The 2005 RPA Timber Assessment Update

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Interim Update of the 2000 RPA Assessment*

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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 is the sixth RPA timber assessment.

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 dollars[2] unless otherwise noted).

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[1] The 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.

[2] The 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

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

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.

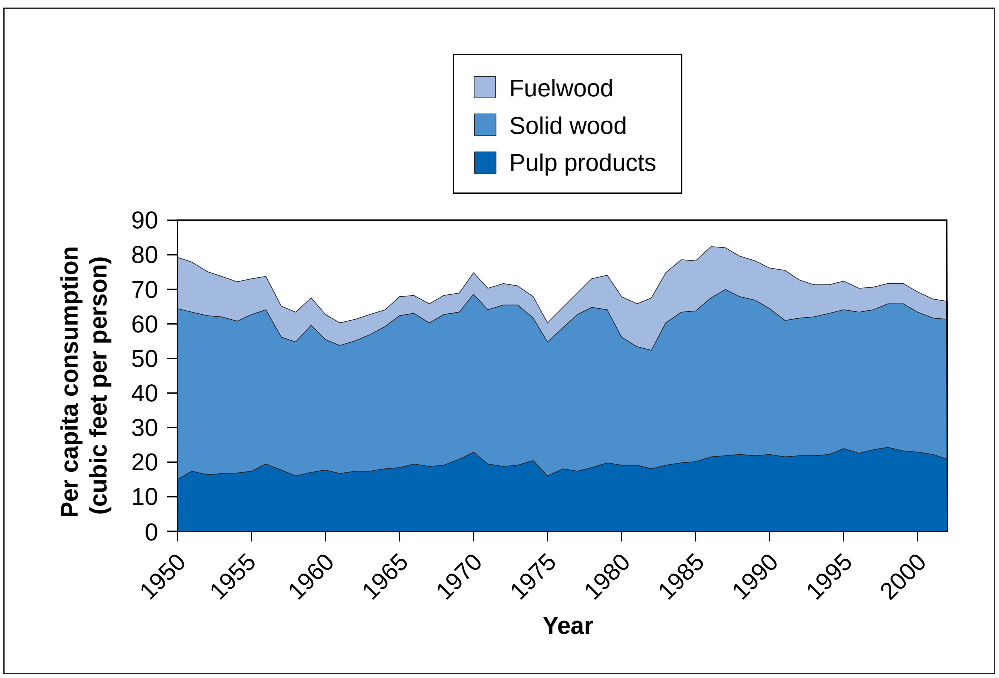

Figure 1—Per capita consumption of timber products by major product.

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[a]	Population: Annual growth rate 1995–2000	Total forest area[b]	Forest types: Tropical	Forest types: Sub-tropical	Forest types: Temperate	Forest types: Boreal/polar	Per capita forest area	Average annual change, 1990–2000
	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

[a] Data for 1999.
[b] Data do not include "other wooded land."
[c] Includes Russian Federation.
[d] United 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).

[3] The Bruntland 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.

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[1] The 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.

[2] The 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*	*Percent*	*Percent*	*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

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[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)

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[4] Details 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.

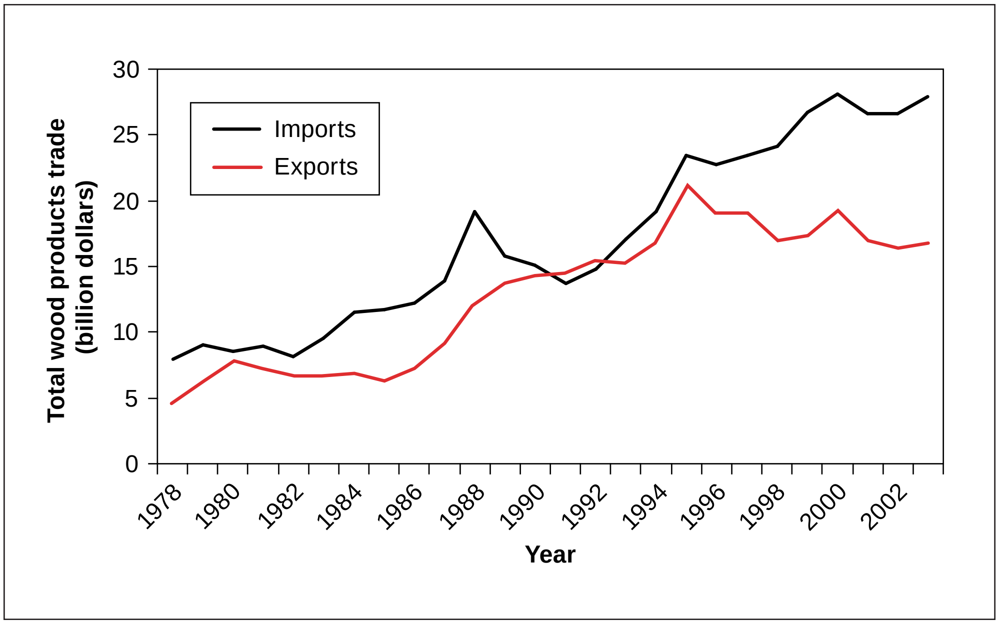

Figure 2a—United States wood products trade balance, 1978–2003.

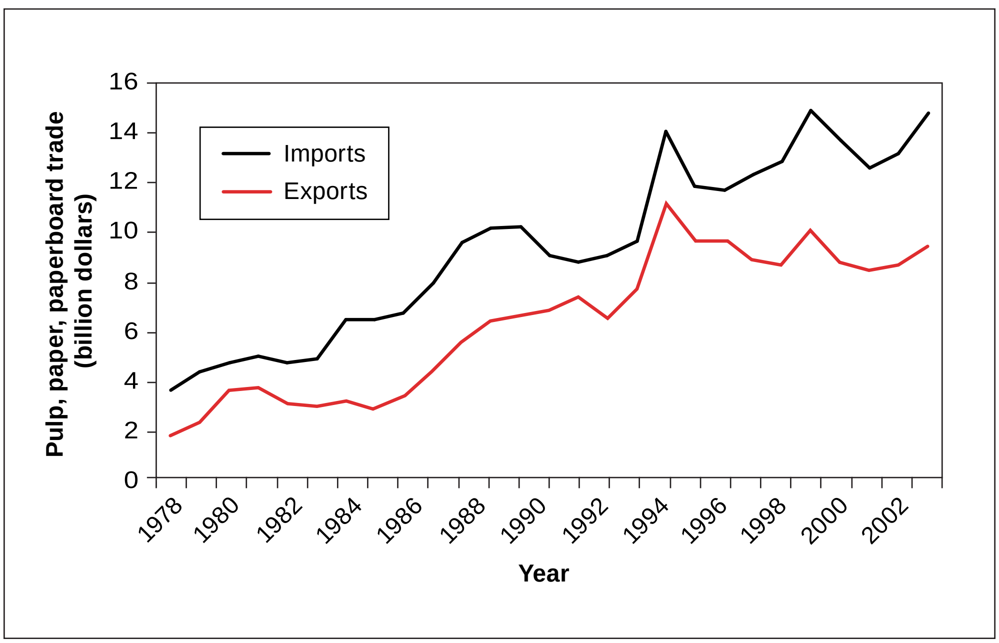

Figure 2b—United States pulp, paper, and paperboard trade balance, 1978–2003.

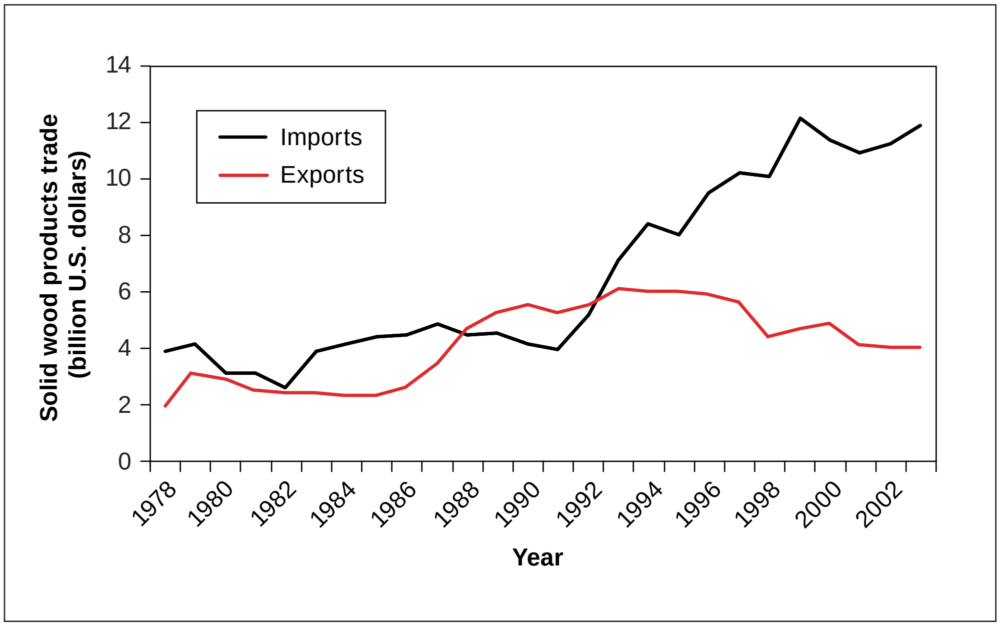

Figure 2c—United States solid wood products trade balance, 1978–2003.

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

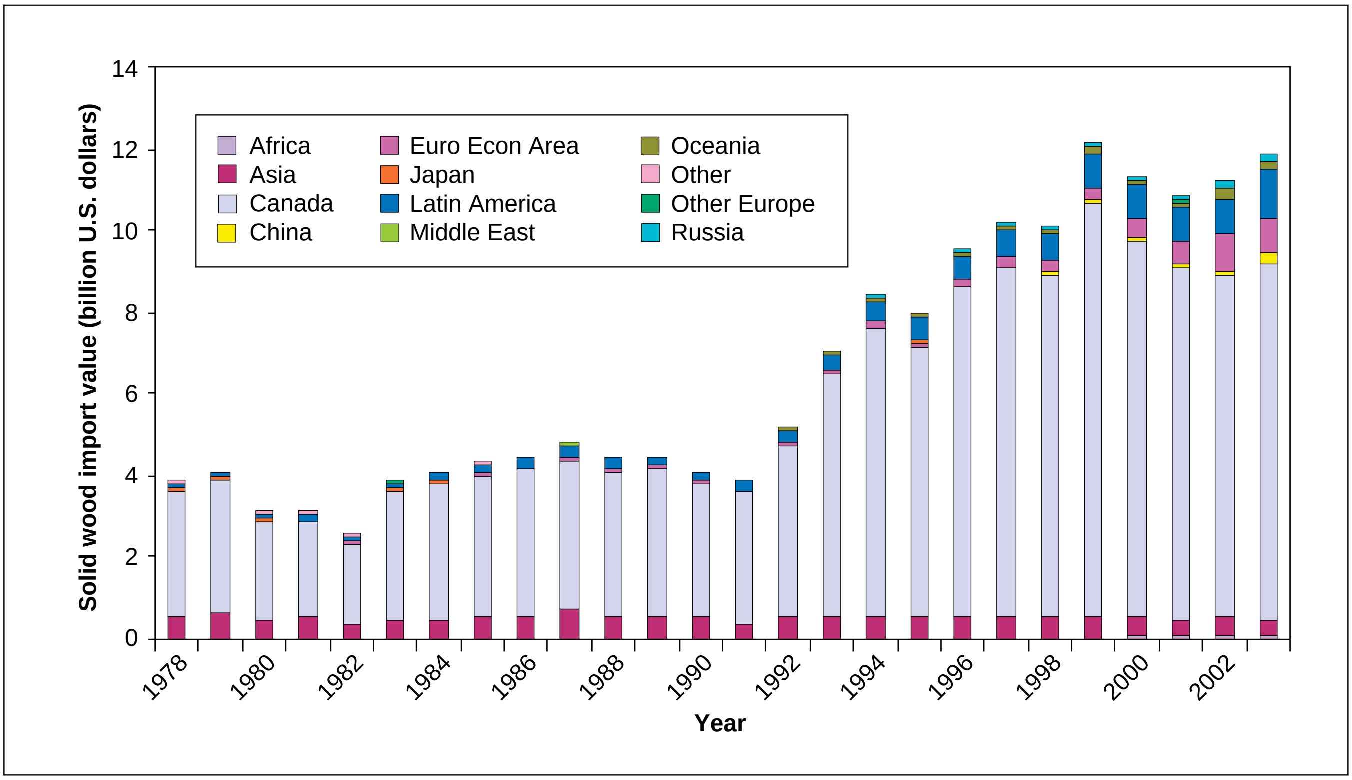

Figure 3a—Total value of U.S. wood product imports by source, 1978–2003.

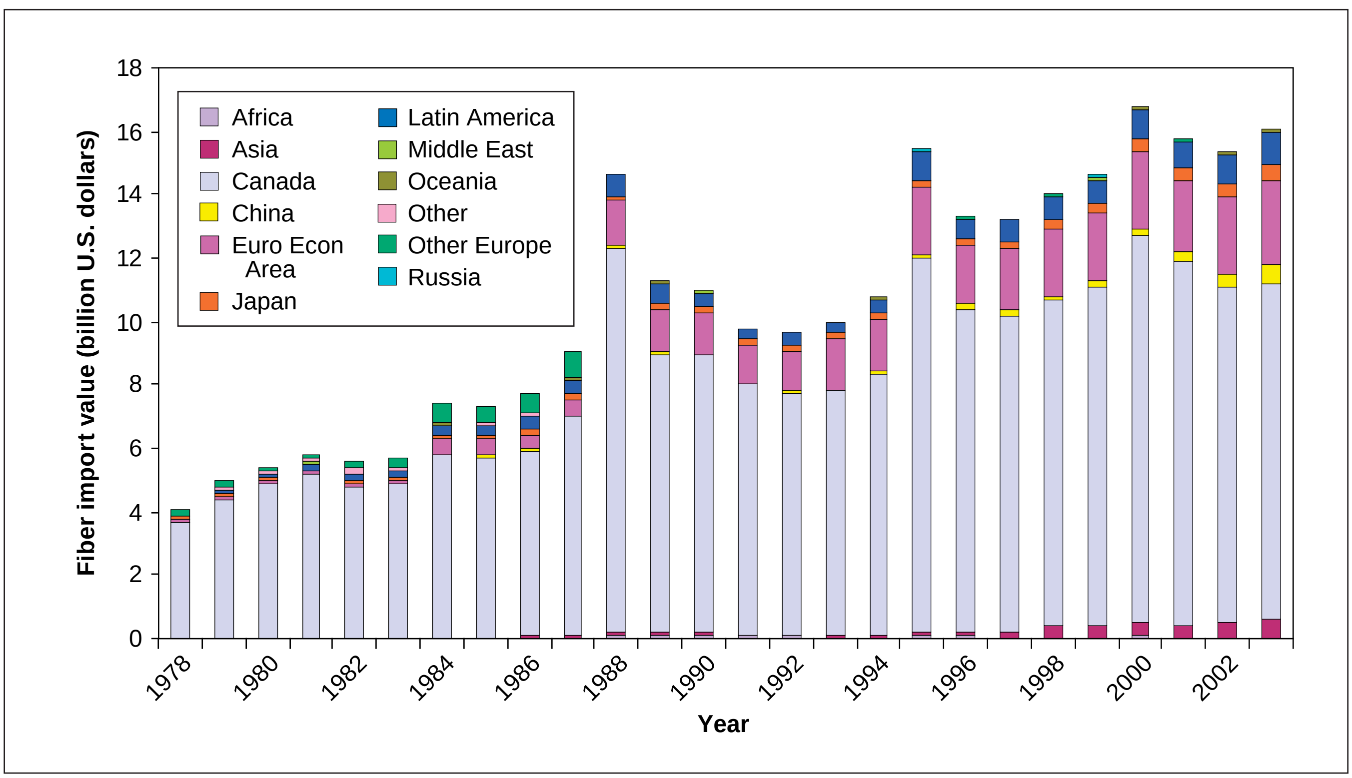

Figure 3b—Total value of U.S. fiber product imports by source, 1978–2003.

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

Year	Customs districts: 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 Projections[5]

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).

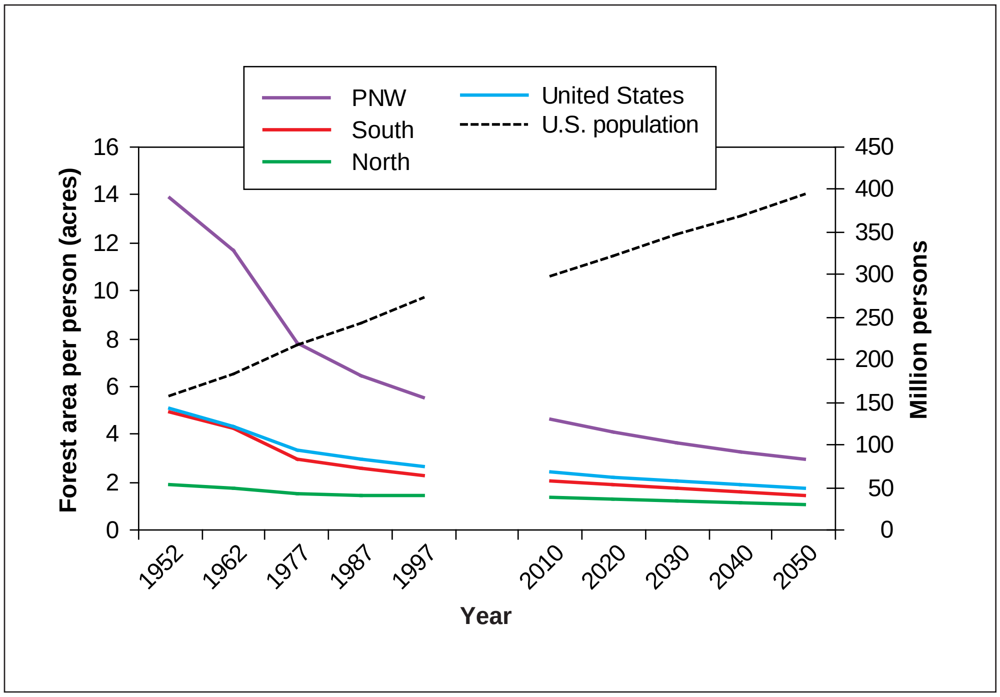

Figure 4—Forest acres per resident in selected regions, 1952–1997 (Smith et al. 2001), with projections to 2050 (Alig et al. 2003) and U.S. population.

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.

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

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

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 1953	1963	1977[a]	1987[a]	1997	2002	Projections 2010	2020	2030	2040	2050
	Million acres										
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

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[8] The 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 nonindustrial 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:

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

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

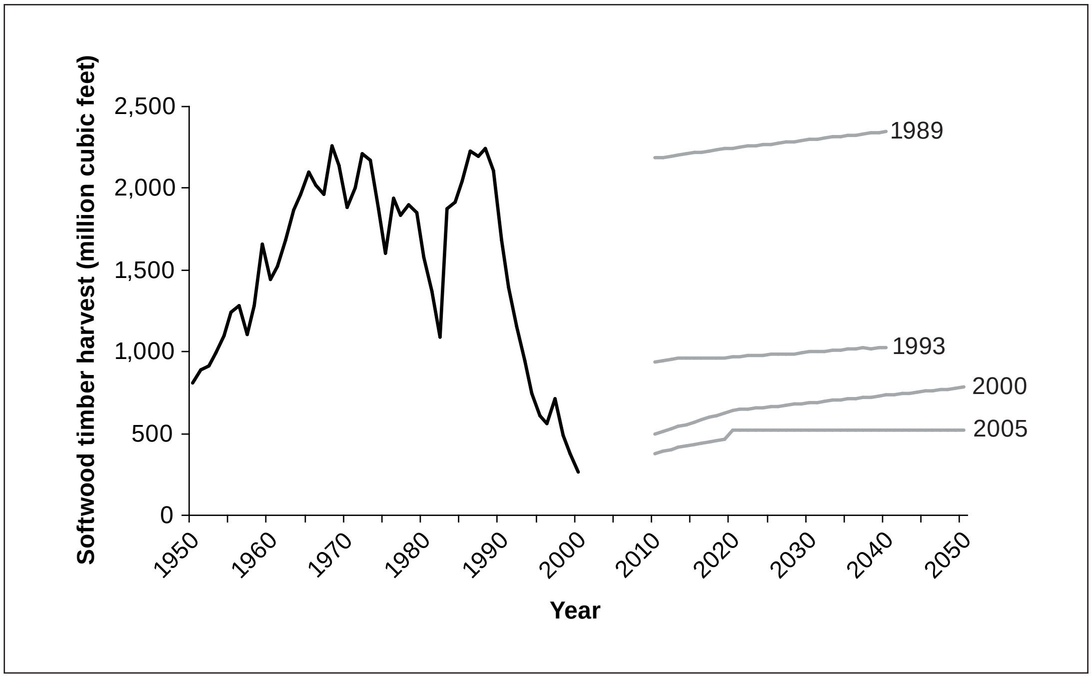

Figure 5—Actual national forest softwood timber harvest 1950–2002 with 1989, 1993, 2000, and 2005 national forest harvest assumptions.

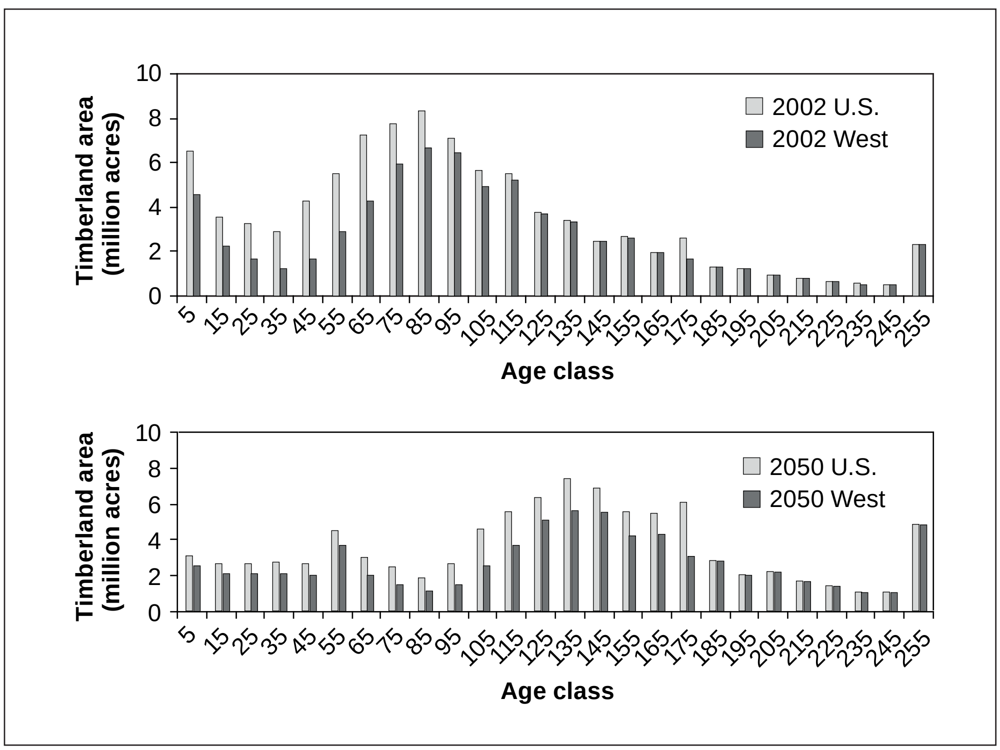

Figure 6—National forest timberland area by age showing the initial (2002) and the projection (2050) distributions.

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).

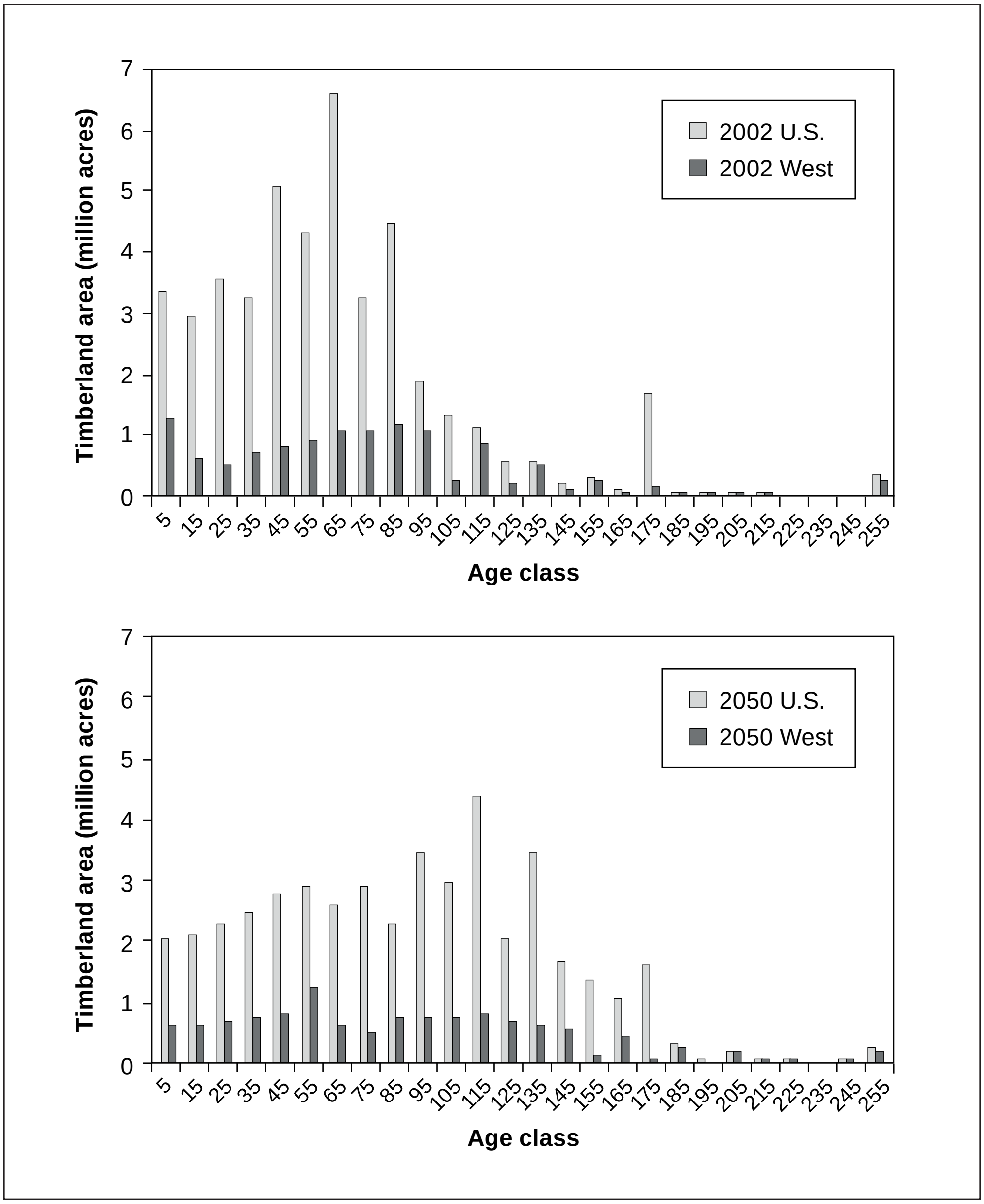

Figure 7—Other public timberland area by age showing the initial (2002) and the projection (2050) distributions.

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