670	9,142	10,717	10,231	10,295	12,001	15,649	18,170	20,014	21,864
South Central:												
Removals	494	341	564	898	1,088	1,259	1,301	1,597	1,924	2,146	2,355	2,471
Harvest	484	328	530	893	1,045	1,196	1,297	1,522	1,830	2,039	2,238	2,347
Net annual growth	707	971	889	894	829	1,135	1,207	1,632	2,117	2,346	2,495	2,515
Inventory	9,738	13,087	13,501	14,430	13,515	14,231	13,844	14,501	17,546	20,399	22,597	23,505
Rocky Mountains:												
Removals	99	130	186	177	158	154	150	100	74	75	75	77
Harvest	128	145	138	115	178	152	180	121	82	83	84	85
Net annual growth	79	92	103	105	125	126	126	103	105	124	151	173
Inventory	6,767	6,447	5,939	5,156	5,343	4,773	4,773	3,481	3,716	4,176	4,902	5,849
Pacific Southwest:												
Removals	456	449	318	344	435	357	357	193	198	191	180	160
Harvest	393	385	294	321	452	371	338	223	232	226	214	193
Net annual growth	90	108	135	139	205	247	247	205	190	200	220	215
Inventory	11,268	9,639	8,244	7,457	7,918	8,592	8,592	6,673	3,716	6,603	6,869	7,284
Pacific Northwest West: ^c												
Removals	1,150	909	1,272	1,302	1,222	657	657	974	950	929	971	1,046
Harvest	1,244	976	1,234	1,268	1,244	643	1,000	1,013	976	954	993	1,068
Net annual growth	337	393	455	606	915	799	734	963	985	1,057	1,105	1,089
Inventory	32,725	27,399	23,767	21,978	20,137	17,648	17,648	17,730	17,862	18,988	20,573	21,404
Pacific Northwest East: ^c												
Removals	103	95	120	162	179	144	144	79	72	77	82	88
Harvest	100	94	117	151	166	160	118	90	82	86	91	97
Net annual growth	62	71	84	85	115	85	70	118	123	135	147	154
Inventory	3,975	3,972	4,038	3,849	4,279	3,557	3,557	3,897	4,381	4,922	5,583	6,266

Table 31—Softwood removals, harvest, growth, and inventory on forest industry^a timberlands in the contiguous United States, 1952–2002, with projections to 2050 (continued)

Region and item	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Million cubic feet</i>												
United States:												
Removals	2,765	2,301	3,084	3,616	4,213	3,683	3,680	4,166	4,794	5,122	5,342	5,601
Harvest	2,796	2,289	2,896	3,417	4,222	3,623	4,207	4,234	4,806	5,110	5,308	5,553
Net annual growth	1,872	2,326	2,626	2,949	3,152	3,382	3,453	4,641	5,377	5,811	6,135	6,129
Inventory	77,439	76,094	75,433	74,526	72,753	66,261	65,857	64,972	69,881	80,970	89,080	95,607

Note: Historical harvest data are estimates of the harvest trends and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data show the average volume that would be harvested given the assumptions of the study. Inventory data for 1952 and 1962 are as of December 31. Inventory data for 1970 and the projection years are as of January 1. Inventory data shown under 1976, 1986, 1997, and 2002 are as of January 1 of following year.

^a Lands held by firms with commercial timber production objectives but no processing facilities (e.g., timberland investment organizations [TIMOs] and real estate investment trusts [REITs]) are included in forest industry and nonindustrial private forest categories, depending on their classification in the starting (approximately 1995) inventory data. See text in chapter 2 “Projected Area Changes for Land Uses and Forest Management Cover Types” section for further discussion.

^b Data for the Great Plains are included in the Rocky Mountains region for the historical period. For projections, western South Dakota is in the Rocky Mountains region, eastern South Dakota and other Great Plains States are in the North Central region.

^c Pacific Northwest West (western Oregon and western Washington) is also called the Douglas-fir subregion, and Pacific Northwest East (eastern Oregon and eastern Washington) is also called the ponderosa pine subregion.

Source: For historical data, Powell et al. 1993; 1997 removals, growth, inventory data Smith et al. 2001; 2002 removals, growth, inventory from Smith et al. 2004; harvest data from Haynes 2003; 2002 harvest estimated from the assessment projections.

Table 32—Hardwood removals, harvest, growth, and inventory on forest industry^a timberlands in the contiguous United States, 1952–2002, with projections to 2050

Region and item	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Million cubic feet</i>												
Northeast:												
Removals	47	51	91	121	110	158	158	160	158	157	156	157
Harvest	44	45	69	89	216	199	163	169	165	163	161	163
Net annual growth	129	156	193	226	230	196	191	217	216	213	210	205
Inventory	4,742	5,554	6,819	7,636	8,835	8,700	8,531	9,592	10,094	10,565	11,017	11,416
North Central: ^b												
Removals	74	45	64	69	142	105	93	56	41	27	13	6
Harvest	73	41	57	55	201	113	62	58	43	29	16	10
Net annual growth	99	100	118	118	105	86	86	80	77	69	61	58
Inventory	2,048	2,673	3,129	3,376	3,430	3,274	3,277	3,533	3,738	4,005	4,310	4,698
Southeast:												
Removals	169	158	161	147	185	285	217	142	107	98	122	130
Harvest	127	96	108	107	176	257	160	126	98	93	119	129
Net annual growth	171	174	230	259	246	191	199	167	159	146	138	129
Inventory	5,588	6,220	7,248	7,542	8,157	6,857	6,566	5,323	5,356	5,326	5,576	5,580
South Central:												
Removals	211	375	202	213	322	454	406	319	301	352	364	360
Harvest	157	227	213	184	323	430	376	304	286	339	353	351
Net annual growth	203	285	379	453	348	358	349	362	317	304	305	308
Inventory	5,656	7,753	8,086	9,661	9,594	9,488	9,633	8,446	8,601	8,376	7,746	7,141

Table 32—Hardwood removals, harvest, growth, and inventory on forest industry^a timberlands in the contiguous United States, 1952–2002, with projections to 2050 (continued)

Region and item	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Million cubic feet</i>												
Rocky Mountains: ^c												
Removals	3	6	3	3	11	3	3	30	33	36	40	40
Harvest	0	0	1	1	27	3	60	66	70	76	82	85
Net annual growth	2	2	2	2	1	8	1	1	1	1	1	1
Inventory	103	101	100	64	33	31	31	24	23	26	30	36
Pacific Southwest:												
Removals	3	4	5	4	4	5	5	15	15	15	14	14
Harvest	2	3	3	3	24	25	38	41	42	43	45	47
Net annual growth	11	15	24	19	46	45	46	52	53	55	56	55
Inventory	336	449	717	679	1,374	1,701	1,701	2,099	2,462	2,831	3,103	3,380
Pacific Northwest:												
Removals	18	24	44	44	44	40	40	96	93	90	87	84
Harvest	18	22	37	34	57	42	136	136	130	123	117	114
Net annual growth	75	98	124	145	154	101	73	120	120	126	125	119
Inventory	1,900	2,675	3,282	3,355	3,888	3,475	3,475	3,234	3,406	3,708	4,034	4,342
United States:												
Removals	525	663	570	600	818	1,050	927	817	749	775	796	792
Harvest	421	434	488	473	1,025	1,069	996	901	834	867	893	900
Net annual growth	690	830	1,070	1,222	1,130	986	945	998	943	914	897	874
Inventory	20,373	25,425	29,381	32,313	35,311	33,526	33,214	32,251	33,680	34,838	35,816	36,594

Note: Historical harvest data are estimates of the harvest trends and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data show the average volume that would be harvested given the assumptions of the study. Inventory data for 1952 and 1962 are as of December 31. Inventory data for 1970 and the projection years are as of January 1. Inventory data shown under 1976, 1986, 1997, and 2002 are as of January 1 of following year.

^a Lands held by firms with commercial timber production objectives but no processing facilities (e.g., timberland investment organizations [TIMOs] and real estate investment trusts [REITs]) are included in forest industry and nonindustrial private forest categories, depending on their classification in the starting (approximately 1995) inventory data. See text in chapter 2 “Projected Area Changes for Land Uses and Forest Management Cover Types” section for further discussion.

^b Data for the Great Plains are included in the Rocky Mountains region for the historical period. For projections, western South Dakota is in the Rocky Mountains region, eastern South Dakota and other Great Plains States are in the North Central region.

^c 1997 increase in growth data is due to changes in inventory procedures.

Source: For historical data, Powell et al. 1993; 1997 removals, growth, inventory data Smith et al. 2001; 2002 removals, growth, inventory from Smith et al. 2004; harvest data from Haynes 2003; 2002 harvest estimated from the assessment projections.

Table 33—Softwood removals, harvest, growth, and inventory on nonindustrial private forest (NIPF)^a timberlands, 1952–2002, with projections to 2050

Region and item	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Million cubic feet</i>												
Northeast:												
Removals	358	274	263	300	226	278	282	251	247	238	236	245
Harvest	338	258	244	278	296	375	324	340	345	342	346	364
Net annual growth	433	539	510	623	441	508	513	444	410	384	355	324
Inventory	13,438	16,031	16,214	17,976	19,244	21,563	21,809	23,608	24,635	25,273	25,598	25,776
North Central: ^b												
Removals	59	61	72	79	109	132	130	183	191	194	193	193
Harvest	62	63	70	74	119	144	194	194	204	207	208	208
Net annual growth	128	152	170	196	250	257	255	274	266	252	236	228
Inventory	2,610	3,382	4,010	4,899	6,246	8,155	8,198	9,919	10,516	10,878	11,071	11,216
Southeast:												
Removals	1,444	1,234	1,235	1,365	1,821	1,826	1,667	1,554	1,630	1,785	2,052	2,237
Harvest	1,414	1,189	1,157	1,247	1,640	1,741	1,312	1,505	1,583	1,723	2,014	2,203
Net annual growth	1,349	1,567	1,882	2,130	1,656	1,688	1,897	1,938	1,835	1,861	1,843	1,830
Inventory	25,087	28,033	32,179	36,150	35,415	34,187	34,915	42,728	45,560	46,851	46,527	43,163
South Central:												
Removals	606	787	1,117	1,278	1,569	2,072	2,200	1,605	1,712	1,851	2,043	2,312
Harvest	584	748	1,129	1,264	1,507	1,995	1,877	1,557	1,672	1,811	2,000	2,264
Net annual growth	792	1,182	1,668	2,000	1,762	1,719	1,876	1,929	2,070	2,259	2,392	2,372
Inventory	11,273	16,128	23,646	28,760	31,555	30,408	32,741	28,086	32,270	36,473	40,799	42,705
Rocky Mountains:												
Removals	127	111	93	109	137	184	231	236	265	278	302	309
Harvest	79	74	118	147	154	221	390	346	408	439	480	499
Net annual growth	213	247	276	283	315	458	446	372	348	352	373	396
Inventory	12,842	13,649	14,112	14,445	13,029	16,489	16,749	17,115	17,968	18,573	19,223	20,015
Pacific Southwest:												
Removals	542	271	178	145	34	145	203	94	96	110	132	152
Harvest	468	230	163	136	35	164	168	109	112	129	157	183
Net annual growth	178	192	211	197	238	270	262	227	211	209	213	208
Inventory	15,256	12,900	9,608	9,337	9,931	9,716	9,716	10,986	12,180	13,136	13,969	14,589
Pacific Northwest West: ^c												
Removals	302	201	259	200	203	304	364	365	333	351	390	435
Harvest	317	207	245	195	232	298	462	381	342	360	399	444
Net annual growth	265	308	358	340	409	404	354	377	410	502	550	512
Inventory	9,510	9,520	10,304	8,458	10,171	10,336	10,335	8,959	9,729	11,263	13,025	14,004
Pacific Northwest East: ^c												
Removals	103	68	49	65	70	153	179	59	67	97	118	136
Harvest	100	67	48	60	65	198	99	64	74	106	129	148
Net annual growth	109	136	148	121	122	217	111	190	192	203	209	207
Inventory	4,495	4,319	4,725	4,604	3,896	7,321	7,324	9,338	10,656	11,936	13,090	13,970
Alaska: ^d												
Removals	—	—	4	2	61	123	120	60	30	15	15	15
Harvest	—	—	5	2	54	93	124	62	31	16	16	16
Net annual growth	1	2	2	3	21	11	15	15	15	15	15	15
Inventory	218	283	323	663	7,103	5,987	4,177	3,502	3,202	3,127	3,127	3,127

Table 33—Softwood removals, harvest, growth, and inventory on nonindustrial private forest (NIPF)^a timberlands, 1952–2002, with projections to 2050 (continued)

Region and item	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Million cubic feet</i>												
United States:												
Removals	3,541	3,007	3,270	3,543	4,230	5,217	5,572	4,408	4,572	4,899	5,482	6,033
Harvest	3,362	2,836	3,179	3,403	4,102	5,189	4,950	4,558	4,772	5,134	5,749	6,330
Net annual growth	3,468	4,325	5,225	5,893	5,214	5,532	5,730	5,767	5,757	6,037	6,184	6,093
Inventory	94,729	104,245	115,121	125,292	136,590	144,162	145,964	154,242	166,718	177,511	186,428	188,566

Note: Historical harvest data are estimates of the harvest trends and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data show the average volume that would be harvested given the assumptions of the study. Inventory data for 1952 and 1962 are as of December 31. Inventory data for 1970 and the projection years are as of January 1. Inventory data shown under 1976, 1986, 1997, and 2002 are as of January 1 of following year. Historical data updated since 2000 report.

— = less than 0.5 million cubic feet.

^a Lands held by firms with commercial timber production objectives but no processing facilities (e.g., timberland investment organizations [TIMOs] and real estate investment trusts [REITs]) are included in forest industry and nonindustrial private forest categories, depending on their classification in the starting (approximately 1995) inventory data. See text in chapter 2 “Projected Area Changes for Land Uses and Forest Management Cover Types” section for further discussion.

^b Data for the Great Plains are included in the Rocky Mountains region for the historical period. For projections, western South Dakota is in the Rocky Mountains region, eastern South Dakota and other Great Plains States are in the North Central region.

^c Pacific Northwest West (western Oregon and western Washington) is also called the Douglas-fir subregion, and Pacific Northwest East (eastern Oregon and eastern Washington) is also called the ponderosa pine subregion.

^d The increase in NIPF removals, harvest, growth, and inventory data in Alaska after 1986 was the result of the Alaska Native Claims Settlement Act that enabled Native corporations to select about 500,000 acres of land from the Tongass National Forest.

Source: For historical data, Powell et al. 1993; 1997 removals, growth, inventory data Smith et al. 2001; 2002 removals, growth, inventory from Smith et al. 2004; harvest data from Haynes 2003; 2002 harvest estimated from the assessment projections.

Table 34—Hardwood removals, harvest, growth, and inventory on nonindustrial private forest (NIPF)^a timberlands, 1952–2002, with projections to 2050

Region and item	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Million cubic feet</i>												
Northeast:												
Removals	424	503	591	623	630	643	647	851	873	905	980	1,099
Harvest	404	438	448	462	1,241	999	1,150	1,247	1,286	1,338	1,446	1,603
Net annual growth	1,018	1,296	1,465	1,491	1,620	1,767	1,722	1,488	1,489	1,481	1,447	1,400
Inventory	32,669	39,863	44,751	49,457	58,505	67,680	68,686	79,050	84,704	89,396	92,922	95,411
North Central: ^b												
Removals	629	661	797	793	932	857	857	848	883	926	969	1,022
Harvest	751	685	738	737	1,326	1,079	1,017	1,074	1,124	1,183	1,248	1,327
Net annual growth	961	980	1,084	1,137	1,377	1,525	1,524	1,648	1,631	1,575	1,512	1,442
Inventory	24,385	29,009	31,821	35,636	42,884	53,655	54,492	66,507	73,277	79,106	83,668	89,936
Southeast:												
Removals	817	861	843	801	1,096	1,138	1,105	1,494	1,605	1,666	1,593	1,540
Harvest	617	523	566	586	1,043	1,035	988	1,370	1,468	1,522	1,466	1,430
Net annual growth	1,020	1,175	1,439	1,715	1,633	1,559	1,646	1,536	1,439	1,425	1,438	1,454
Inventory	32,316	36,288	40,583	46,478	51,487	54,432	54,640	56,314	54,915	52,390	50,223	48,894

Table 34—Hardwood removals, harvest, growth, and inventory on nonindustrial private forest (NIPF)^a timberlands, 1952–2002, with projections to 2050 (continued)

Region and item	Historical							Projections				
	1952	1962	1970	1976	1986	1997	2002	2010	2020	2030	2040	2050
<i>Million cubic feet</i>												
South Central:												
Removals	1,396	1,313	1,012	948	1,208	1,633	1,688	2,000	2,190	2,260	2,373	2,518
Harvest	937	730	848	713	1,212	1,535	1,945	1,900	2,077	2,140	2,249	2,389
Net annual growth	1,424	1,459	1,845	2,117	1,800	2,239	2,345	2,197	2,134	2,098	2,130	2,152
Inventory	37,669	39,691	42,243	45,836	53,471	60,699	67,646	62,719	63,175	61,631	59,687	56,718
Rocky Mountains: ^c												
Removals	27	18	18	17	7	20	18	31	34	38	41	41
Harvest	1	1	1	1	17	29	60	66	70	76	82	85
Net annual growth	46	51	57	60	84	284	96	49	43	42	42	41
Inventory	2,251	2,412	2,600	2,720	3,462	4,971	4,905	2,998	3,038	3,044	3,028	2,991
Pacific Southwest:												
Removals	4	7	10	8	1	2	2	26	25	23	21	20
Harvest	2	4	7	7	8	14	47	51	51	51	51	52
Net annual growth	29	30	40	36	95	80	78	94	89	85	80	74
Inventory	998	1,050	1,562	1,598	3,352	4,054	4,054	5,037	5,661	6,279	6,878	7,457
Pacific Northwest:												
Removals	8	29	22	47	7	46	54	141	134	127	120	115
Harvest	6	24	16	37	9	51	181	184	173	161	151	145
Net annual growth	99	131	156	148	189	150	109	164	169	175	168	169
Inventory	3,197	3,972	4,711	3,807	5,201	5,185	5,185	5,519	5,782	6,212	6,653	7,163
Alaska: ^d												
Removals	—	—	—	—	—	3	3	6	12	12	12	12
Harvest	—	—	—	—	—	3	3	3	3	3	3	3
Net annual growth	—	—	—	—	38	21	11	11	11	11	11	11
Inventory	39	82	102	121	2,312	1,040	515	574	594	584	574	564
United States:												
Removals	3,305	3,392	3,293	3,237	3,881	4,342	4,374	5,397	5,756	5,956	6,109	6,366
Harvest	2,718	2,405	2,624	2,543	4,856	4,745	5,658	5,895	6,252	6,474	6,696	7,033
Net annual growth	4,597	5,122	6,086	6,704	6,836	7,625	7,530	7,189	7,005	6,892	6,827	6,743
Inventory	133,524	152,367	168,373	185,653	220,674	251,716	260,123	278,717	291,145	298,642	303,634	306,136

Note: Historical harvest data are estimates of the harvest trends and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data show the average volume that would be harvested given the assumptions of the study. Inventory data for 1952 and 1962 are as of December 31. Inventory data for 1970 and the projection years are as of January 1. Inventory data shown under 1976, 1986, 1997, and 2002 are as of January 1 of following year. 1997 data updated since 2000 report.

— = less than 0.5 million cubic feet.

^a Lands held by firms with commercial timber production objectives but no processing facilities (e.g., timberland investment organizations [TIMOs] and real estate investment trusts [REITs]) are included in forest industry and nonindustrial private forest categories, depending on their classification in the starting (approximately 1995) inventory data. See text in chapter 2 “Projected Area Changes for Land Uses and Forest Management Cover Types” section for further discussion.

^b Data for the Great Plains are included in the Rocky Mountains region for the historical period. For projections, western South Dakota is in the Rocky Mountains region, eastern South Dakota and other Great Plains States are in the North Central region.

^c 1997 increase in growth data is due to changes in Rocky Mountain inventory procedures.

^d The increase in NIPF removals, harvest, growth, and inventory data in Alaska after 1986 was the result of the Alaska Native Claims Settlement Act that enabled Native corporations to select about 500,000 acres of land from the Tongass National Forest.

Source: For historical data, Powell et al. 1993; 1997 removals, growth, inventory data Smith et al. 2001; 2002 removals, growth, inventory from Smith et al. 2004; harvest data from Haynes 2003; 2002 harvest estimated from the assessment projections.

Table 35—Average diameter^a of timber harvested on private timberlands in the timber assessment regions

Year	Pacific Coast ^b		Rocky Mountains ^b		North		South	
	Hardwood	Softwood	Hardwood	Softwood	Hardwood	Softwood	Hardwood	Softwood
<i>Inches</i>								
1976	—	27.5	—	16.9	13.3	11.3	13.7	13.1
1986	16.6	18.7	18.9	9.6	14.2	12.0	12.4	9.9
1990	16.5	17.4	17.5	9.5	13.6	12.0	12.1	10.7
1997	16.1	16.1	9.7	10.3	14.2	11.3	11.0	9.6
2002	16.2	15.8	9.9	10.0	13.1	11.2	11.3	9.2
2010	16.5	15.5	10.4	10.1	13.2	11.3	11.5	8.7
2030	16.8	15.2	11.9	11.0	13.8	10.7	11.6	8.5
2050	16.8	14.6	10.8	11.4	14.3	11.1	11.2	9.0

^a Diameter measured at breast height. Data do not include commercial thinning or area loss volume.

^b For this table, Pacific Coast = Pacific Northwest West and Pacific Southwest regions, Rocky Mountains = Pacific Northwest East and Rocky Mountain North and South regions.

Table 36—Projections of Canadian softwood harvest

Year	Total harvest	Sawtimber	Pulpwood	Annual allowable cut
<i>Million cubic feet</i>				
1970	3,816	2,225	1,591	NA
1980	4,927	3,331	1,596	NA
1986	5,577	3,861	1,716	5,862
1990	4,946	3,586	1,360	6,639
1997	5,371	4,462	909	6,251
2002	5,641	4,903	738	6,251
2010	6,322	5,248	1,075	NA
2020	5,423	4,383	1,040	NA
2030	5,423	4,431	992	NA
2040	5,389	4,462	927	NA
2050	5,371	4,477	894	NA

NA = not available.

Source: Historical data: National Forestry Database Program, Canadian Forest Service (1999).

Table 37—National forest timberland by seral stage

Species and area	Serai stage					Total
	Seedling ^a	Poles-saplings ^b	Young ^c	Mature ^d	Old mature ^e	
Thousand acres						
Softwood:						
North—						
2002	345	559	1,115	600	158	2,777
2010	231	501	1,103	821	121	2,777
2020	232	341	990	1,086	128	2,777
2030	197	263	889	1,372	139	2,777
2040	208	228	622	1,550	169	2,777
2050	192	228	447	1,715	194	2,777
South—						
2002	1,075	1,150	3,028	596	59	5,908
2010	166	1,174	2,784	1,732	52	5,908
2020	191	345	2,294	3,004	74	5,908
2030	180	363	1,498	3,738	130	5,908
2040	180	351	694	4,239	443	5,908
2050	173	343	700	3,412	1,280	5,908
West—						
2002	4,335	4,485	13,104	28,023	16,190	66,137
2010	2,752	6,983	8,698	29,034	18,671	66,137
2020	2,724	7,651	6,324	28,246	21,193	66,137
2030	2,650	7,891	5,603	25,139	24,854	66,137
2040	2,578	6,343	7,607	21,654	27,956	66,137
2050	2,516	6,181	8,520	16,916	32,005	66,137
Hardwood:						
North—						
2002	434	1,195	2,668	2,136	690	7,123
2010	255	1,313	1,725	3,140	691	7,123
2020	238	1,130	1,387	3,649	719	7,123
2030	224	895	1,191	4,061	753	7,123
2040	211	692	1,308	3,881	1,032	7,123
2050	200	649	1,126	3,979	1,169	7,123
South—						
2002	303	660	3,967	216	191	5,337
2010	91	576	3,806	653	211	5,337
2020	92	266	3,002	1,607	370	5,337
2030	88	263	1,724	2,463	800	5,337
2040	85	252	966	2,193	1,842	5,337
2050	82	243	757	1,198	3,058	5,337
West—						
2002	232	614	522	3,472	748	5,588
2010	45	680	329	3,670	864	5,588
2020	34	565	300	3,673	1,015	5,588
2030	33	279	466	3,600	1,208	5,588
2040	34	93	527	3,370	1,563	5,588
2050	32	82	251	3,142	2,080	5,588

^a Seedlings seral stage = age 5 all regions and fiber except North softwood, which includes 5 to 15.^b Poles and saplings seral stage = age 25 to 35 North softwood; 15 to 35 North hardwood; 10 to 15 South softwood; 10 to 20 South hardwood; 15 to 35 West hardwood and softwood.^c Young sawtimber seral stage = age 45 to 65 North; 20 to 35 South softwood; 25 to 55 South hardwood; 45 to 75 West softwood; 45 to 55 West hardwood.^d Mature sawtimber seral stage = age 75 to 135 North; 40 to 75 South softwood; 60 to 75 South hardwood; 85 to 135 West softwood; 65 to 135 West hardwood.^e Old mature sawtimber seral stage = age 145+ North; 80+ South; 145+ West.

Table 38—Other public timberland by seral stage

Species and area	Seral stage					Total
	Seedling ^a	Poles-saplings ^b	Young ^c	Mature ^d	Old mature ^e	
Thousand acres						
Softwood:						
North—						
2002	657	1,221	2,404	1,627	362	6,270
2010	688	1,058	2,001	2,288	235	6,270
2020	682	657	2,099	2,605	228	6,270
2030	514	688	1,590	3,267	210	6,270
2040	442	682	1,345	3,505	296	6,270
2050	399	514	1,058	3,925	374	6,270
South—						
2002	523	1,191	2,336	381	5	4,436
2010	293	822	2,547	773	1	4,436
2020	294	578	2,013	1,544	8	4,436
2030	277	586	1,400	2,160	12	4,436
2040	296	565	1,164	2,327	84	4,436
2050	303	597	1,151	2,107	278	4,436
West—						
2002	1,109	1,469	3,262	3,643	979	10,463
2010	706	1,996	2,930	3,602	1,228	10,463
2020	677	2,335	2,426	3,870	1,156	10,463
2030	626	2,493	2,152	3,644	1,549	10,463
2040	583	2,010	2,578	3,772	1,521	10,463
2050	550	1,885	2,703	3,451	1,874	10,463
Hardwood:						
North—						
2002	810	3,287	6,654	4,619	1,260	16,630
2010	1,104	3,300	4,178	6,936	1,112	16,630
2020	924	3,057	4,050	7,452	1,147	16,630
2030	817	2,838	3,287	8,577	1,112	16,630
2040	726	2,845	3,300	8,335	1,425	16,630
2050	671	2,467	3,057	8,942	1,492	16,630
South—						
2000	463	1,156	3,691	95	140	5,545
2010	175	915	4,128	210	117	5,545
2020	201	540	3,812	862	129	5,545
2030	220	620	2,576	1,947	182	5,545
2040	242	671	1,721	2,396	516	5,545
2050	244	717	1,538	1,582	1,465	5,545
West—						
2002	142	346	286	744	111	1,629
2010	74	336	297	807	114	1,629
2020	63	286	276	886	118	1,629
2030	55	279	194	971	130	1,629
2040	48	192	212	1,047	131	1,629
2050	43	165	216	1,005	199	1,629

^a Seedlings seral stage = age 5 all regions and fiber except North softwood, which includes 5 to 15.

^b Poles and saplings seral stage = age 25 to 35 North softwood; 15 to 35 North hardwood; 10 to 15 South softwood; 10 to 20 South hardwood; 15 to 35 West hardwood and softwood.

^c Young sawtimber seral stage = age 45 to 65 North; 20 to 35 South softwood; 25 to 55 South hardwood; 45 to 75 West softwood; 45 to 55 West hardwood.

^d Mature sawtimber seral stage = age 75 to 135 North; 40 to 75 South softwood; 60 to 75 South hardwood; 85 to 135 West softwood; 65 to 135 West hardwood.

^e Old mature sawtimber seral stage = age 145+ North; 80+ South; 145+ West.

Table 39—Private timberland area by seral stage

Species and area	Seral stage					Total
	Seedling ^a	Poles-saplings ^b	Young ^c	Mature ^d	Old mature ^e	
Thousand acres						
Softwood:						
North—						
2002	3,196	5,394	8,026	6,686	206	23,508
2010	4,175	2,692	9,146	6,098	260	22,371
2020	3,204	3,254	6,751	7,863	301	21,373
2030	2,483	4,216	5,589	7,529	383	20,200
2040	1,782	3,235	4,894	8,716	426	19,052
2050	1,660	2,502	4,865	8,464	731	18,222
South—						
2002	12,675	25,587	30,262	14,942	1,020	84,487
2010	13,290	27,480	36,211	10,914	1,169	89,064
2020	11,957	26,727	41,438	10,174	1,541	91,837
2030	12,253	24,792	40,147	14,584	1,933	93,708
2040	11,486	24,176	39,612	16,177	2,265	93,717
2050	11,611	23,069	39,527	16,307	2,548	93,062
West—						
2002	6,477	9,299	10,683	12,089	2,576	41,124
2010	4,392	14,053	7,526	12,654	2,368	40,994
2020	2,779	15,941	6,631	11,914	3,591	40,856
2030	2,796	13,828	8,397	11,870	3,705	40,596
2040	2,974	10,126	12,348	9,719	5,394	40,559
2050	3,237	8,678	14,099	7,770	6,638	40,422
Hardwood:						
North—						
2002	11,175	29,946	36,459	28,693	618	106,891
2010	9,450	27,569	41,171	28,692	1,254	108,140
2020	7,618	28,376	32,794	37,097	1,561	107,445
2030	7,054	28,970	29,391	38,131	2,786	106,333
2040	6,577	24,456	27,212	43,008	3,475	104,728
2050	6,832	21,494	27,994	41,154	5,893	103,367
South—						
2002	6,042	18,891	42,449	19,228	8,912	95,521
2010	4,073	19,397	36,017	18,486	12,406	90,379
2020	4,842	13,848	40,202	13,812	14,269	86,973
2030	5,457	16,436	39,062	9,020	14,751	84,726
2040	5,226	19,009	39,331	7,646	12,813	84,025
2050	5,116	20,292	39,824	7,945	10,805	83,983
West—						
2002	480	1,571	1,828	3,285	94	7,259
2010	606	1,427	1,509	3,454	70	7,067
2020	587	1,517	1,092	3,617	153	6,966
2030	491	1,688	890	3,642	203	6,915
2040	511	1,718	791	3,468	406	6,893
2050	543	1,625	874	3,238	620	6,900

^a Seedlings seral stage = age 5 all regions and fiber except North softwood, which includes 5 to 15.^b Poles and saplings seral stage = age 25 to 35 North softwood; 15 to 35 North hardwood; 10 to 15 South softwood; 10 to 20 South hardwood; 15 to 35 West hardwood and softwood.^c Young sawtimber seral stage = age 45 to 65 North; 20 to 35 South softwood; 25 to 55 South hardwood; 45 to 75 West softwood; 45 to 55 West hardwood.^d Mature sawtimber seral stage = age 75 to 135 North; 40 to 75 South softwood; 60 to 75 South hardwood; 85 to 135 West softwood; 65 to 135 West hardwood.^e Old mature sawtimber seral stage = age 145+ North; 80+ South; 145+ West.

Table 40—Indices of change for selected indicators for the North, South, and West regions

Area	Old stands	Fragmentation	Area of timberland	Total growing- stock inventory	Softwood inventory	Growth/harvest	Composite index
----- 1952 = 100 -----							Percent
North:							
1952	100	100	100	100	100	188	115
1962	95	76	101	124	101	242	132
1970	93	73	100	140	102	245	136
1976	91	68	99	157	103	250	140
1986	106	113	100	183	96	134	119
1991	115	120	102	200	94	116	120
1997	121	92	103	207	88	147	133
2002	121	86	103	210	88	156	137
2010	128	82	103	242	84	141	142
2020	136	76	103	262	83	137	148
2030	161	71	101	281	82	132	156
2040	189	69	99	296	82	122	162
2050	249	69	98	309	82	111	172
South:							
1952	100	100	100	100	100	134	106
1962	95	77	102	117	106	185	121
1970	96	80	99	134	110	185	122
1976	98	78	98	150	111	190	126
1986	102	97	96	165	106	121	114
1991	110	95	97	169	101	120	117
1997	117	110	98	173	100	112	115
2002	117	95	99	180	99	134	123
2010	145	104	98	183	105	126	124
2020	160	109	98	196	112	116	125
2030	166	113	98	202	118	111	125
2040	164	118	97	207	122	107	124
2050	178	125	97	206	125	100	123
West:							
1952	100	100	100	100	100	89	98
1962	96	106	100	100	99	100	99
1970	94	119	98	98	98	105	97
1976	92	117	93	95	98	111	96
1986	88	132	90	91	96	124	96
1991	87	127	88	90	95	126	96
1997	87	81	95	100	95	225	123
2002	83	78	95	102	95	206	120
2010	88	82	95	109	95	182	117
2020	90	77	95	118	95	175	119
2030	94	72	95	128	95	172	122
2040	99	70	94	137	95	164	124
2050	104	68	94	146	94	153	125

Source: The data for all columns except old stands are given in tables 4 and 12. The indices were computed by dividing each value by the 1952 value for that series except the ratio of growth to harvest, which is used directly. See Haynes (2007) for computation details.

Table 41—Summary of base case and alternative scenarios

Year	Base	Reduction in nonindustrial private forest area	Climate plus CO ₂	Climate only	Sequestered carbon in plantations	Reduced southern pine plantation	Restoration thinning public land
<i>Million board feet</i>							
Softwood lumber production:							
2002	35,831	35,831	35,831	35,831	35,831	35,831	35,831
2010	33,690	33,684	33,711	33,692	33,690	33,689	34,886
2020	35,400	35,379	35,453	35,383	35,412	35,379	36,615
2030	37,165	37,131	37,346	37,202	37,194	37,125	38,676
2040	40,387	40,335	40,706	40,465	40,424	40,300	41,784
2050	43,968	43,807	44,456	44,137	44,035	43,792	45,507
Softwood lumber consumption:							
2002	55,981	55,981	55,981	55,981	55,981	55,981	55,981
2010	58,964	58,963	58,969	58,965	58,964	58,964	59,302
2020	58,522	58,517	58,535	58,515	58,525	58,516	58,967
2030	60,906	60,893	60,941	60,905	60,916	60,884	61,537
2040	65,801	65,789	65,879	65,824	65,813	65,758	66,483
2050	71,324	71,274	71,497	71,386	71,352	71,259	72,129
Softwood lumber imports:							
2002	20,980	20,980	20,980	20,980	20,980	20,980	20,980
2010	26,273	26,279	26,258	26,273	26,273	26,275	25,416
2020	24,248	24,263	24,207	24,258	24,238	24,262	23,477
2030	24,991	25,012	24,845	24,953	24,973	25,008	24,111
2040	26,788	26,830	26,549	26,734	26,764	26,833	26,074
2050	28,857	28,968	28,541	28,749	28,818	28,967	28,122
<i>1982 = 100</i>							
Softwood lumber price index:							
2002	1.303	1.303	1.303	1.303	1.303	1.303	1.303
2010	1.198	1.199	1.197	1.198	1.198	1.199	1.161
2020	1.388	1.390	1.384	1.389	1.387	1.390	1.332
2030	1.354	1.358	1.345	1.354	1.353	1.360	1.286
2040	1.402	1.406	1.386	1.395	1.400	1.408	1.345
2050	1.462	1.474	1.436	1.451	1.458	1.474	1.400
Hardwood lumber price index:							
2002	1.360	1.360	1.360	1.360	1.360	1.360	1.360
2010	1.455	1.455	1.453	1.454	1.455	1.455	1.452
2020	1.557	1.558	1.554	1.557	1.557	1.557	1.552
2030	1.603	1.606	1.598	1.603	1.603	1.603	1.599
2040	1.642	1.646	1.635	1.642	1.642	1.642	1.639
2050	1.664	1.671	1.654	1.663	1.664	1.663	1.662
<i>1982 dollars/thousand board feet</i>							
South softwood sawtimber harvest price:							
2002	209	209	209	209	209	209	209
2010	248	248	245	246	248	248	243
2020	246	247	241	248	245	249	242
2030	232	234	221	233	228	240	227
2040	226	230	207	225	219	240	222
2050	227	235	201	225	217	249	222

Table 41—Summary of base case and alternative scenarios (continued)

Year	Base	Reduction in nonindustrial private forest area	Climate plus CO ₂	Climate only	Sequestered carbon in plantations	Reduced southern pine plantation	Restoration thinning public land
<i>1982 dollars/thousand board feet</i>							
Pacific Northwest West softwood sawtimber harvest price:							
2002	208	208	208	208	208	208	208
2010	169	170	167	169	169	169	162
2020	229	231	225	230	229	229	218
2030	217	222	205	215	216	218	216
2040	217	225	190	206	214	218	220
2050	231	246	189	212	226	232	235
North hardwood sawtimber harvest price:							
2002	186	186	186	186	186	186	186
2010	172	172	170	171	172	172	172
2020	170	170	169	170	170	170	170
2030	181	181	179	180	181	181	181
2040	193	193	193	193	193	193	193
2050	208	208	210	208	207	208	208
South hardwood sawtimber harvest price:							
2002	99	99	99	99	99	99	99
2010	83	83	82	82	83	82	83
2020	91	92	88	90	91	90	90
2030	99	103	93	98	98	98	98
2040	108	116	98	106	108	107	108
2050	118	132	101	115	117	116	118
<i>Million cubic feet</i>							
North softwood growing-stock removals:							
2002	643	643	643	643	643	643	643
2010	690	690	690	690	690	690	687
2020	656	656	658	658	656	656	654
2030	626	626	629	628	626	626	624
2040	614	619	617	617	615	619	614
2050	620	624	623	623	621	623	621
South softwood growing-stock removals:							
2002	6,514	6,514	6,514	6,514	6,514	6,514	6,514
2010	6,082	6,082	6,115	6,120	6,082	6,083	6,027
2020	7,031	7,012	7,025	6,974	7,032	7,013	6,982
2030	7,646	7,614	7,729	7,601	7,660	7,576	7,537
2040	8,335	8,398	8,393	8,302	8,327	8,195	8,363
2050	9,117	8,952	9,128	9,130	9,108	8,836	8,918
West softwood growing-stock removals:							
2002	2,759	2,759	2,759	2,759	2,759	2,759	2,759
2010	2,769	2,769	2,769	2,768	2,769	2,769	2,968
2020	2,749	2,748	2,752	2,749	2,749	2,750	2,936
2030	2,788	2,785	2,800	2,792	2,788	2,791	3,029
2040	2,944	2,938	2,971	2,955	2,946	2,948	3,158
2050	3,101	3,084	3,145	3,124	3,106	3,108	3,340
North hardwood growing-stock removals:							
2002	2,068	2,068	2,068	2,068	2,068	2,068	2,068
2010	2,182	2,182	2,181	2,182	2,182	2,182	2,181
2020	2,224	2,223	2,214	2,226	2,224	2,224	2,223
2030	2,270	2,273	2,246	2,269	2,260	2,272	2,259
2040	2,373	2,397	2,336	2,396	2,341	2,388	2,370
2050	2,563	2,598	2,454	2,622	2,475	2,549	2,556

Table 41—Summary of base case and alternative scenarios (continued)

Year	Base	Reduction in nonindustrial private forest area	Climate plus CO ₂	Climate only	Sequestered carbon in plantations	Reduced southern pine plantation	Restoration thinning public land
<i>Million cubic feet</i>							
South hardwood growing-stock removals:							
2002	3,557	3,557	3,557	3,557	3,557	3,557	3,557
2010	4,097	4,096	4,060	4,065	4,097	4,098	4,099
2020	4,350	4,328	4,324	4,354	4,350	4,340	4,340
2030	4,576	4,539	4,567	4,553	4,579	4,547	4,560
2040	4,644	4,585	4,705	4,637	4,644	4,655	4,659
2050	4,767	4,576	4,799	4,785	4,736	4,797	4,750
U.S. sawtimber softwood harvest:							
2002	5,887	5,888	5,887	5,887	5,887	5,887	5,887
2010	5,075	5,074	5,078	5,075	5,075	5,074	5,227
2020	5,071	5,069	5,078	5,069	5,073	5,068	5,211
2030	5,170	5,167	5,192	5,174	5,175	5,163	5,335
2040	5,445	5,440	5,481	5,452	5,449	5,431	5,593
2050	5,697	5,681	5,749	5,712	5,705	5,670	5,861
U.S. nonsawtimber softwood harvest:							
2002	3,911	3,911	3,911	3,911	3,911	3,911	3,911
2010	4,695	4,695	4,724	4,732	4,695	4,697	4,704
2020	5,600	5,582	5,592	5,548	5,598	5,587	5,600
2030	6,138	6,107	6,213	6,097	6,148	6,081	6,110
2040	6,704	6,770	6,755	6,681	6,694	6,591	6,802
2050	7,414	7,255	7,418	7,442	7,403	7,178	7,298
U.S. sawtimber hardwood harvest:							
2002	2,509	2,509	2,509	2,509	2,509	2,509	2,509
2010	2,466	2,466	2,468	2,467	2,466	2,466	2,464
2020	2,470	2,469	2,473	2,471	2,471	2,471	2,467
2030	2,498	2,495	2,502	2,498	2,498	2,498	2,492
2040	2,546	2,541	2,552	2,546	2,545	2,547	2,540
2050	2,583	2,576	2,592	2,584	2,584	2,585	2,577
U.S. nonsawtimber hardwood harvest:							
2002	4,770	4,770	4,770	4,770	4,770	4,770	4,770
2010	4,937	4,936	4,901	4,908	4,937	4,937	4,939
2020	5,231	5,211	5,195	5,236	5,231	5,222	5,225
2030	5,495	5,470	5,457	5,471	5,488	5,472	5,476
2040	5,698	5,677	5,699	5,713	5,665	5,719	5,712
2050	6,062	5,947	5,963	6,138	5,943	6,069	6,048
North private softwood growing-stock inventory:							
2002	37,155	37,155	37,155	37,155	37,155	37,155	37,155
2010	39,710	39,710	40,033	39,931	39,710	39,710	39,716
2020	41,645	41,644	42,401	42,021	41,680	41,646	41,665
2030	43,337	43,335	44,722	43,972	43,448	43,339	43,378
2040	44,676	44,656	46,787	45,642	44,863	44,659	44,728
2050	45,884	45,833	48,738	47,271	46,160	45,835	45,931
South private softwood-growing stock inventory:							
2002	91,795	91,795	91,795	91,795	91,795	91,795	91,795
2010	97,261	96,640	100,592	99,214	97,261	97,106	97,364
2020	110,970	108,387	119,726	113,178	113,809	108,475	111,420
2030	121,837	115,489	139,937	126,104	131,182	113,679	123,021
2040	129,881	119,042	158,855	135,788	143,414	116,915	131,785
2050	131,182	115,222	172,254	139,387	147,268	114,656	133,414

Table 41—Summary of base case and alternative scenarios (continued)

Year	Base	Reduction in nonindustrial private forest area	Climate plus CO ₂	Climate only	Sequestered carbon in plantations	Reduced southern pine plantation	Restoration thinning public land
<i>Million cubic feet</i>							
West private softwood growing-stock inventory:							
2002	69,735	69,739	69,735	69,735	69,735	69,735	69,737
2010	70,419	70,275	70,655	70,254	70,419	70,419	70,783
2020	74,732	74,315	75,883	74,424	74,793	74,726	76,664
2030	80,472	79,600	84,623	81,430	80,789	80,455	84,447
2040	87,319	85,709	96,539	90,704	88,112	87,268	92,812
2050	92,664	90,067	109,057	99,671	94,100	92,564	97,375
North private hardwood growing-stock inventory:							
2002	145,696	145,696	145,696	145,696	145,696	145,696	145,696
2010	157,492	157,491	159,232	158,522	157,492	157,492	157,493
2020	170,482	170,474	174,160	171,781	170,502	170,480	170,473
2030	181,607	181,614	188,480	183,798	181,695	181,616	181,650
2040	190,323	190,216	201,016	193,650	190,527	190,220	190,359
2050	196,747	196,477	211,511	201,689	197,496	196,580	196,893
South private hardwood growing-stock inventory:							
2002	131,468	131,468	131,468	131,468	131,468	131,468	131,468
2010	132,752	131,648	135,067	133,679	132,752	133,914	132,753
2020	131,983	128,732	137,570	132,547	132,207	133,984	132,013
2030	127,645	121,379	138,934	129,186	128,256	130,226	127,783
2040	123,139	112,987	141,741	125,315	123,990	126,522	123,458
2050	118,225	103,604	147,226	122,408	119,597	121,955	118,669
<i>1982 = 100</i>							
Price index for paperboard:							
2002	110.374	110.374	110.374	110.374	110.374	110.374	110.374
2010	102.188	102.199	102.127	102.138	102.188	102.392	102.408
2020	101.303	101.713	101.293	101.827	101.296	101.548	101.525
2030	98.926	98.829	98.898	98.952	99.027	99.006	99.080
2040	99.267	99.294	97.963	98.591	98.285	99.517	99.530
2050	101.776	103.855	102.843	102.024	104.275	103.888	103.725
Price index for paper:							
2002	125.324	125.324	125.324	125.324	125.324	125.324	125.324
2010	131.257	131.258	130.793	130.806	131.257	131.284	131.282
2020	124.411	124.946	124.462	124.299	124.411	124.921	125.674
2030	118.109	117.827	117.697	117.871	117.648	118.690	119.222
2040	118.522	118.869	116.396	117.783	117.074	118.551	117.634
2050	118.855	119.952	117.202	118.911	117.107	120.299	118.731
<i>1982 dollars/cord</i>							
Southern softwood pulpwood price:							
2002	12	12	12	12	12	12	12
2010	18	18	17	17	18	18	19
2020	15	15	13	15	15	16	16
2030	10	11	8	10	9	12	11
2040	12	15	7	11	9	15	13
2050	13	18	6	12	9	17	13

Table 41—Summary of base case and alternative scenarios (continued)

Year	Base	Reduction in nonindustrial private forest area	Climate plus CO ₂	Climate only	Sequestered carbon in plantations	Reduced southern pine plantation	Restoration thinning public land
<i>1982 dollars/cord</i>							
Southern hardwood pulpwood price:							
2002	11	11	11	11	11	11	11
2010	7	7	6	6	7	6	7
2020	5	5	5	5	5	5	5
2030	10	11	9	10	9	9	10
2040	17	20	12	16	15	17	18
2050	20	22	13	20	19	21	20
<i>Million short tons</i>							
U.S. paper production:							
2002	45.1	45.1	45.1	45.1	45.1	45.1	45.1
2010	41.9	41.9	41.8	42.0	41.9	41.9	41.9
2020	42.3	42.2	41.8	43.0	42.3	42.3	42.3
2030	44.4	43.8	43.6	44.6	44.2	43.7	43.6
2040	46.0	46.0	45.6	46.0	46.0	45.5	45.6
2050	46.7	45.9	46.7	47.7	47.2	46.0	45.9
U.S. paperboard production:							
2002	51.5	51.5	51.5	51.5	51.5	51.5	51.5
2010	52.9	52.9	52.9	52.9	52.9	53.0	53.0
2020	61.3	61.0	61.0	59.9	61.3	61.0	61.5
2030	68.9	69.5	69.4	67.6	69.1	69.3	69.1
2040	76.4	77.2	76.6	74.8	74.9	75.3	78.0
2050	83.5	84.3	80.6	80.9	81.1	82.0	82.7
<i>Million cubic feet</i>							
U.S. softwood pulpwood harvest:							
2002	3,188	3,188	3,188	3,188	3,188	3,188	3,188
2010	3,987	3,987	4,016	4,024	3,987	3,989	3,999
2020	4,900	4,883	4,893	4,849	4,898	4,887	4,927
2030	5,370	5,337	5,438	5,324	5,375	5,309	5,359
2040	5,881	5,944	5,928	5,860	5,876	5,766	5,993
2050	6,527	6,368	6,532	6,553	6,509	6,290	6,413
U.S. hardwood pulpwood harvest:							
2002	2,843	2,843	2,843	2,843	2,843	2,843	2,843
2010	2,846	2,845	2,810	2,817	2,846	2,846	2,848
2020	3,026	3,006	2,990	3,031	3,026	3,017	3,020
2030	3,189	3,156	3,152	3,164	3,181	3,158	3,169
2040	3,232	3,218	3,233	3,250	3,199	3,260	3,256
2050	3,424	3,298	3,332	3,492	3,305	3,433	3,403
<i>Percent</i>							
U.S. wastepaper recovery rate:							
2002	48.20	48.20	48.20	48.20	48.20	48.20	48.20
2010	52.45	52.45	52.58	52.52	52.45	52.46	52.45
2020	51.03	51.21	51.54	51.26	51.07	51.17	51.46
2030	50.46	50.83	50.63	50.52	50.61	50.65	50.75
2040	50.41	50.34	50.41	50.35	50.63	50.49	50.14
2050	49.92	50.43	50.14	49.45	50.35	50.31	50.07

Appendix 2: A Price-and-Yield-Sensitive Mechanism for Allocation of Regeneration Area to Management Intensity Classes in ATLAS

Within the Aggregate Timberland Assessment (ATLAS) timber inventory projection model, private timberland area shifts between management intensity classes (MICs) only at the time of regeneration (after harvest). For a given region, ownership, forest type, and site class (called a “stratum”), harvested areas from all MICs are pooled and assigned to new MICs in the subsequent rotation. In past assessments this assignment has been based on exogenously determined patterns or percentages developed to emulate the expected behavior in the stratum. These patterns were generally not sensitive to changes in prices, costs, or yields save to the extent that they were modified in some cases, based on judgment, to reflect variation in these factors. In the 2005 update, an alternative mechanism was developed to allocate regeneration areas to MICs in a way that is sensitive to both the financial and yield characteristics of alternative MICs and, in the South only, reflects the results of past surveys on owner intentions to undertake various MIC regimes.

As in the development of the private timber supply relations used in Timber Assessment Market Model (TAMM) and North America Pulp and Paper (NAPAP), we assume that private owners manage their lands so as to maximize their intertemporal utility. For industrial owners this may be largely a function of the present value of future net returns from timber sales, whereas for nonindustrial private (NIPF) owners, utility may depend on both net returns and other factors including satisfaction derived directly from the ownership of some area or volume of timber. To illustrate the derivation, consider a simple case in which only net returns matter. We examine only three periods and use a highly simplified form for the utility function. Following Ovaskainen (1992), the owner’s problem can be written as:

$$\text{Maximize } U = u(c_1) + \beta u(c_2) + \beta^2 u(c_3)$$

subject to:

$$c_1 = p_1 H_1 - w_1 E_1$$

$$c_2 = p_2 H_2 - w_2 E_2$$

$$c_3 = p_3 H_3$$

$$I_1 = I_0 - H_1$$

$$I_2 = I_1 - H_2 + F(I_1, E_1)$$

$$I_3 = I_2 - H_3 + F(I_2, E_2) = 0 ,$$

where

U is the owner's overall intertemporal utility,

u is the utility contribution from a single period (assumed to be separable),

β is the owner's rate of time preference or "discount" rate,

c_t is net return in period t ,

H_t is harvest,

p_t is the price of timber,

E_t is the management investment or management "effort,"

w_t is the unit cost of management input,

I_t is the inventory of timber after harvest (I_0 is the initial inventory), and

$F(I_t, E_t)$ is the growth of the forest in period t that depends on the starting inventory and the extent of management investment.

We assume that F rises with I and with E —more intensive management produces higher yields.

Ovaskainen (1992) shows that the owner's solution to this problem leads to rules for harvest and management investment that can be summarized as:

$$\begin{aligned} H^* &= H^*(p_t, p_{t+1}, \beta, w, I_0) \\ E^* &= E^*(p_t, p_{t+1}, \beta, w, I_0) \end{aligned}$$

Both harvest and management input depend on current and expected future timber prices, the "discount" rate, the cost of management inputs and the initial inventory. The harvesting expression motivates the form of the timber supply relations used elsewhere in TAMM and NAPAP. The management input or management "effort" expression provides the basis for our alternative model of MIC allocation. Note that the specific form of E^* will depend on an array of unobservable conditions, including the specific forms of the u 's and F .

In the ATLAS context, management intensity/investment is set at the start of a rotation by selecting the allocations of regeneration lands to different MICs. By analogy with the E^* equation above, we assume that owners wish to allocate portions of their regeneration land to various MICs within a given stratum depending on the anticipated soil expectation value (SEV) of the MIC and an array of other concerns linked to specific owner, region, type, and site conditions. The SEV incorporates current and anticipated prices, costs, and discount rates. We ignore I_0 , as it is fixed. The desired fractional allocation to MIC j in stratum i can be written as:

$$A_{i,j,t}^* = f(\text{SEV}_{i,j,t}, \{D_i\}) \quad \text{for all } i, j \quad [\text{A } 1]$$

where

$A_{i,j,t}^*$ is the desired fractional allocation of regeneration lands to MIC j in stratum i in period t ,

$\text{SEV}_{i,j,t}$ is the estimated soil expectation value of land allocated to MIC j in stratum i in period t , and

$\{D_i\}$ is a set of measures of the characteristics of the stratum that relate to the form and nature of the u 's and F as noted above.

Since the $A_{i,j,t}^*$ are fractions of the total regeneration area $\sum_j A_{i,j,t}^* = 1$.

It seems likely, however, that an array of limitations on owners will preclude their immediate achievement of the desired A^* allocation, including lack of knowledge or expertise in some aspects of silviculture, restrictions on equipment or planting stock, and uncertainties about departing from past forms of management. As a consequence, we assume that in any given period owners adjust only partially from their MIC allocations of the previous period. That is:

$$\Delta A_{i,j,t} = \rho_i (A_{i,j,t}^* - A_{i,j,t-1}) = \rho_i f(\text{SEV}_{i,j,t}, \{D_i\}) - \rho_i A_{i,j,t-1} \quad [\text{A } 2]$$

where

$\Delta A_{i,j,t}$ is the observed or actual adjustment of the proportion of regeneration land allocated to MIC j between $t-1$ and t ,

ρ_i is a partial adjustment coefficient ($0 < \rho_i < 1$), and

$A_{i,j,t}$ is last period's allocation.

Because the sum of the $A_{i,j,t}$ and $A_{i,j,t-1}$ over the MICs (j 's) is 1, the $\sum_j A_{i,j,t} = 0$.

In the application of this model to the South, we were able to develop estimates of the parameters ρ_i by means of data on intended allocations of regeneration area from past studies and subsequent surveys of Southern private owners. Conducted to provide estimates for the fixed allocation approach used in previous assessments, the surveys (weighted by area to give regionwide averages) indicate the intended allocation of new regeneration land to each of the MICs used in ATLAS. The first regionwide study was conducted for the South in the early 1980s (USDA FS 1988). Those results were later modified for use in ATLAS in the late 1980s and early 1990s (Haynes 1990; Haynes et al. 1995; Mills 1988, 1993). They are used here to represent management intentions in about 1995. Surveys targeting managers and Southern state foresters were conducted in the late 1990s and used to represent intentions in 2000 (AF&PA 1999; Moffat et al. 1998a; Siry 1998, 2002).

These surveys give data for the $A_{i,j,t}$ and $A_{i,j,t-1}$, where $t = 2000$ and $t-1 = 1995$ and comprise a panel with two time observations across a large number of strata (regions, owners, sites, and forest types). We computed SEVs for each MIC by stratum as of 2000 by using costs as estimated for that year and prices as projected in the 2000 RPA timber assessment (Haynes 2003). As there is a wide range of SEVs depending on site and type, we replaced the raw SEV values with the SEV rankings (1, 2, 3, etc.). And as most of the attributes that would compose the set $\{D_i\}$ are unobservable, we use a set of region, owner, site, and type dummies as surrogates. The function $f(\cdot)$ in [A 2] was assumed to be linear. The equation to be estimated thus becomes:

$$\Delta A_{i,j,t} = \rho_i [\varphi_0 + \varphi_1 \text{SEVRANK}_{i,j,t} + \varphi_2 \{D_i\}] - \rho_i A_{i,j,t-1} \quad [\text{A } 3]$$

Regression results for the Southern model used in this 2005 update are given in the following table. Because both timber prices and costs are largely out of the control of individual owners, we take them as exogenous. Ordinary least squares (OLS) was the estimation method. Standard errors are in parentheses below the coefficients. After some experimentation with specification, the model was modified to allow separate SEVRANK coefficients for both owner (FI = forest industry, OP = NIPF) and forest type (PP = planted pine, OT = all other types) and separate coefficients for the lagged allocation term for industry and NIPF owners.

Estimates of coefficients for equation [A 3] in linear form

Intercept	SEVRANK ($\rho_i \varphi_1$)	Lagged allocation ($-\rho_i$)	Region	Type	Site
0.5402 (.1804)	-0.0416 FI_PP (.0052)	-0.4504 FI (.0871)	-0.0304 (.0206)	-0.0052 (.0137)	0.0057 (.0119)
	-.0775 FI_OT (.0145)	-.8093 OP (.0716)			
	-.0444 OP_PP (.0082)				
	-.0503 OP_OT (.0182)				

Adjusted $R^2 = 0.482$; observations = 264.

Estimates of the ρ_i are the negatives of the lagged allocation coefficients. Both are within the expected range and both are highly significant. Based on the relative sizes of the adjustment coefficients, NIPF owners appear to adjust more rapidly to SEV changes than does industry. The SEVRANK coefficients are also highly

significant with a large difference only for the “industry-other types” case. These coefficients have negative signs because the SEVRANK variable starts at 1 for the highest SEV and increases for lower rankings. None of the region, type, or site dummies are significantly different from zero.

For the Pacific Northwest West (PNWW) region, comparable historical data on owner allocation intentions were not available, so empirical estimation of the adjustment coefficients in [A 3] was not possible. In this case, we continued to employ the partial adjustment model form but set the adjustment coefficients based on judgment. Because we can not estimate the ϕ_1 , the desired allocation was assumed to be 100 percent to the MIC with highest SEV (i.e., one of the $A_{i,j,t}^*$ is 1 and all others are 0). In the final base case projections, ρ_i was set at 0.5 for all owners, types, and sites.

In both the South and PNWW forms, the MIC allocations are based on an initial set of timber price expectations. Each period in the projection the SEVs and SEVRANKs are recomputed by using these price expectations, costs, and the previous period’s allocations. At the end of the simulation, the projected prices will very likely differ from the expectations used in the SEV computations. We believe that it is reasonable to assume, however, that owners know at least as much about future timber markets as the projection model (their expectations are rational). Thus we use the new price projections as the price expectations in a second iteration of the simulation. We continue this iteration process until the prices used as expectations in the last iteration differ by only a small amount from those projected in the current iteration. In this way, choices of MIC allocations in the simulations are sensitive to both current and projected prices.

Projecting the Unavailable Class of Timberland

Surveys of land managers and state foresters in the South (AF&PA 1999; Moffat et al. 1998a, 1998b; Siry 1998, 2002) indicated the fifth RPA timber assessment should recognize some timberland to be explicitly set aside from harvest. This class of timberland would represent more recent trends in the attitudes and behavior of landowners; the land would remain in the timberland inventory but not be harvested or actively managed. This was named the “unavailable class.” The timber resource itself was accounted for and growth was projected, but no further active management or harvest occurred on timberland in this class.

There has been confusion surrounding this representation of timberland. Part of it stems from how timberland is defined, and part from the way availability is expressed in the TAMM and land AREACHANGE models. The formal definition

of timberland states it meets a minimum forest productivity requirement and is land not withdrawn or reserved from timber production by administrative statute, such as formally declared wilderness or national park lands. These reserved lands are not formally considered timberland and not included in our projections. Our use of the term “unavailable” is for land that meets timberland classification but is simply withheld from harvest owing to a variety of factors. Working groups indicated the reasons for this class include local rules and regulations that are perhaps tied to environmental or ecological considerations, operability constraints making harvest too expensive, or simply owner preferences.

In TAMM there is a built-in assumption that at any given time there is a proportion of mature timber not available for harvest. Based on historical data of inventory and harvest, a set of cut-to-inventory ratios is incorporated into timber supply functions for forest industry and nonindustrial private owners, and this links the availability of timber to the behavior of market forces, namely prices.

The land AREACHANGE models are also developed around historical data. These models project the movement of timberland to other uses while simultaneously projecting the movement of land (mostly from agriculture) to timberland. Data from successive forest inventory and analysis (FIA) inventories is most often used to predict the behavior of forest owners over time as they face various markets for wood and agricultural products. These land movements are typically between forests and agriculture, although a certain amount of forest is permanently lost to development. Another movement of forest is between cover types. These movements occur owing to changing species composition from natural succession or owner management activities (e.g., hardwood forest types to pine plantations).

The survey responses indicated that historical information might not reflect what owners see as the coming trends. Forest industry owners thought that in addition to operational constraints, a portion of their lands would be set aside in the future for habitat conservation or other environmental reasons. State foresters were seeing a trend where nonindustrial private owners were purchasing and managing timberland with objectives that did not include timber harvest, and this was happening at higher rates than in the past. Timber harvest might not be permanently eliminated from these lands, but urban encroachment and population pressure would add weight to wildlife, ecological, and aesthetic objectives that may exclude or minimize harvesting.

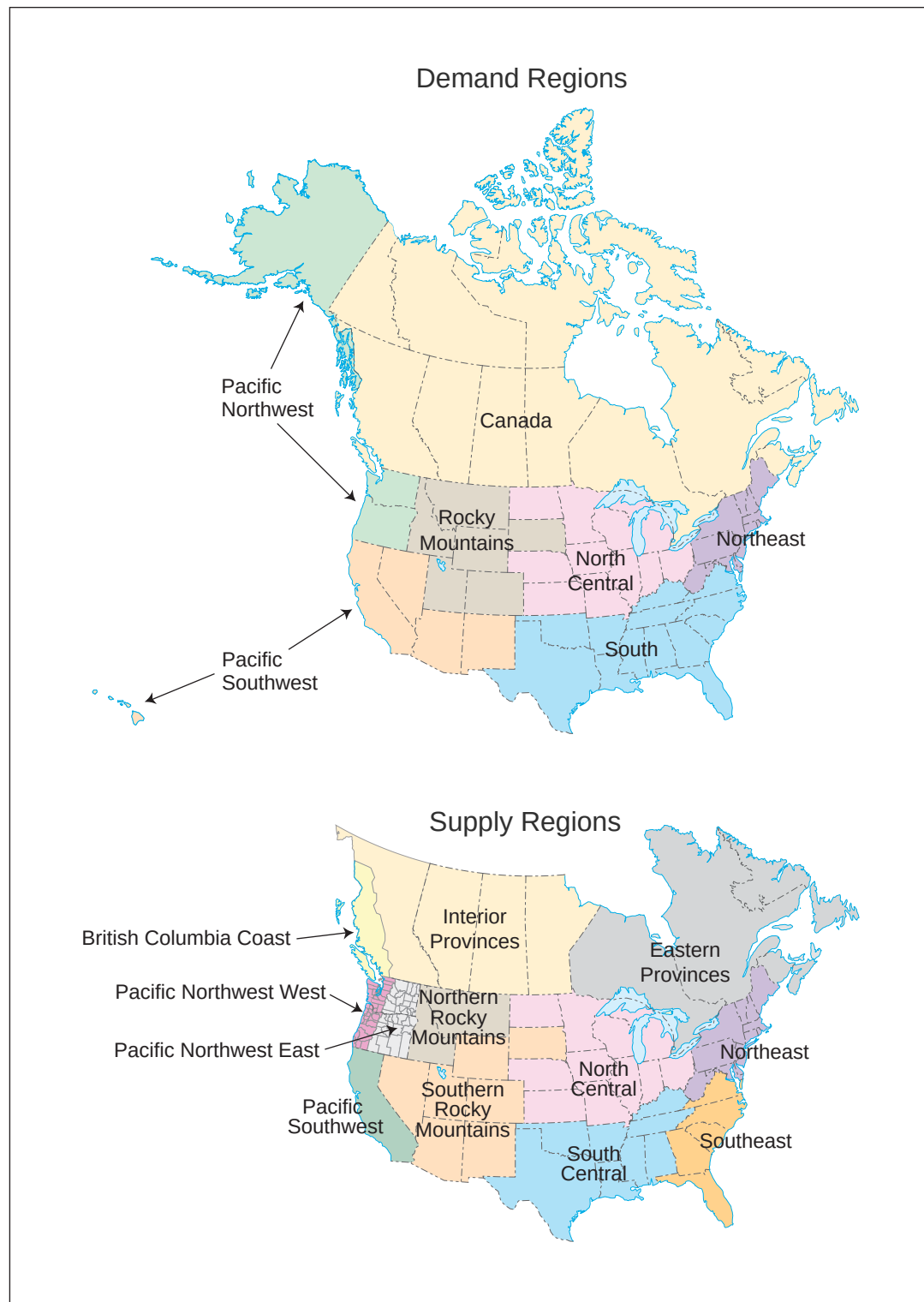
Because of the way the surveys were designed, industrial land managers and state foresters responded differently in their assessment of the amount of land that

would be available for timber production, both now and in the future. The industry response was specific in terms of the number of acres by forest type and site for successive rotations, whereas the state foresters responded in terms of percentage of area by forest type by decadal points in time (2000, 2010, and 2020).

To allocate area to the unavailable class, timberland was pooled by ownership, forest type, site class, and age from which all acres were equally likely to be assigned to any of the associated management classes. This approach was used because the FIA forest inventory does not classify timberland plots by using variables that might be directly associated with actual timber availability. One might try examining plot variables to help make the availability classification; for example, one could make the case that it would be unlikely for a 15-year-old recently thinned planted pine plot to be assigned to the unavailable class. But the thinning data does not tell us if the action was for timber production or other goals such as habitat enhancement. Although surveys did indicate that some planted pine would be unavailable for future harvest, it never made up more than a few percent of all the unavailable acres. But neither the surveys nor the data could tell us which stands those would be.

The unavailable class was managed by using a custodial approach; the growth and yield parameters from the owner's lowest management class. Stands were grown forward with no harvesting allowed, and none of the inventory was recognized by TAMM as part of the "available" fiber supply. The growth and standing volume were added back to the rest of the timberland inventory for reporting purposes.

When considering the South as a whole, the initial unavailable area and volume on private land was significant. In 1995, 12.3 million acres and 17 billion cubic feet of inventory were classified as unavailable. This is just about 8 percent of the private timberland area and 9 percent of the associated volume. About 71 percent of both the unavailable area and volume were in forest types predominated by hardwood tree species. Additions to the unavailable class were made as the projection progressed, by 2020 the area and volume reached 11 and 14 percent of the total, and by 2050 additions of area had slowed while the volume increased at a faster rate owing to normal growth. The totals amounted to 16 and 23 percent, or 27.7 million acres supporting 59 billion cubic feet. Throughout the projection, roughly two-thirds of the volume in the unavailable class was composed of hardwood species.



Pacific Northwest Research Station

Web site	http://www.fs.fed.us/pnw/
Telephone	(503) 808-2592
Publication requests	(503) 808-2138
FAX	(503) 808-2130
E-mail	pnw_pnwpubs@fs.fed.us
Mailing address	Publications Distribution Pacific Northwest Research Station P.O. Box 3890 Portland, OR 97208-3890

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