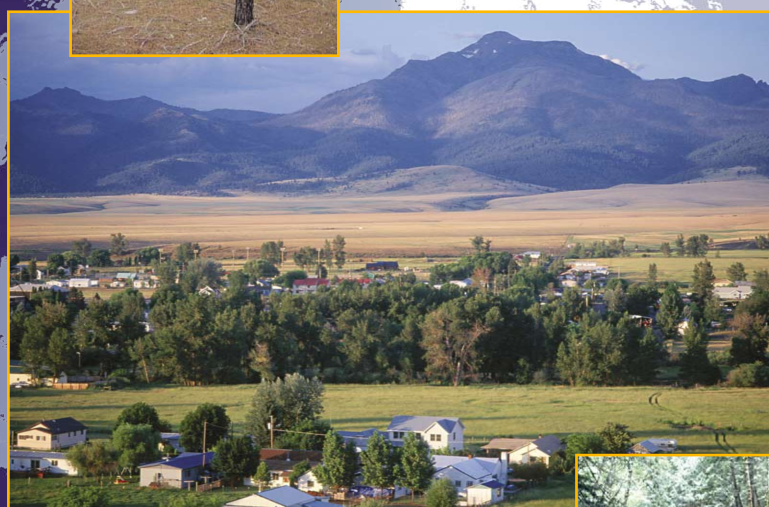
An Analysis of the Timber Situation in the United States: 1952 to 2050



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An Analysis of the Timber Situation in the United States: 1952 to 2050

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Abstract

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For more than a century, national assessments of supply and demand trends for timber have helped shape perceptions of future commodity consumption and resource trends. These perceptions have guided forest policy. Since 1952, U.S. timber harvest has risen by nearly 67 percent, accompanied by growing timber inventories on both public and private lands, but there has been a decline in the critical private timberland base. The current assessment envisions forest products consumption rising 42 percent by 2050 and marked shifts in the extent and location of domestic and imported supplies. Prospective shifts include a temporary near-term decline in U.S. roundwood harvest and an increase in the share of consumption from imports. In the longer term, U.S. timber harvest expands by 24 percent. As a result of steady improvement in growth and productivity on U.S. forest lands, this increased harvest is accommodated by continued expansion in inventory despite decreasing area in the private timberland base.

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

Executive Summary

The Fifth Resources Planning Act (RPA) Timber Assessment

For more than a century, the United States has developed periodic national assessments of future supply and demand prospects for timber that have helped shape perceptions of resource trends and needs for new or modified forest policies. Since 1952, U.S. timber harvest has risen by nearly 67 percent, accompanied by growing timber inventories on both public and private lands but a decline in the critical private timberland base. Projections to 2050 in the fifth RPA timber assessment show the forest products sector continuing to change, with U.S. timber harvest expanding by an additional 24 percent to meet increased consumption needs. As a result of steady improvement in growth and productivity on U.S. forest lands, this harvest increment can be accommodated by continued expansion in inventory despite decreasing area in the private timberland base.

Highlights

Projections to 2050 show the forest products sector changing and expanding to meet a 40-percent increase in U.S. consumption of forest products by 2050. The rate of increase is less than one-third the annual rate of increase over the last 33 years owing, in part, to declining use of paper and paperboard per dollar of gross domestic product, and projected relatively stable housing starts. Increasing consumption needs would be met by (1) an increase in U.S. timber harvest of 23 percent, (2) an increase in log, chip, and product imports of 85 percent, and (3) an increase in use of recovered paper of 85 percent. With a near-term economic recession, U.S. roundwood harvest is projected to decrease in the short term, then increase. The proportion of total roundwood needed for domestic product consumption that comes from domestic timber harvest decreases from 80 to 73 percent by 2050. The remainder is provided by harvest in other countries. Per capita U.S. wood and paper product consumption will remain just under three-quarters of a ton per person per year while per capita U.S. timber harvest will decline. Consumption shifts toward pulp and paper products from a 27-percent share in 2000 to a 37-percent share by 2050, and the share of composites increases from 3 to 7 percent. Oriented strandboard (OSB) production displaces softwood plywood, further eroding the importance of solid wood products. Hardwood lumber production grows more slowly than softwood lumber production. Softwood lumber imports from Canada rise in the near term, and after 2015, softwood lumber production increasingly expands largely in the South and, to a limited degree, the Pacific Northwest. Pulp, paper, and paperboard production increases most in the South, mainly in the South-Central region.

Relatively stable forest product prices are expected over the next five decades. Softwood sawtimber prices are projected to increase over the next 50 years, but at a rate (0.6 percent per year) considerably below that of the past 50 years (1.9 percent per year). Market-based adjustments on private timberlands plus increased imports help meet expected increases in U.S. consumption. Despite generally rising prices, stumpage markets in the West will continue to be weak for small-diameter logs. Hardwood pulpwood prices will remain relatively low but will increase at the end of the projection period with increasing limitations on availability of harvestable hardwoods on nonindustrial private timberlands in the South. Softwood pulpwood prices will remain at or below recent depressed levels, then rise at the end of the projection. Prices for softwood and hardwood lumber will increase at about the same pace as for sawtimber. The increase rate for softwood lumber is less than for the last 50 years. Prices for oriented strandboard increase faster than for softwood plywood but remain less than the softwood plywood price. Prices for nonstructural panels and for paper and paperboard remain relatively stable through 2050.

In the period to 2050, annual U.S. timber harvest is projected to increase 24 percent to 22.4 billion cubic feet. Softwood harvest is projected to increase to 13.7 billion cubic feet and hardwoods to 8.8 billion cubic feet. In addition, the consumption of hardwood agrifiber grows to about 0.1 billion cubic feet. With lumber and plywood composing a decreasing share of total forest products output, virtually all of the projected increase in U.S. harvest is in nonsawtimber trees—trees used for OSB or paper and paperboard. The overall share of harvest from nonsawtimber will increase from 44 percent in 2000 to 66 percent by 2050. The share of total harvest from nonindustrial private land will increase from 61 to 63 percent. Softwood timber inventories will increase by 53 percent, mostly on public timberlands. Hardwood inventories, almost entirely in private forests, will increase by 27 percent. Inventory changes expected for softwoods are similar across regions, but there are differences for hardwoods for which there is a decrease in the South. Over the next 50 years, the species composition is projected to remain comparable to current conditions with the exception that in the South, upland hardwood acres decrease while planted pine acres increase. For the most part, age structure of forests will shift toward a greater proportion of acres in sawtimber with the exception of decreasing sawtimber acres for private hardwood timberland in the South and for private softwood timberland in the West, although in the West, the sawtimber proportion will increase after 2020.

Most (80 percent in 1997) of timber harvest takes place in the Eastern United States. Most of the expected increase in harvest will come from managed stands primarily in the South. By 2050, about 60 percent of the softwood timber harvest from private timberlands will come from plantations (both in the South and the Pacific Northwest West) that occupy about 30 percent of the softwood timberland area and less than 20 percent of the total timberland area.

The proportion of the roundwood harvest consumed in the United States for wood pulp is expected to remain relatively constant at 30 percent; wood pulp capacity is projected to increase modestly by 26 percent after 2010 as paper recycling rates stabilize. Use of softwood pulpwood from pine plantations, and use of recycled fiber are expected to increase.

Canada is expected to provide the primary source of imports (over 75 percent), but imports from other sources also are expected to increase. Canada will provide roughly 30 percent of U.S. softwood lumber consumption over the next 50 years, but imports from other countries (Eastern Europe, the Nordic countries, Southern Hemisphere countries) are expected to increase to 15 percent of U.S. softwood lumber consumption. Canada currently provides 80 percent of U.S. paper and paperboard imports, which amount to 14 percent of U.S. paper and paperboard consumption. Other countries provide imports for 3 percent of consumption. Canadian share of U.S. consumption will increase in the near term to 17 percent then decline to 12 percent by 2050. Other countries' share will increase from 3 to 10 percent of consumption. Imports from Canada of paper and paperboard are projected to continue increasing; imports from Canada of printing and writing paper increase in the near term, then level off; and imports from Canada of newsprint decline. United States imports of printing and writing paper will come increasingly from Europe and Asia. Canadian exports of higher valued printing and writing paper will increase.

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Chapter 4: Alternative Futures

by Darius M. Adams, Peter J. Ince, Richard W. Haynes, Ralph J. Alig, and John R. Mills

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by Darius M. Adams, Richard W. Haynes, Brett J. Butler, Ralph J. Alig, Kenneth E. Skog, John R. Mills, Peter J. Ince, David J. Brooks, and Xiaoping Zhou

Chapter 1: Overview[1]

Introduction

This chapter provides context for the fifth RPA timber assessment (hereafter called the timber assessment).[2] For the past century, national assessments of supply and demand trends for timber have helped shape perceptions of future commodity consumption and have guided discussions of the need for or the effectiveness of various forest policies.[3] The Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974 (amended by the National Forest Management Act of 1976) formalized 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.

We present the results of the fifth RPA timber assessment in six parts. Chapter 1 sets the context for the timber assessment. 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 is a discussion of selected management implications. Chapter 6 summarizes the conclusions and broad implications.

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[1] The authors for this chapter are Richard W. Haynes, David J. Brooks, David B. McKeever, and Kenneth E. Skog.

[2] The past four 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), and the 1993 RPA timber assessment update (Haynes et al. 1995). Hereafter these reports will be referred to by the year such as the 1989 assessment.

[3] Analysis of the demand and supply situation for timber has a history dating back to 1876 (see Haynes 1990). The structure, methods, and much of the historical base developed in earlier assessments, and particularly those immediately preceding, have been carried forward with modifications and refinements.

The map shown on page 254 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[4] unless otherwise noted).

The Context

The context for the timber assessment is set by various factors including how society values forests as a provider of goods and services, the forces shaping demand and supply, the forest products industry, and the relations of the U.S. forest sector to the rest of the world.

Forests as a Provider of Goods and Services

United States forests have always been seen as providers of multiple goods and services. But wood itself remains one of the primary goods. Wood has been long valued for its beauty, utility, and role as an industrial commodity.[5] The wide availability of wood has both increased its acceptance and led to widely dispersed processing facilities. There is also growing recognition that use of wood in place of alternative materials may yield environmental benefits. For example, by using wood in residential construction rather than nonrenewable structural materials such as steel, aluminum, concrete, brick, and plastics, less fossil fuel is consumed in the process. This results in emission of less carbon dioxide. For example, a 1-billion-board-foot increase in timber harvest that is manufactured into structural wood products and used to replace nonrenewable products decreases carbon dioxide emissions by about 7.5 million tons (2.0 million tons of carbon) (Koch 1992).

In the last decade, there has been an expanding awareness of the variety of ecosystem goods, functions, and conditions that are derived from forests. Table 1 (Haynes and Horne 1997) lists indicators of possible ecosystem goods, functions, and conditions. In this sense, “ecosystem goods” are defined as specific components of ecosystems, for example, minerals, timber, forage, mushrooms, huckleberries, salmon, grizzly bears, and grey wolves. “Ecosystem functions” are beneficial processes, such as carbon storage and groundwater recharge. “Ecosystem conditions” refer to systemic, or integrated states people want to find on the land, such as old-growth forests, roadless areas, beautiful scenery, and healthy ecosystems. One difficulty is that today we may not recognize an output that may emerge in the future as having value. Two decades ago, few would have identified the ability to store carbon as valuable ecosystem outputs.

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

[5] Forests serve a variety of uses and functions including scenic, subsistence, industrial, and as spiritual or cultural places (see Brooks 1993 for discussion of these uses at a global scale; see Haynes and Horne 1997 for a discussion at the ecoregion scale).

Table 1—Indicator variables for outputs from FS- and BLM-administered lands suitable for an ecosystem market basket

Indicator variable
Carbon storage
Ecosystem health
Fire risk to life and property
Fish
Game
Minerals
Passive-use values:
Existence of salmon
Existence of other threatened and endangered species
Existence of unroaded areas
Range
Recreation:
Access (roads)
Access to riparian areas
Science integrity
Soil productivity
Special forest and range products
Timber
Visibility
Water quality

Source: Haynes and Horne 1997.

For the most part, wood production and many of the goods and services listed in table 1 are produced jointly. This is especially the case when considering the highly dynamic nature of forested ecosystems. Whereas the timber assessment deals explicitly with timber supply, inferences can be drawn for other goods and services based on perceptions of resource conditions.

Outputs have consumptive uses, nonconsumptive uses, or passive uses. Timber is an example of an ecosystem good with consumptive use value. Consumptive use values can exist for goods traded in markets and goods for which no market exists. Other ecosystem outputs with consumptive uses include minerals, mushrooms, berries, floral greens, wildlife (to hunt), and fish (to catch). People also are interested in nonconsumptive uses that do not reduce what remains for others to enjoy: hiking on trails, viewing scenery, or birdwatching. Still others benefit from passive uses that do not involve direct use. Examples of passive uses are option (knowing a natural resource will be available for personal future use), existence (knowing a natural resource exists even when the likelihood of using it is small), bequest (knowing one's grandchildren will be able to enjoy a natural resource), and stewardship (knowing ecosystems are maintained in a healthy state) (Field 1994). Calls to maintain habitats and protect soils stem from complex motives, including the desire to ensure the availability of consumptive uses (hunting), nonconsumptive uses (birdwatching), and passive uses (maintaining soil productivity, which leaves productive ecosystems for future generations). Both consumptive and nonconsumptive uses can and do take place in a compatible fashion over time at broad spatial scales.

Forces Shaping Demand

The U.S. demand for forest products is varied and large (about 1,800 pounds per person per year), and is shaped by economic forces and evolving consumer tastes. On the economic side, low prices for wood relative to other materials have made wood an attractive material for home and building construction, paper and packaging materials, and as an industrial commodity. The United States, though, is no longer the world's lowest cost producer of wood or wood fiber products; competitiveness further complicated by a strong U.S. dollar has made U.S. products less competitive in world markets and has caused increased imports of wood products to satisfy consumer demands. Because of the abundance and diversity of wood types, consumers value wood in a variety of uses. In addition, wood is the basis for many products ranging from resins to the ubiquitous array of paper products.

For much of the 20th century, public attention focused on understanding the supply, demand, and prices for forest products and how they are influenced by changes in population, income, technologies, and resource conditions. Figure 1 illustrates the nature of these relations for softwood lumber. In the case of Douglas-fir lumber, real prices have nearly tripled since 1920, while consumption has about doubled, but per capita incomes have grown about fourfold between 1929 and 1999. For softwood lumber, at least, it appears that increases in income have offset the negative effects of rising prices yielding growth in consumption. Changes in timber supply are also important in the near term. For example, reductions in Western timber harvest as part of the habitat conservation strategy for the northern spotted owl (*Strix occidentalis caurina*) resulted in reduced overall softwood sawtimber harvest in the Pacific Coast States and lower supply and higher product prices. These higher prices, however, did not reduce the consumption of wood products much, as consumers with higher incomes were willing (and able) to pay the higher prices, and alternative sources of wood products rapidly became available, thus eventually lowering prices.

Forces Shaping Supply

The supply of wood has been shaped by a changing array of forces influencing land use. 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. 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 into the U.S. Forest Service. During the 1890s, domestic concerns about timber supply and the emergence of professionally trained (initially in Europe) foresters led to the first federal forestry efforts. In 1905, the U.S. Forest Service was moved to the U.S. Department of Agriculture where it quickly evolved as a land management agency relying on scientific approaches to meet a variety of societal goals.

Almost from the outset, the development of land management strategies has been based on an understanding of the relations between timber inventories, their attributes, land management objectives, and timber markets. Since World War II, much of the attention has been on the development of explicit forest regulation models (both area and volume approaches) and on the notion of timber availability as a function of an

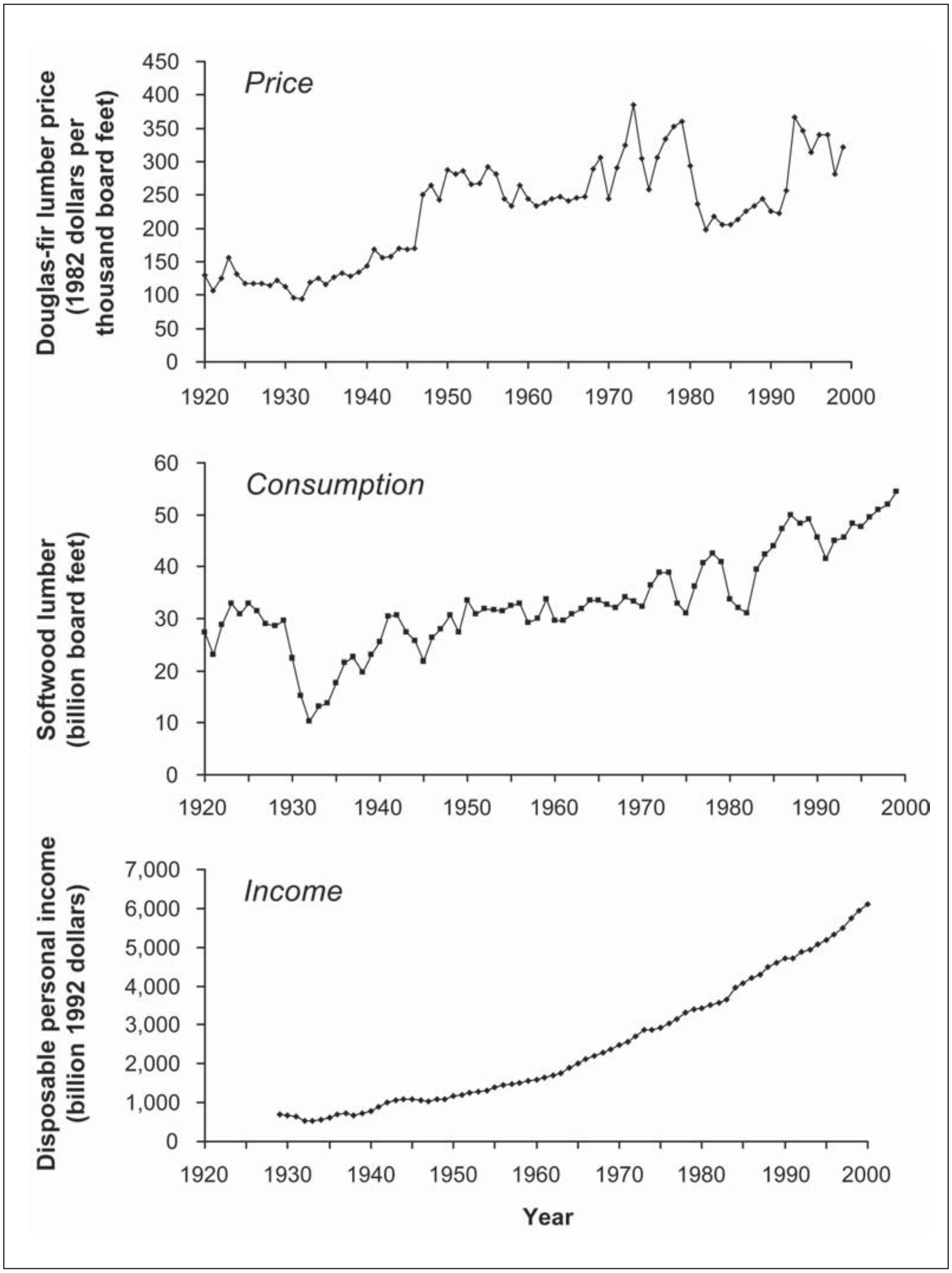

Figure 1—Douglas-fir lumber prices, softwood lumber consumption, and disposable personal income, 1920–1999.

array of stand and market attributes and conditions. In the past 25 years, the development of empirically explicit timber supply relations has evolved to explain the collective behavior of timberland owners relative to economic 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 Importance of the Forest Products Industries

In 1996, more than 18 billion cubic feet of roundwood timber products were harvested in the United States (Howard 2001). These products were valued at nearly $23 billion. Overall, roundwood timber was the second highest valued agricultural crop in the Nation (all timber harvest is regarded here as a “crop” whether or not the trees are grown in plantations). Only corn was higher at $25 billion. Roundwood timber products accounted for 17 percent of the value of all agricultural crops in 1996, which was unchanged from 1986. In 1986, however, timber was the highest valued crop in the United States (McKeever and Howard 1995). Its drop to second highest in 1996 was due largely to the variability in stumpage prices and regional shifts in harvest. In 1986, timber harvest in the Pacific Northwest accounted for 26 percent of total harvest, but 40 percent of total value. By 1996, volume harvested was just 15 percent of the total volume harvested, and 24 percent of the total value. Harvest in the South responded to declining Pacific Northwest harvest levels by increasing from 46 percent in 1986 to 59 percent of total harvest in 1996. Its value, however, increased by just 10 percent from 40 to 50 percent of total harvest value. Overall, the volume of U.S. timber harvested in 1996 was less than in 1986 and consisted of slightly lower valued products. The value of timber fell from 31 percent of all crops in the Pacific Northwest in 1986 (highest value) to just 21 percent in 1996 (second highest). In the South, timber was by far the single highest valued crop at $11 billion. Its value was more than twice that of cotton, the second-highest valued crop in the South. Timber was the fourth-highest valued crop in the North, and fifth-highest in the Rocky Mountain region in 1996, both unchanged from 1986.

The North American industrial classification system (NAICS) defines 21 major manufacturing sectors within the United States. In 1996, in terms of total value of industry shipments, paper manufacturing (NAICS 322) ranked 9th at $153 billion, wood products manufacturing (NAICS 321) ranked 12th at $98 billion, and furniture and related product manufacturing (NAICS 337) ranked 18th at $57 billion. Combined, these timber processing industries accounted for nearly 9 percent of all manufacturing shipments in 1996. Many areas throughout the country rely on timber harvesting and on processing and manufacturing of forest products for major support of local and regional economies. Many people depend on these industries for employment and income and for their contribution to the economic diversity of the communities in which they live. In 1996, employment by the timber processing industries totaled more than 1.8 million, about 10 percent of manufacturing employment. Wages and salaries paid to these employees totaled nearly $47 billion (constant 1992 dollars), more than 9 percent of all manufacturing wages and salaries. Regionally, timber processing industries in the North and South were the single largest employing regions in 1996, with 752,000 and 695,000 employees, respectively. Combined, the North and South regions accounted for 80 percent of all timber-processing industry employment and wages and salaries.

A large and varied forest products sector has evolved within the United States to meet diverse demands. The conversion of standing timber into forest products requires a high level of specialized industrialization. It also requires the timber processing industries to respond to changes in consumer demand and in timber supply. The development of new products and processing technologies helps satisfy existing demands while creating new demands for wood products. New products and technologies use existing wood and paper fiber more efficiently and create new uses for previously unused wood and paper fiber. Improvements in conversion of the forest resource are most apparent in product recovery where new technologies, use of wood residues, and increased recycling have increased the production of forest products from roundwood. Our consumption of wood products is ultimately determined by the mix of solid wood and paper products and the ability of the timber processing industries to convert roundwood and other fiber into usable wood products.

Relations of the U.S. Forest Sector to the Rest of the World

Forests in the United States account for about 6 percent of world forest cover (table 2). World forests cover just under 4 billion hectares (about 10 billion acres) of the Earth's surface, about 30 percent of the land area. This includes all types of forests: closed and open natural forest, forest plantations, and other woodland. Shrub, scrub, and brushland cover about 1 billion additional hectares (about 2.5 billion acres).

Half of the world's forests and 80 percent of the world's population are in Asia, Latin America, and Africa (table 2). 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; in 2000, forest cover (excluding other wooded land) was about 0.6 hectare (1.48 acres) per capita (Gardner-Outlaw and Engelman 1999). This is about one-third of the world forest endowment in the early 1900s. Cumulated across all regions, deforestation has occurred at rates estimated from 0.3 to 0.6 percent per year (11 million to 20 million hectares [27.2 million to 49.4 million acres] per year) in the past two decades, while the world population has grown at more than 1.5 percent per year. Increases in the area of temperate forests have been more than offset by reductions in tropical forest area. Lowland tropical forests account for most of the tropical forest area and tropical deforestation; however, the rate of deforestation is greatest in the dry tropical forest where population pressure and environmental stress are combined.

About two-thirds of the world's forests are in some form of public ownership. Although slightly more than half of temperate forest is in public ownership, nearly all tropical forest is in public or communal ownership. The United States, Japan, and the Nordic countries have relatively higher proportions of private ownership than other developed countries. Ownership patterns affect the mix of forest outputs and the type of management practices. Although public ownership is typically thought to best assure provision of nonmarket goods and intangible forest benefits, private management is recognized as efficiently providing commodity-based forest outputs.

Table 2—Population, population growth rate, and forest area in 2000, and average annual change in forest area 1990–2000, by geographic region

Region	Population		Forest area[b]	
	Total[a]	Annual growth rate, 1995–2000	Total	Average annual change, 1990–2000
	Millions	*Percent*	*Million hectares*	*Percent*
Asia	3,634	1.4	548	-0.1
Africa	767	2.4	650	-.8
Europe[c]	729	0	1 039	.1
North and Central America:	478	1.6	549	-.1
United States[d]	276	.8	226	-.2
South America	341	1.5	886	-.4
Oceania	30	1.3	197	-.2
World	5,978	1.3	3 869	-.2

[a] Data for 1999.
[b] Data do not include "other wooded land."
[c] Includes Russian Federation.
[d] United States is included in North and Central America data.
Source: Food and Agriculture Organization 2001a.

About 3.5 percent of the world's forests are plantation forests (Brown 2000). 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. The plantation forest area increased nearly 40 percent in the past 15 years. Plantations are about 4 percent of the forest area of the temperate zone and less than 2 percent of the forest area of the tropical zone. Plantations are estimated to account for about 6 percent of the forest area of the United States.

Temperate zone plantations, predominantly coniferous species, are mostly managed for industrial wood products. Many of these plantations are the consequence of reforestation rather than afforestation; that is, they generally do not expand existing forest area. Afforestation of idle crop or grazing land (in the United States and United Kingdom, for example) is an exception. 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. In the past decade, production from exotic softwood plantations in New Zealand, Chile, and Australia has increased significantly; these plantations now account for about 3 percent of world coniferous industrial roundwood production—more than three times their share of coniferous forest area. By the year 2020, however, harvests from softwood plantations in the Southern Hemisphere may 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).

Three countries—India, Indonesia, and Brazil—account for 80 percent of plantations in the tropical zone plantations (Brown 2000). More than half of the plantations in the tropical zone were established for purposes other than production of timber; these include plantations for charcoal and erosion control, for example, and agroforestry plantations—joint production of trees and agricultural crops. Tree plantations established for annual crop production in the tropical zone (such as rubber, coconut, and oil palm) also have contributed to the supply of wood and wood products.

In the developed countries, including the United States (which has 0.8 hectare [1.98 acres] per capita of forests), forests are valued for a variety of goods and services that include production of industrial commodities and environmental services (such as maintaining biodiversity and sequestering carbon). In developing countries, forests are predominantly a source of fuel and land for food production, although there is increasing recognition of the role of forests in providing local as well as regional and global environmental services. Nevertheless, differences in basic needs and values contribute to the challenge of finding a basis for global agreements on management and use of forests.

United States per capita wood consumption (72.8 cubic feet in 1999) (Howard 2001) is similar to other developed, wood-rich countries (e.g., 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 (87 percent in 1999) in the form of industrial raw material.

Chapter 2: Assumptions and Methods Used in Projections[1]

Introduction

This chapter provides a summary of major economic assumptions used in this fifth timber assessment with a focus on changes in economic assumptions since the 1989 timber assessment and 1993 RPA timber assessment update, especially those that are important determinants of projected supply and demand for various forest products. These assumptions are key to understanding the results of the timber assessment as they are used as inputs to the model of the forest sector modeling system[2] that we used to develop projections (as described in a final section of this chapter).

In the following discussion, economic assumptions are grouped according to their relation to the demand (consumption) and supply (or production) aspects of the assessment. Demand assumptions include macroeconomic activity; pulp and paper, the context for trade; and fuelwood demand. Supply assumptions include land use, area of timberland, investment in land management by different owners, adjustments for timber removals, and harvest from public timberlands.

Macroeconomic Activity

Projections of population and general economic activity are the foundations for our long-range projections on the demand side of forest product markets and for parts of the supply side as well (table 3). For example, aggregate measures of nationwide economic activity such as per capita gross domestic product (GDP) are central to projections of future demand for fiber products, such as paper and paperboard, that are widely used

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[1] The authors for this chapter are Darius M. Adams, Peter J. Ince, Ralph J. Alig, Brett J. Butler, John R. Mills, David J. Brooks, Richard W. Haynes, Kenneth E. Skog, and Xiaoping Zhou.

[2] Forest sector models are characterized by a systems view of forestry's biological and social processes. The importance of this systems view is that it can be used to explore the interactions between the biological development of forest resources and the attendant dynamics of the forest industry and timber markets over time, and under alternative futures and various forest management strategies. A basic premise is that we can specify various relations that describe (or mimic) biological and social (predominantly economic) processes. See Kallio et al. (1987) for further details.

Table 3—Population, gross domestic product, and disposable personal income in the United States, selected years, 1950–99, with projections to 2050

Year	Population		Gross domestic product		Disposable personal income		Labor force participation rate	Growth in civilian labor force	Growth rate of U.S. labor
		Growth		Growth		Growth			
	Millions	*Percent*	*Billion 1987 dollars*[a]	*Percent*	*Billion 1987 dollars*[a]	*Percent*	*- - - - - - - - -*	*Percent*	*- - - - - - - - -*
1950	152	1.7	1,419	8.7					
1955	165	1.8	1,768	5.6	1,182	7.4	59.2	2.0	3.5
1960	181	2.1	1,971	2.2	1,377	2.4	60.0	1.9	.3
1970	194	1.3	2,874	0	2,413	3.1	61.2	2.6	-2.5
1980	227	1.0	3,776	-.5	2,644	-2.3	65.7	1.9	-2.4
1981	230	1.3	3,843	1.8	2,659	.6	65.4	1.6	.2
1982	232	1.0	3,760	-2.2	2,662	.1	65.3	1.4	-3.5
1983	234	.9	3,907	3.9	2,769	4.0	65.1	1.2	2.7
1984	236	.9	4,149	6.2	2,918	5.4	65.5	1.8	4.3
1985	238	.9	4,280	3.2	2,997	2.7	65.9	1.7	1.4
1986	240	.9	4,405	2.9	3,123	4.2	66.5	2.1	.8
1987	242	.9	4,540	3.1	3,206	2.6	66.9	1.7	1.3
1988	245	.9	4,719	3.9	3,340	4.2	67.1	1.5	2.4
1989	247	.9	4,838	2.5	3,462	3.7	67.5	1.8	.7
1990	249	.8	4,897	1.2	3,528	1.9	68.1	1.6	-.4
1991	252	1.4	4,868	-.6	3,518	-.3	67.6	.4	-1.0
1992	255	1.1	4,979	2.3	3,644	3.6	67.8	1.4	.9
1993	258	1.1	5,135	3.1	3,700	1.5	67.7	.8	2.2
1994	260	1.0	5,344	4.1	3,846	3.9	68.1	1.4	2.6
1995	263	1.0	5,513	3.2	3,954	2.8	68.1	1.0	2.2
1996	265	.9	5,710	3.6	4,064	2.8	68.3	1.2	2.3
1997	268	1.0	5,963	4.4	4,194	3.2	68.8	1.8	2.6
1998	270	.9	6,223	4.4	4,303	2.6	68.7	1.0	3.3
1999	273	.9	6,486	4.2	4,441	3.2	68.8	1.2	3.0
2010	298	.8	8,018	2.4	5,693	1.9	73.8	1.3	1.1
2020	323	.8	9,750	2.0	6,922	2.0	73.8	.9	1.1
2030	347	.7	11,671	1.8	8,266	1.4	74.0	.7	1.1
2040	370	.6	13,889	1.8	9,861	1.8	74.3	.6	1.1
2050	394	.6	16,569	1.8	11,781	1.8	75.7	.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 3). Population projections from Day 1996.

across many sectors of the economy. Likewise, estimates of activity in construction, particularly new residential construction and residential upkeep and alteration, are critical determinants of demand for the solid wood industry.

The macroeconomic outlook underlying these projections is based in part on the U.S. Bureau of the Census 1996 middle series projection of the U.S. population (see Day 1996) and entails the following major developments:[3]

- Labor force growth will decline owing to slower population growth. Labor force growth will average only 0.8 percent over the period 2000 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.
- Consumer price index (CPI) inflation will stabilize at about 3.0 percent per year owing to successful Federal Reserve (Fed) transition policy from deficit to balance in the federal budget and an absence of cost pressures (table 4).
- Long-term real interest rates will be lower because of shrinking federal debt relative to GDP and a higher savings rate from an aging population. Low inflation will reduce the risk premium on long-term bonds, and the term structure of interest rates will flatten somewhat (short-long gap of about 1 percent). Higher savings rates will increase the supply of loanable funds, as will the falling demand for financing the federal debt. The long-term interest rate will drop to 5.5 percent stimulating capital spending and allowing a return to long-term labor productivity growth rates of roughly 1.1 percent.
- Real GDP will grow at 2.0 percent per year on average.

Five related assumptions merit specific mention. First, employment will grow at the same rate as the labor force, and the labor force will grow somewhat faster than the core population, contributing to significant gains in GDP per capita. Business cycles are ignored, so there is no divergence between labor force and employment growth. Labor force growth that is faster than core population growth implies increases in labor force participation rates relative to the past. As noted at a later point, some of this will come through mandated older retirement ages and some through inducements of higher wages. Second, the federal budget will remain in balance, on average, with continued operation of automatic fiscal policy offsets to cyclical shifts and continued decline in federal debt. Third, freed of the need to accommodate shifting federal budget deficits, the Fed will concentrate on controlling inflation with fewer short-term movements in interest rates. Thus, a relatively stable long-term Fed policy is envisioned, and this will contribute to maintaining a relatively strong U.S. dollar, promoting further gains for wood product imports, and weak growth in U.S. exports. Fourth, real crude oil prices will 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 the pulp and paper industry. Between 1982 and 1998, real petroleum import 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 price increases (beginning in 1999) are seen as part of a longer term effort by Organization of Petroleum Exporting Countries (OPEC) to

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[3] 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: Dave Darr, 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.

Table 4—Inflation and interest rates

Year	CPI inflation[a]	PPI inflation[a]	Long-term nominal interest rate[b]
		Percent	
1970	5.7	3.7	6.6
1980	13.5	14.1	10.8
1990	5.4	3.7	8.7
1999	2.2	.9	6.1
2010	3.0	2.5	5.0
2020	3.0	2.5	5.0
2030	3.0	2.5	5.0
2040	3.0	2.5	5.0
2050	3.0	2.5	5.0

[a] Measured as growth in the consumer price index (CPI) for all urban workers. PPI = Producer price index (all industrial commodities).
[b] Yield on long-term government bonds of 10 or more years of maturity.
Source: U.S. Department of Agriculture, Economic Research Service, Commercial Agricultural Division (see footnote 3).

recover the loss in real petroleum prices over the past 20 years and to maintain values in the future. Mineral prices will rise at less than 2 percent and agricultural prices will continue to fall in real terms. Fifth, labor compensation will grow just at the rate of productivity. Despite a continuing tight labor market, wage and salary growth will remain noninflationary.

Population and Labor Force

The growth rate of the U.S. adult population (ages 18 and older) rose steadily after World War II with the emergence and aging of the "baby boomers." It declined episodically over the past two decades as the boomer and post-boomer birth rate fell. In our projections, growth of the adult population declines to roughly 0.6 percent per year by 2040 and remains at that rate through 2050.[4] Despite a declining growth rate, the adult (18 and older) population will still increase by about 46 percent in absolute terms between 2000 and 2050 adding roughly 94 million people to the current adult population.

The core population (ages 18 to 65), a still more restrictive population measure, has significance because it is the pool (at present) from which most of the labor force is drawn. Growth of this group will decline from about 1 percent per year in recent years to near zero by 2025 then rebound slowly. At the same time, the proportion of the population outside the core range, the so-called dependent population, will rise markedly in relative terms. For example, the population age 65 and older relative to the core, will rise from roughly 21 percent in recent years to near 37 percent at its projected peak in 2040. In absolute terms, the number of persons age 65+ will increase by some 44 million between 2000 and 2050, while the core population will grow by about 50 million.

[4] This differs only modestly from projections in the 1989 assessment (the current projection is higher) and mostly in the longer term owing to slightly higher fecundity and immigration assumptions.

These demographic trends imply declining growth in the labor force and, hence, that labor force participation will be a key issue in the long-term future. Labor force participation rose rapidly in the post-World War II period as women moved into the labor force in increasing numbers (see table 3). The projection envisions continued growth in labor force participation, with lengthening periods of working years (retirements beyond age 65), continued growth in female participation, and an increase in the currently static male participation rates (induced in part by rising compensation). The projected rate rises sharply until 2010, then slows in the remainder of the period to 2050. 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 3). By the last two decades of the projection, employment growth drops to about 0.6 to 0.7 percent annually, the lowest rate since the Depression.

Productivity

Labor productivity growth depends on important aggregate supply variables such as the level, quality, and growth of capital stock. Capital stock includes plant and business equipment, human capital, and infrastructure such as schools, airports, railroads, and highways. Research and development and education are important factors contributing to productivity. A growing share of export in GDP has also been associated with periods of high aggregate productivity growth. One explanation is that in periods with above-average productivity growth rates in these sectors, the United States becomes increasingly competitive in world markets for manufactured and agricultural goods, which make up a large share of exports.

Our baseline economic and demographic assumptions, however, do not indicate the probability of above-average productivity growth in the decades ahead, and thus do not indicate the likelihood of significant expansion in U.S. exports or manufactured goods. Expansion of low-cost production capacity in other countries coupled with a strong U.S. dollar that appears unlikely to weaken significantly in the near future makes it appear unlikely at present that U.S. producers will regain competitive advantage in forest products trade any time soon, and thus we project further gains for product imports with little growth in product exports.

Average productivity growth of 1.1 percent is projected over the period to 2050 as indicated in table 3. This is consistent with historical performance and is roughly equal to the average growth of productivity since 1960. Of course, productivity growth has shown marked variation historically. During the 1960s, low real interest rates, tax cuts, and government spending boosted investment. By the 1970s, oil and commodity price shocks, inflation, rising real interest rates, increased expenditures on environmental protection, and a huge wave of inexperienced new workers (the boomers) coming into the labor force had combined to slow it. Tight money and the wave of merger activity in the 1980s acted to offset the otherwise positive effects of the period’s tax cuts, and productivity continued to lag. The projection, although lower than the halcyon days of the 1960s, 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 toward services.

Gross Domestic Product

The rate of growth of GDP is the sum of growth rates of the labor force and labor productivity. As shown in table 3, the labor force and productivity considerations discussed above lead to a projected average post-2000 real GDP growth rate of only 2.0 percent. This is lower than the 1989 assessment update (Haynes 1990) and 1993 assessment (Haynes et al. 1995) projections. It is also substantially below the post-World War II average of 3.1 percent. The primary reason for the lower current projection is the slowdown in labor force growth. Despite marked 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.

Viewed from a broader perspective, the demographic changes that bring an aging population and a slowing of labor force growth may have some profound influences on the structure of the U.S. economy. First, the personal savings rate is likely to rise. Second, the demand for services is likely to grow relative to the demand for consumer durables, again reflecting an aging population. The retiree is more likely to use a home-health care aid than to buy a new car. Third, household formation slows, and thus spending on durables stagnates. Fourth, until growth in the dependent population stabilizes (after 2030), there will be strong pressure for government spending to grow. Should this happen, rising taxation could eat into wage gains and slow growth in disposable income.

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 (table 4). This is a stable inflationary environment (partly why stronger investment and positive productivity growth are foreseen) because it means less uncertainty about the future for investors. The costs of lowering inflation below 3 percent, however, are considerable because of the high levels of consumer and business debt (the burden of the debt goes up sharply with big reductions in inflation). It is assumed that the Fed opts to stop inflation at 3 percent in the long run.

Real long-term interest rates are projected to average only 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). The 1-percent spread is, on average, narrower than that observed over the past 25 years, but consistent with the view that there will be a much lower government-debt-to-GDP ratio, lower inflationary expectations, and a relatively strong U.S. dollar.

Housing

Projections of housing starts and expenditures on residential upkeep and alteration derive from an analysis of household decisions on investment in housing stock. Households are seen as establishing some desired level of investment in housing (change in the value of the housing stock) in each period and the distribution of that investment between new housing or improvement (upkeep and alteration) of the existing stock. Investment in new housing is then translated into the number of new units built and their average size (app. tables 27 and 28). In investment decisions, income at both the individual and household levels is critical as is the age class structure of the population. Income and age structure are also important in decisions on housing type, as are costs of construction, including costs of land.[5]

The projection envisions continued high levels of all types of starts, reflecting in part, growth in the number of households (the rate of growth is declining, but the total increases by nearly two-thirds between 2000 and 2050 or some 71 million additional separate living units). The number of new households will average 1.4 million per year

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[5] Details of the housing model and an analysis of housing forecasts are given in Montgomery 2001.

over the next 50 years, while housing starts will average 1.9 million per year. This compares to 1.3 million new households and 1.8 million housing starts per year since 1963. The gap between housing starts and new households does not narrow in the future as might be expected for two reasons: (1) an aging, but healthy, retired population will be more likely to acquire second homes, and (2) the aging housing stock will require higher than historical replacements of existing units.

Most of the increase in housing starts relative to new households is likely to occur in single-family dwellings, also for two reasons: (1) decreasing proportion of young adults in the population will lead to less demand for multiple-family housing (apartments), and (2) increasing income will increase the likelihood that home ownership will be attainable. The upward shift in the single-family projection in 2010–15 derives from the housing of the "baby boom echo" (children of the boomers). The increase after 2030, in contrast, depends on growth in numbers of second homes and the replacement of older housing units in the stock.

For materials use in residential construction, a key determinant is the average size of units built, usually measured as the floor area per unit. Driven by income and household preferences, the average size of single-family homes has roughly doubled in the past 50 years. The average size of new housing units is projected to continue to increase as a result of increasing household income, but at slower than historical rates. Single-family units will increase from a recent average size of 2,190 to 2,590 square feet by 2050, multiple-family housing from 1,015 to 1,210 square feet, and mobile homes from 1,450 to 1,950 square feet.

Expenditures on residential upkeep and alteration experienced a major jump in the 1980s (app. table 28).[6] This spending is heavily dependent on 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 during the 1986–98 period. After 2030, expenditure per household begins to rise slowly, reflecting continued growth in income.

Assumptions for Pulp and Paper

Determinants of demand for paper and paperboard are highly diffuse in the U.S. economy and in international trade, because paper and paperboard commodities generally serve a broad range of consumer, industrial, and transportation end-use activities. Major end-use activities include transportation and protection of goods in commerce (shipping containers and packaging), communication and information storage (reading and writing), and health and sanitary purposes (tissue and sanitary paper products). Because these end-use activities are widely dispersed throughout the domestic economy, broad indicators of economic activity such as per capita GDP and population serve adequately as general determinants of domestic demands for paper and paperboard. In this analysis, price-responsive domestic demand functions were estimated for all principal categories of paper and paperboard in the U.S. economy. Demand functions

[6] Expenditures are thought to have increased despite the change in reporting methods—which may have accounted for 15 to 20 percent of the upward shift (see Montgomery 2001).

were estimated in relation to per capita U.S. GDP and U.S. population (Zhang 1995, Zhang and Buongiorno 1997). Domestic market substitution of plastics in packaging and electronics in communication were also taken into account via statistical analysis.

Markets were analyzed and projected for all paper products such as newsprint, printing and writing paper, tissue and sanitary paper, and packaging paper, as well as all paperboard products such as containerboard, bleached board, and recycled paperboard. Domestic demands differ among different commodities with respect to population and per capita GDP, with varying potential for product substitution by electronic media or plastics (Zhang 1995, Zhang and Buongiorno 1997).

Pulpwood Demand and Supply

Conventional and projected sources of pulpwood supply in the United States include pulpwood harvest and wood residues. Projected pulpwood supply includes pulpwood harvest on forest land (hardwood and softwood roundwood harvested on forests or forest plantations and delivered to mills in log or chip form), hardwood and softwood residues such as chips or slabs supplied as pulpwood to wood pulp mills from sawmills or plywood mills, and a small quantity of hardwood pulpwood supply from agrifiber plantations (wood from fiber crops such as hybrid poplars or cottonwoods grown on agricultural land). Price-responsive pulpwood supply functions were estimated for roundwood pulpwood from private forest lands in each principal supply region of the Eastern United States (Northeast, North Central, Southeast, and South Central), with separate equations for hardwoods and softwoods, and for forest industry and nonindustrial private forest lands. Supply curves were shifted over time with a direct relation to projected timber inventory and by relations to projected interest rates and regional income. No constraints or other adjustments were applied to the pulpwood supply equations. Regional supplies of pulpwood in the form of wood residues were determined in the projections from projected regional levels of lumber and plywood production (which generate wood residue byproducts). Regional supplies of pulpwood from public forest lands and from timberland in the Western United States were determined by trend analysis.

Conventional and projected pulpwood demands include pulpwood receipts at U.S. pulp mills, roundwood pulpwood receipts at wood panel mills such as OSB (oriented strand board) mills, and pulpwood exports. In this analysis, all roundwood receipts at wood panel mills (such as OSB mills) are regarded as part of the total historical and projected “pulpwood” demand, but pulpwood does not include wood residue receipts at wood panel mills (such as particleboard mills). Nevertheless, the overall timber analysis does account for all wood panel production and all wood residue usage in the U.S. economy (including residues such as sawdust and planer shavings used at particleboard mills).

This timber assessment assumes a continuation of existing government policies such as those related to forest resources, paper recycling, trade, or environmental protection. The projected market equilibrium for pulpwood each year is obtained by maximizing total consumer and producer surplus of the North American pulp and paper sector, subject to production capacity and technology constraints, material balance, trade assumptions, and pulpwood demands for wood panel products (this is discussed in more detail in the projection models section). Production capacities of different manufacturing processes in pulp and paper are projected to evolve gradually over the multidecade projection period, with annual changes in regional capacity favoring the more efficient processes in a continuous response to evolving fiber markets.

Hardwood agrifiber supply—Growing short-rotation hardwood tree crops, such as fast-growing hybrid poplars or cottonwoods on agricultural lands for fiber products, has been developed commercially on a limited scale in the United States, with about 0.1 to 0.2 million acres of agricultural land planted in short-rotation woody crops in the 1990s (less than 0.1 percent of current U.S. cropland area). Hardwood agrifiber plantations on agricultural land have much higher potential productivity than natural hardwoods in forest stands, typically up to five or six times higher, but higher productivity comes at the expense of higher costs. The "base case" analysis evaluated the potential of conventional nonirrigated short-rotation woody crop systems and assumed that hardwood agrifiber supply would have a potential to expand in the future if equilibrium prices for hardwood pulpwood remain high enough to justify the higher costs of agrifiber supply.

A key technical assumption about short-rotation woody crops in the base case outlook was that the biological productivity of such crops relative to productivity of the late 1990s would increase by more than 50 percent in the North and West, and approximately double in the South over the next several decades, through improvements such as genetic engineering and better cultivation techniques. This assumption lowered the assumed competitive cost of delivered pulpwood chips from hardwood agrifiber in the projections, by more than 20 percent in the South for example, but as shown in the results, there was little projected expansion in the equilibrium supply of hardwood agrifiber (and not until late in the projection period when hardwood stumpage prices were projected to increase).

At current productivity for agricultural short-rotation woody crops, real prices required to cover the costs of hardwood agrifiber supply were estimated in this analysis to be about $50 per dry ton of clean chips delivered to roadside in the South, and slightly higher in the North (in 1982 dollars, assuming onsite chipping and debarking). This reflects estimated costs and productivity known to be achievable with such crops based on conventional technology. In this analysis, it was assumed that these costs would be reduced in the future, for example to about $40 per dry ton of clean chips delivered to roadside in the South with an assumed doubling in biological productivity. Agricultural land rent, tree harvesting, and chip transportation costs were not assumed to be reduced by gains in biological productivity, so the savings in delivered chip costs are not directly proportionate to increases in biological productivity. The productivity and cost data assume that agrifiber crops are fertilized periodically and treated chemically to suppress weed competition early in the rotation (this is common practice in conventional poplar plantations, although chemical applications are much lower than in most other agricultural crops). The productivity and cost data assume that the woody crops will not be irrigated (although irrigation is used in a few highly productive plantations in the West and South, affording higher productivity and shorter rotations, but with higher costs per acre).

A review of estimated costs for other potential fiber supply sources, such as the production costs of nonwood agrifiber crops (kenaf, hemp, etc.) and delivered wood costs for imported hardwood pulpwood chips (e.g., from Latin America), indicated that such alternatives would cost more and are therefore less likely to be developed as alternative fiber supplies than domestic agricultural wood fiber crops. However, in any case, we also projected that hardwood pulpwood imports would increase in the projection period from less than 0.5 million cubic meters per year in recent years to around 2 million cubic meters in 2050. Most of the projected increase is assumed to be plantation-grown hardwood pulpwood from Latin America, and most of the increase occurs after 2020 when growth in domestic hardwood pulpwood supplies are projected to become more limited because of declining hardwood timber inventories in the South. Despite the projected fourfold increase, U.S. imports of hardwood pulpwood chips remain less than 1 percent of total U.S. pulpwood supply throughout the projection period. Prospective phyto-sanitary restrictions may limit these imports to Canada or bordering states of Mexico.

Canada—In the baseline projections, pulpwood receipts at Canadian wood pulp mills were assumed to increase from levels characteristic of the past decade (100 to 110 million cubic meters per year) to reach a peak at 125 million cubic meters per year around 2010, and then gradually subside to a level just over 100 million cubic meters by 2050. Wood residues (primarily from Canadian lumber mills) are projected to remain the dominant element of pulpwood receipts at pulp mills in Canada (more than 60 percent). Thus, projected pulpwood supply trends in Canada largely follow projected trends in Canadian lumber production, with residue outputs adjusted gradually downward over time by assumed improvements in lumber recovery efficiency. Roundwood pulpwood harvest in Canada was projected to reach a peak at just over 40 million cubic meters per year around 2010, but then gradually recede back to recent harvest levels of around 35 million cubic meters in 2050. Thus, Canada is projected to remain a significant element within the North American pulp and paper sector. With a strong U.S. dollar and relatively weak Canadian dollar, Canada is projected to remain the largest source of U.S. paper and paperboard imports, although Canadian paper and paperboard producers are not projected to gain dominant U.S. market shares in any major commodity area. With declining U.S. consumption of newsprint in the long run, relatively low production costs, and favorable exchange rates, Canadian producers are projected to increase production and export to the United States of printing and writing paper products and paperboard.

In addition, total U.S. exports of recovered paper increased from less than 1 million tons in the early 1970s to 10.6 million tons in the year 2000. Recovered paper exports are projected to continue increasing, to just over 20 million tons in 2050, as projected U.S. paper and paperboard capacity growth remains relatively subdued by increased product imports. Canada will import a large share of this projected increase in recovered paper exports for use in expanding Canadian paper and paperboard mills.

Context for Trade Assumptions

Trade in forest products has been an important dimension of the U.S. forest sector for more than 300 years. Timber was one of the first natural resources to be exploited in, and exported from, North America. Up to the early part of the 20th century, the United States was a net exporter of forest products; after World War I, a combination of domestic economic growth and expansion of the forest industry in Canada produced a relatively rapid expansion of the forest products trade deficit, measured in both volume (roundwood equivalent) and value terms. In the past three decades, the forest products trade deficit has increased, but it has also been quite volatile, declining to near zero during U.S. recessions.

The United States currently relies on imports for about 20 percent of consumption; at the same time, exports account for about 12 percent of U.S. harvest.[7] The importance of trade differs widely across regions of the country and among forest product commodities. For most of the past 50 years, softwood lumber, pulp, and paper (primarily newsprint), almost entirely from Canada, have dominated U.S. forest products imports. Until

[7] Imports as a share of consumption, and exports as a share of production, based on the roundwood equivalent of all products and raw material traded.

relatively recently, softwood logs and lumber, produced primarily in the Pacific Northwest and going predominantly to Japan, have accounted for a significant share of U.S. forest product exports.

The trade outlook for the timber assessment includes assumptions[8] that some long-standing trends, such as reliance on imports for an important component of growth in U.S. consumption and the importance of Canada as a source for U.S. product imports, will continue.[9] However, the projections also reflect the expectation that there will be changes in the structure and pattern of U.S. forest products trade, based in part on the continuation of trends observed in the past decade or longer. Important changes include a large increase in imports of low-cost non-Canadian forest products, including softwood lumber and hardwood pulp from Latin America and paper products from overseas producers; reductions in softwood log and lumber exports from the Pacific Northwest (most of which took place over 1990–99); generally decreasing hardwood product exports (in relative and absolute terms); and a continuing shift in the composition of trade toward value-added products. Tropical timber products are expected to continue to play a relatively small role in U.S. consumption.

Projected increases in the import share of paper and paperboard consumption followed by relative stability after 2010 reflect a baseline assumption of very little weakening in the exchange value of the U.S. dollar over the next decade followed by static exchange rates for the remainder of the projection period. The import share of total U.S. paper and paperboard consumption rose gradually from 12 percent in the 1970s to 14 percent in 1996, but then it increased much more rapidly to over 17 percent in 2000. It is projected to reach 21 percent in 2010, at which point the import share is projected to become relatively stable at 21 to 22 percent of consumption throughout the projection period. Thus the projections indicate that low-cost foreign producers of paper and paperboard will continue to expand their production capacity and exports to the United States in line with trends since the late 1990s, exploiting and maintaining competitive advantages afforded by the strong U.S. dollar.

The United States is projected to experience little growth in the export share of paper and paperboard production. The export share of total U.S. paper and paperboard production receded from a peak of just over 11 percent in 1997 to around 9 percent in 2000, and the export share of production is projected to remain in the range of 9 to 10 percent throughout most of the projection period with no significant depreciation in the value of the strong U.S. dollar.

A large share of projected expansion in the U.S. imports of paper and paperboard occurs over the next decade, in line with trends since the late 1990s, but after 2010 imports are projected to increase more, in line with projected growth in domestic consumption. Total U.S. imports of paper and paperboard are projected to approximately double over the projection period (from around 17 million tons at present to 24 million tons in 2010 and 35 million tons in 2050). Although Canada is projected to remain the

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[8] The actual assumptions are shown on various tables in chapter 3.

[9] Projections of U.S. trade with Canada are calculated as part of both timber assessment market model (TAMM) (for the solid wood sector) and North American pulp and paper model (NAPAP) (for the pulp and paper sector).

dominant source of U.S. paper and paperboard imports, most of the projected increase in U.S. imports is assumed to derive from capacity expansion among other low-cost overseas producers in Latin America, Europe, and Asia.

World timber supplies are expected to be relatively abundant over most of the projection period, owing in part to more intensive resource management and the expansion of plantation area in both the temperate and tropical forest zones. Expansion of hardwood pulpwood supply (such as plantation-grown eucalyptus) and hardwood market pulp capacity in Latin America and elsewhere is projected to contribute to a significant expansion in U.S. hardwood market pulp imports (from just over 2 million tons per year to over 7 million tons per year by 2050). The projected increase in hardwood market pulp imports will help offset declining hardwood pulpwood supply in the South owing to projected declines in hardwood timber inventory and availability. Expected timber resource availability, worldwide, is also consistent with increased availability of non-Canadian sources of forest products (such as softwood lumber and hardwood market pulp) in U.S. markets.

Some of the trade-related changes are a consequence of domestic resources and polices; some are more directly attributable to broader trends in regional and global economies and the effects of these trends on the U.S. forest sector. For example, trade agreements and accompanying tariff reductions have contributed to world economic growth and to the importance of globalization and free trade for nearly all industrial sectors in most countries. Although the direct effect of tariff reductions on the volume of forest products trade, especially that of the United States, is small by most estimates, effects on both the composition and patterns of trade (trading partners) are somewhat greater.[10] Of much greater importance are the broad effects of market globalization and monetary exchange rates, which clearly have profound implications for U.S. trade in sectors such as pulp and paper.

Fuelwood Demand Projections

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.

National 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).

Roundwood use for fuelwood declined from 3.11 billion cubic feet in 1986 to 2.36 in 2000, but is projected to increase to 3.46 billion cubic feet by 2050 (app. table 29). Industrial, commercial, and utility use of roundwood for fuel is projected to increase steadily from 0.18 billion cubic feet in 1996 to 0.52 billion cubic feet in 2050 owing to increasing nonwood fuel prices for these sectors. Residential use is projected to

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[10] For further discussion, see Bourke and Leitch (1998), Brooks et al. (2001), Tomberlin et al. (1998).

decline, however, from 2.95 billion cubic feet in 1986 to 2.15 billion cubic feet in 2000 then slowly increase to 2.94 billion cubic feet in 2050. The average price for residential fuels is projected to decline through 2020.

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

In the timber assessment, the supply of timber at any point is based on the contributions of four broad groups of timberland owners: national forest, other public, forest industry, and nonindustrial private. Timber harvest from the public landowners is assumed to be set by agency policy as discussed later in this section. Timber supplies from the two private landowners are modeled, in part, as functions of private timber inventory levels and stumpage prices. The methods used to project timber supplies require assumptions relating to timberland area change, trends in future management investment, and the efficiency of harvest utilization. Finally, assumptions are required that define 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

Projections of timber supply and prices are sensitive to the assumptions made regarding future forest area (Alig et al. 1983). These assumptions include changes in area by ownership, forest cover type, and site. Changes in the area of total timberland, ownerships, and forest cover types may not only impact prospective timber supplies, but supplies of water, wildlife, forage, and outdoor recreation as well. Change in total timberland area is the net result of the conversion of timberland to nonforest and the shifting of nonforest to timberland by natural reversion or afforestation. Ownership changes in the timberland base may result in different land management objectives or new owners with different available resources to invest in forest management. Changes in the areas of forest 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 the North, South, Rocky Mountains and Great Plains, and the Pacific Coast regions. Within regions, projections were made for two private forest ownership classes—forest industry (FI), and nonindustrial private (NIPF). Public timberland projections were provided by public agencies. Consistent with the basic assumption of constant current policies in the base projection, the areas of public forest land were assumed to be fixed over the next 50 years. The area projection methods and results are described in more detail in a supporting technical document (Alig et al., n.d.), and are summarized here.

Projecting changes in private land use—Forest area was projected in two steps: (1) shifts in major land uses and (2) changes in area by forest cover type. First, area changes were projected for the major land uses (forestry, agriculture, urban or developed, and other) by region based on land use simulation models (e.g., Alig et al. 1999; Kline and Alig 2001; Mauldin et al. 1999a, 1999b; Plantinga et al. 1999). Changes in private timberland area are attributable primarily to two processes: shifts between agriculture and forestry, and permanent loss of forest area to development. For example, the rate of loss of timberland to developed uses depends on population growth and changes in the real income of individuals. Increasing populations raise the demand for land for residences and places to work and play. In general, as incomes increase, more land is used for living and recreation. Incomes from land enterprises, such as agriculture and forestry, also influence land use changes, and timber price projections from the timber assessment are used in the land use models.

Area changes in timberland reflect the interaction of a number of forces. Timberland conversion takes place as the result of land clearing for agriculture, highways, powerlines, and reservoirs, along with urban development. Public lands can be withdrawn for parks, wilderness, and other recreation uses. At the same time, public forest land can be reclassified as timberland, including cases when new surveys result in revised forest productivity estimates (Smith et al. 2001). Private forest lands that have been acquired for second homes or recreation use contribute to the reduction in timberland. In some regions, additions to the timberland base from idle crop and pasture land have recently been increasing owing, in part, to changes in public dairy programs and other changes in agricultural institutions. Projecting area change requires the consideration of complex economic and social factors. Thus, a mixture of judgment and quantitative models was used to make projections of timberland area.[11]

Although federal farm policy has played a major role in causing land to shift from forestry to agriculture, recent developments may eventually tend to reduce this impact. The passage of the Federal Agricultural Improvement and Reform Act of 1996 (FAIR96) was designed to eliminate agricultural target prices and land retirement programs, except for the Conservation Reserve Program (CRP) (Alig et al. 1998a). Prior to FAIR96, federal commodity policies contributed to maintaining total agricultural supply (stocks plus production) above the quantity that would clear the market at a price acceptable to both agricultural consumers and producers. Target prices provided production incentives in excess of market requirements, and government stock levels were managed with land retirement and demand enhancement programs. The absence of such programs would potentially improve forestry's competitive position relative to agriculture in some cases (Alig et al. 1998a), especially for marginal agricultural lands in the Eastern United States. Annual adjustments in the last half of the 1990s, however, have resulted in significant amounts of traditional program payments to farmers, and any further adjustments are difficult to predict.

The amount of land used for agriculture has a great impact on the amount of timberland available. But even if recent farm legislation does improve the competitive position of forestry relative to agriculture in the decades ahead, it is not clear that large numbers of landowners will switch land uses or enterprises. Historically, most land has moved from agriculture to forestry via a passive route, where farm lands are simply abandoned and revert naturally to forests through processes of vegetation succession. It is true that major afforestation programs such as the Soil Bank of the late 1950s and later CRP resulted in substantial amounts of afforested agricultural land, but these programs have been episodic and largely unpredictable (e.g., Alig et al. 1980).

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[11] Major research studies by region that supported development of area projections by the AREACHANGE system were South—Adams et al. (1996a, 1996b); Ahn et al. (2001, 2002); Alig (1985), Alig et al. (1998a, 1998b, 2001), Hardie and Parks (1997); PNW—Kline and Alig (1998, 2001), Parks and Murray (1994); North—Plantinga et al. (1999). Relations from these studies were incorporated into a projection system similar to that described by Alig (1985). If a research-based equation for a particular land use was not available, projections of area changes in those cases were constructed from expert opinion or other studies (e.g., Alig et al., n.d.; Vesterby et al. 1994, based on the earlier approach of Alig et al. 1990).

Agricultural productivity, agriculture exports, and prices of agricultural crops also influence land use changes (e.g., Alig et al. 1998a). Future agriculture commodity supplies and effective prices, however, are likely to be more closely tied to total harvest (the product of yields times area) than has been the case in recent decades (Alig et al. 1998b). From the macroeconomic forecast, real agriculture prices are expected to continue to decline. Assumptions on the future rate of change in agricultural productivity and associated land incomes were derived from other USDA studies (e.g., Agricultural Outlook for the next 10 years, USDA ERS 2000).

Population changes are a major determinant of future timberland area (Alig and Healy 1987). The Bureau of the Census projects a 126 million increase in U.S. population by 2050 (USDC BOC 1997). The housing projections for the timber assessment estimate that this overall population increase will yield an additional 76 million households over the same period (Montgomery 2001). In the past, each additional household has consumed about 1 acre of land. Thus, if the population forecast is realized, the implications for forestry may be a significant continued loss to urban or developed uses.

The available data show that forests made up more than one-third of rural land converted to urban or developed uses between 1982 and 1992 (USDA NRCS 2001). Americans continue to move to the South and West, with cities such as Atlanta, Georgia, growing much faster than the national average. In addition, some metropolitan areas are becoming denser in surrounding counties, with thinner central cores. The fastest growing one-fifth of U.S. counties were primarily in the South (56 percent), and in coastal areas. The South is seen by both the agricultural and forestry sectors as a region of potential expansion. Rapid population growth in the South, however, raises questions about the compatibility of continued growth in all land uses (Alig et al. 1998b).

Projecting area change in forest cover—The second step in projecting forest area is to develop projections by major forest cover classes. For example, in the South, the five forest cover classes for which projections are prepared for forest industry and nonindustrial private forest timberlands are planted pine, naturally regenerated pine, oak-pine, upland hardwoods, and lowland hardwoods. Forest cover projections are made with Markov chain models (Alig and Wyant 1985; Butler and Alig, n.d.) that use timber harvest probabilities from the TAMM/NAPAP/ATLAS (timber assessment market model/North America pulp and paper model/aggregate timberland assessment system) portion of the modeling system for harvest disturbances. For other disturbance categories, primary data sources were USDA Forest Service's Forest Inventory and Analysis (FIA) periodic forest surveys, American Forest and Pulpwood Association (AF&PA) survey data, and a survey of State Foresters regarding nonindustrial private forest timber management tendencies documented by Moffat et al. (1998a, 1998b). Because projected timber harvests are one of the inputs in the forest cover projections, several iterations with other models in the TAMM/NAPAP/ATLAS/AREACHANGE (timberland area change model) system were required (see fig. 2). Timber harvest probabilities were updated after a TAMM/NAPAP/ATLAS run and fed to the forest cover modeling component. The forest cover projections were in turn fed back to the TAMM/NAPAP/ATLAS component. This linkage reflected the relation between forest investment (e.g., establishment of additional pine plantations) and projected timber prices, where price changes might lead to shifts in timber harvest and subsequently a change in the mix of forest cover types regenerated after harvest.

Changes in area among forest cover types affect both the nature and volume of timber available from forests. For example, decreases in timber production can occur when commercial species are replaced by noncommercial species. Area change projections by

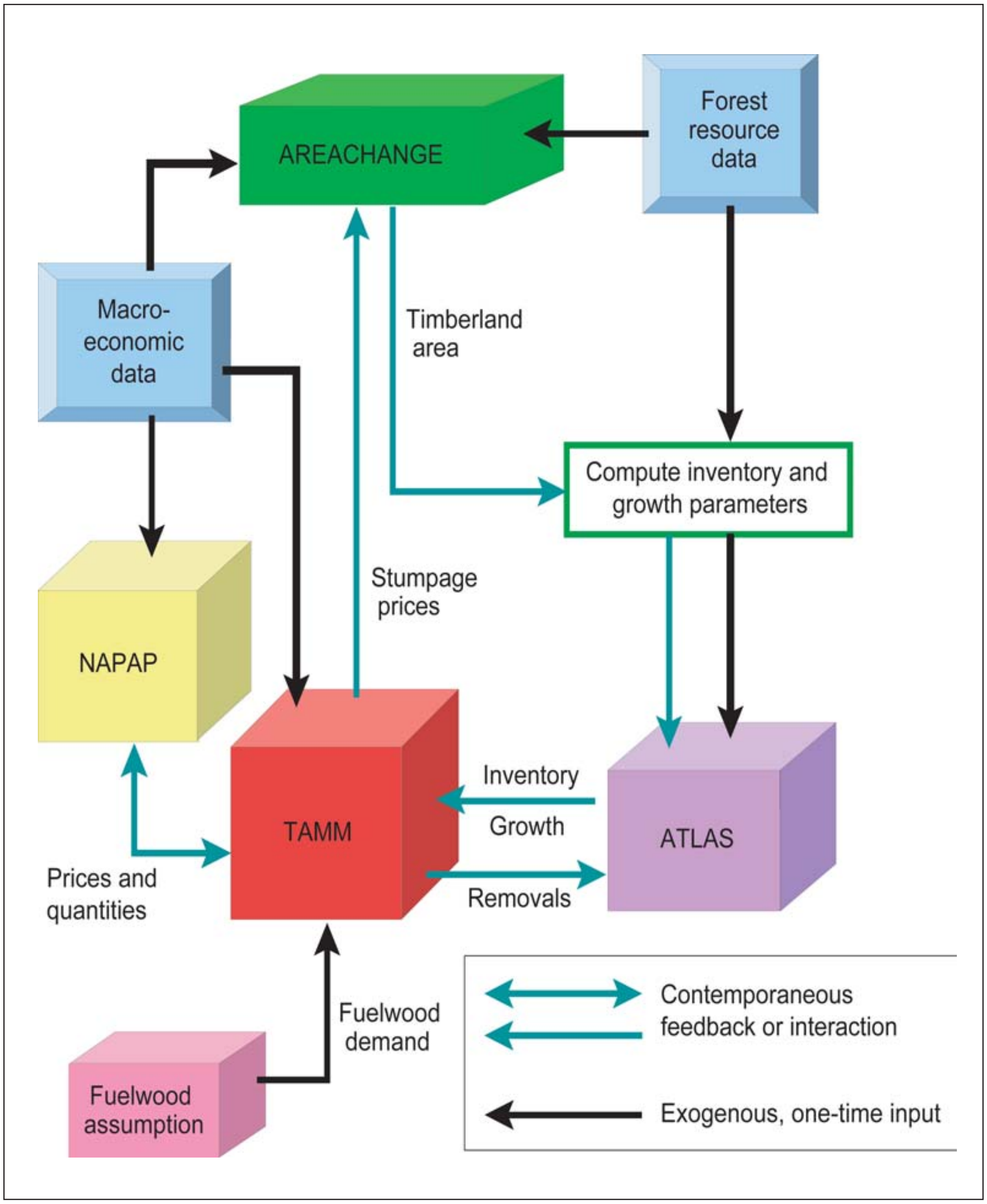

Figure 2—Bioeconomic modeling system for the timber assessment.

forest management type were based on assumptions about the probability that a particular acre will receive a certain type of management and the associated probabilities that an acre so managed will remain in the same forest type or will make the transition to other forest types (Butler and Alig, n.d.).

Forest cover dynamics can be influenced, in part, by the land use changes discussed above and by other human-caused disturbances. Afforestation, such as the conversion of an agricultural field to a conifer plantation, is one important example. Deforestation when land is converted from forest land to nonforest, such as converting a hardwood area to a residential development, is another example of human-caused disturbances that can have significant influences on forest composition. The disturbances also can set back successional trends. Successional processes involving recruitment, growth, reproduction, and mortality are involved in determining interspecies and intraspecies competition and forest stand dynamics. Timber harvests are an important driving force with respect to changes in forest cover types (Butler and Alig, n.d.), and one of the external inputs in modeling forest cover changes was timber harvest probabilities taken from projections by the TAMM/NAPAP/ATLAS modeling system described earlier.

The largest impact on forest cover dynamics in the United States in the recent past has been human influence (Butler and Alig, n.d.), especially changes in management objectives. In the last half of the 20th century, application of intensive forestry in some cases has influenced the composition, structure, and ecological processes of forests. For example, plantations and clearcutting have replaced natural regeneration and selective harvesting on some sites in the United States. Intensive forestry has generally reduced rotation lengths, which increases the probability of more forest cover changes. At the same time, a countervailing trend is seen in expansion in the number of forested acres acquired by private owners for purposes other than timber production. This growth in nontimber objectives and the incorporation of forest lands into residential ownerships have reduced the likelihood of some acres being intensively managed.

Historical Trends in Timberland Area

Area of timberland in the United States steadily declined as the country was settled. From 1800 to 1930, timberland area declined by 300 to 350 million acres (Clawson 1979). Some of the converted forest land was used for urban and infrastructure developments, but most was cleared for agriculture. These land use changes reflected federal policies of the time to transfer the original public domain to private hands to expand agricultural production. The net movement of land between forestry and agriculture has become far less marked with the elimination of the public domain, establishment of permanent federal forest reserves, conversion of most suitable nongovernment forest lands to some form of cropping or pasture, and dramatic improvements in agricultural productivity. Between 1945 and 1992, U.S. cropland area increased by about 2 percent, pastureland area decreased by 11 percent, forest land area decreased by 7 percent, and area in urban or developed uses increased by more than 285 percent (USDA ERS 1995).

Although the pre-1930 trends in intersectoral land shifts have moderated, rural land use remains mutable in the short term. Substantial acreages have shifted back and forth between uses. 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). Between 1930 and the early 1960s, the area of timberland increased by about 50 million acres as the worked-out cotton lands in the South, cleared areas on hill farms in the East, and marginal farms in other regions reverted back to forests. By 1963, the timberland area in the United States reached 515 million acres (table 5). During the 1960s, the upward trend in timberland area was reversed, and by the 1970s the rate of acreage loss began to accelerate. As a result, timberland area dropped to 486 million acres by 1987. Some reduction in timberland area was due to reclassification to wilderness, although the land still retained forests. However, the decadal rate of decline in timberland area lessened to about 2 percent, in part because of surplus crop production in the agricultural sector.

Table 5—Area of timberland in the United States by ownership and region, 1953–97, with projections to 2050

	Historical					Projections				
Ownership and region	**1953**	**1963**	**1977[a]**	**1987[a]**	**1997**	**2010**	**2020**	**2030**	**2040**	**2050**
					Million acres					
Forestland:										
Region—										
North	160.8	165.7	164.2	165.5	170.3	172.1	171.0	168.6	166.2	163.8
South	226.0	228.4	217.0	211.1	214.1	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	144.2	143.8	143.2	142.5
Pacific Coast	227.8	227.4	224.2	221.5	219.3	216.3	213.9	211.6	209.4	207.1
Total	756.2	761.9	743.6	737.8	747.0	745.9	741.7	735.9	729.9	723.8
Timberland:										
Ownership—										
Public	145.4	146.2	138.2	132.4	146.1	146.1	146.1	146.1	146.1	146.1
Forest industry	59.0	61.4	68.9	70.3	66.9	66.4	66.1	65.6	65.2	64.9
NIPF[c]	304.4	307.5	285.3	283.6	290.8	289.6	287.0	284.4	281.0	278.1
Total	508.9	515.1	492.4	486.3	503.8	502.1	499.2	496.0	492.2	489.0
Region—										
North	154.3	156.6	153.4	154.4	159.4	159.4	157.9	155.6	153.1	151.0
South	204.5	208.7	199.6	197.3	201.1	200.3	199.6	199.3	198.6	197.8
Rocky Mountains[b]	66.6	66.9	60.2	61.1	71.0	71.4	71.3	71.2	71.0	70.9
Pacific Coast	83.4	82.9	79.1	73.5	72.2	71.0	70.3	69.9	69.6	69.3
Total	508.9	515.1	492.4	486.3	503.8	502.1	499.2	496.0	492.2	489.0

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] American Indian and Alaska Native lands 1953–2050 are now included in nonindustrial private forest (NIPF); in past reports they were shown in public lands.
Source: Alig et al., n.d.; Smith et al. 2001; only private lands are modeled, and public timberland area is assumed to be constant in the future.

Between 1987 and 1997, there was a net increase in U.S. timberland area of some 18 million acres. Approximately four-fifths of the area increase was on public timberlands, largely owing to reclassification (Smith et al. 2001). Private timberland area increased about 4 million acres, or 1 percent. During 5 years of this period, the CRP was operative, representing one of the Nation’s largest tree planting programs. Under the CRP, trees were planted on about 3 million acres of erodible and environmentally sensitive land, primarily pine plantations in the South. In the North, excess capacity in the agriculture sector resulted in natural reversion of some former agricultural land to trees. At the same time, continued urbanization converted several million acres of forest land (USDA NRCS 2001).

Area Projections by Region

The total area of U.S. timberland is projected to decrease about 3 percent between 1997 and 2050 (table 5). 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 as more resources flowed into the agriculture sector. However, after

1997, reduction in forest land area will mainly result from conversion to other land uses such as reservoirs, urban expansion, highway and airport construction, and surface mining.

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 unknown technological developments, the social acceptability of these innovations (e.g., genetically modified food), and major changes in the agricultural policy environment (Alig et al. 1998b). With FAIR96 proposing to eliminate agricultural target prices and land retirement programs (except for the CRP) and reducing government-held agricultural stocks, U.S. agriculture has potentially been placed on a footing quite different from that of the last 60 years. Agricultural experts are uncertain whether or not heavier reliance on market forces will lead to more fluctuations in agricultural commodity prices (Alig et al. 1998b). The absence of both the land retirement programs and the need to maintain crop base acreage to access price support programs would enable agricultural producers to choose among all potential agricultural production enterprises. Future market prices may be much more dynamic as a result.

Tens of millions of acres of agricultural land, primarily in the South, are suitable for afforestation (Alig et al. 1998a). This includes more than 20 million acres of marginal cropland and pasture in the South, including highly erodible land that could yield higher rates of return to the owners if they planted pine (Alig et al. 1998a, USDA FS 1988). This land is distributed in fairly large acreages across most Southern States. Future fluctuations in relative prices of agricultural and forestry commodities could lead to further cycles of shifts in these lands alternately from forestry to agriculture and back. However, because our baseline projections indicate relatively modest increases in timber stumpage prices (with flat to declining pulpwood stumpage prices for several decades) there is little gain in existing market incentives for afforestation of agricultural land in the private sector. Thus, although we project some expansion in the area of timber plantations, particularly in the South, the projections by no means approach the limits of afforestation in the United States.

North—Projections for the North (table 5 and app. table 30) show a slow declining trend in timberland area. The total timberland area in the North drops from about 159 million acres in 1997 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. Development pressures on northern forests have prompted calls for changes in programs to conserve the northern forest (Northern Forest Lands Council 1994). 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 (Alig et al., n.d.).

Converted timberland area is projected to come largely from nonindustrial private forest lands, with a slight projected decrease in forest industry ownership. In the heavily forested state of Maine, private timberland area is projected to decline by almost 3 percent by 2050, while urban area increases by 56 percent (Plantinga et al. 1999). This is due in large part to a projected population increase of 16 percent by 2050. Timberland area in the Lake States is also projected to decline (Plantinga et al. 1999), as conversions to urban and developed uses dominate natural reversions from former agricultural land.

In 1997, maple-beech-birch and aspen-birch were the most abundant forest cover types on private timberlands in the Lake States, and maple-beech-birch and oak-hickory were the most abundant forest covers 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 (Butler and Alig, n.d.).

South—Projections of changes in southern timberland area (table 5 and app. table 31) show a decline from about 201 million acres in 1997 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, Georgia. 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 (e.g., Ahn et al. 2001).

The projected net reduction in timberland area in the Southeast reflects the direct conversion of timberland to urban and developed uses and other timberland acres 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 fall for agricultural commodities. Further, possible reduction of agricultural subsidies and related programs, owing to the FAIR96 legislation already mentioned, could improve the competitive land use situation for forestry. This is especially true for the relatively large land base of the mid-South, where many acres are suitable for use in either agriculture or forestry.

Private owners control approximately 90 percent of the South's timberland, and this is projected to continue. Area changes among the major groups of private owners have been substantial. Around 20 million acres in nonindustrial private forest ownership have been converted to other uses or transferred to other owners since 1952. Most of this area reduction has occurred on farmer ownerships, and the trend is projected to continue.

Between 1987 and 1997, the area of forest industry timberland declined, while the area of nonindustrial private forest timberland increased. Some of that measured shift can be attributed to changes in corporate ownership and structure designed to eliminate surplus properties, monetize assets, or pay off acquisition debt. Other individual and corporate private owners have acquired many of the timberland acres that were once owned by farmers. The role of timberland investment organizations (TIMOs) and other corporate ownership is projected to increase in size. This is partly due to investment in southern pine timberland,[12] but it is uncertain how all of these corporate lands will be managed in the future (USDA FS 1988, Zinkhan 1993). In this analysis, we assume that these corporate lands will continue to be managed largely in support of industrial

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[12] A survey of TIMO's 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).

forestry objectives as in the past, to produce efficient and expanded output of timber crops and primarily southern pine in the South. Individual owners, the other component of the nonindustrial private forest ownership 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 nonindustrial private forest owner group are projected to reduce their holdings of timberland in the future.

In 1997, forest industry owned about 37 million acres of timberland in the South, 5 million acres more than in 1953. Recent data suggest a slackening in the rate of timberland acquisition by forest industry and divestitures in some cases. Several factors seem to be operating that reduce the attractiveness of industrial ownership of timberland. These include cash flow and tax considerations, other investment opportunities and refocusing of corporate priorities on areas of "core competency" (e.g., production facilities and product distribution as opposed to forest management), 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 forest industry ownership will slowly decrease through 2050. Forest industry area is projected to decrease in the Southeast, which generally has higher opportunity costs for timberland. Most future land acquisitions are expected to be in the South-Central region, which is projected to have a slight increase in forest industry area.

In 1997, 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 (see fig. 3). Over the last 50 years, the largest area changes have been the substantial decrease in the area of natural pine and the increase in planted pine area (Butler and Alig, n.d.). Consistent with this history, the largest projected percentage of change in net area is for planted pine (fig. 3). Planted pine area on private lands increased by more than 25 million acres between 1952 and 1997, more than a tenfold increase. The private area in pine plantations is projected to increase by about 14 million acres by 2050, approximately a 52-percent increase. More than half of the addition of pine plantations would be on forest industry lands. With management intensification on these industrial 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 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) (Butler and Alig, n.d.). Losses include an assumed continuation of trends in substantial hardwood encroachment after harvest of pine stands on nonindustrial private forest lands, which has been raised as an issue for several decades (e.g., Alig 1985, Knight 1973). Gains include reversions to timberland from abandoned agriculture land that seeds 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 or 16-percent loss projected by 2050. The projection represents a change from long-term historical trends for the South (Butler and Alig, n.d.). A combination of factors underlies the projected reduction: conversion to nontimberland uses, conversion to pine

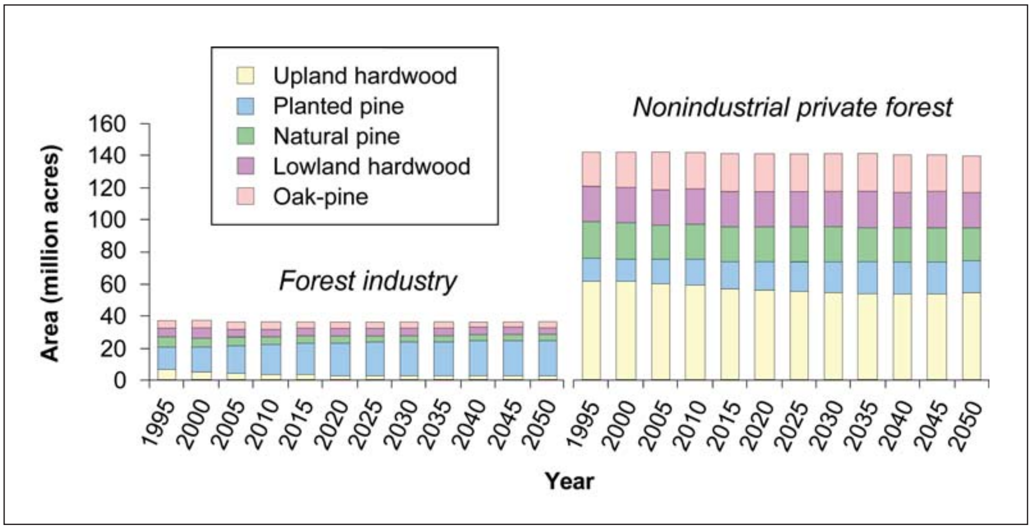

Figure 3—Area of forest cover types on private timberlands in the South, 1995–2050.

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-to-falling softwood prices. Transitions between planted and naturally regenerated stands involve significant amounts of two-way flows, including substantial numbers of harvested pine plantations reverting to naturally regenerated forest types. Based on estimates provided by state forestry offices in the South, roughly 18 percent of upland hardwood timberland on nonindustrial private forest lands were assumed to be unavailable for timber harvest in the future (Moffat et al. 1998a, 1998b).

Rocky Mountains and Great Plains—Total timberland area in the Rocky Mountains and Great Plains is projected to fall slightly from 71.0 million acres in 1997 to 70.9 million acres in 2050 (table 5 and app. table 32). The projected decrease is largely on the nonindustrial private forest 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 dominated 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, whereas area of urban and related uses increases. Pasture and range area is projected to have a downward long-term trend, especially later in the projection period when some CRP grasslands are converted to crop use. Only small relative 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 72.2 million acres in 1997 to 69.3 million acres by 2050 (table 5 and app. table 33). As in the Rocky Mountains, most of the projected reduction is for the nonindustrial private forest ownership (Kline and Alig 2001). 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 physiography, and projected changes are smaller than historical ones. The projected net area changes reflect direct conversion of timberland to urban and developed uses and other acres converted to replace cropland lost to urban and developed uses.

Currently, forest industry 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. Around 4 million acres or 19 percent of the area in nonindustrial private forest ownership was converted to other uses or transferred to other owners between 1953 and 1977. Between 1977 and 1987, around 6 million acres of timberland were transferred from public ownership to nonindustrial private forest ownership in Alaska, resulting in an overall increase of over 4 million acres for the nonindustrial private forest class in the Pacific Coast region. Future area transfers between ownerships are expected to be much smaller, with total timberland area on the nonindustrial private forest ownership projected to drop 15 percent by 2050.

In 1997, the most extensive forest covers on private land were Douglas-fir in the Pacific Northwest West (PNWW) (see fig. 4), Douglas-fir and ponderosa pine in the Pacific Northwest East (PNWE), and mixed conifers and hardwoods in the Pacific Southwest (PSW). The most substantial cover type changes in the Pacific Coast region are projected to occur on forest industry 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 nonindustrial private forest lands are distributed across all forest types.

Management Intensity Classes

Projections of timber growth and inventory were developed by using ATLAS. The resource management assumptions in the assessment were updated in collaboration with American Forest and Paper Association (AF&PA) and the Southern Forest Resource Assessment Consortium (SOFAC). In the South, two landowner surveys were designed, one for forest industry owners who were members of AF&PA and a second to represent nonindustrial private forest owner intentions, which was sent to state foresters. The forest industry surveys were compiled by AF&PA (1999), whereas the responses from the state foresters were compiled at North Carolina State University (Moffat et al. 1998a, 1998b; Siry 1998). A similar process was used in the West for forest industry lands. Western management information for nonindustrial private forest owners was derived from both surveys and recent related work such as the western Washington timber supply study (Adams et al. 1992). The results were translated into parameters for the ATLAS model and linked to the FIA inventories. Review meetings covered the development, distribution, and compilation of the surveys; models for yield regimes that reflected pine plantation management options; land use and cover assumptions; programming enhancements of the ATLAS model; the conversion of survey results to ATLAS input parameters; and preliminary projections. This publication reflects implementation of the Southern assumptions; however, updates to inventories and management assumptions in the West are expected in future analysis.

Projecting growth requires a baseline forest inventory and forecasts of yields, which depend critically on assumptions about future management investment. In ATLAS, the form and extent of management investment are characterized by a set of management intensity classes (MICs), each corresponding to a specific regime of silvicultural treatments. As described in a later section, parameters dictate stand development in terms of net growing-stock volume as the model simulates growth, harvesting, and regeneration. The MIC represents a regional average response for a particular forest type. These

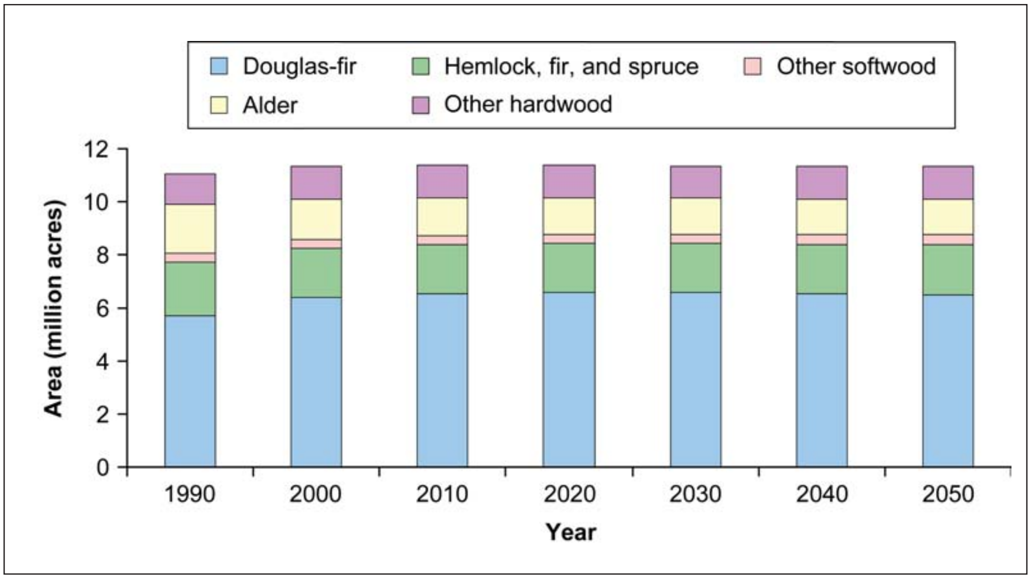

Figure 4—Area of forest cover types on private timberlands in the Pacific Northwest West, 1990–2050.

MICs are initially populated with a timberland inventory derived from FIA plots.[13] Another set of parameters moves area among MICs over time to simulate shifting investment preferences. For the timber assessment, ATLAS was expanded to represent up to 12 MICs for each forest type and site class combination in the major producing regions of the Pacific Northwest West and South. Treatments range from a low-investment custodial land management approach to very intensive higher cost approaches. In regions outside the Pacific Northwest West and South a single, "average" management regime is used. Through time, these MICs project inventory in the context of the demand for wood fiber.

Pacific Northwest West—Management intensity classes were developed for the Douglas-fir and western hemlock forest types as stratified by three site productivity classes. Both forest industry and nonindustrial private owners were assumed to use the same practices; what varied was the amount of area each ownership managed under the various regimes (as discussed later). Five regimes were developed to represent Douglas-fir management: MIC-1, custodial management; MIC-2, planting only; MIC-3, planting and precommercial thinning; MIC-4, planting with genetically improved stock, precommercial thinning, and fertilizing; and MIC-5, all of MIC-4 plus commercial thinning. Growth by treatment differed by site class, age class, initial stocking, and

[13] 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, and 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.

density change parameters. Figure 5 shows a summary of the average projected volume by age for Douglas-fir on forest industry lands when we aggregate across site classes. It can be seen that available volume is reduced by commercial thinning at age 45, which is the first age class that allows final harvesting for industrial stands. Just two regimes were developed for western hemlock: MIC-1, custodial management; and MIC-3, planting and precommercial thinning.

South—In the South, 10 management regimes were identified that represented forest management activities in aggregate across all Southern forests. There were differences between ownerships: the forest industry was assumed to use all 10 regimes, whereas the nonindustrial ownership used a subset. Three of these regimes represented the management of natural stands of softwoods and hardwoods, six were specific to stands of planted pine, and one regime represented timberland not available for harvest.

Planted pine—This forest type received more attention than any other. For the planted pine type on forest industry timberland, five regimes were developed with and without the option to apply commercial thinning, one was a short-rotation regime, and one regime was unavailable for harvest. All were then tailored to represent growth associated with three site productivity classes, which made a total of 36 planted pine MICs for industry owners. The basic plantation regimes were (1) planted traditional—representing stands previously established with regular planting stock and then thinned for stocking control and fertilized; (2) planted low—for newer plantations established with genetically improved planting stock, managed for mixed pulpwood and sawtimber, with no stocking control or fertilization; (3) planted medium—established with genetically improved stock, with stocking control or fertilization; (4) planted high—established with genetically improved stock and then more intensely managed by using both stocking control and fertilization; (5) planted high-plus—established with advanced genetics and using aggressive weed control and fertilization; and (6) short-rotation softwood regime—planted with advanced genetics, aggressive management, with a 15-year rotation. These six regimes were the same across the South except for commercial thinning (in the first five regimes), which was assumed to occur at slightly younger ages in the Southeast. In addition, the unavailable regime represented area not harvested because of operational constraints, environmental considerations, or aesthetic reasons. For the unavailable regime, yields from the planted-traditional (1) were used. Figure 6 shows the aggregate (combining regions and site classes) projected yields in terms of volume by age for the five nonthinned, planted pine regimes.

For consistency, the regimes developed for nonindustrial private forest owners were borrowed from the industrial classes. It was assumed that, on average, these owners are less interested in investment aimed at increasing fiber production than are the forest industry owners. The regimes were identified as low, medium, and high and assumed to have the same yields developed for the industrial regimes (1), (2), and (3). Like the industrial regimes, each had a commercial thinning counterpart. The unavailable class was also present, represented by the low yield table.

Another difference between the assumptions for nonindustrial private forest and forest industry lands in terms of growth and yield was the assignment of a lower regeneration stocking percentage to the nonindustrial private forest ownership. The Southern nonindustrial private forest ownership was modeled as two separate subowners; FIA categorizes these as farmer and other private, and miscellaneous corporate. The initial regeneration stocking percentages were tiered; because the miscellaneous corporate owner includes companies with objectives similar to industry, their productivity was

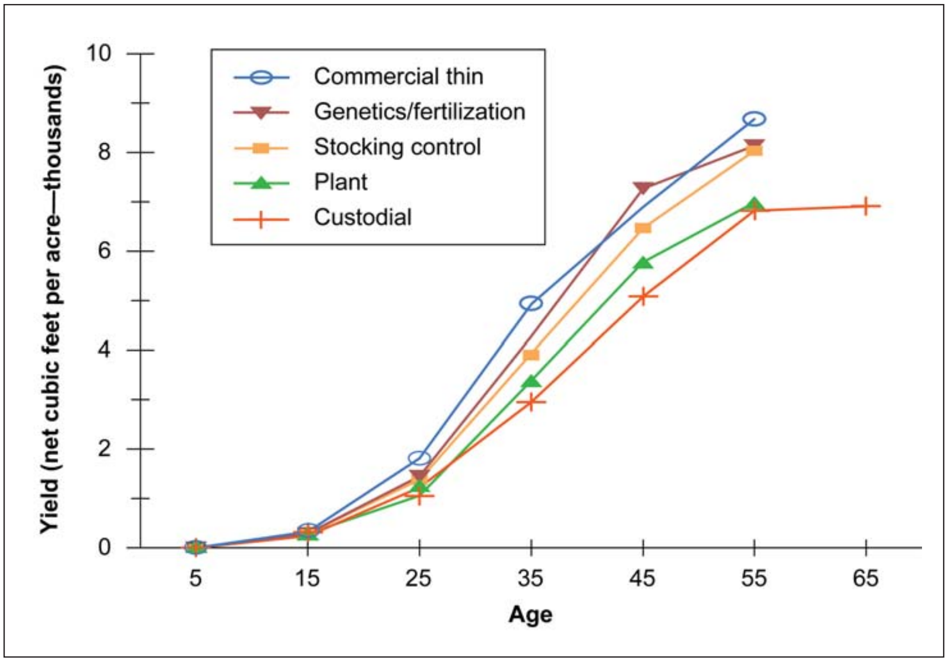

Figure 5—Projected average Douglas-fir yields in the Pacific Northwest West on forest industry timberlands, by age and management intensity class.

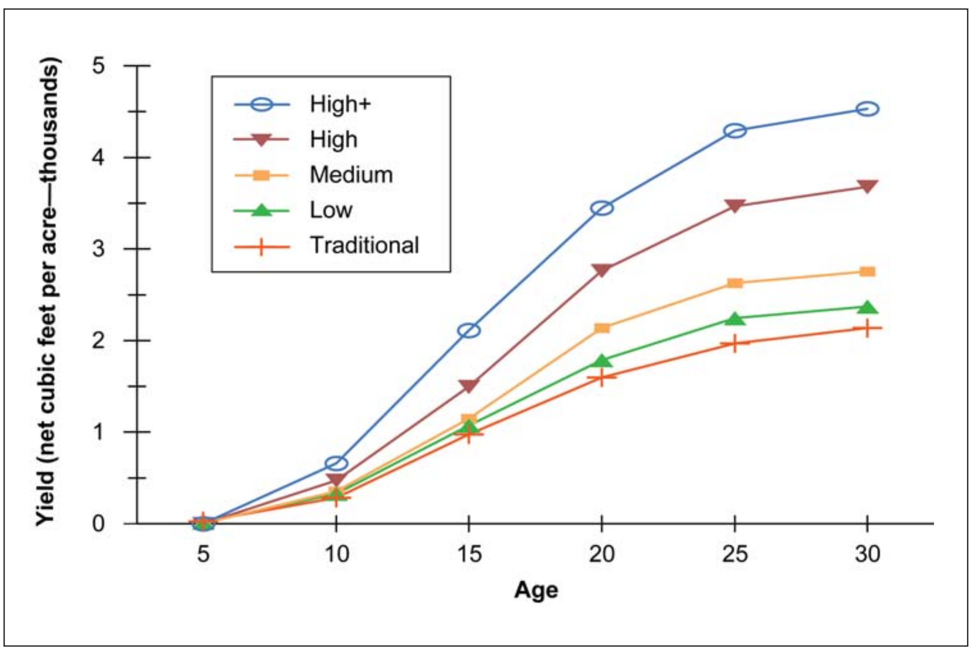

Figure 6—Projected average planted pine yields (with no commercial thinning) on Southern forest industry lands, by age and management intensity class.

assumed to fall between the traditional farmer and other private and the industry owners. Figure 7 shows the regional average planted-pine yields. It can be seen that these yields are slightly higher than comparable industry values; differences can be attributed to a greater proportion of nonindustrial private forest acres in high site classes, higher initial stocking (from older existing stands), and generally longer rotation ages that allow a greater proportion of acres to reach age 30.

In figure 8 we can see the effective difference management intensity has in terms of growth. From this perspective, the difference between ownerships is more obvious, and within a regime we can see the range dictated by site productivity class. Although both owners carry about 30 percent of their area in the high site class, the majority, between 65 and 70 percent, is in the medium class. As can be seen in the projected yields, industry can potentially improve production over a range that exceeds 100 percent whereas nonindustrial private forest options are more limited.

Southern natural pine, oak-pine, upland, and lowland hardwoods—Management regimes were also developed for the remaining four Southern forest types. In general, it was assumed that these forest types are naturally regenerated and receive less investment than planted pine. The MICs represent either a low, a high, or an unavailable regime, where low assumes no treatment and high includes investment to improve growth, such as precommercial thinning or fertilization. The only exception was a high-plus regime developed for natural pine in the nonindustrial private forest ownership. As for the planted pine regimes, each regime included a commercial thinning or partial harvest option. The difference in yield between the low and high regimes ranged between 15 and 20 percent.

The MICs for forest industry were (1) uneven-age management, low intensity, selective harvest (partial cut); (3) custodial even-age management, natural regeneration with no treatments; (4) MIC-3 plus commercial thinning; (5) natural regeneration with some precommercial thinning, fertilization, or both; (6) MIC-5 plus commercial thinning; and (12) unavailable, (assuming MIC-3 yield). The nonindustrial private forest ownership included (1) low, even-age management; (2) low, uneven-age management; (3) high, even-age management; (4) high, uneven-age management; (5) high-plus, even-age management; (6) high-plus, uneven-age management; and (12) unavailable, (assuming MIC-1 yield). The high-plus classes, MIC-5 and MIC-6, were implemented for only the natural pine type.

Allocation to Management Intensity Class

As a projection proceeds, lands move in and out of the timberland base, various forms of harvest occur, growth is applied as forests advance in age, and land to be regenerated is allocated among the MICs. The future allocations differ by region, owner, forest type, and site class, but a general assumption is that over time, the private owners will increase the proportion of area under management. The models used for our projections do not have a formal price-feedback mechanism; that means the allocation schedule of regeneration by MIC is set ahead of time and not based on “real time” projected prices. There is an informal feedback where price projections are used to “fine tune” the allocation, such as reducing the rate of shift to the highest investment levels should stumpage prices be falling. As the projection progresses, this process shows us the results of today’s assumptions in terms of the way forests will be managed in the future.

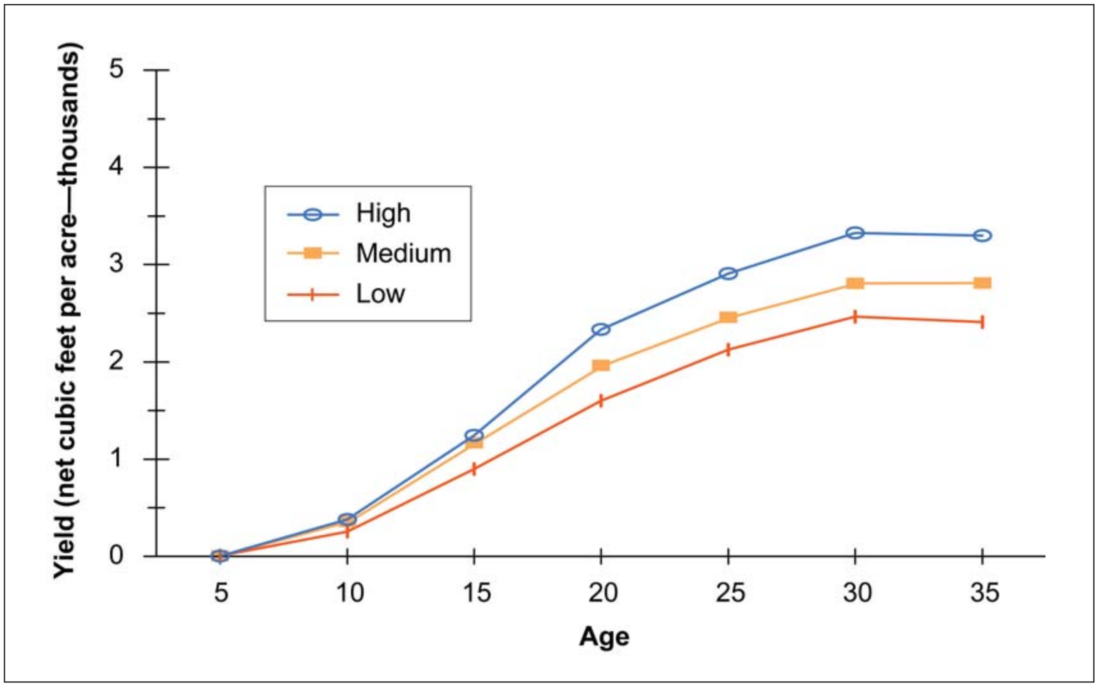

Figure 7—Projected average planted pine yields (with no commercial thinning) on Southern nonindustrial lands, by age and management intensity class.

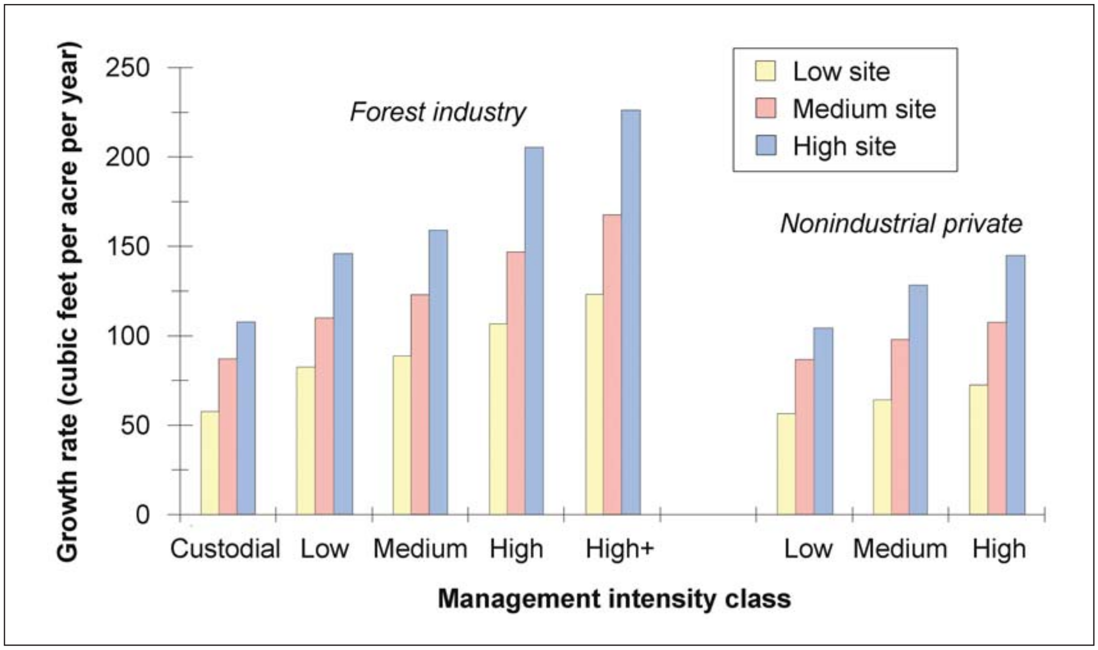

Figure 8—Average annual growing-stock growth rates projected for nonthinned stands of Southern planted pine, by owner, management intensity, and site productivity class.

Pacific Northwest West—The Douglas-fir and western hemlock forest types account for almost 90 percent of all forest industry softwood timberland and 82 percent of nonindustrial private forest softwood timberland in the Pacific Northwest West region. As the projection proceeds, regeneration following harvest generally is at higher levels of investment. As illustrated in figure 9, over time this regeneration strategy shifts area out of the custodial class toward the higher investment to the right. By 2020, the biggest shifts have occurred; the area in the second-highest class has nearly doubled, accounting for over 40 percent of all softwood timberland in the forest industry ownership but just 15 percent of nonindustrial private forest softwood acres. In the last 30 years of the projection, the distribution among forest industry owners holds constant, with only 13 percent of their Douglas-fir/western hemlock acres in custodial management, whereas slightly over half of the nonindustrial private forest acres remain there. The nonindustrial private forest ownership also experiences a slight reduction in the more intensive management classes by 2050. Considering the ownership as a whole, however, just 39 percent of all softwood acres were predicted to be under a form of management by 2050.

Not explicitly shown are area changes to the timberland base. The forest industry ownership is predicted to gain 18 percent in Douglas-fir acres and lose 14 percent of hemlock for a net increase of 480,000 acres by 2050, while the nonindustrial private forest ownership gains 163,000 acres, two-thirds of which are in the Douglas-fir forest type.

South—In the South, the planted pine forest type accounts for nearly 60 percent of forest industry softwood area at the start of the projection increasing to 75 percent (a shift of 7.6 million acres) by 2050. Although the nonindustrial private forest ownership begins the projection with nearly as many acres of planted pine as industry, natural pine and oak-pine make up over three-quarters of nonindustrial private forest softwood timberland. The nonindustrial private forest owners are predicted to shift 5.6 million acres to planted pine, and by 2050, still two-thirds of the acres will be in the other softwood types. As shown in figure 10, both owner types are projected to aggressively manage planted pine. For the forest industry ownership, investment moves most future stands into the high or high-plus levels of management (the largest share to high-plus with commercial thinning). This trend is in line with traditional industrial forestry objectives, to produce efficient and expanded output of timber crops, primarily southern pine. We assume that this objective will be maintained on forest industry lands despite projected periods of flat to declining pulpwood stumpage prices for several decades. Indeed, the projected market outcome reflects in large part the achievement of industrial forestry objectives (abundant supplies of fiber resources for decades to come), but it also reflects impacts of projected trends on the demand side, including decelerating paper and paperboard demands, rising product imports, and a period of relatively stagnant pulp mill capacity over the next decade. As shown in figure 10, the shift in nonindustrial private forest planted pine is not as dramatic; the medium management intensity class holds steady, and the high class experiences a 150-percent increase in area (coming from the gain in planted pine acres). Although much smaller, the unavailable class also more than doubles in area. These are acres planted with pine for reasons other than timber production. Although management objectives for nonindustrial pine plantations may not necessarily 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.

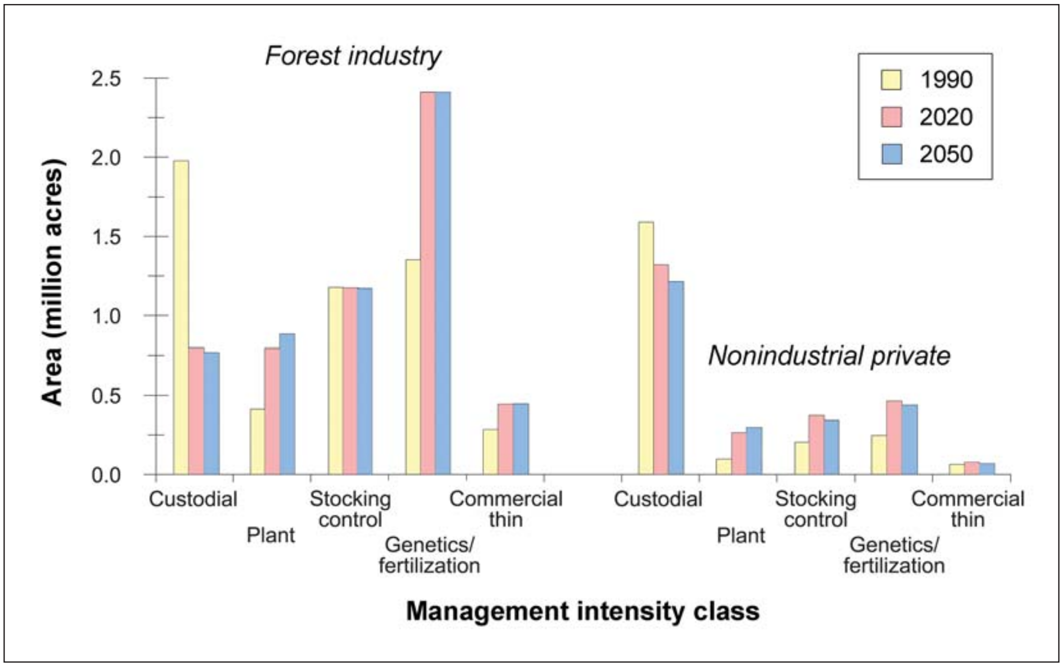

Figure 9—Combined projection of Douglas-fir and western hemlock acres by management intensity class in the Pacific Northwest West region by two ownerships and three points in time (all sites).

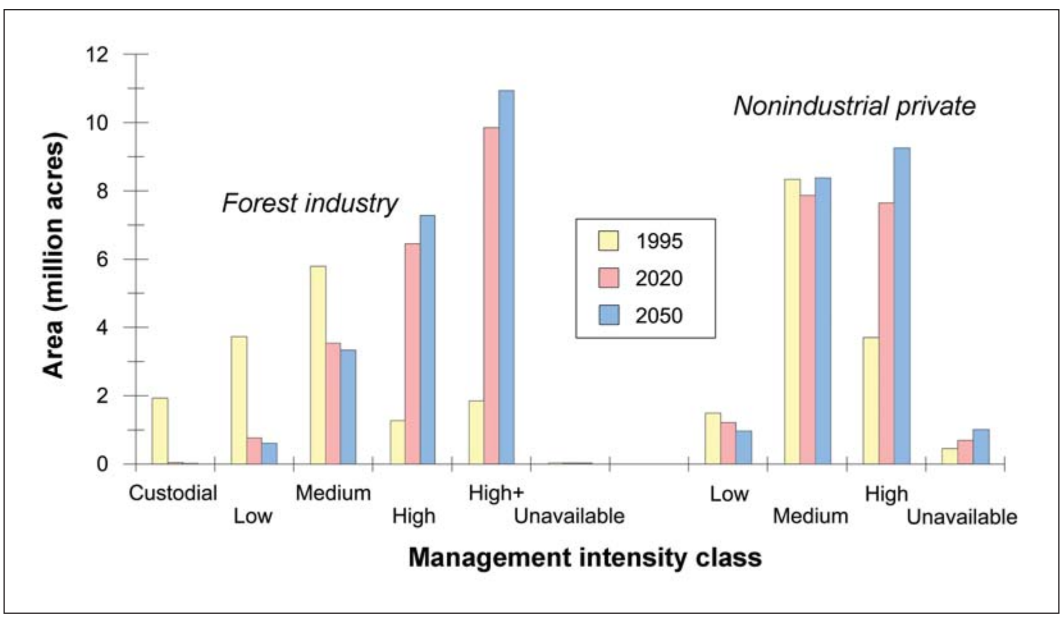

Figure 10—Southern planted pine acres projected by owner and management intensity class showing three points in time (all sites).

Shifts in management among the remaining forest types can be seen in figure 11, where forest industry carries a much smaller relative share of the timberland area. What also can be seen in figure 11 is the net loss of area that occurs in these forest types. Overall, the industrial stands, other than planted pine, lose 38 percent of their area by 2050 (8.6 million acres). Most of this change is not a loss of timberland, but a shift, or conversion, to the management of pine. The greatest loss, or shift, takes place in the upland hardwood type, which shows a 59-percent reduction in area (3.4 million acres). The natural pine type is reduced by 35 percent (2 million acres). There is significant shifting within natural pine, however, as the area in the low-level-partial-cutting regime doubles. Shifting to higher intensity management does occur, but the movement out of these types masks the change. Although it is hard to see in the graph, the unavailable class for industry increases by about 500,000 acres.

The largest shift in management of the remaining forest types occurs on timberland in the nonindustrial private ownership. Although this ownership experiences a loss (or conversion) of 2.1 million acres of natural pine and 7.6 million acres of upland hardwoods, this is less than 8 percent of the area in types other than planted pine. The shift to managed stands outweighs the loss of area, as area managed under the high regime more than doubles. Of significance for this ownership is a 10-million acre increase in area of the unavailable class. Most of this increase is from the upland hardwood forest type, and it reflects the opinions of state foresters that in the future, a sizeable area would not be managed for timber production.

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 the various summary tables in the appendix. Wood used to produce forest products comes from growing stock and nongrowing-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 nongrowing-stock sources, such as dead timber or trees harvested from nonforestland such as urban areas. Other removals include noncommercial thinnings, timber lost through changes in land use, and withdrawal of timberland for parks, wildernesses, and other nontimber uses. Timber removals from growing stock are computed by subtracting the removals from nongrowing-stock sources from projected total timber harvest, then adding the other components of removals—logging residues and other removals. The data for these three adjustments are derived from the timber product output tables given in Powell et al. (1993), Smith et al. (2001), and Waddell et al. (1989).

Logging residues—Logging residues have always been an important component of timber removals, although they have been declining during the past 50 years as a percentage of the total (table 6). These declines largely reflect the effects of rising stumpage prices that have made it economical to remove more of the lower quality material that previously was left as logging residues. Technological innovations such as in-woods chipping and rapid growth in the demand for wood in the pulp industry and for both residential and industrial fuelwood have also contributed to the increased utilization.

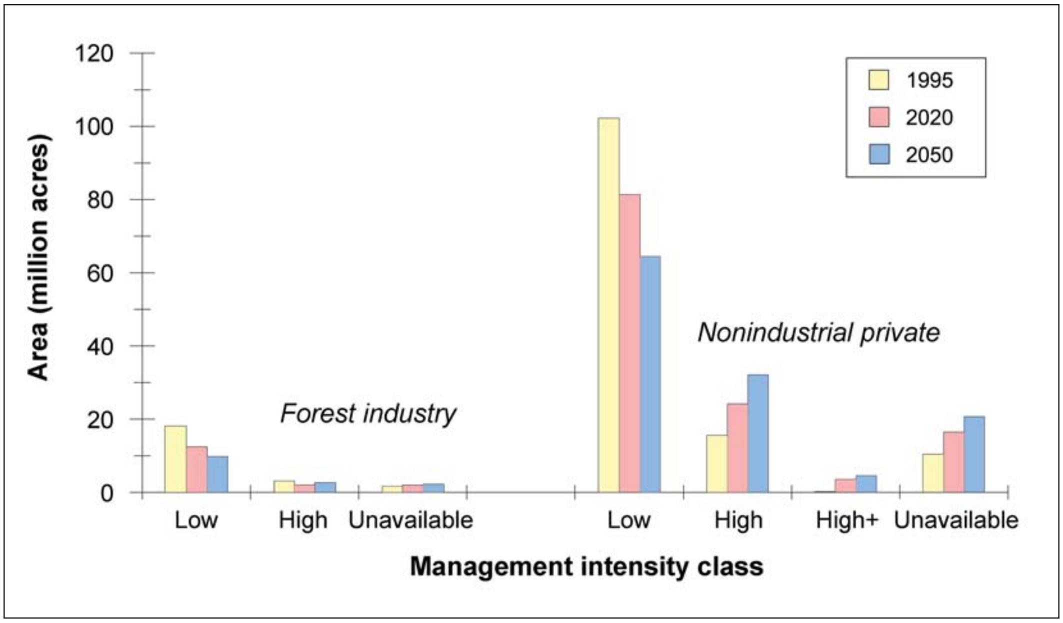

Figure 11—Southern acres of natural pine, oak-pine, and hardwoods projected by owner and management intensity class showing three points in time (all sites).

For the projection period, it has been assumed that logging residues from softwoods will decline slightly or remain constant as a percentage of product removals from growing stock (table 6). Logging residues from hardwoods decline more (table 6) reflecting the trends of the past two decades. In general, the shift to the harvest of second- and third-growth timber in the West and increased use of hardwoods for pulping and fuelwood are expected to contribute to the improved utilization as are anticipated improvements in felling and bucking practices. Projected declines reflect cases where there is intensified competition for wood fiber that results in increased use of smaller stems, chunks, and low-quality stems for fuelwood and pulpwood. Increased tree-length logging and in-woods chipping of pulpwood and fuelwood also will reduce residual formation.

Other removals—The part of timber removals classified as other removals is composed of (1) 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; and (2) timber removed in cultural operations such as noncommercial thinning. The historical data on other removals are estimates of actual volumes for the indicated years (Powell et al. 1993, Smith et al. 2001, USDA FS 1982, Waddell et al. 1989). These estimates do not include removals associated with the reclassification of timberland to wilderness or other reserved uses as they do not take place on a regular basis and do not involve timber harvesting. Projections of other removals are reflected indirectly in the assumptions about changes in land use and cover (see table 5 and the associated discussion) and assumptions in the inventory projection system about the proportion of harvest that comes from timberland projected to change land use.

Timber supplies from nongrowing-stock sources—Part of timber harvest comes from salvable dead trees, rough and rotten trees, tops and limbs, trees in urban areas, fence rows, and from forested lands other than timberland. The proportion of harvest

Table 6—Logging residues as a percentage of timber product removals from growing stock in the United States, by softwoods and hardwoods and region, 1952–97, with projections to 2050

	Historical							Projections				
Ownership and region	**1952**	**1962**	**1970**	**1976**	**1986**	**1991**	**1997**	**2010**	**2020**	**2030**	**2040**	**2050**
						Percent						
Softwoods:												
North	11.5	11.0	10.8	11.0	4.6	4.6	4.7	4.6	4.6	4.6	4.6	4.6
South	6.6	6.3	6.9	5.9	6.7	6.1	6.0	5.9	5.9	5.8	5.8	5.7
Rocky Mountains	10.9	10.9	11.1	11.0	10.8	9.3	9.0	8.9	8.9	8.8	8.8	8.7
Pacific Coast[a]	12.2	11.7	12.5	10.2	12.6	9.7	7.0	6.9	6.9	6.8	6.7	6.7
United States	9.8	9.6	10.0	8.4	9.0	7.5	6.4	6.3	6.2	6.1	6.1	6.0
Hardwoods:												
North	15.8	15.3	15.2	17.2	9.9	9.9	11.2	11.1	11.0	10.9	10.8	10.7
South	25.9	24.4	22.6	16.6	15.6	13.6	13.7	12.3	11.2	10.2	9.1	8.0
Rocky Mountains	(*b*)	(*b*)	(*b*)	25.0	19.7	8.5	8.3	8.3	8.3	8.3	8.3	8.3
Pacific Coast[a]	28.6	26.0	27.4	25.2	7.2	9.0	5.0	5.0	5.0	5.0	5.0	5.0
United States	22.2	20.7	19.7	17.1	13.2	12.0	12.4	11.6	10.9	10.2	9.6	9.0

[a] Includes Alaska.
[b] Hardwood timber harvests are too small for accurate estimation of logging residues.
Source: Historical data: Powell et al. 1993, Smith et al. 2001, Waddell et al. 1989.

originating from softwood nongrowing-stock sources dropped between 1952 and 1976 (table 7). The hardwood supply showed a similar trend until the early 1970s. Timber product output from nongrowing-stock sources rose from 6.9 percent in 1976 to 9.3 percent in 1997 for softwoods, and from 14.0 percent in 1976 to 25.0 percent in 1997 for hardwoods. These changes are almost entirely explained by the rapid increase in the use of fuelwood in the late 1970s and early 1980s and the growing use of pulpwood over the two decades.

There are regional trends that differ noticeably from the general U.S. trends. In the 1950s, the old-growth forests on the Pacific Coast and in the Rocky Mountains contained large volumes of salvable dead timber leading to relatively higher levels of nongrowing-stock timber. During the 1980s, increasing use of lower quality materials for chips and fuelwood increased the proportion of softwood timber supplies coming from nongrowing-stock sources on the Pacific Coast. This trend is expected to remain high relative to that in the South. This is especially noticeable in the Rocky Mountains where nongrowing-stock sources provided 4.5 percent of the softwood supply in 1976, 11.9 percent by 1986, and 23.4 percent in 1997.

In the North, nongrowing-stock sources provided about 12.6 percent of the softwood timber supplies in 1976. This increased to 27.4 percent in 1986 and declined slightly in recent years. The proportion of softwood nongrowing-stock output in the South is low—5.0 percent in 1976 and 6.2 percent in 1997. In both cases, these proportions are projected to remain about constant over the next five decades.

Table 7—Timber product output from nongrowing-stock sources as a percentage of timber supplies in the United States, by softwoods and hardwoods and region, 1952–97, with projections to 2050

Ownership and region	Historical							Projections				
	1952	1962	1970	1976	1986	1991	1997	2010	2020	2030	2040	2050
							Percent					
Softwoods:												
North	13.3	12.6	12.6	12.6	27.4	26.7	22.8	23.3	23.8	24.2	24.6	25.0
South	8.4	8.7	4.5	5.0	4.0	5.3	6.2	6.2	6.1	6.1	6.0	6.0
Rocky Mountains	5.8	5.6	4.7	4.5	11.9	14.5	23.4	23.8	24.1	24.4	24.7	25.0
Pacific Coast[a]	12.4	11.6	8.9	8.6	17.4	17.2	9.2	9.4	9.5	9.7	9.8	10.0
United States	10.4	10.0	7.0	6.9	11.5	11.9	9.3	9.2	8.9	8.7	8.6	8.5
Hardwoods:												
North	23.5	17.7	11.9	16.5	51.8	49.4	33.6	36.4	38.5	40.7	42.8	45.0
South	19.0	18.9	13.9	11.9	21.9	22.7	18.9	19.2	19.4	19.6	19.8	20.0
Rocky Mountains	(*b*)	(*b*)	(*b*)	(*b*)	79.7	74.0	75.1	75.1	75.1	75.0	75.0	75.0
Pacific Coast[a]	14.3	11.5	6.1	11.3	46.2	52.8	36.0	36.0	36.0	36.0	36.0	36.0
United States	20.9	18.5	13.9	14.0	38.5	37.5	25.0	25.7	26.7	28.1	29.5	30.8

[a] Includes Alaska.
[b] Hardwood timber harvests are too small for accurate estimations of output originating from nongrowing-stock sources.
Source: Historical data: Powell et al. 1993, Smith et al. 2001, Waddell et al. 1989.

Hardwood forests contain large volumes of rough and rotten trees and tops and branches. Hardwoods also make up most of the urban forest, fence rows, and other similar sources of nongrowing-stock timber supplies. As a result, a substantial fraction of hardwood roundwood supplies, 25.0 percent in 1997, comes from nongrowing-stock sources. The increasing demand for fuelwood and improvements in techniques for harvesting and processing hardwood for pulp and paper that occurred in the early 1980s resulted in nongrowing stock being an important and, in most regions, a growing part of hardwood timber supplies.

National Forest Harvest Levels and Inventory Projections

Harvests from timberland within the national forests decreased in the 1990s as a result of changes in the goals for federal land management. Under the base case assumption of continuation of current policies, national forest harvest is projected to continue at these lower levels for the next five decades, representing expectations based on current Forest Service policy guidelines. Harvests do rise slightly in some regions reflecting actions to maintain forest health consistent with current regulations. Historical and projected levels of total national forest softwood harvest are shown in figure 12 and in appendix table 34; hardwood harvest is shown in appendix table 35.

Projected national forest softwood harvest in 2010 is less than one-fourth of the level assumed in the 1989 assessment projection (498 million cubic feet compared to 2,180 million cubic feet) and is about 53 percent of the level assumed in the 1993 assessment. The 1989 assessment projected national forest softwood harvest of 2,315 million cubic feet in 2040 compared to the current projection of 733 million cubic feet. The largest reductions in timber removals from 1989 and 1993 assessment projections are for the Rocky Mountains and West Coast regions.

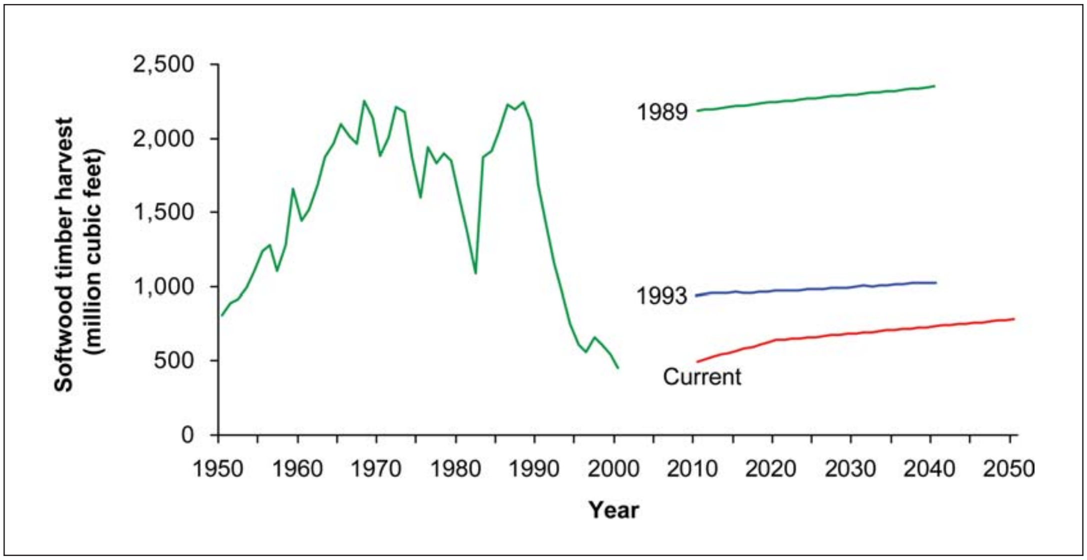

Figure 12—National forest softwood timber harvest comparing 1989, 1993, and current RPA timber assessments (excluding Alaska).

National forest inventory projections are shown in appendix tables 34 and 35. These projections were developed by using the ATLAS model (Mills and Kincaid 1992) in a manner similar to that used for private timberlands. The current projection applies three management regimes on national forest lands. The first allows regeneration removals (i.e., the stands will be final harvested 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 acres fall in the third regime.

Although the inventory change differs across regions, the total national forest inventory is projected to increase 70 percent for softwoods and 78 percent for hardwoods under the current projected removal levels. Both softwoods and hardwoods on the national forests are expected to increase sharply in all regions ranging from 39 to 93 percent for softwoods, and 62 to 96 percent for hardwoods. As the inventory grows, more timberland area accumulates in older age classes. Figures 13A and 13B show the area distribution of national forest timberland by age classes for the entire United States and for the West. In 1997, 15 percent of the national forest timberlands had trees older than 150 years. This is expected to increase to 35 percent by 2050. Currently, about 20 percent of national forest timberland in the West has trees older than 150 years. This fraction is expected to double to 44 percent by 2050.

Mills and Zhou (2003) present alternative projections that explicitly consider the effects of large-scale mortality events, namely fire and outbreaks of insects and disease, on inventory when they occur both with and without harvest. Data were obtained from Forest Service records of regeneration needs (USDA FS 2002). In addition to fire, insect, and disease mortality, the data included area entering the nonstocked pool owing to regeneration failures. The rates of mortality and regeneration failures were calculated by region for the latest 10-year period on record. (This includes the 2000 fire season addition of over 500,000 acres, one of the largest amounts in modern history). These occurrences were then projected to affect 140,000 acres of timberland each year.

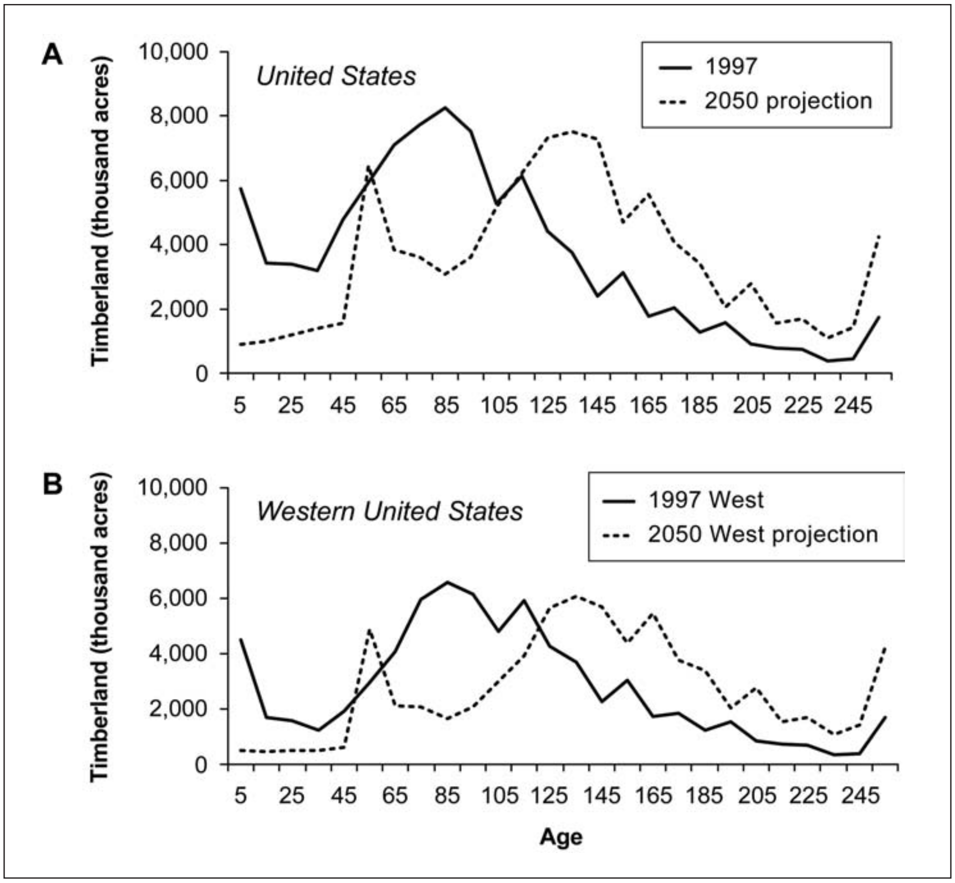

Figure 13—National forest timberland area distribution by age. Western United States includes Pacific Northwest (excluding Alaska), Pacific Southwest, and Rocky Mountain regions.

The resulting inventories most affected reflect those with the greatest (recent) reported incidence of these disturbances, namely the softwood inventories in the West. By 2050, the Rocky Mountain North and Pacific Southwest inventories dropped 15 and 11 percent below the base, respectively. This was similar to the inventory projection made under the higher level of removals that was assumed in the 1989 assessment. In the Pacific Northwest, the softwood projection drops just 4 percent, reflecting lower fire losses, but matching the outcome when the 1993 assessment removals were projected. The impacts were smaller in the remaining regions, and the results fall a little below the base and above the scenarios with higher harvests. The net result when explicitly considering fire over the 50-year projection is an 8-percent drop in softwood volume; however, the overall trend continues to show expanding inventories.

In terms of the age class distributions, these disturbances had the largest impact on the area projected in younger classes. By 2050, the change in the share of Western stands older than 150 dropped from 44 percent in the base to 40 percent, whereas that area supporting stands younger than 50 experienced a threefold increase, rising from 4 to 12 percent of the total distribution. For the younger classes this is nearly identical to the distribution today (if the current “blip” in the 5-year age class is reduced). A detailed description of the national forest projection and analyses for other harvest scenarios can be found in Mills and Zhou (2003).

Other Public Harvest Levels

“Other public” ownerships include a diverse collection of landowners, including the Department of Defense, many counties and states, and the Bureau of Land Management. Historical and projected harvest, net annual growth, and growing-stock inventories are shown in appendix table 36 for softwoods and appendix table 37 for hardwoods. The historical data for 1952–97 are from the various timber resource summaries. The projections were developed by using the growth and harvest projections from the 1993 assessment (extended to 2050) extrapolating inventory by adding growth and subtracting removals in each period (the growth-drain identity).

Both softwood and hardwood inventories on other public lands are expected to continue to increase during the next five decades. The softwood inventories increase at a somewhat faster rate than do the hardwood inventories. The larger increases in softwood inventories reflect reductions in federal (non-Forest Service) and state harvests for many of the same reasons that have led to harvest reductions on national forests. Toward the end of the projection period, the difference between harvest and growth narrows for hardwoods. Net growth especially for hardwoods is expected to drop as stands mature and growth rates drop. The largest drops in hardwood growth are already underway. Softwood growth continues to increase but at a diminishing rate.

Projection Models Used in the Timber Assessment

Figure 2 shows the bioeconomic modeling framework used to develop the projections for the timber assessment. This framework has evolved over the past 25 years to fill needs for greater geographic and product specificity in the projections. The framework consists of four submodels:

- The timber assessment market model (TAMM) embraces the solid wood products sector and also provides the linkage between product markets (solid wood and pulpwood) and the timber inventory.
- The North American pulp and paper model (NAPAP) is an economic model of the pulp, paper, and paperboard sector with detailed treatment of fiber supply (recycled, roundwood, and short-rotation woody crops) used to project pulpwood stumpage markets.
- The aggregate timberland analysis system (ATLAS) is a biological modeling structure for projecting timber growth and inventory over time given timber harvest.
- The AREACHANGE model explains the shifting of timberland between forest and nonforest uses and among forest types.

The system shown in figure 2 is an example of a bioeconomic model, as it combines explanations of both biological and economic processes. Figure 2 also shows the major links between models. Harvest estimates lead to adjustments in timber inventories (and broad-scale vegetation conditions) given changes in forest growth and timberland loss and gain. The volume of available timber inventory is then fed back to both the solid wood and paper and board models as a major determinant of stumpage supply. The economic models are built on spatial equilibrium concepts that solve for simultaneous equilibrium in both regional product and stumpage markets.

The United States has a long history of using formal forest sector models to support national assessments of supply and demand trends for timber (see Haynes 1993 for a discussion of the evolution of forest sector models). The USDA Forest Service has been one of the chief sponsors of forest sector models in the United States. Starting in the 1950s, the Forest Service developed a forest sector model based on a trend analysis of future demands for forest products and the availability of timber resources as separate entities (USDA FS 1958, 1965, 1974, 1982). Policies and emerging trends were discussed in the context of the gap between the trajectories of the demands for forest products expressed in roundwood equivalents and the prospective availability of timber. In time, this approach became known as a gap analysis (or the gap model) and was applied in the United States as the primary forest sector model until the late 1970s. During the two decades that it was commonly used, gap analysis evolved to include methods for estimating the price trends that would be required to close the gap.

Much of the evolution of forest sector models beyond the gap approach was stimulated by changes in the ways in which timber policy issues are characterized, shifting from potential future quantity shortfalls toward a focus on future price trends and impacts. This shift occurred in the mid-1970s during a period of rapid changes in commodity prices and concern about the effectiveness of various policies in attaining desired price trajectories. Starting in 1977, the Forest Service undertook the development of a forest sector model designed to explicitly describe regional stumpage price behavior as required by the Resources Planning Act (RPA). The resulting model was called TAMM (Adams and Haynes 1980, 1996; Haynes and Adams 1985). It produced regional price trends in both product and factor (stumpage) markets that recognized simultaneous market interactions and differences in regional timber resources.

These models continue to provide useful policy-relevant information, especially in light of the ongoing discussions about resource sustainability. Many of these discussions revolve around notions of balancing timber demands and supplies with changes in resource conditions.

The Timber Assessment Market Model

Since its inception in the late 1970s, TAMM has undergone a number of extensions and revisions designed to improve the realism of its projections and the utility of its output to resource analysts and policymakers. Details about the various input assumptions used in TAMM are described in the 1989 assessment (Haynes 1990), the 1993 assessment (Haynes et al. 1995), and model features in Adams and Haynes (1996).

The TAMM is a spatial model of the solid wood and timber inventory elements of the United States forest products sector and of softwood lumber and OSB production in Canada (Adams and Haynes 1980, 1996; Haynes and Adams 1985). The TAMM provides annual projections of volumes and prices in the solid wood products and sawtimber stumpage markets and estimates of total timber harvest and inventory by geographic region for periods of up to 50 years. Projections of fiber products are derived from the NAPAP model (Ince 1994), which is linked to TAMM through the quantities and prices of roundwood and residues. Endogenous trade flows in TAMM are limited to softwood lumber and OSB/waferboard shipments between the United States and Canada. All other flows, including sawlog imports and exports, are established externally.

Like many other spatial models, TAMM can be viewed as having a modular structure.

Product demands—There is one set of product demand relations for each of the major products modeled in TAMM: softwood lumber, softwood plywood, OSB/waferboard and hardwood lumber. These relations explicitly recognize the opportunities for substitution between these classes of products and so are interdependent in product prices (contemporaneous price-based substitution).

The demand module for softwood solid wood products uses Spelter’s diffusion analysis of demands for U.S. softwood lumber, softwood plywood and OSB/waferboard (Spelter 1984, 1985, 1992). Spelter’s model considers the demand for each product category separately in various end uses (several components of single-family home construction, residential upkeep and alteration, multifamily and mobile units, nonresidential construction, manufacturing, and shipping, a total of 18 uses in all). Hardwood lumber demand is disaggregated into eight end-use categories (furniture, millwork, flooring, ties, pallets, mining, containers and dunnage, and miscellaneous). Demand relations employ an “end-use factor” form and, as for softwoods, are dependent on prices of substitute materials in the current period.[14] In general, aggregate product demands have been found to be inelastic with respect to changes in price in the short term. Sustained price increases, however, lead to various adjustments in consumption and act to increase effective demand elasticities twofold to threefold or more (depending on the end use) over a 5-year period.

Product supplies—In RPA timber assessment projections, it has been customary to treat trends in the technology of wood products processing and logging by means of specific scenarios of future technical developments and associated impacts on the use of the wood (log) input. Wood use efficiency in milling is represented by “product recovery factors”: product output-log input ratios (e.g., board-foot lumber tally output per cubic-foot log input). To explicitly incorporate these projections in the representations of product supply, the current solid wood products supply module assumes that product output is obtained in fixed proportions to log input (the product recovery factor linkage) but in variable proportions to all other factors, implying that logs are separable from other inputs in production. Details of the derivation of relations in this module are described in Adams and Haynes (1996). These are econometric relations with parameters estimated by using historical time series data. Canadian supplies of softwood lumber and OSB/waferboard are explicitly represented in this module and are integral, price-sensitive elements. Estimated product supply elasticities with respect to product price differ markedly across regions and products. Although most are inelastic, many, including those for the largest producing regions, are close to unit elasticity.

Log demands—Given the assumptions of fixed log input-product output relations in TAMM, the derived demand for logs is simply the product of recovery factors times output. This same accounting allows the model to track residues generated in the production process and their disposition. Estimated residues generated in milling depend on projections of product recovery, size of logs processed, and the size mix of products. Assumptions regarding future product recovery trends are described elsewhere in this timber assessment.

Log and timber supplies—The supply of wood to processing facilities is modeled as a mixture of price-sensitive relations, and exogenous flows describing the volumes of timber available for immediate harvest and the volumes of logs delivered to mills. Harvests from public lands are set outside the projection model as a policy input. Private timber supply relations derive from explicit hypotheses of multiperiod harvest behavior for industrial and nonindustrial owners (Adams and Haynes 1996). The resulting relations link harvest to prices, inventory, interest rates, and, for nonindustrial private forest owners, income from nonforest sources. Price sensitivity for both softwood and hardwood supplies has been found to be low (inelastic) for all regions and owner groups.

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[14] See Adams et al. (1992) for a description of the end-use factor form of demand relations. Estimated coefficients of the demand equations are illustrated in Adams and Haynes (1996).

Timber harvest and inventories—The TAMM also includes a program module that provides linkage to the ATLAS timber inventory system (Mills and Kincaid 1992) for the solid wood, paper and board, and fuelwood models. Product volumes are aggregated, converted to amounts derived from live growing stock, and adjusted for additional removals owing to logging residues and cultural treatments. The operation of ATLAS is described in a later section. This module also allows estimation of timber harvest in Canada, although it does not attempt to model Canadian timber inventories. Canadian harvest estimates are derived from projected softwood lumber, paper and board, and OSB/waferboard production, with adjustments for hardwood lumber, nonstructural panels, miscellaneous products, and log trade, which are not explicitly modeled.

North American Pulp and Paper Model

An updated and revised version of the NAPAP model was used in this analysis to develop projections of equilibrium supply, demand, and production levels for pulp, paper, and paperboard commodities along with projections of market equilibria for pulpwood and recovered paper supply and demand. The model structure and methodology are described in Zhang et al. (1996), and the current revised structure of the model was described more recently in Ince (1999).

The NAPAP model applies conventional regional market modeling techniques to compute annual market equilibria based on optimization of consumer and producer surplus in the pulp and paper sector (Ince 1999; Zhang et al. 1993, 1996). The model computes market equilibria over a 65-year period, extending historically from 1986 through the present and out to the year 2050. The overlap of model projections with 15 years of actual historical data allows for extensive testing and calibration of model performance (average errors between historical data and projected equilibrium product demands, pulpwood supply, and recycling rates over the historical period are less than 1 percent per year). Changes in regional production capacities for pulp and paper manufacturing processes, including shifts between virgin fiber and recycling technologies, are simulated in the model as economic responses to projected market conditions, and in turn, projected market equilibria are influenced by shifts in capacity and embodied changes in technology.

The introduction in the 1990s of somewhat more sophisticated economic modeling techniques based on market analysis and technology forecasting resulted in projections of pulpwood market trends lower than those in previous timber assessments, largely because the NAPAP model accurately simulated the impact of increased paper recycling (Ince 1994, 1999). The total projected U.S. pulpwood supply and demand quantities in the current analysis are even lower than those of the 1993 assessment base scenario (Haynes et al. 1995, Ince 1994) because of the impact of the current economic recession in the pulp and paper sector and a revision to the trade outlook based on a strong U.S. dollar scenario. The ongoing economic downturn in the pulp and paper sector since 1999 rivals the last major multiyear economic downturn that occurred during the energy crisis of the early 1970s, and the strong dollar has weakened U.S. trade competitiveness. Thus, the current baseline projections of pulpwood supply and demand are much lower than projections in earlier Forest Service assessments of the 1970s and 1980s (Haynes 1990; USDA FS 1982, 1988).

Whereas TAMM produces projections for solid wood industries and sawtimber markets, the NAPAP model produces projections for the pulp and paper industry, pulpwood markets, and recovered paper markets. The NAPAP model uses linear programming to solve for annual market and production equilibria. Equilibria are adjusted over time by endogenous changes in production capacity and exogenous changes in supply and demand. The NAPAP model shows how markets for pulpwood and recovered paper are expected to evolve in response to changing market conditions, including changing technology (shifts in production capacity embody shifts in technology). The model includes regional supply functions for pulpwood and recovered paper, and a detailed representation of regional production capacity and production volume for all principal grades of paper, paperboard, and market pulp produced in the United States and Canada. The model also includes demand functions for all end products, with separate demand functions for U.S. domestic demand, Canadian domestic demand, and demand for exports outside of the United States and Canada.

The current NAPAP model is an extended and revised version of the original NAPAP model used in the 1993 assessment (Haynes et al. 1995, Ince 1994). Details of NAPAP model methods and results can be found in Ince (1994, 1999) and Zhang et al. (1996). NAPAP model methods are an application of the price endogenous linear programming system (PELPS), an economic modeling system developed primarily for modeling the pulp and paper sector over the past decade (Calmels et al. 1990, Gilless and Buongiorno 1985, Zhang et al. 1993).

In the NAPAP model, commodities in production and demand include the following:

Paper grades	**Paper grade market pulps**	**Paperboard grades and other**
Newsprint	Softwood kraft	Linerboard (unbleached kraft and recycled)
Uncoated free sheet paper	Hardwood kraft	Corrugating medium (semichemical and recycled)
Coated free sheet paper	Recycled	Solid bleached paperboard
Uncoated groundwood paper	Chemithermalmechanical pulp (CTMP)	Recycled board (other than corrugated boards)
Coated groundwood paper		Dissolving pulp
Tissue and sanitary paper products		
Specialty packaging and industrial paper		
Unbleached kraft packaging paper		

In the NAPAP model, there are three demand regions (United States, Canada, and Other World). Separate United States and Canadian demand functions are included for each principal paper and paperboard grade. United States demands for paper and paperboard grades are elastic with respect to product price, per capita U.S. GDP, U.S. population, and price of capital. Equilibrium prices are derived endogenously within the model, whereas other independent variables are projected exogenously. United States demands for communication paper grades are elastic with respect to price indexes of television or radio and computers. Econometric analysis has shown that demands for communication paper grades and electronic media are complementary, and thus declining real prices for media such as computers exert a positive influence on demand for paper (Zhang 1995). United States demands for packaging paper and paperboard grades are elastic with respect to a price index of plastic substitutes and the all-commodity PPI. Econometric analysis has shown that plastics are weak substitutes for paperboard grades, and prices of plastic substitutes are not expected to decline significantly (Zhang 1995). Canadian demands for paper and paperboard grades are elastic with respect to price and Canadian GDP.

Projected growth rates in U.S. demands for most paper and paperboard commodities were also adjusted downward in the period from 2000 to 2005, to more accurately reflect the impact of the current economic recession in the pulp and paper sector. Although domestic GDP growth did not slip into a recession until the third quarter of 2001, U.S. paper and paperboard consumption has been receding from a recent peak of over 750 pounds per capita in 1999 to around 700 pounds per capita in 2001, and domestic paper and paperboard production has dropped by about 7 percent in that period. This is the most significant drop in consumption and production since the period of the energy crisis in the early 1970s. Thus, projections of U.S. demand in the NAPAP model incorporate a period of slow growth in the near term, with a full recovery to more normal expected rates of growth in demand after 2005.

There are eight pulpwood supply regions in the model (United States North Central, Northeast, South Central, Southeast, West, Canada East, Canada West, Other World), six production regions (United States North, South Central, Southeast, West, Canada East, Canada West), five recovered paper supply regions (United States North, South, West, Canada East, Canada West).

Pulpwood supplies for eastern U.S. supply regions include supplies from harvests on forest industry lands, harvests on nonindustrial private forest lands, harvests on public forest lands, and wood residues supply (from sawmills and plywood mills), for both hardwoods and softwoods (eight distinct sources of pulpwood supply in each eastern U.S. region). Pulpwood supplies for United States West and both Canadian supply regions include supplies from timber harvests and wood residues, for both hardwoods and softwoods (four distinct sources of pulpwood supply).

Pulpwood stumpage supply functions were estimated for pulpwood harvest from forest industry and nonindustrial private forest lands in eastern U.S. regions (separately for hardwoods and softwoods). Stumpage supply functions have unitary elasticity with respect to timber inventories projected by TAMM and ATLAS. Pulpwood supplies were estimated to have relatively low elasticity with respect to pulpwood stumpage price (less than 0.5 in most cases). Public forest pulpwood harvest quantities and total roundwood pulpwood harvest in the United States West are projected exogenously. Pulpwood residue supply quantities are determined by lumber and plywood production activities projected in the TAMM model. Canadian roundwood pulpwood supply equations are elastic with respect to delivered pulpwood price, sawtimber price, and labor wage rates in Canada (projected exogenously). Canadian pulpwood residue supply quantities are elastic with respect to delivered pulpwood price and Canadian lumber production activities; the latter are projected in TAMM.

In the NAPAP model, recovered paper supply is modeled for five categories of recovered paper including old newspapers, old corrugated containers, mixed paper, pulp substitutes, and high-grade deinked paper. For U.S. supply regions, recovered paper supply consists of two elements, “long-term contract” and “spot market” supply. Large quantities of recovered paper are collected and transferred to mills under long-term negotiated contract arrangements (particularly in the domestic sector). The remainder of the market is an open or “spot” market (particularly for exports). For purposes of estimating recovered paper supply, domestic supply volume was used as a proxy for long-term contract supply, and export supply volume was used as a proxy for spot market supply. Long-term contract supply quantity is modeled as unresponsive to price but increasing gradually over time in relation to consumption of paper and paperboard commodities (recovery is increasing but at a declining rate over time). Spot market supply is elastic with respect to price, landfill tipping fees, and consumption of paper and paperboard commodities. The total supplies of the various categories of recovered paper are each limited by assumed maximum feasible recovery rates.

Trade flows are modeled separately for all pulp, paper, paperboard, and fiber input commodities in which there have been significant trade volumes in the past decade. The market equilibria for U.S. pulp, paper, and paperboard imports from Canada are modeled endogenously by the NAPAP model, as influenced by regional production costs and currency exchange rate assumptions. Other significant trade flows (total exports from Canada to Other World, total U.S. exports, and total imports from Other World to the United States and Canada) are projected by using trend analysis with significant adjustments for the assumed impacts of global capacity expansion and currency exchange rate conditions. In particular, the current outlook for U.S. export of paper and paperboard is more pessimistic than in the past assessments because of the observed negative impacts of the strong dollar on U.S. competitiveness in recent years, weakened domestic capacity growth, and continued overseas capacity expansion.

The Aggregate Timberland Assessment System Timber Inventory Model

The biological projection system, ATLAS, was developed to model timber inventories at multiple geographic scales.[15] Its function is to simulate growth, harvest, land use change, forest type change, and shifts in timber management for approximately 356 million acres of private timberland and 134 million acres of national forest timberland in the conterminous United States. At its most basic level, ATLAS uses an “even-age” model of the timber inventory. That is, it represents the inventory as a collection of age classes, and advances or adjusts these classes over time to simulate the growth and development of the forest. Original field inventory data relate to the stand level, whereas TAMM and ATLAS deal at the regional (multistate) level. Aggregating from the stand level to the regional level combines a broad mix of conditions, and the even-age characterization used by ATLAS gives way, in effect, to a multiage model where age classes might alternatively be thought of as growth classes.

The inventory projections depend on the development of inputs under several assumptions regarding the stratification and aggregation of the basic timber resource data. These data are derived from approximately 180,000 permanent ground plots maintained by the FIA programs within the USDA Forest Service. For the timber assessment, the resource data are divided into nine timber supply regions (see map on page 254). Within each region, timberland was stratified by up to four ownerships, up to 10 forest types, and up to 18 age classes. Five-year age classes are used in the South and 10-year age classes for all other regions. Resource data in the South and the Pacific Northwest West were further stratified by 3 site productivity classes and up to 12 management intensity classes. In these regions, the most detailed set of attributes used to identify a unit of inventory would be region, owner, forest type, site productivity class, management intensity class, and age. Resource data for national forests were only stratified into three management classes.

Throughout the projection, each unit of area, or “cell,” can be identified by these attributes. Weighting is dependent on the area associated with each stratum. Given the flexible stratification scheme, cells can range in size from several thousand acres up to a million or more acres. The projection mechanism in ATLAS moves each aggregate

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[15] The ATLAS system evolved from earlier work by Beuter et al. (1976) and Tedder et al. (1987).

cell along an independent yield trajectory. The yield estimation process projects cell volumes period by period in a fashion consistent with the inventory stand age classes. The yield tables and associated yield projection inputs required for the growth models were derived from timberland inventory plot data collected by the various USDA Forest Service FIA units (see Mills 1990), from cooperative research and consultation with private forest landowners, and from previous studies (the inventory data inputs are summarized in Mills 1989, 1993).

When stratified, the FIA private timberland data occupied 6,900 cells at the start of the projection. To avoid introducing unnecessary errors, the initial FIA plot values were not adjusted to a common starting point in time. The starting year represents roughly the average year the data were collected: 1995 in the South, and 1990 in the seven remaining U.S. regions. To reach 2050, the South was projected for eleven 5-year periods, and all other regions are projected for six 10-year periods. By the end of the projection, some proliferation of age and management groups had occurred and the inventory resource was distributed among 7,100 cells.

Cells can shift in growth, area, harvest, and management intensity. Although growth is simulated for each cell independent of all other cells, the amount of harvest or area change occurring in a particular cell will often depend on the cell's "weight" relative to other cells. That is, the amount of harvest removed, or the amount of area lost, will depend on a cell's relative available volume or relative area among a targeted group of cells.

In each simulation period, inventory change is the result of growth, area change, and harvest. Periodic change in inventory volume is the sum of four components: net growth (+), volume lost owing to area loss (-), harvest (-), and volume gained owing to area gain (+). Net growth is the sum of growth (net of mortality) from all possible activities that could affect the inventory: normal inventory growth, plus growth on the volume harvested, plus growth on area gained, and growth on area lost.

Over time, an inventory cell can change management intensity classes, shift forest types, or be lost from the forest land base to nonforest uses. Forest type and management intensity changes are governed in part by externally developed scenarios of prospective future private management decisions, as described in an earlier section of this chapter. Management intensity changes are not endogenously sensitive to price or any other market elements. A limited amount of market response was incorporated, however, by making judgmental adjustments to regimes during a sequence of successive projections. In previous versions of ATLAS, parameters directed shifts to occur from one management regime to another. Modifications made for the timber assessment changed the mechanism so now all final harvested acres are assigned to a common pool, from which regenerated acres are allocated among the entire set of management regimes. This is similar to a "model II" formulation describing even-age regeneration developed by Johnson and Scheurman (1977). Final-harvested acres can be regenerated to an alternate management regime or alternate forest type, remain nonstocked, or lost from the timberland base.

Timberland Area Change Model

The land area projection system, AREACHANGE, was developed to project land use and forest type changes at regional and national scales. The system was linked to the ATLAS and TAMM models in the 1989 assessment (Haynes 1990) and the study of "The South's Fourth Forest" (USDA FS 1988). A projection by the system operates in two phases. In the first phase, area changes in major land uses are projected to provide regional estimates of total timberland area by ownership. In the second phase, the system projects area changes for major forest types on each ownership. Price projections from other parts of the timber assessment modeling system are used as one of the inputs in the first phase of the projections, and projections of management intensity class changes from the ATLAS model are used as an input in the second phase (fig. 2).

For the first phase, econometric analyses of the determinants of land use by region (e.g., Ahn et al. 2002, Mauldin et al. 1999b, Plantinga et al. 1999) were used in developing simulation models to project regional area changes in timberland by private ownership (Alig et al., n.d.). Land use competition between forestry and other sectors is modeled by using statistical relations between changes in timberland area and determinants such as population, per capita income, and income from land-based enterprises such as forestry or agriculture.

In the second phase, area changes for forest types on a particular ownership can result from four basic sets of activities: afforestation, deforestation, shifts among forest types on retained timberland, and ownership exchanges. In contrast to ecological processes, land use changes and disturbances can differ significantly by type of private ownership. Land use changes involving afforestation and deforestation affect forest type areas over time. Deforestation is most often caused by conversion to other land uses. This contrasts to timber harvests as part of typical forestry activities, as timber harvests are most often followed by regeneration back to forest. Land exchanges between ownerships are largely driven by financial, strategic, and other socioeconomic factors (Alig 1985).

Forest type transitions on timberland are based on data from remeasured FIA survey plots. Projections of such area changes for major forest types take into account likelihood of final harvest and forest successional forces (Alig and Wyant 1985). Forest type transitions for an aggregate grouping of timberland (by a stratum representing a specific region and ownership) are conditional on three types of timber harvest—no harvest, final or clearcut harvest, and other harvest types. Projected harvest information is provided by the overall TAMM/NAPAP/ATLAS/AREACHANGE modeling system.

Linkage Among Modeling of Area Changes, Timber Management Intensity, and Economic Timber Supplies

Solution of the integrated model system shown in figure 2 involves an iterative approach. Starting estimates of land use and forest cover from the AREACHANGE system are fed into the ATLAS model, which also embodies estimates of timber management intensity. The resulting impacts on forest growth are reflected in the biological process models, which adjust timber inventories. The adjusted physical measure of available timber inventories are used to shift timber stumpage supply curves in the economic models of timber supply embodied in the TAMM and NAPAP models. Price projections from the latter models are then fed back to the AREACHANGE system, to account for the impacts of any altered timber harvest levels and timber prices on land use and forest cover projections. The revised land use and forest cover projections are input then into new ATLAS runs, and so on. This iterative rerunning of models proceeds until there is a reasonable convergence of linked model outcomes.

Chapter 3: Timber Demand-Supply Relations: Base Projection[1]

Introduction

One of the primary objectives of the fifth RPA timber assessment is to provide a plausible baseline projection of future changes in the Nation's demand for timber products and in the domestic timber resource that supplies a substantial part of our timber requirements. These projections provide a means of identifying emerging opportunities in the timber resource sector and a base for analyzing economic, social, and environmental implications of alternative policies and programs. The resource projections presented here are also of value as background for public discussion of individual and collective perceptions of the future of the forest resource—perceptions that ultimately will influence forest management decisions.

Projections in this timber assessment depend directly on the assumptions made about major determinants of demand and characteristics of the timber resource as described in the preceding chapter. The projections would change if these assumptions were modified. There is no intent to portray the baseline trends projected here as socially or economically desirable or undesirable. Indeed, the economic, social, and environmental implications of these trends may stimulate actions to either change or reinforce them.

This chapter presents the base projections of future market activity for both timber products and timber stumpage. The base projections assume that (1) population and general economic conditions in the United States, forest land area, private investment in forest management, and developments in wood processing technologies follow trends as described in chapter 2; and (2) public policies in the overall economy and policies regulating management on both private and public forest lands remain fixed in the forms and structures observed in the late 1990s. Given this specific policy framework, the projections are considered to be a "most likely" future outlook under specific assumptions, but no claim is made that continuation of past policies is the recommended or, indeed, most likely policy future. Any effort to forecast change in policy

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[1] The authors for this chapter are Darius M. Adams, Richard W. Haynes, Peter J. Ince, Kenneth E. Skog, John R. Mills, and David B. McKeever.

would be inappropriate in a document designed to provide science-based information for policy decisionmaking. Thus, the base case provides only a datum against which to measure impacts of alternative assumptions on economic and policy developments.

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

Trends in production, consumption, trade, and prices are projected to differ somewhat across the diverse classes of timber products over the next five decades. Rising gross domestic product (GDP) and personal income will play central and common roles, driving overall consumption up, although at a declining pace. Price-based substitution, as so often in the past, will continue to have a major impact on use trends as well. Underlying many of these prospective developments will be significant changes in the characteristics of timber supply. The trade outlook, which envisions continued expansion in U.S. product imports and only modest expansion in exports, reflects the assumption that current trade policies will continue and a relatively strong U.S. dollar will persist.

Solid Wood Products

Solid wood products are an important raw material for the construction, manufacturing, and shipping segments of the U.S. economy. Nearly all new U.S. single-family houses and low-rise multifamily residential structures are framed with lumber and sheathed in wood panels. Large amounts of wood products are also used in the construction of new nonresidential buildings, and in the upkeep and improvement of existing structures. Solid wood is used extensively in a variety of manufactured products, and nearly all manufactured products are shipped on wooden pallets. Wood also provides a renewable energy source for industrial, commercial, and residential applications.

The use of wood in the United States has changed in many ways over the past decades. Changes include the substitution of nonwood materials for wood in existing applications and the development and adoption of new wood products to substitute for existing wood and nonwood products. Other changes in wood use can be attributed to statutory changes that favor one type of material over another and to shifts in consumer preferences for a particular type of product or material. This section gives an overview of the major uses of solid wood products, how market shares or product importance have varied, and recent consumption trends as background to the projections. The primary end uses considered are construction, manufacturing, shipping, and fuelwood.

Construction is the largest overall market for solid wood in the United States, and consists of new residential building, residential upkeep and improvement, and nonresidential construction. In 1996, about 65 percent of all lumber, 86 percent of all structural panels, and 40 percent of all nonstructural panels were consumed in construction (fig. 14). This compares to 72, 85, and 62 percent, respectively, in 1986. Declines in the percentages of all lumber and of all nonstructural panels that were used for construction between 1986 and 1996 were due to many factors. Two most notable were the continued substitution of nonwood for wood building products, and the substitution of engineered wood for lumber and nonstructural panels. Steel framing, vinyl siding, and metal cabinets and millwork continue to take market share away from lumber and nonstructural panels, and wood I-joists substitute for larger dimension lumber in floor and roof framing, laminated veneer lumber (LVL) and wood I-joists for window and door headers, and oriented strand board (OSB) for nonstructural panel sheathing.

New residential construction accounted for about 53 percent of all wood products used in construction in 1996. Nearly 19.8 billion board feet of lumber, 17.0 billion square feet (3/8-inch basis) of structural panels, and 3.9 billion square feet (3/8-inch basis) of nonstructural panels were consumed for new residential construction in 1996 (fig. 15). Single-family homes used 82 percent, multifamily homes 8 percent, and mobile homes

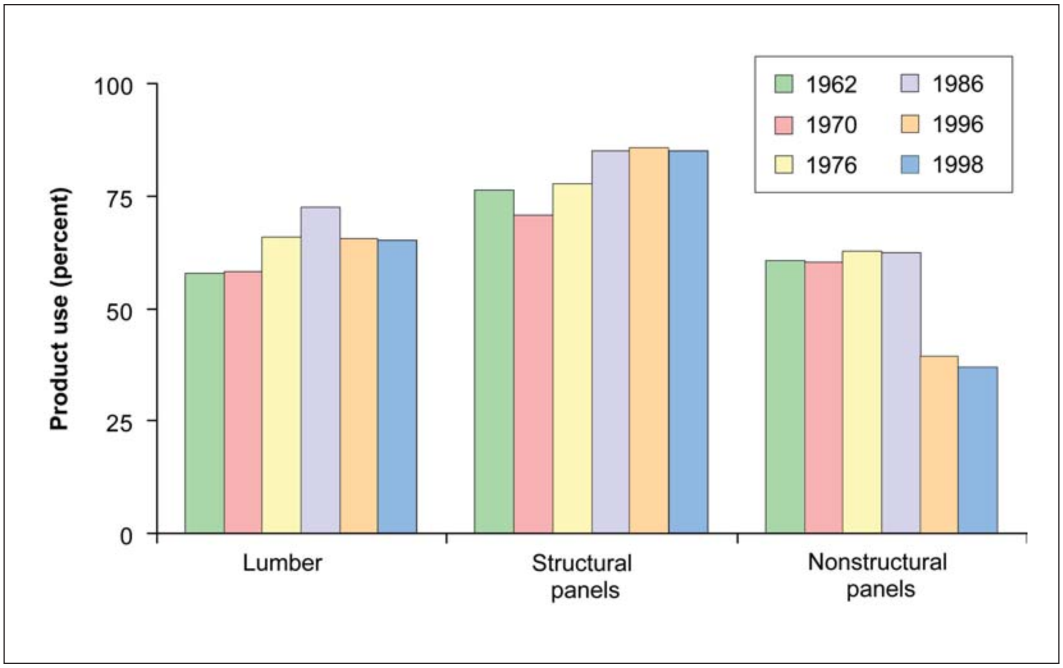

Figure 14—Timber products used for construction as a percentage of total timber products consumption, by product.

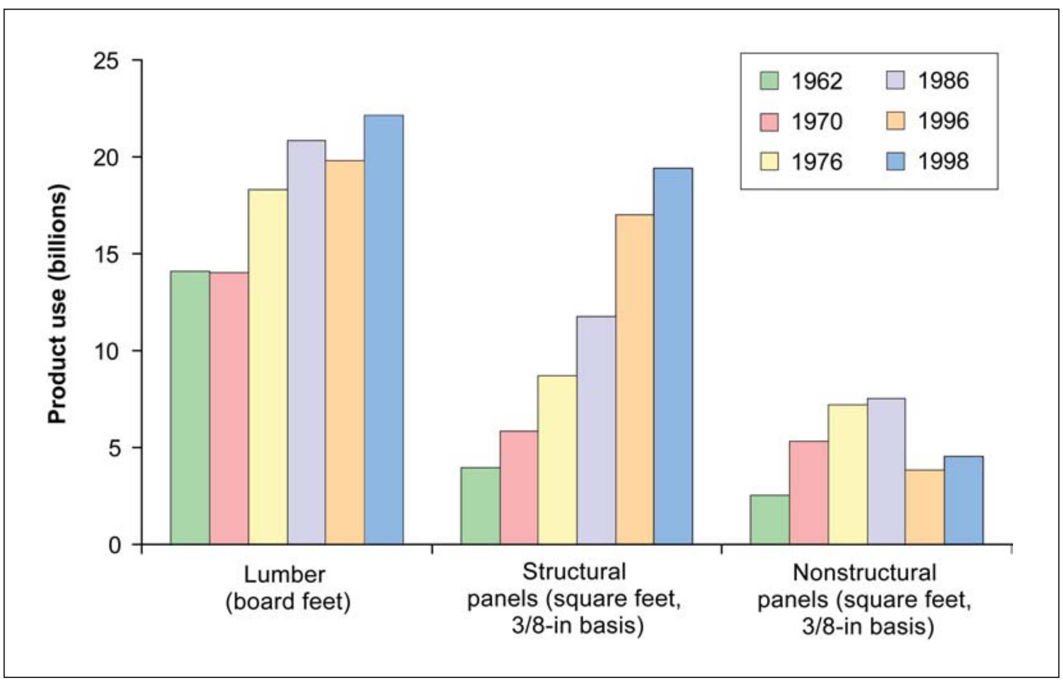

Figure 15—Timber products used for new residential construction, by product.

10 percent of these products. Percentage used for single-family houses remained unchanged from 1986. Multifamily houses decreased 5 percent, and mobile homes increased 5 percent from 1986.

Residential upkeep and improvements have become a much more important market for wood-based building products in recent years. Prior to 1986, this market was less than half as large as the new single-family residential construction market. Since 1986, it has grown to about 85 percent as much volume as the single-family market, and for some products (such as softwood lumber) it has become the largest end use. Residential upkeep and improvements accounted for 36 percent of all wood products used in construction in 1996, about the same as in 1986. Nearly 15.4 billion board feet of lumber, 7.5 billion square feet of structural panels, and 3.2 billion square feet of nonstructural panels were consumed for residential upkeep and improvements in 1996 (fig. 16). The end of the 1990s has seen a slowdown in markets for wood-based products that are used in residential upkeep and improvement. This slowdown is expected to be reversed as the economy starts to recover.

Nonresidential construction accounted for about 11 percent of the wood used in construction in 1996, down about 1 percent from 1986. Nearly 4.1 billion board feet of lumber, 2.5 billion square feet of structural panels, and 1.2 billion square feet of nonstructural panels were consumed for new nonresidential construction in 1996 (fig. 17).

Manufacturing activities in the United States accounted for about 13 percent of the lumber, 10 percent of the structural panels, and 47 percent of the nonstructural panels consumed in 1996. Nearly 7.9 billion board feet of lumber, 3.2 billion square feet of structural panels, and 9.9 billion square feet of nonstructural panels were consumed in manufacturing in 1996 (fig. 18). Lumber consumption for manufacturing increased by nearly 30 percent between 1986 and 1996. Structural panels increased by about 80 percent and nonstructural panels by about 50 percent.

Packaging and shipping accounted for about 10 percent of the lumber, and 2 percent or less of all structural and nonstructural panels consumed in 1996. Just over 6.4 billion board feet of lumber, 0.5 billion square feet of structural panels, and 0.1 billion square feet of nonstructural panels were consumed for packaging and shipping in 1996 (fig. 19). The 388 million new pallets produced in 1996 required 5.8 billion board feet of lumber, more than 90 percent of all the lumber used for packaging and shipping. Recent advances in pallet repair, recovery, and design have resulted in a reduced rate of growth in the numbers of new pallets being built, and reduced amounts of lumber per pallet. In 1996, an estimated 180 million pallets were recovered by the pallet industry, 114 million more than in 1992. About 2.4 billion board feet of salvaged lumber was used to repair, rebuild, and manufacture the 150 million recycled pallets produced in 1996.

In 1996, wood energy consumption in the United States was nearly 2.5 quadrillion (10^{15}) British thermal units (Quad), or about 2.6 percent of the total 94.0 Quad consumed (fig. 20). About 23 percent of wood-derived fuel was roundwood, 38 percent was mill and other wood waste, and 39 percent was black liquor from pulping. These fuels were used for residential heating (24 percent), energy in the forest products and other industries (74 percent), and commercial buildings and electric power generation (2 percent). Currently, about 35 percent of roundwood fuel comes from timberland growing stock. The share of wood energy coming from roundwood increased sharply in the late 1970s through mid-1980s when fossil fuel prices rose sharply but has decreased in subsequent years with the drop in fossil fuel prices.

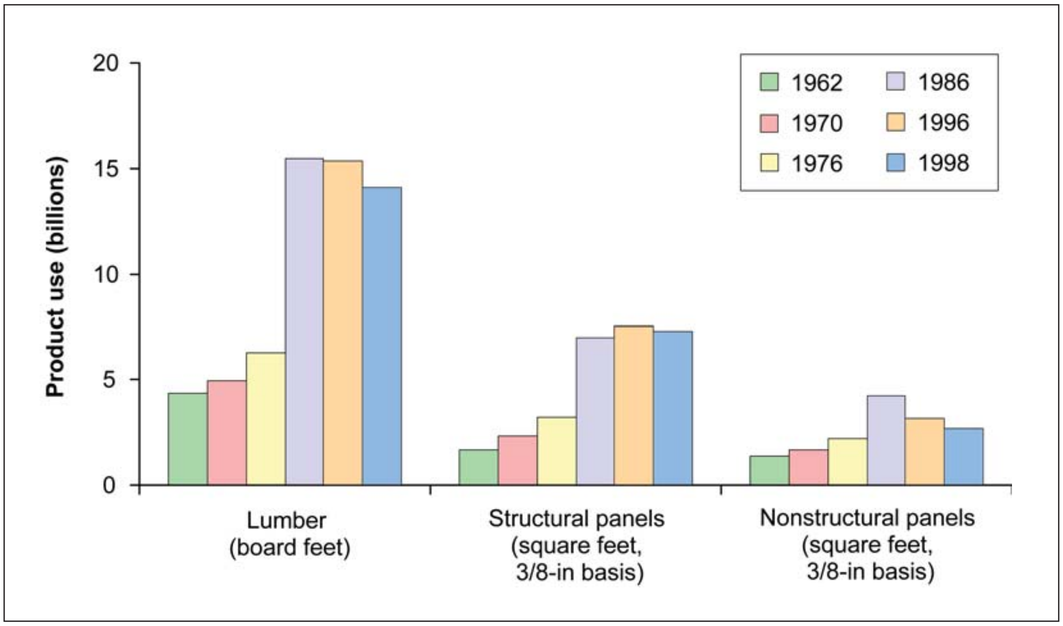

Figure 16—Timber products used for residential upkeep and improvements, by product.

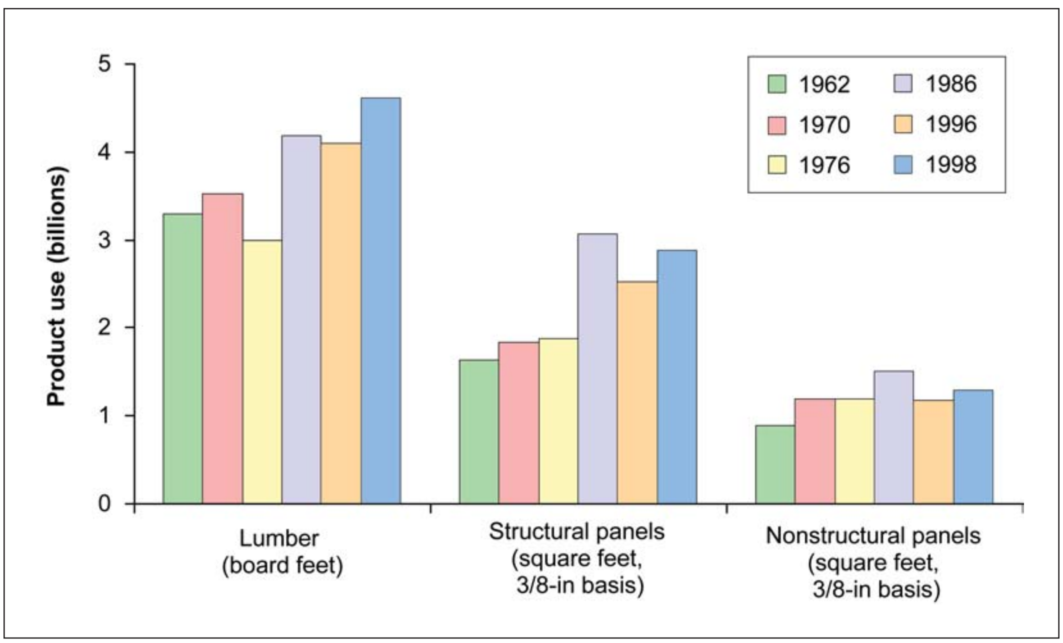

Figure 17—Timber products used for new nonresidential construction, by product.

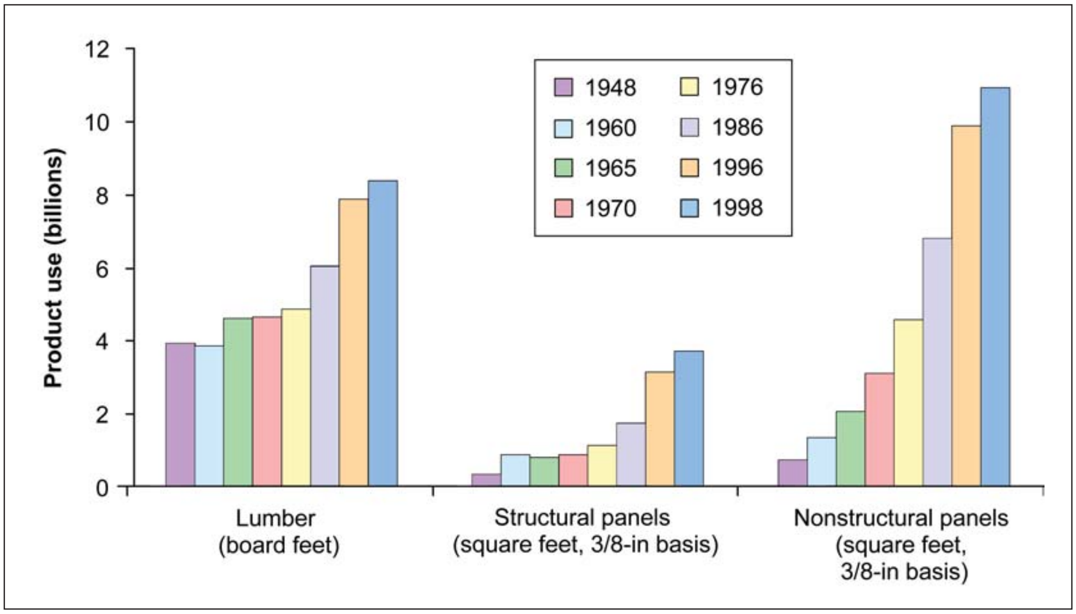

Figure 18—Timber products used for manufacturing.

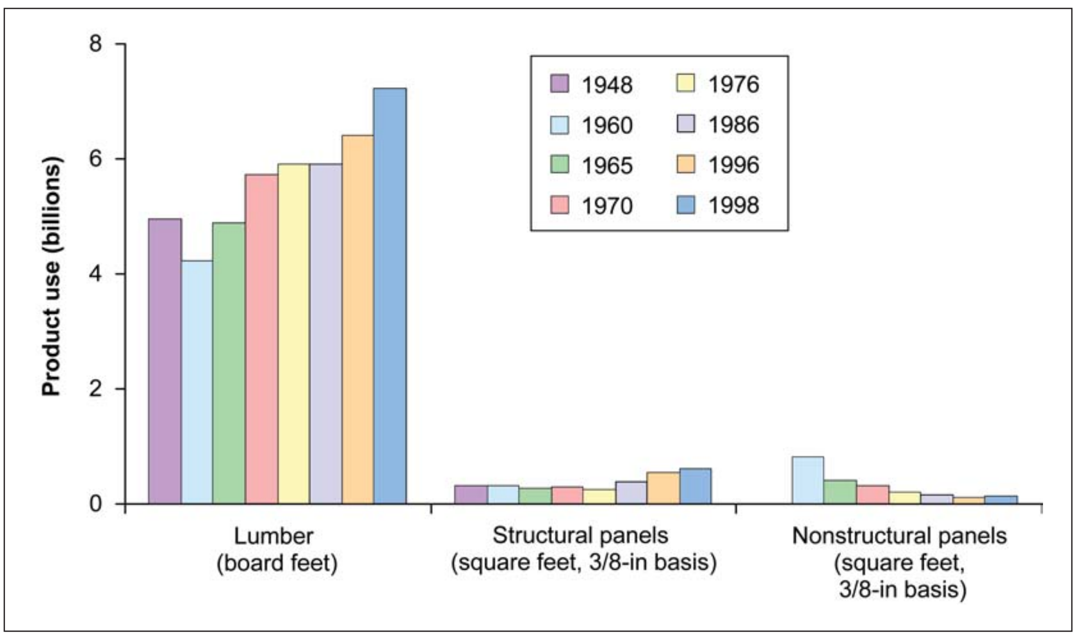

Figure 19—Timber products used for packaging and shipping.

Lumber—Growing steadily from a recessionary low in 1991, U.S. lumber consumption reached 61.3 billion board feet in 1996 (see app. table 38) and an historical high of 68.3 billion board feet in 1999 (Howard 2001). These volumes are more than 50 percent higher than earlier peaks observed in the first half of the 20th century, and the 1999 value exceeds the previous post-World War II peak set in 1987 at 57.4 billion board

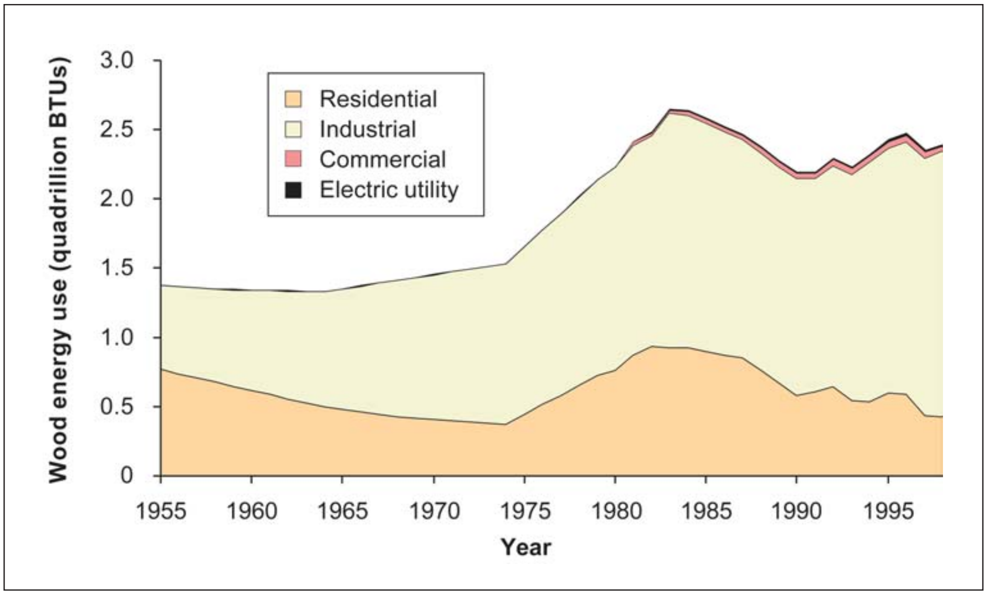

Figure 20—Wood energy use, by sector, 1955–98.

feet. Lumber consumption is forecast to rise throughout the projection period (see app. table 38) reaching 77.3 billion board feet by 2040[2] and 83.0 billion board feet by 2050. On a per capita basis, consumption peaked in the 1980s, fell in the 1990s, and declines in the projection until 2040.

Engineered wood products[3] as substitutes for lumber are beginning to gain market share, particularly in construction applications. About 30 million cubic feet of structural composite lumber, primarily LVL, 236 million board feet of glulam timbers, and 445 million linear feet of wood I-joists were consumed in 1996 (fig. 21). These volumes of engineered wood products, when converted to their board foot equivalents, accounted for about 4 percent of all wood products used for framing in 1996. Use was greatest for new residential construction at about 6 percent, and least for residential upkeep and improvements at about 2 percent. Consumption of LVL and wood I-joists increased by 22 million cubic feet and 346 million linear feet, respectively, between 1986 and 1996. Glulam timber consumption fell by 94 million board feet during the same period. Overall, the use of each engineered wood product in construction is expected to increase steadily in the short term. Based on U.S. and Canadian production forecasts (Adair 2000), overall engineered wood products production is expected to increase by about 175 percent between 1996 and 2005. Nearly all this increased production will be used for construction applications. In the projections that follow, the volumes of engineered wood products are combined with those of their traditional substitutes in the various end uses.

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[2] The 1993 RPA timber assessment update (Haynes et al. 1995) projected consumption of some 74.0 billion board feet by 2040. Higher consumption in the current projection derives from higher forecasts of housing activity and residential upkeep and improvement expenditures.

[3] See Glossary for definitions of engineered wood products.

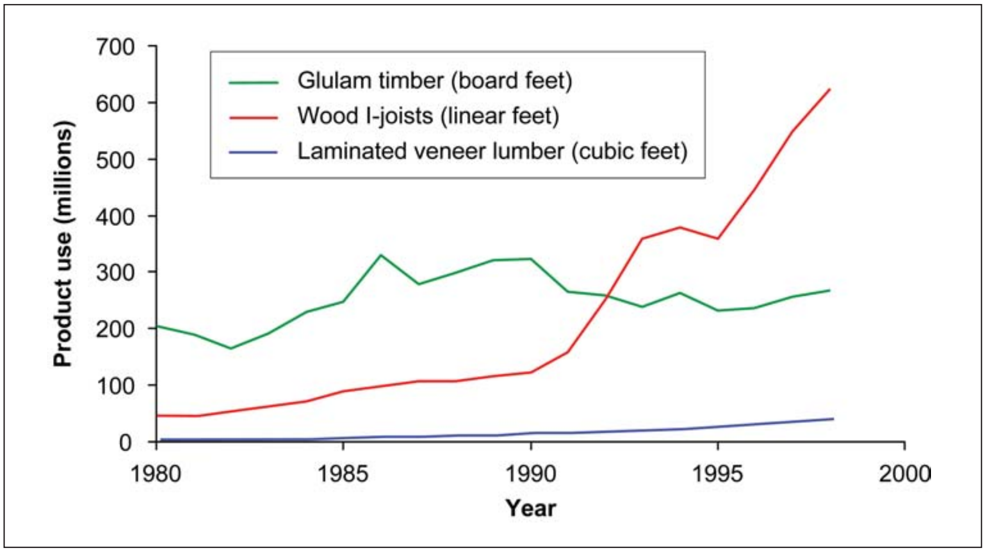

Figure 21—Engineered wood products use, by type, 1980–98.

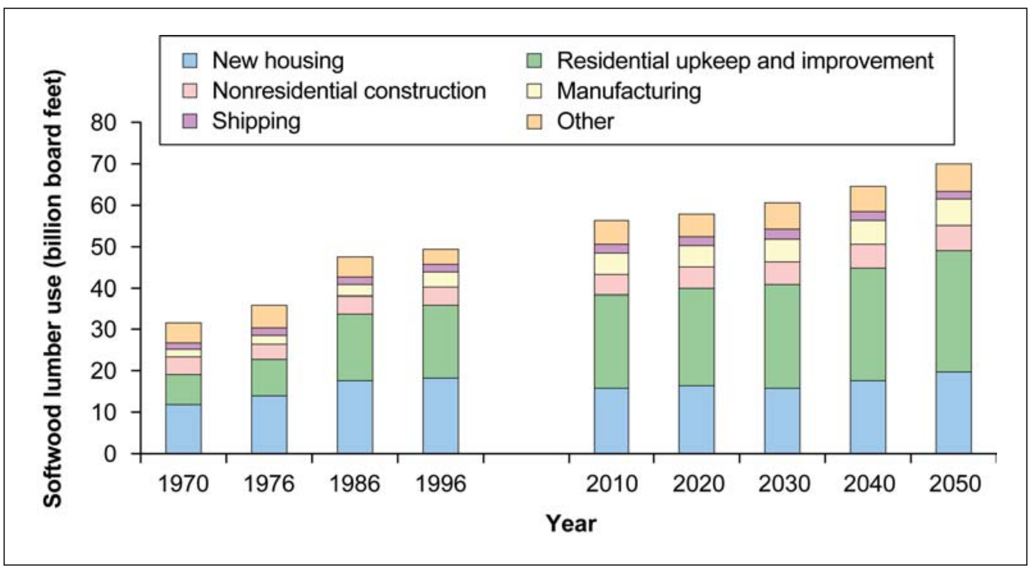

Figure 22—U.S. softwood lumber use by end-use category, with projections to 2050. Historical values are estimates.

Softwood lumber—The most dramatic historical trend in softwood lumber consumption has been its growth in residential upkeep and improvement applications (fig. 22). Use has increased both because of steadily rising expenditures on upkeep and improvement and because more softwood lumber is being used per dollar of expenditure. Use trends in new housing, in contrast, are the result of a more complex set of shifts. In single-family homes (see panels A–E in fig. 23), lumber use per square foot of floor area fell from the 1950s through the 1960s as a result of substitution from softwood plywood and other materials, rose during the 1980s in the face of low relative lumber prices, and fell again sharply in the 1990s as lumber prices rose. Throughout this period, the average size of single-family homes continued to rise. This acted to offset the effects of

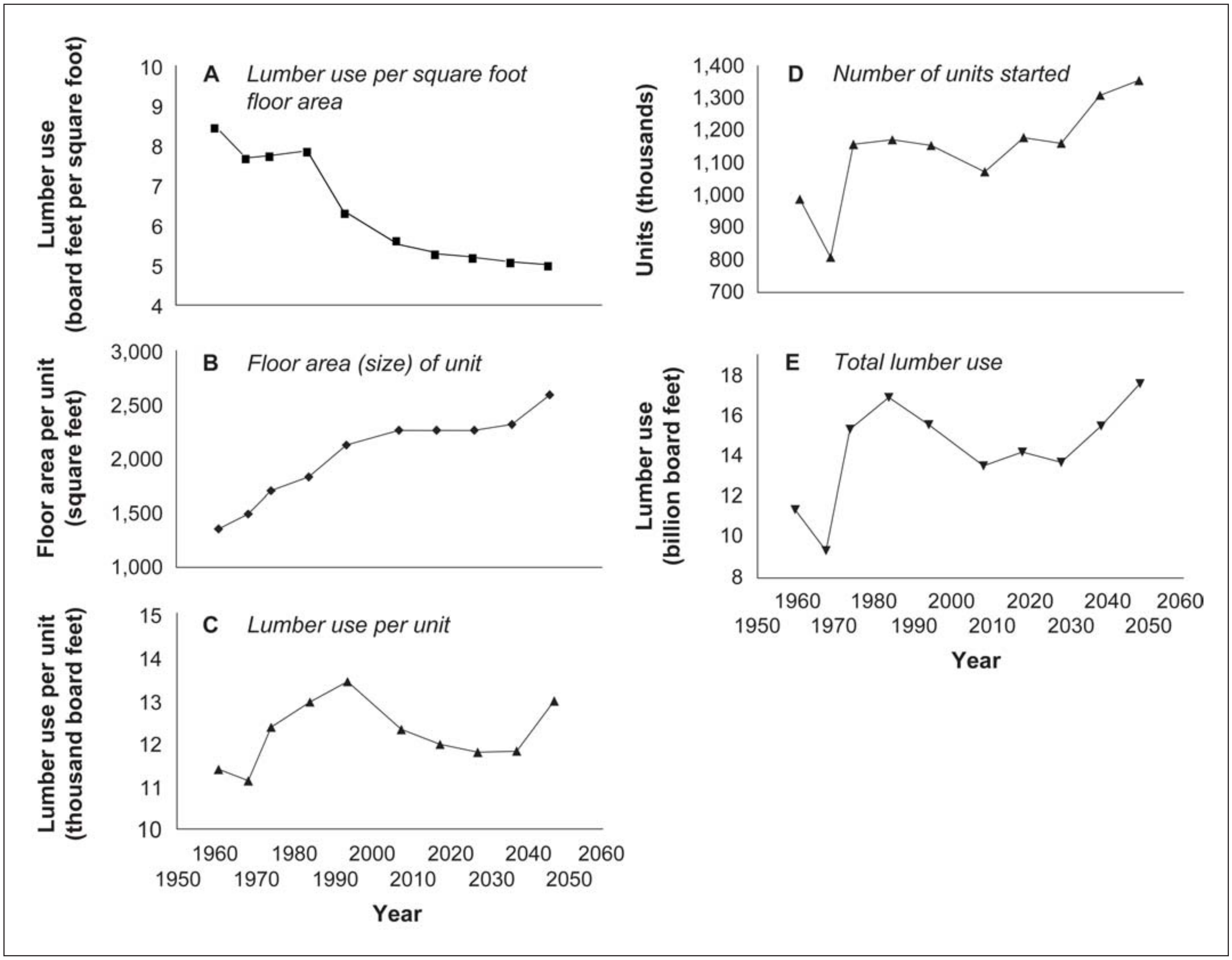

Figure 23—Components of U.S. softwood lumber use in single-family dwellings, with projections to 2050.

declining lumber use per square foot of floor area so that use per dwelling unit actually rose from the 1970s through the late 1990s (panel C, fig. 23). Overall lumber consumption in single-family dwellings is the product of use per dwelling unit and the total number of single-family housing units started. The sensitivity of new housing starts to changes in interest rates adds further volatility to the lumber use total (see panels D and E in fig. 23).

Continuing the trends of the past decades, residential upkeep and improvement is the primary source of change in domestic softwood lumber consumption in the projections, exceeding use in new housing (fig. 22). As noted in the discussion of the macroeconomic outlook in the previous chapter, new housing starts are projected to decline and then recover to near recent levels over the next two decades. They rise strongly after 2030 owing to a surge in replacements and second home construction. Residential upkeep and improvement expenditures, in contrast, grow steadily with income. This difference is seen clearly in the softwood lumber use projections. Consumption in nonhousing uses also rises over the projection. Driven by growth in GDP, lumber use in manufacturing, nonresidential construction, and "other"[4] categories rises slowly. Detailed tables of historical and projected lumber consumption, production, and trade are given in the appendix (see tables 38 through 40).

Aggregated across all uses, softwood lumber consumption rises steadily over the projection, reaching some 70 billion board feet by 2050, 15 billion board feet above the estimated 1999 peak (fig. 24). The mix of sources of this consumption, however, varies over time. In the first decade, domestic production remains roughly stable, as in the decade of the 1990s, while imports continue to rise to fill the shortfall between production and consumption, reaching roughly 25 billion board feet by 2010. After 2010, both domestic production and imports expand to meet continued demand growth.

The origins of these shifts in domestic production lie at the resource level, as later sections of this chapter discuss in greater detail. Over the 2000–15 period some private timberland ownerships in the United States face limitations in merchantable volumes of timber. These limitations lead to stable or reduced harvests. With the passage of time, young stands mature and inventory positions change. As a result, harvest on many of these ownerships will grow after 2010–15. Resource conditions overseas also contribute to increasing production and export to the U.S. market.

In Canada, opportunities for continued timber harvest expansion may be limited, despite differences between current harvest and nominal annual allowable cut (AAC) levels in some provinces.[5] Indeed, harvest restrictions had already been put in place in some areas of coastal and interior British Columbia in the early 1990s. As a consequence, limits have been placed on potential future sawtimber harvests across the Canadian regions in this analysis. In the British Columbia Coast region, sawtimber harvest can rise no higher than 1990 levels. In the Canadian Interior region, the upper bound was set at the peak level observed in 1992 (some 2.0 billion cubic feet per year) and held there until 2010. Between 2010 and 2020, the upper bound falls back to the lowest harvest level observed in the decade of the 1990s (roughly 1.75 billion cubic feet per year) and remains there for the rest of the projection. In the Canada East region, AACs are substantially higher than current harvests. In this instance, projected harvest is allowed to increase no more than 15 percent above approximate 1999 levels (to about 2.6 billion cubic feet per year), until 2010. Between 2010 and 2020, the bound falls back to roughly the average level observed during the 1990s (about 2.0 billion cubic feet per year). In the projections, these bounds become effective for all Canadian regions by 2005 and act to restrict all subsequent sawtimber, and hence lumber, output.

In 1996, the United States and Canada entered into the Canadian-United States Softwood Lumber Agreement (SLA) designed to restrict Canadian exports of softwood lumber to the United States through a structure of quotas and tariffs. The SLA expired in

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[4] The "other" category includes a sizable component of nonresidential upkeep and improvement and various other applications not fully captured in the wood use accounting for the construction, manufacturing, and shipping groups.

[5] See Canadian Forest Service, 1999. The AACs and recent harvest levels are reported in "Profiles Across the Nation" beginning on page 26. See also http://nrcan.gc.ca/cfs/proj/ppiab/sof/sof.html and the *Compendium of Canadian Forestry Statistics* at http://nfdp.ccfm.org/framesinv_e.htm in section 2.

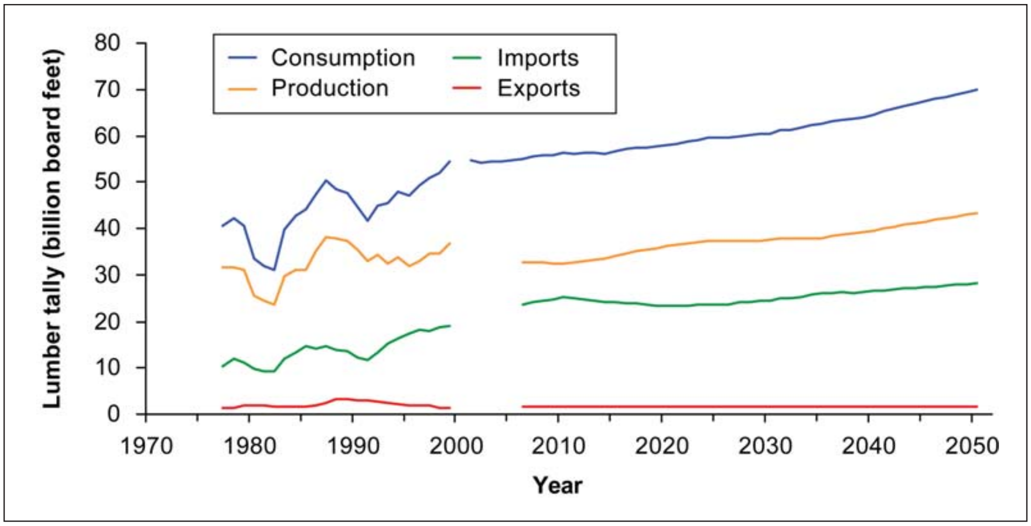

Figure 24—U.S. consumption, production, imports, and exports of softwood lumber, with projections to 2050.

April 2001. In 2002, U.S. firms successfully petitioned the U.S. International Trade Commission; the Department of Commerce is to institute a duty as a result of a countervailing duty and antidumping investigation.

During the first 4 years of the SLA, softwood lumber imports from Canada rose from 17.3 billion board feet to 18.4 billion board feet owing primarily to growth in shipments from provinces not subject to duty. In the first quota year (April 1996 to March 1997), some 17.3 billion board feet were imported in total: 14.8 billion duty free (includes 0.1 billion of "bonus" volume), 1.0 billion subject to some duty, and 1.5 billion exempted. In the fourth quota year (April 1999 to March 2000), total imports were approximately 18.4 billion board feet: 14.8 billion board feet duty free, 0.9 billion board feet (about 5 percent of the total) subject to some duty, and 2.7 billion board feet exempted.[6] In the base projection, it was assumed that the outcome of the ongoing U.S.-Canada trade dispute would result in an environment for U.S.-Canada softwood lumber trade similar to that of the past decade. Therefore, we assumed that the same sources of import expansion would continue to be available, allowing Canadian imports to rise to 20.1 billion board feet by 2010 (about 10 percent higher than the quantity imported in calendar year 2000).

Figure 25 gives a detailed picture of softwood lumber imports as a percentage of U.S. consumption. The share for total imports has grown steadily over the past several decades. Most of this wood comes from Canada, but in recent years, imports from other regions, including Europe, South America, and Oceania (primarily New Zealand), have increased as well. In 1999, it is estimated that non-Canadian softwood lumber imports totaled nearly 0.9 billion board feet (about 1.6 percent of U.S. consumption). In the base projection, the share of these non-Canadian imports continues to rise to about 12.5 percent by 2020. In subsequent years (2021–50), they rise to roughly 15 percent of U.S. consumption reaching an annual volume of 10.5 billion board feet. Canada's share of U.S. consumption at its highest point in the projection (2005) reaches 36 percent then drops back to about 25 percent by 2050.

[6] Most of the exempted volume originated in provinces not covered under the SLA.

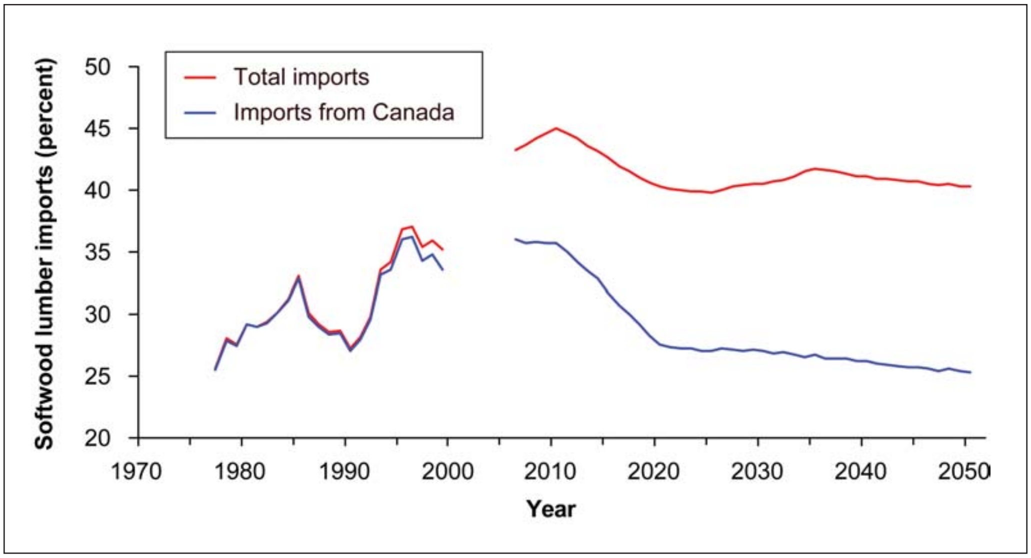

Figure 25—Total and Canadian imports as shares of U.S. softwood lumber consumption, with projections to 2050.

An increasing contribution from non-Canadian sources is based on the expected strength of the U.S. market (including the U.S. dollar) relative to international markets, and resource conditions in regions that have emerged as competitive suppliers to the U.S. market. Expanding timber harvests and exports will depend on intensive management of native species (in Europe) and plantations of exotic species (in South America and Oceania). By 2050, the contribution to U.S. consumption of softwood lumber that is expected to come from Europe will require only a small portion (about 10 percent) of the current difference between net annual growth (increment) and harvest (fellings) of softwood growing stock on forests available for wood supply (UN ECE 2000). In South America, Asia, and Oceania, production from softwood plantations—currently more than 25 million acres, at least a third of which are in private ownership (FAO 2001b)—is the source of raw material for expected increases in production and shipment to U.S. markets. The role of these plantations in meeting U.S. demand for softwood lumber is consistent with projected increases in world timber harvests (ABARE 1999).

Exports show no growth in figure 24, as the United States is assumed to remain one of the world's high-cost softwood lumber producers. In addition, the strength of domestic markets, expanding softwood lumber production overseas, and increased competition in traditional U.S. markets all act to limit U.S. exports.

During the 2000–10 period, the base projection suggests that no U.S. region has the potential for significant softwood lumber supply expansion (fig. 26). In the Pacific Northwest West, lumber output rises in the long term, by nearly two-thirds between the 1990s and 2050, but there is little prospect of significant near-term growth. Long-term expansion is based on (1) continued improvement in lumber recovery (more lumber per unit of log input); (2) maturation of second-growth timber on forest industry lands, which allows maintenance of industry harvests at or above the levels of the 1990s throughout the projection; (3) gradual growth in nonindustrial private harvests back toward their peak levels in the late 1980s driven by more than a 20-percent expansion in their timber inventories; and (4) reallocation of log supplies from plywood to lumber as plywood output declines.

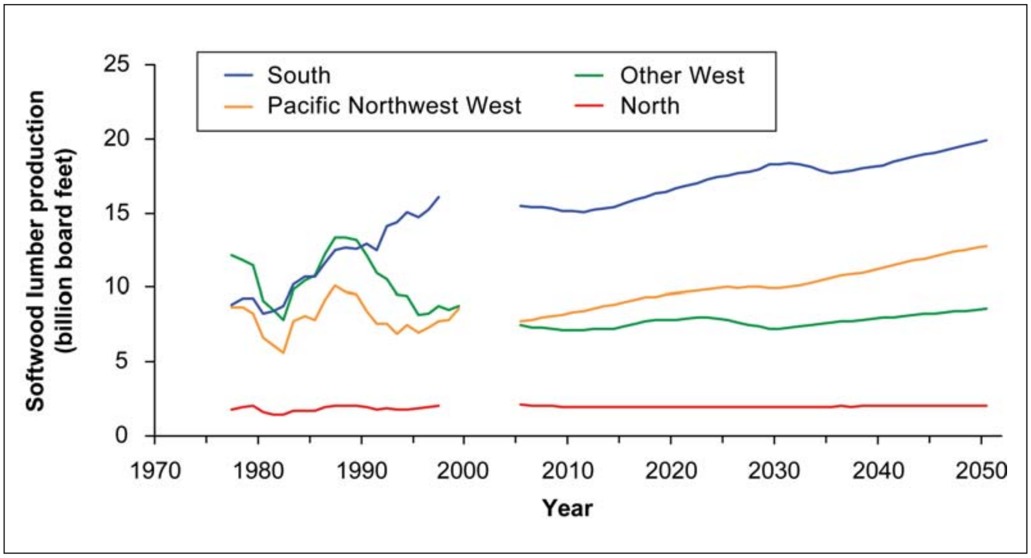

Figure 26—Softwood lumber production by U.S. region, with projections to 2050.

In the South, softwood lumber output is roughly constant during the first decade of the projection, then rises by one-third from 2015 to 2050. The next 10 to 15 years will see a major departure from the rapidly rising output trends of the past 30 years. The underlying cause of this break in trend (as discussed in greater detail in the section on timber resources) is a limitation in merchantable timber on nonindustrial private forest lands in the South-Central region and on forest industry lands in the Southeast. In these cases, sawtimber harvest will either decline, or expand only very slowly, over the next 15 to 20 years to remain within the limits of available merchantable volume. After this period, however, timber growth expands sharply, and harvest will increase apace.

Hardwood lumber—With the advent of wide-scale pallet reuse, recycling, and repair, growth in new pallet production has slowed appreciably and with it the rate of growth in hardwood lumber production. In the late 1990s, hardwood lumber consumption averaged about 12.5 billion board feet per year, roughly one-fourth the level for softwoods. In the base projection, hardwood lumber output and consumption continue to grow, although at slower rates than observed over the last 30 years (fig. 27). Production rises by some 1.4 billion board feet over the 2000–50 period. United States exports continue to outpace imports, with net export volumes projected to rise slightly in the next decade, then stabilize at about 1.1 billion board feet.

Consumption growth in hardwood lumber is due to changes in several end uses (fig. 28):

- A modest increase in lumber use in pallets. The pallet projection calls for new pallet production to rise from about 420 million per year in the late 1990s to just under 500 million by 2030, then roughly stabilize. At the same time, however, hardwood lumber use per pallet continues to decline in line with recent trends to substitute various nonlumber materials.
- Expanded use in flooring and millwork. This is driven largely by continued growth in residential upkeep and improvement expenditures.

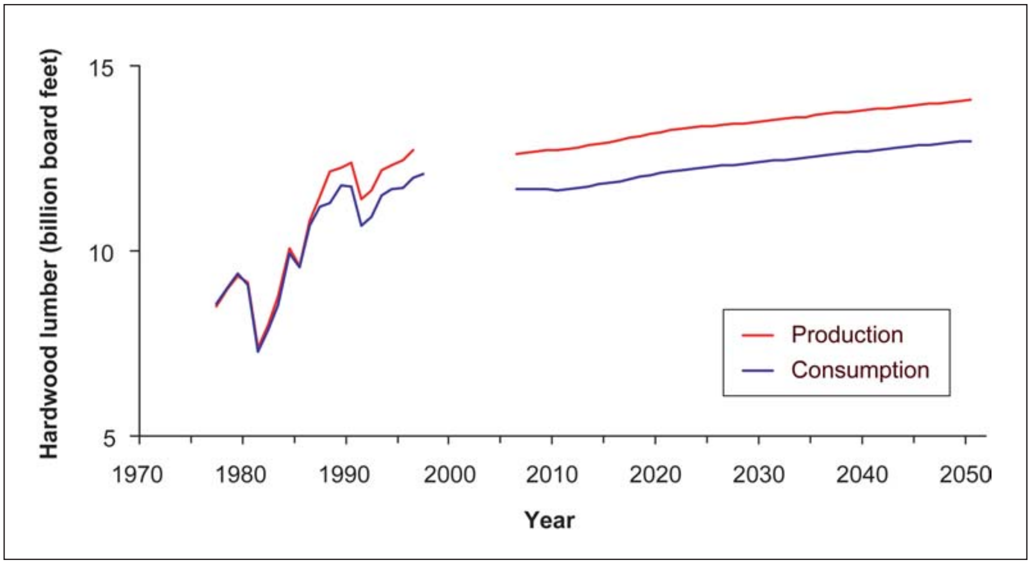

Figure 27—U.S. production and consumption of hardwood lumber, with projections to 2050.

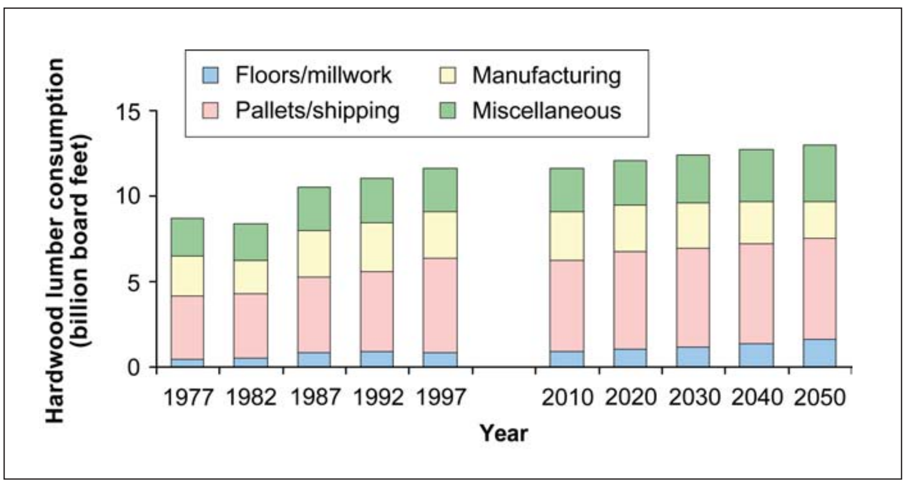

Figure 28—U.S. consumption of hardwood lumber by end-use category, with projections to 2050.

- Growth in miscellaneous uses. In the case of hardwood lumber, this category includes all construction applications except flooring and millwork, and made-at-home and on-the-job products such as advertising and display structures.
- Hardwood lumber use in furniture and other applications declines slightly.

Over the past two decades, hardwood lumber output has expanded in all regions, with particularly rapid growth in the North and the South-Central (fig. 29) regions. In the projections, output continues to rise in the North and Southeast but declines in the South-Central region. Limitations in Southern hardwood inventories and timber growth restrict options for future lumber production. Production in the North, in contrast, can rise more rapidly based on large and expanding hardwood inventories on nonindustrial private forest ownerships.

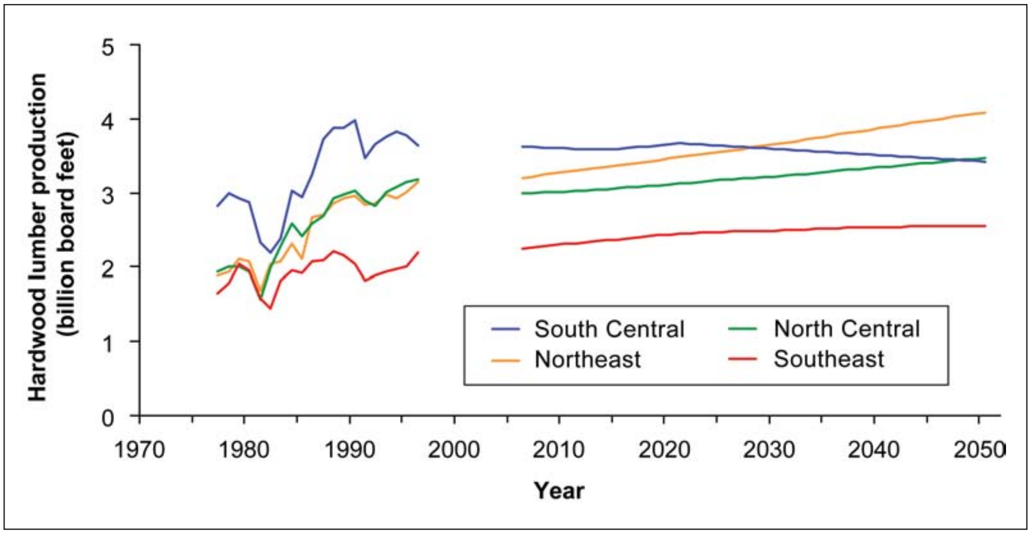

Figure 29—U.S. hardwood and lumber production by region, with projections to 2050.

Structural panels—Consumption of structural panels (softwood plywood, OSB), reached 31.6 billion square feet in 1996 and some 34.4 billion square feet by 1999.[7] These levels represent substantial increases over consumption just one decade earlier (the 1999 level is 30 percent higher than consumption in 1989). The two product components of the structural panels group have not enjoyed comparable development, however. Decades ago, growth of softwood plywood consumption in the United States was based, in part, on substitution of plywood for lumber in various decking and sheathing applications in new housing construction. Since the late 1970s, plywood in turn has been replaced in key markets by OSB. As shown in figure 30, plywood consumption has shown no trend over the past 20 years, drifting up and down with movements in housing starts, while OSB consumption has grown to exceed plywood use. In the base projection, softwood plywood consumption declines slowly to just below 10 billion square feet. Oriented strand board consumption grows less rapidly in the future, as it approaches saturation levels in many end uses, but still reaches nearly 41 billion square feet by 2050.

Underlying the declining softwood plywood trend are downward adjustments in consumption across all end uses. By the late 1990s, softwood plywood use had decreased by more than half in all new housing applications compared to levels in the late 1970s. It had a comparable share loss in residential upkeep and improvement uses relative to levels in the late 1980s. For the future, OSB will continue to gain ground by replacing use of softwood plywood in housing applications. Use of OSB per square foot of floor area in new housing will continue to rise until about 2010. Consumption growth after 2010 will derive primarily from residential upkeep and improvement, shipping, and manufacturing applications (fig. 31). In these uses, OSB will continue to replace softwood plywood and will capture all the future growth in structural panel consumption.

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[7] Detailed tables of historical data and projections are shown in appendix table 41.

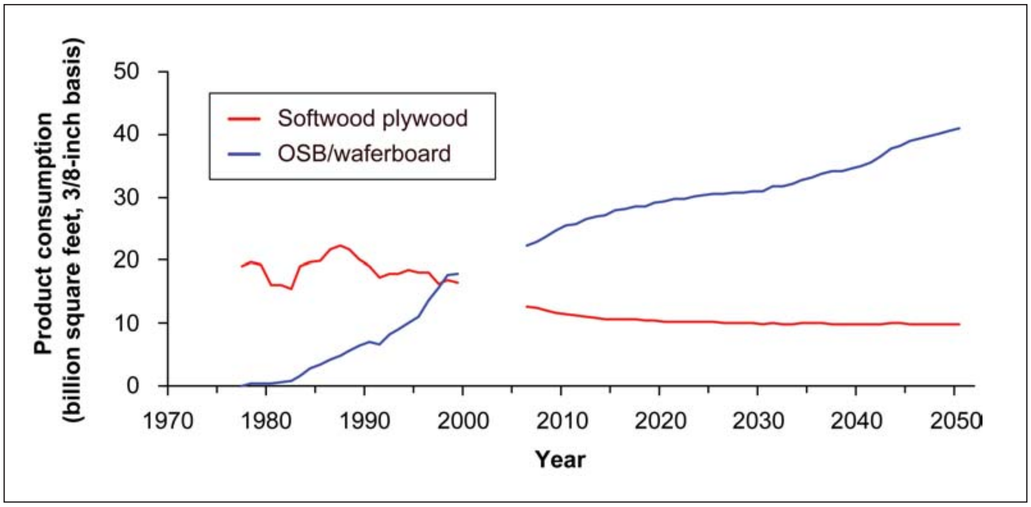

Figure 30—U.S. consumption of structural panel products, softwood plywood, and oriented strand board (OSB)/waferboard, with projections to 2050.

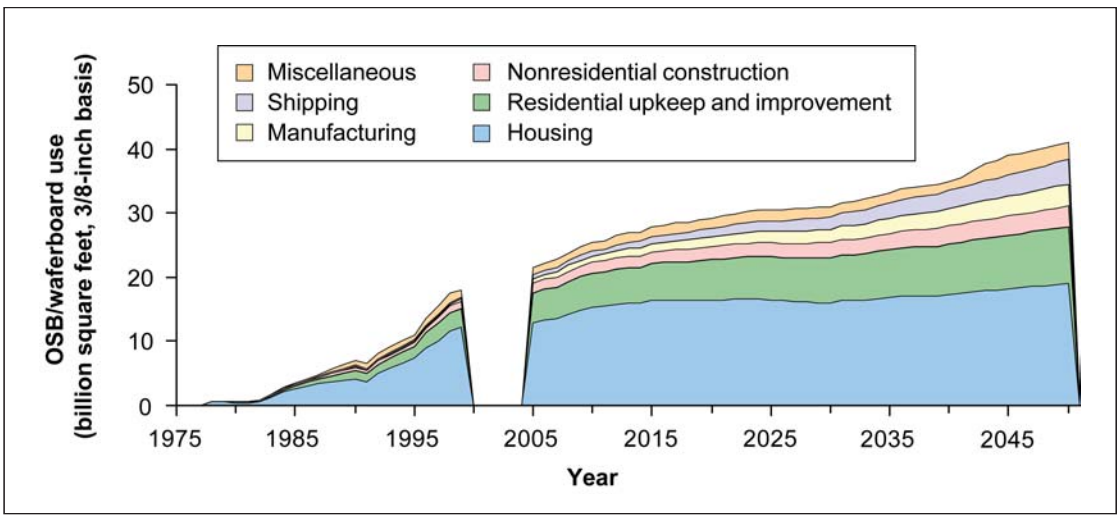

Figure 31—U.S. consumption of oriented strand board (OSB)/waferboard by end-use category, with projections to 2050.

Softwood plywood production and capacity have fallen sharply in the Pacific Northwest West (fig. 32) since the late 1980s in the face of major reductions in public timber harvest and competition from OSB. This decline is expected to continue over the first decade of the projection, as this region remains the high-cost producer in North America. By 2010, Pacific Northwest West production will be concentrated primarily in specialty grades for domestic use and export. Modest levels of production will continue in the West in regions east of the Cascade Range. Output in the South will follow a trajectory similar to that in the West, with the largest losses in the next decade.[8]

[8] Production, consumption, and trade details for structural panels are given in appendix tables 46 and 47.

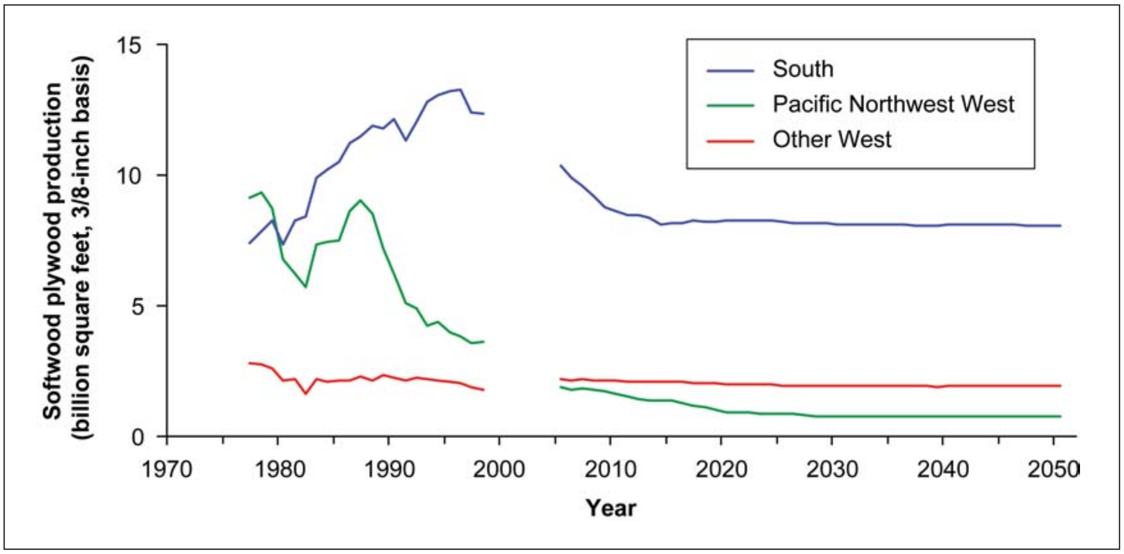

Figure 32—U.S. production of softwood plywood by region, with projections to 2050.

Domestic producers gain a larger share of the continued, if less rapid, growth in markets for OSB (fig. 33). In the United States, the North's market share rises slowly at the expense of the South after 2010. Domestic regions (North and South) and imports from Canada split the U.S. market in nearly equal proportions by 2050.

Nonstructural panels—Nonstructural panel consumption, including hardwood plywood, insulating board, hardboard, and particleboard, rose to 21.0 billion square feet (3/8-inch basis) in 1996, virtually unchanged from 1986 (fig. 34). Record-high nonstructural panel consumption was set in 1987 when 22.6 billion square feet were consumed. Particleboard (including medium density fiberboard [MDF]) was the most important nonstructural panel in 1996 accounting for 60 percent of total consumption. Hardwood plywood and insulation board were second at 16 percent each, followed by hardboard at 8 percent. Net imports accounted for about 15 percent of nonstructural panel consumption in 1996, down from 30 percent in 1986, but equal to the net import contribution in 1976. Since 1996, however, imports of particleboard and MDF rose significantly, and by 2001 accounted once again for about one-fourth of U.S. particleboard and MDF consumption.

Projected total demand for nonstructural panels increases to 25.8 billion square feet in 2010 and 30.9 billion square feet by 2050.[9] Because the future outlook in major markets varies, as do prospective rates of market penetration and product substitution, different trends in demand are projected for the four products. Consumption of insulating board, whose major market is residential construction, is expected to decline in the face of continued competition from other materials. Hardwood plywood, used in manufacturing as well as construction, also declines slowly through 2050. Particleboard, in contrast, is expected to show continued growth, paralleling output in furniture, cabinetry, and underlayment in new single-family residences, its major end uses. Consumption of hardboard, used in siding, underlayment, paneling, and furniture, also continues to rise slowly.

[9] Production, consumption, and trade details for nonstructural panels are given in appendix table 48.

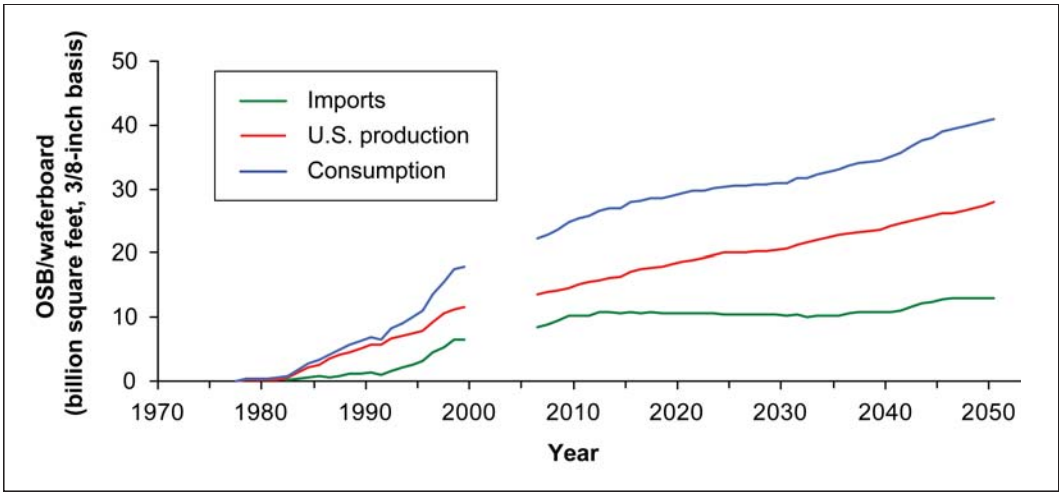

Figure 33—U.S. oriented strand board (OSB)/waferboard production, consumption, and imports, with projections to 2050 (exports are negligible).

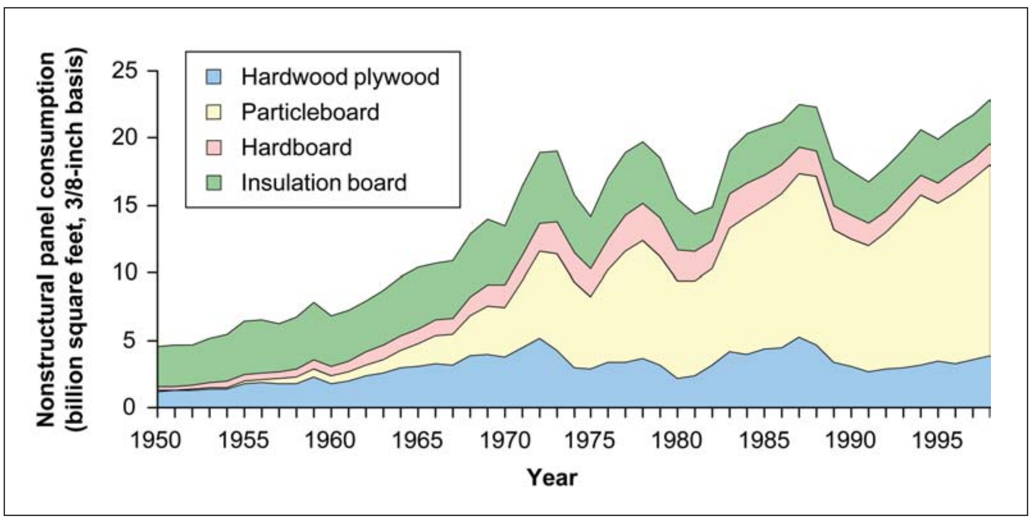

Figure 34—Nonstructural panel consumption by type of panel.

Imports of hardwood plywood have been an important trade flow in the nonstructural panels group in the past, although surpassed in recent years by rising imports of particleboard and MDF. Currently, about two-thirds of all the hardwood plywood consumed in the United States is imported, chiefly from Indonesia. Imports from these and other sources rose rapidly until the late-1980s to 3.8 billion square feet. Since then, they have fallen into the 1.7 to 2.0 billion square feet range as consumer tastes and price base substitution have shifted consumption away from wood-based paneling. In the future, imports are expected to stabilize at about 1.7 billion square feet per year. Pushed by rising U.S. demand, particleboard imports, mostly from Canada, are expected to continue to rise, climbing 80 percent above recent levels. Imports of other panels and exports of all panel types are expected to change little from recent levels.

Other industrial timber products—Various other industrial timber products are consumed in the United States, including poles; piling; posts; round mine timbers; hewn ties; bolts used for shingles, handles, and woodturnings; cooperage logs; chemical wood; and miscellaneous items. Total consumption of roundwood for these products amounted to an estimated 0.50 billion cubic feet in 1996, about equally split between hardwoods and softwoods. There has been no distinct trend in aggregate consumption of this category over the past several decades. Consumption dropped in the 1970s and 1980s but by 1996 returned to near the 1966 level of 0.56 billion cubic feet. The largest producing region is the North Central with more than 25 percent of the national output, predominantly in hardwoods. Projected U.S. consumption remains stable at about 0.52 billion cubic feet per year through 2050.

Paper and Board

Overall, U.S. paper and paperboard consumption and production were generally increasing throughout the 20th century, although the rate of increase has been gradually decelerating in recent decades. Since 1999, declining U.S. GDP growth and a recession in the overall manufacturing sector precipitated a significant drop in paper and paperboard consumption and production, the first multiyear decline since the "energy crisis" of the early 1970s. United States paper and paperboard purchases (excluding building paper) peaked at 103.4 million tons in 1999, but purchases dropped to an annual level less than 97 million tons in 2001 (AF&PA 2001). Thus, per capita consumption of paper and paperboard in the U.S. economy reached its historical peak at over 750 pounds per person in 1999 (excluding building paper), but consumption receded to only about 700 pounds per capita in 2001. Nevertheless, consumption still remains at historically high levels that had not been attained in the United States until the early 1990s. In 1960, per capita consumption was just less than 400 pounds, and in 1900, it was only about 60 pounds.

In recent decades, paperboard consumption increased more rapidly than paper consumption, a trend that is projected to continue, but growth is decelerating in both paper and paperboard demands. Paperboard consumption rose from 243 pounds per capita in 1980 (at 6.0 tons per million dollars of real GDP, in 1992 dollars) to its historical peak of 342 pounds per capita in 1999 (at 5.9 tons per million dollars of real GDP), a gain of about 40 percent in per capita consumption but a slight drop in consumption per unit of real GDP. With recent recessionary trends in the manufacturing sector, paperboard consumption fell to an annual rate of around 320 pounds per capita in 2001. Paperboard consumption is projected to recover from the current recession and then climb to 350 pounds per capita by 2010 and 418 pounds per capita by 2050.

Paper consumption (excluding paperboard and building paper) rose from 326 pounds per capita in 1980 (at 8.0 tons per million dollars of real GDP, in 1992 dollars) to its all-time historical peak of 419 pounds per capita in 1999 (at 7.3 tons per million dollars of real GDP), a gain of 28 percent in per capita consumption, but unlike paperboard, paper consumption declined more significantly relative to real GDP. Also, paper consumption suffered a more significant recessionary decline since 1999 (dropping to an annual rate of only about 380 pounds per capita in 2001). Paper consumption on a per capita basis is projected to recover but is not projected to reach the peak level of 1999 again in the decades ahead. Paper consumption is projected to climb back to an annual rate of 401 pounds per capita by 2010, to peak again at 414 pounds in 2030, and then decline gradually to 391 pounds in 2050.

Demand trends differ greatly among individual paper products. Per capita U.S. newsprint consumption, for example, rose throughout much of the 20th century but peaked at 113 pounds in 1987 and then declined to 89 pounds per capita in 1996. Newsprint consumption picked up again in the late 1990s with the strong economy and strong newspaper advertising demands (to 96 pounds in 1999), but then newsprint consumption fell with receding economic growth to less than 90 pounds in 2001. Newsprint consumption on a per capita basis is projected to continue gradually receding, falling to 81 pounds by 2010 and only 43 pounds by 2050. The projected trend for newsprint reflects an assumption that newspaper consumption will continue yielding to gradual substitution by electronic news and advertising media. Similarly, consumption of unbleached kraft paper is projected to gradually recede, reflecting continued substitution for paper by plastic bags, although not declining so rapidly as in the past two decades. On the other hand, per capita consumption of printing and writing paper continued to increase in recent decades, rising from 142 pounds in 1980 to 237 pounds in 1999, boosted by complementary demands for computer printers, office copiers, and print media. However, as with other paper and paperboard grades, consumption of printing and writing paper declined amid recessionary trends since 1999, dropping to an annual rate of around 220 pounds per capita in 2001. Printing and writing paper consumption is projected to recover in the next decade but then increase at a decelerating rate of growth, climbing back to 235 pounds per capita by 2010 and 263 pounds by 2030 before gradually receding to 255 pounds by 2050, with gradually declining consumption per unit of GDP. Tissue, toweling, and sanitary paper products increased in per capita consumption from 38 pounds in 1980 to 51 pounds in 1999, and consumption is projected to gradually increase throughout the projection period, reaching 63 pounds per capita by 2050, with receding consumption per unit of GDP.

Among paperboard commodities, the growth trends are more consistently upward, particularly for containerboard (paperboard grades used to make corrugated boxes and shipping containers). Per capita consumption of containerboard climbed from 166 pounds in 1980 to the recent peak of 246 pounds in 1999 (an increase of 48 percent), while per capita consumption of all other categories of paperboard (other recycled paperboard and bleached paperboard) plus building paper rose from 89 to 101 pounds between 1980 and 1999 (an increase of 13 percent). With projected recovery and economic expansion in the base case, per capita containerboard consumption is projected to increase to 256 pounds in 2010 and 324 pounds in 2050, although consumption of containerboard per unit of GDP is projected to gradually recede over the projection period. Other paperboard consumption is projected to remain at around 100 pounds per capita throughout the projection period.

Figure 35 illustrates the historical and projected trends in U.S. per capita consumption and consumption per million dollars of real GDP for paper and paperboard. Per capita consumption of paper and paperboard (excluding building paper) is projected to return to the recent peak level of 750 pounds by 2010 and then gradually climb to 809 pounds in 2050. The pronounced pattern of decelerating growth in demand observed in the latter half of the 20th century is projected to continue, with compound growth in per capita consumption averaging only about 0.2 percent per year from 2000 to 2050 (versus 1.7 percent compound growth between 1960 and 1999). Consumption of paper and paperboard per million dollars of real GDP is projected to decline from around 13.2 tons in 1999 to around 7.7 tons in 2050. The base case analysis finds that projected shifts in fiber supply and prices exert only modest influences on equilibrium demand levels, as indicated by a flat projected trajectory for product price cycles despite increased consumption.

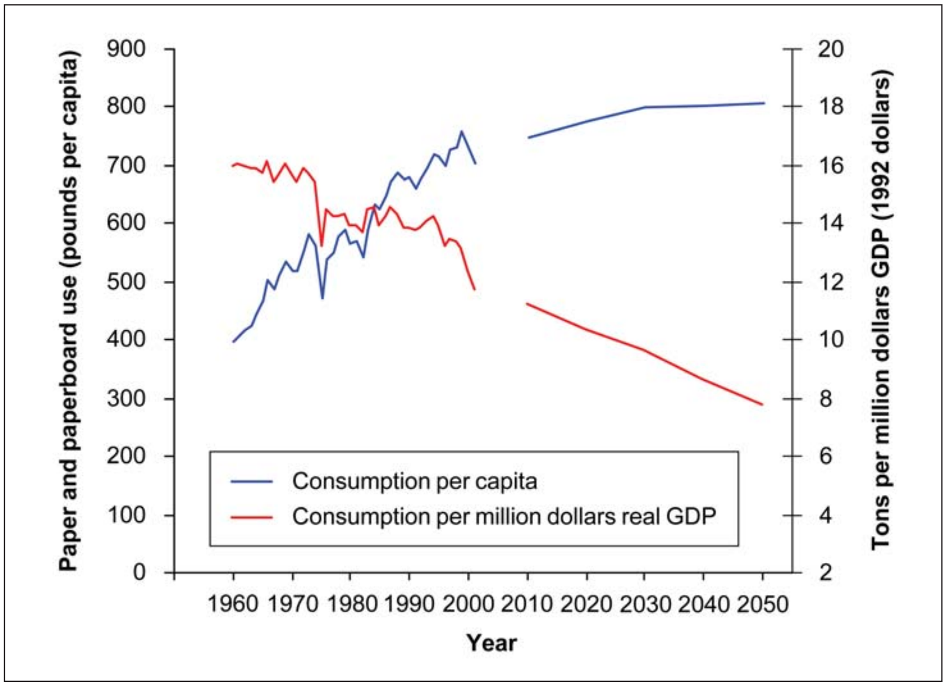

Figure 35—U.S. paper and paperboard consumption per capita and per million dollars of real gross domestic product (GDP) (in 1992 dollars).

On a total tonnage basis, U.S. consumption of primary paper and paperboard products (excluding building paper) recently declined from its all-time peak of 103 million tons in 1999 to a level of around 97 million tons in 2001, a decline of about 6 percent, with demand weakened by recessionary trends in the overall economy. However, with growing population and projected economic growth, U.S. demand for paper and paperboard is projected to recover, and total consumption is projected to reach 112 million tons in 2010 and 159 million tons in 2050. The projected annual rate of growth in tonnage of paper consumed from 2000 to 2050 is 0.8 percent, less than one-third the average rate of growth from 1960 to 1999 (2.8 percent).

Total U.S. production of primary paper and paperboard products (including building paper) reached a record level of 98 million tons in 1999 (AF&PA 2000). Impacted by recessionary trends in the manufacturing sector and increased imports, U.S. paper and paperboard production fell since 1999 to an annual rate of about 91 million tons in 2001 (including building paper).

In general, U.S. paper and paperboard production levels are projected to increase at a pace that is considerably slower than projected increases in domestic consumption; as a consequence, the United States will depend on imports for an increasing share of consumption. As is the case with softwood lumber, this trade outlook is based on the assumption that current trade policies will continue and a relatively strong U.S. dollar will persist. We also expect a continuation of other factors that contribute to the attractiveness of U.S. markets and weaken the relative competitiveness of U.S. exports. These other factors include the strength of the U.S. economy relative to that of other countries, and rates of capital investment and reinvestment in the United States that are low relative to those of competitors. The result is increasing imports and dampened prospects for exports.

The base projection describes a future that is consistent with trends of the past decade: increased U.S. imports of pulp, paper, and paperboard, with growth in exports slower than the long-term historical trend. Domestic production is expected to supply the bulk of projected increases in domestic demands over the next 50 years, as in past decades. However, nearly one-third of the projected increase in U.S. paper and paperboard consumption will be met by expansion in imports. While production of paper and paperboard is projected to increase by 43 percent over the next 50 years reaching 135 million tons by 2050 (excluding building paper), imports of paper and paperboard are projected to double, reaching 35 million tons by 2050. Imports of hardwood market pulp also are expected to increase, as fast-growing eucalyptus plantations in the Southern Hemisphere provide the raw material for this product.

Canada is projected to remain the primary source for U.S. imports of most paper and paperboard commodities, but low-cost producers in other world regions are expected to account for most (about 70 percent) of the projected increase in U.S. imports. By 2050, about 45 percent of U.S. paper and paperboard imports are expected to originate in Europe, Asia, and South America, compared to about 20 percent in 2000. The raw material for these imports will come from intensely managed native forests (in Europe), from plantations of selected exotic species (in Asia and South America), and from recovered fiber (in Europe and Asia), some of which may be imported from the United States. Figure 36 illustrates historical and projected U.S. paper and paperboard production, consumption, and trade on a tonnage basis.

One important projected shift in U.S. fiber supply is the expected increase in softwood pulpwood supply that results from expanded plantations and intensified management. Softwood pulpwood supplies are projected to be more than adequate to meet projected U.S. softwood fiber demands. Hardwood pulpwood supplies on the other hand, are projected to become more limited as landowners gradually reduce their propensity to harvest hardwoods on their timberlands. Consequently, hardwood market pulp production is projected to gradually decline as imports of hardwood market pulp (from Latin America and elsewhere) triple (from around 2 million tons to around 6 million tons per year). Conversely, production and exports of softwood market pulp are projected to increase. Export growth is projected to be modest, however, with exports increasing about 43 percent, to 5.4 million tons by 2050.

Pulpwood demand—In 2000, pulpwood receipts at U.S. wood pulp mills were 238 million green tons or approximately 7.3 billion cubic feet solid wood equivalent, down from a peak of 265 million green tons or 8.1 billion cubic feet in 1994, including roundwood and chips from forest harvest and wood residues (based on tonnage data for pulpwood receipts from the Forest Resources Association [2001], formerly American Pulpwood Association [1999], assuming 30.7 cubic feet per green ton). Pulpwood receipts at wood pulp mills are projected to continue receding for several years and then gradually recover along with recovery in wood pulp production, reaching 8 billion cubic feet again just after 2020 and 9.3 billion cubic feet by 2050.

Roundwood pulpwood consumption at wood panel mills (such as OSB mills) was estimated to be nearly 0.6 billion cubic feet in 1996 and is projected to exceed 2 billion cubic feet in 2050. Total demand for pulpwood in the United States (including pulpwood receipts at wood pulp mills and roundwood pulpwood consumption at wood panel mills) is projected to increase by 43 percent between 1996 and the end of the projection period (2050), with pulpwood receipts at wood pulp mills increasing by 26 percent and roundwood pulpwood receipts at wood panels mills increasing by more than 280

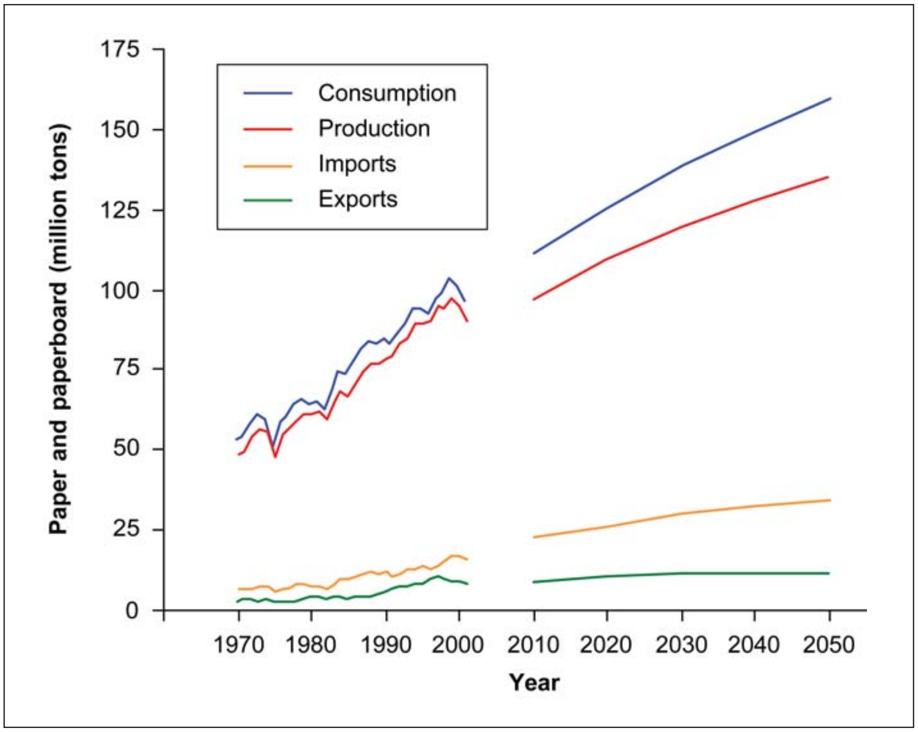

Figure 36—U.S. paper and paperboard consumption, production, imports, and exports, historical and projected.

percent. Thus, wood panel mills account for nearly half of the projected growth in pulpwood demand in the period between 1996 and 2050. United States pulpwood exports are projected to drop by over 40 percent between 1996 and 2050 as world supplies of pulpwood increase with expanded global development of fiber plantations. Table 8 shows historical estimates and projections of U.S. pulpwood receipts at wood pulp mills and wood panel mills along with pulpwood exports and estimated roundwood pulpwood harvest on forest land in 1986 and 1996, and at decade intervals from 2010 to 2050.

The sluggish trends of the late 1990s in pulpwood demands at U.S. wood pulp mills are projected to continue into the next decade, impacted in part by the current economic recession. Slow wood pulp mill capacity expansion, some additional gains in paper recycling, and limited growth in product exports will continue to dampen pulpwood demands at U.S. wood pulp mills, but toward 2010 and beyond, wood pulp production and pulpwood receipts at U.S. wood pulp mills are projected to increase. Most projected growth in pulpwood receipts at wood pulp mills occurs in the South, which has been the leading U.S. region in pulpwood consumption for many years. Pulpwood receipts at wood pulp mills in the South receded from the historical peak level of around 6.1 billion cubic feet in 1994 to 5.4 billion cubic feet in 2000. Pulpwood receipts at wood pulp mills in the South are projected to be 5.2 billion cubic feet in 2010 and 8.1 billion cubic feet in 2050. Pulpwood receipts at wood pulp mills in the North are projected to gradually decline over the projection period, from 1.1 billion cubic feet in 2000 to 0.6 billion cubic feet in 2050, while pulpwood roundwood receipts at OSB and wood panel mills in the North are projected to increase. Pulpwood receipts at wood pulp mills in the West are projected to gradually recede from around 0.8 billion cubic feet in 2000 to 0.6 billion cubic feet in 2050.

Table 8—Demands for pulpwood produced in the United States, including pulp mill receipts (roundwood and residues), wood panel mill receipts (roundwood pulpwood only), and pulpwood exports, along with sources of pulpwood supply, including forest harvest, residues, and agrifiber

	Historical		Projections				
Source	**1986**	**1996**	**2010**	**2020**	**2030**	**2040**	**2050**
			Million cubic feet				
Demand:							
Pulp mill receipts	7,473	7,446	6,712	7,660	8,481	8,894	9,345
Wood panel mill receipts	205	552	1,178	1,418	1,659	1,867	2,114
Pulpwood export	158	528	347	326	312	306	297
Supply:							
Harvest from forest land	5,016	6,274	6,439	7,676	8,741	9,467	10,054
Wood residue pulpwood supply	2,821	2,237	1,797	1,726	1,707	1,589	1,599
Agrifiber harvests[a]	0	16	2	2	5	10	104
Total supply	7,837	8,527	8,238	9,404	10,453	11,067	11,757

[a] Pulpwood from agrifiber is harvested from agricultural land and not included in forest harvest.
Source: Historical data: Derived from Ingram et al. 1999. Projections: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory.

Although increased U.S. production of paper and paperboard placed additional demands on fiber resources in recent decades, substantial gains were also made in paper recycling since the 1980s (fig. 37). Recycling contributed to a relatively constant (and recently subsiding) level of total pulpwood demand and pulpwood receipts at U.S. pulp mills. On the other hand, pulpwood supply to wood panel mills increased, mainly for OSB. Wood residue receipts at wood pulp mills have declined significantly over the past decade with increased production of wood products that generated fewer residues for pulping (such as OSB, for example) and with reductions in Western lumber and plywood production.

Pulpwood supply—Table 9 shows that the base case is characterized by expansion in softwood roundwood pulpwood supply, decelerating growth in paper recovery for recycling, and limited growth in hardwood pulpwood and wood residue supplies. Expansion of softwood pulpwood harvest, primarily in the South, accounts for most of the projected increase in pulpwood supply in the long run. The future growth in supplies of wood residues will remain limited. Hardwood pulpwood harvest is projected to increase nationwide until 2030 and then level out as a function of available forest inventories. Softwood pulpwood harvest is projected to steadily increase, facilitated by intensified forest management mainly in the South.

Paper recycling will dampen growth in pulpwood demands at U.S. wood pulp mills in the near term, but pulpwood demands in the long run are projected to increase as paper recovery and recycling rates level out (fig. 37). In the base case analysis, the paper recovery rate for recycling is projected to climb only gradually to 50 percent by 2010, and then remain at or around 50 percent through the projection period to 2050. The tonnage of paper and paperboard recovered for recycling in the United States has

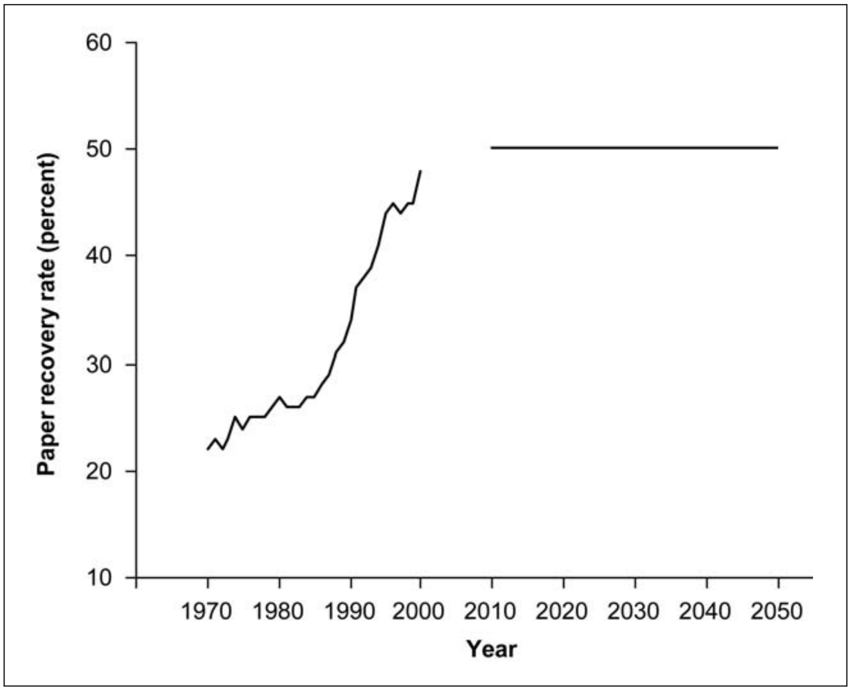

Figure 37—U.S. paper recovery rate, historical and projected. Recovery rate = (tons of paper and paperboard recycled / tons of paper and paperboard consumed) × 100.

Table 9—U.S. wood fiber supply, historical and projected

	Historical		Projections				
Type of fiber	**1986**	**1996**	**2010**	**2020**	**2030**	**2040**	**2050**
	Millions of short tons (pulpwood on dry weight basis)						
Softwood pulpwood:	69.1	69.3	67.4	78.2	89.4	97.1	105.5
Roundwood harvest	39.2	46.2	50.9	63.1	74.6	83.9	92.3
Wood residues	29.9	23.1	16.5	15.1	14.8	13.2	13.2
Hardwood pulpwood:	38.4	50.5	49.0	55.1	59.2	60.1	59.6
Roundwood harvest	30.3	42.8	40.5	46.1	50.2	51.1	50.5
Wood residues	8.1	7.6	8.5	9.0	9.0	9.1	9.1
Hardwood Agrifiber	0	.1	0	0	.1	.2	1.7
Total pulpwood	107.5	120.0	116.4	133.3	148.7	157.4	166.9
Recovered paper	22.5	43.1	55.8	63.0	69.8	74.9	79.7
Total	130.0	163.1	172.2	196.2	218.5	232.3	246.5

doubled since the mid-1980s, but growth in the recovery rate has slowed as industry capacity expansion has slowed and as price volatility in recovered paper markets replaced the recycled fiber market glut of the early 1990s.

Pulpwood usage—Although wood panel production is boosting roundwood pulpwood demand, total pulpwood usage is receding relative to paper and paperboard consumption and production, largely because of gains in paper recycling and rising imports of paper and paperboard. The total supply of pulpwood in the United States (roundwood and residue receipts at wood pulp mills, pulpwood exports, and roundwood pulpwood for wood panels) in dry weight per ton of paper and paperboard consumed in the United States receded from 1.38 tons in 1986 to 1.28 tons in 1996. This ratio is projected to decline to 1.04 in 2010, and then remain relatively constant to 2050. The ratio for total pulpwood use per ton of paper and paperboard produced in the United States (1.52 in 1986 and 1.33 in 1996) is projected to increase slightly in the future with the increasing supply of pulpwood used for wood panel production.

Figure 38 shows recent historical and projected trends for pulpwood usage, balancing U.S. supply and demand quantities by source and destination. Sources of supply include hardwood and softwood (roundwood forest harvest and wood residues) and hardwood agrifiber. Destinations include pulpwood receipts at domestic wood pulp mills (by far the largest category), roundwood pulpwood receipts at wood panel mills (such as OSB mills), and pulpwood exports. Receipts at wood panel mills are projected to increase several fold and account for nearly half of projected growth in pulpwood supply and demand. Panel mills are projected to account for 14 percent of total pulpwood supply by 2010 and 18 percent by the end of the projection period in 2050. Hardwood agrifiber is projected to supply only a small fraction of total U.S. pulpwood supply, just 1 percent by 2050. United States pulpwood exports are projected to decline with worldwide expansion of global fiber supply from wood fiber plantations.

Prices of Forest Products

All forest products and timber prices in this assessment are presented in **deflated** or **real** terms. That is, the effects of general, economy-wide inflation have been removed from the projections. This is accomplished by dividing the original, or **nominal,** price series by the all commodity producer price index (1982 = 100)—a general measure of prices at the wholesale level in the U.S. economy.[10]

The base projection envisions only modest trend movements in long-term prices for all classes of products over the next five decades. Slow price growth reflects (1) limited growth in stumpage prices for many (although not all) classes of timber, (2) continued improvement in product recovery per unit of wood or fiber input, (3) continued substitution by the least costly sources of fiber in all product categories, (4) substitution between classes of wood and nonwood products by consumers, and (5) growth in imports of some major product classes augmenting total supply. Despite fairly substantial projected increases in the consumption of forest products in the United States, a combination of domestic and import supply expansion will act to offset much of the pressure for price growth. For paper and paperboard products, this will mean that future prices remain at about the relatively high levels experienced in the recent past. In the solid wood sector, price behavior differs across products. Both softwood and hardwood lumber prices rise at about 0.6 percent per year measured over the period from the mid-1990s

[10] Projections of general price inflation in the U.S. economy, including the producer price index, are discussed in chapter 2.

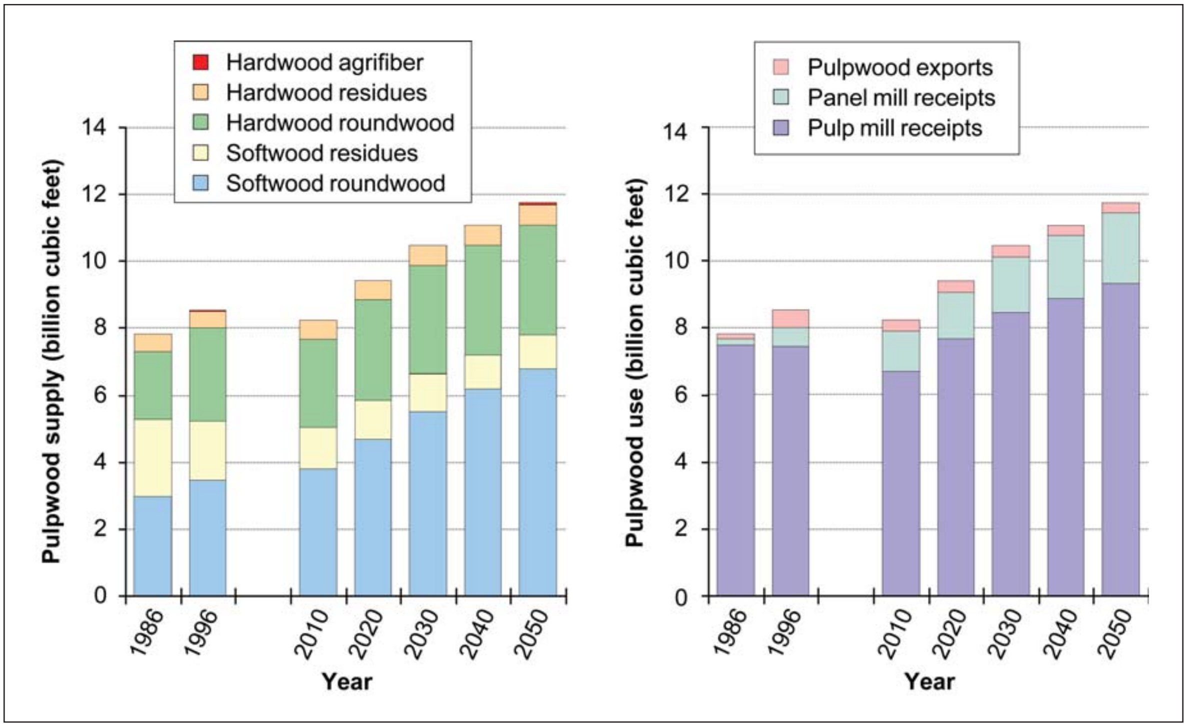

Figure 38—U.S. pulpwood supply by source and by destination, historical and projected.

to 2050 (table 10). The softwood price cycle centered roughly at 2020 is caused by reductions in Canadian imports prior to 2020 and gradual, compensating expansion in U.S. output and non-Canadian imports. In the face of strong competition from OSB and stable wood costs, softwood plywood prices also show limited upward trend (a 0.3-percent increase per year). The key aspect of the projections for these products, however, is that prices do not return to the lower levels experienced in the 1980s or earlier periods. Having shifted upward during the 1990s, they remain at these higher levels. Oriented strand board prices, in contrast, showed considerable volatility in the 1990s but no major growth, and projected prices continue at the average of the past two decades with no upward shift (see table 10).

Solid wood products—Hardwood lumber prices rise through 2050 by roughly 30 percent above recent levels (fig. 39). The initial upward movement is driven by wood costs and ultimately by sawtimber stumpage prices, which rise in both the North and South.

Softwood lumber prices remain near levels of the 1990s in the first 10 years of the projection, then rise through two cycles by nearly 40 percent in the ensuing 40 years. Near-term stability is aided by steady housing activity and expansion in both Canadian and non-Canadian lumber imports. After 2010, our assumptions regarding limitations in future Canadian sawtimber harvests act to constrain Canadian lumber output, and exports to the United States fall. Rising prices improve the profitability of production in the United States, augmenting domestic capacity and output (primarily in the Pacific Northwest West and South). They also attract further import growth from non-Canadian sources. At the same time, growth in U.S. wood costs is limited because of major increases in Southern softwood sawtimber supplies (as discussed in a later section) and continued improvement in recovery efficiency. Softwood plywood prices are about stable

Table 10—Indices of deflated prices[a] for selected timber products in the United States, by softwoods and hardwoods, 1952–97, with projections to 2050

Product, unit, and species group	Historical							Projections				
	1952	1962	1970	1976	1986	1991	1997	2010	2020	2030	2040	2050
	Index of price per unit—1982 = 100											
Lumber: (1,000 board feet)												
Softwoods	100.0	88.3	95.4	126.2	108.2	107.9	161.8	146.0	170.3	166.1	187.2	198.8
Hardwoods	104.4	103.5	118.4	109.8	118.0	110.3	136.4	159.2	170.9	175.6	179.5	182.3
Structural panels: (1,000 square feet, 3/8-inch basis)												
Plywood	172.0	118.9	109.2	143.7	109.2	103.7	137.5	151.5	150.3	147.1	154.1	157.4
Structural panels: (1,000 square feet, 7/16-inch basis)												
OSB-waferboard[b]	NA	NA	NA	NA	112.5	94.2	83.6	115.6	112.4	113.7	117.8	123.1
Nonstructural panels: (1,000 square feet, 3/8-inch basis)												
Plywood	193.8	176.8	153.6	110.8	98.4	89.3	90.8	88.0	87.2	86.5	85.7	85.0
Other panels[c]	151.5	166.3	119.2	93.2	105.4	94.0	107.0	99.5	99.5	99.5	99.5	99.5
Paper and paperboard:[d] (metric tons)												
Paper	93.2	102.8	105.1	104.2	106.8	108.9	112.8	98.1	99.4	98.6	98.2	100.1
Paperboard	130.4	121.1	107.6	112.9	106.3	111.8	113.5	114.6	117.5	115.0	115.0	117.2

NA = Not available.
[a] All price indexes deflated by the all-commodity producer price index.
[b] OSB historical prices updated.
[c] Hardboard, particleboard, and fiberboard products.
[d] 1991 prices updated.
Source: Historical data from Producer Prices and Price Indices, U.S. Bureau of Labor Statistics 1958–96; Random Lengths 1998.

throughout the projection as a result of declining demand and continued recovery improvement. Prices for OSB do not rise because of limited growth in wood costs, particularly for softwood pulpwood in the South and hardwood pulpwood in the North.

Paper and board prices—Historical paper and paperboard prices have shown considerable volatility over the post-World War II period, rising and falling with cycles in the U.S. economy and in the extent of capacity utilization. There has been no long-term rising or falling trend in these prices, however, with average prices in the late 1960s very close to averages in the late 1990s (fig. 40). The absence of price trends, despite significant growth in output and consumption, reflects both major improvements in productivity and shifts to less costly fiber sources. These adaptations are expected to continue in the future supplemented by continued growth in imports. Projected paperboard prices recover to about the average of the past two decades by 2020 and remain stable thereafter. Paper prices remain near their late-1990s low.

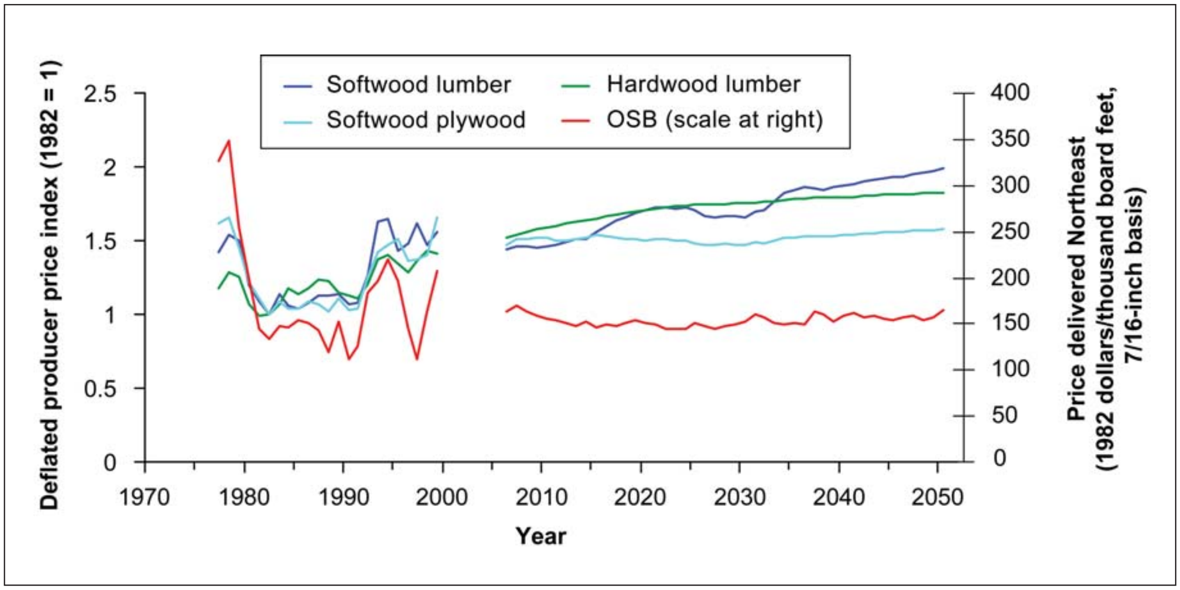

Figure 39—Prices and price indexes for softwood lumber, softwood plywood, hardwood lumber, and oriented strand board (OSB)/waferboard, all deflated to 1982 values, with projections to 2050.

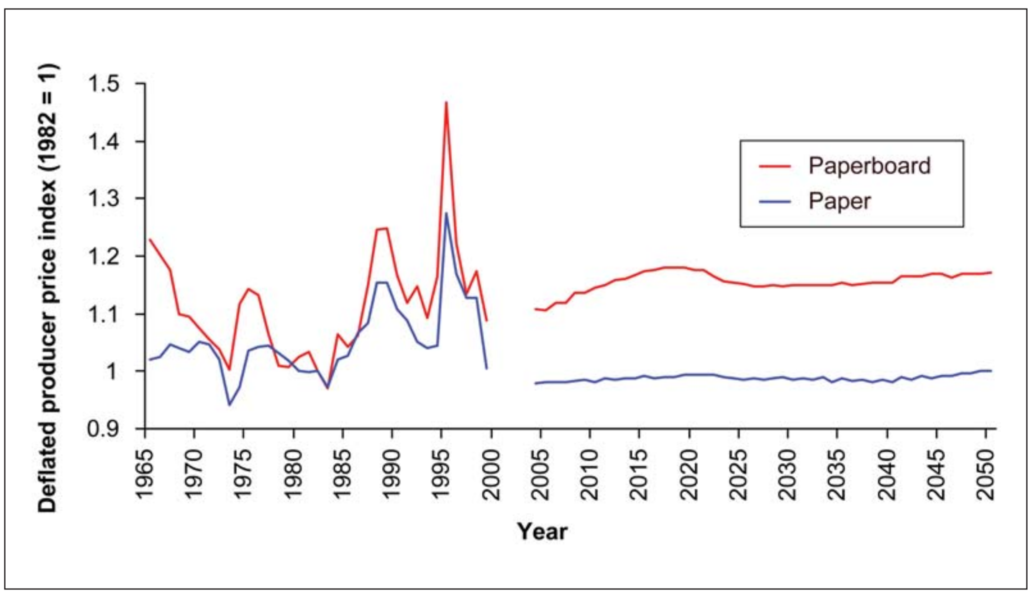

Figure 40—Real price indexes of U.S. paper and paperboard (1982 = 100), with projections to 2050.

Shifts in U.S Forest Products and Source Materials

The following section gives (1) an overview of trends in all forest products the United States consumes and exports and the materials used to make them (outputs and inputs), and (2) a more detailed view of trends in roundwood in U.S. forest products consumption, production, and trade. The first section expresses quantities in million tons of roundwood and products in order to compare solid wood and paper products. The second section expresses quantities in billions (10^9) of cubic feet of roundwood.

U.S. forest products outputs and inputs—Harvested roundwood is one of several raw materials required to meet U.S. forest product demands. United States consumption and export demands are satisfied by a combination of forest products produced in the United States for domestic use and for export, by wood used for energy, and by product imports. Source materials needed to meet these consumption and export demands include:

- U.S. roundwood harvest
- Log, chip, and product imports
- Recovered paper
- Nonwood fillers in products.

The relation between product outputs (demands) and wood inputs (material sources) can be expressed as the following identity:

All outputs (demands)
  = U.S. production for domestic use
    + product exports
    + log and chip exports
    + wood energy consumption
    + forest products imports
  = U.S. roundwood harvest
    + log and chip imports
    + forest product imports
    + recovered paper use
    + nonwood fillers in products
  = all inputs (material sources).

In 1998, the amount of all outputs (and inputs) was 349 million tons. This is projected to increase 36 percent to 476 million tons by 2050 (0.6 percent per year). This is much slower than the 1.7-percent-per-year increase rate between 1965 and 1998 (figs. 41 and 42). Of this 127-million-ton increase, 53 percent will come from increased U.S. roundwood harvest, 27 percent from increased imports, and 20 percent from increased recovered paper and fillers.

Over the course of the projection, significant changes are expected in the composition of the inputs (material sources) and outputs (demands):

- The mix of outputs will change—Import of products increases at a faster rate than production for domestic use, exports, and energy (fig. 41); and, for U.S. product production, paper production increases faster than lumber or composites production (fig. 43).
- The mix of inputs will change—Import of products will increase faster than recovered paper use or roundwood harvest; virtually all increase in roundwood harvest is for nonsawtimber uses (fig. 44); roundwood harvest from nonindustrial private forest land increases faster than that from industrial or public land; and roundwood harvest increases faster in the South than in the North or West (figs. 45a and 45b).
- Improvement in U.S. productivity in making products from roundwood will be limited by small increases in recycling rates and few improvements in wood residue use for products.

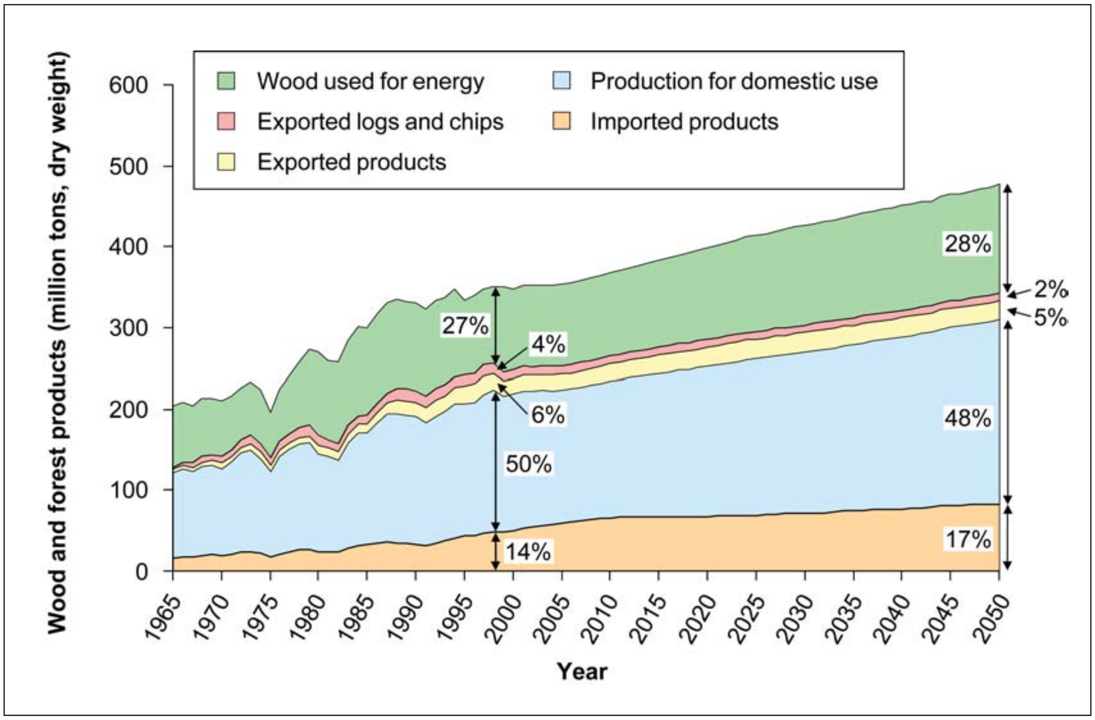

Figure 41—U.S. production, export, and import of wood and forest products by category, 1965–98, with projections to 2050.

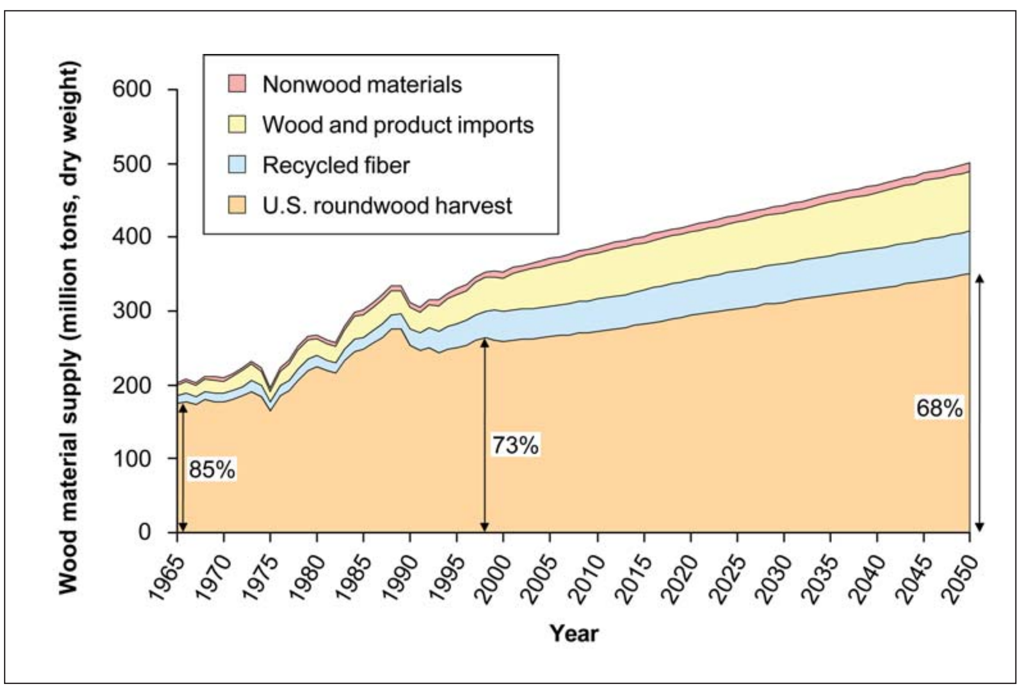

Figure 42—Material sources for U.S. forest product consumption and exports, 1965–98, with projections to 2050.

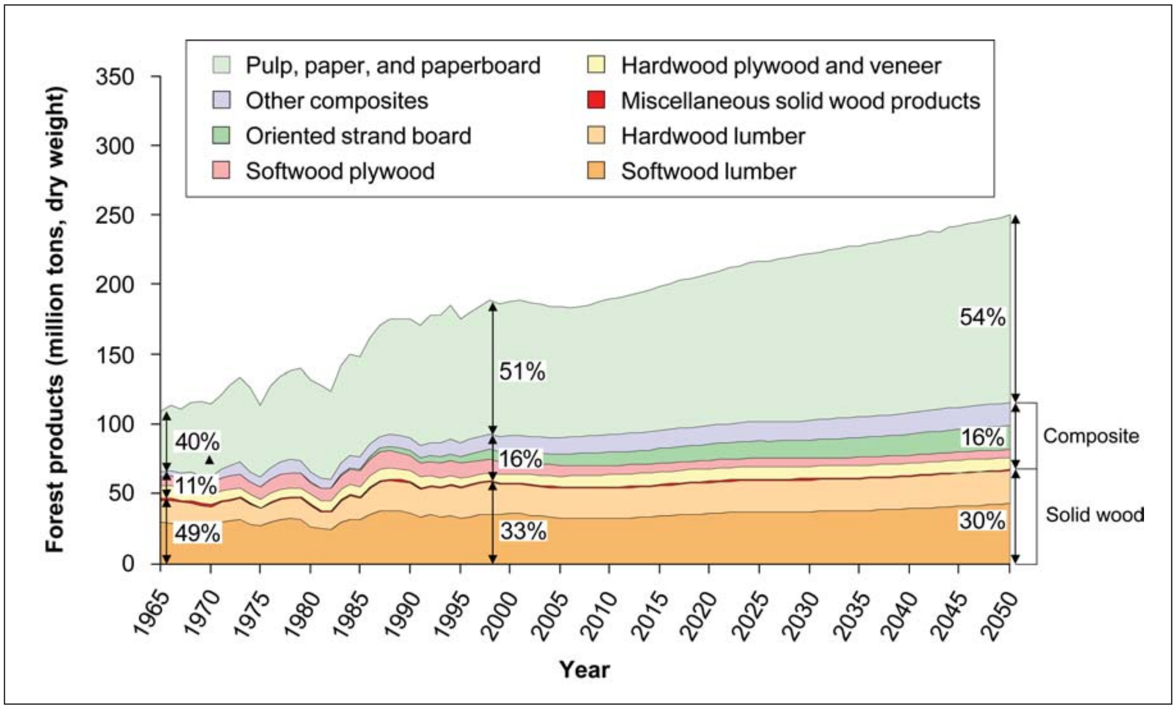

Figure 43—U.S. production of forest products by category, 1965–98, with projections to 2050. Percentages are for solid wood; composites (OSB, plywood, and veneer); and pulp, paper, and paperboard as a percentage of total production.

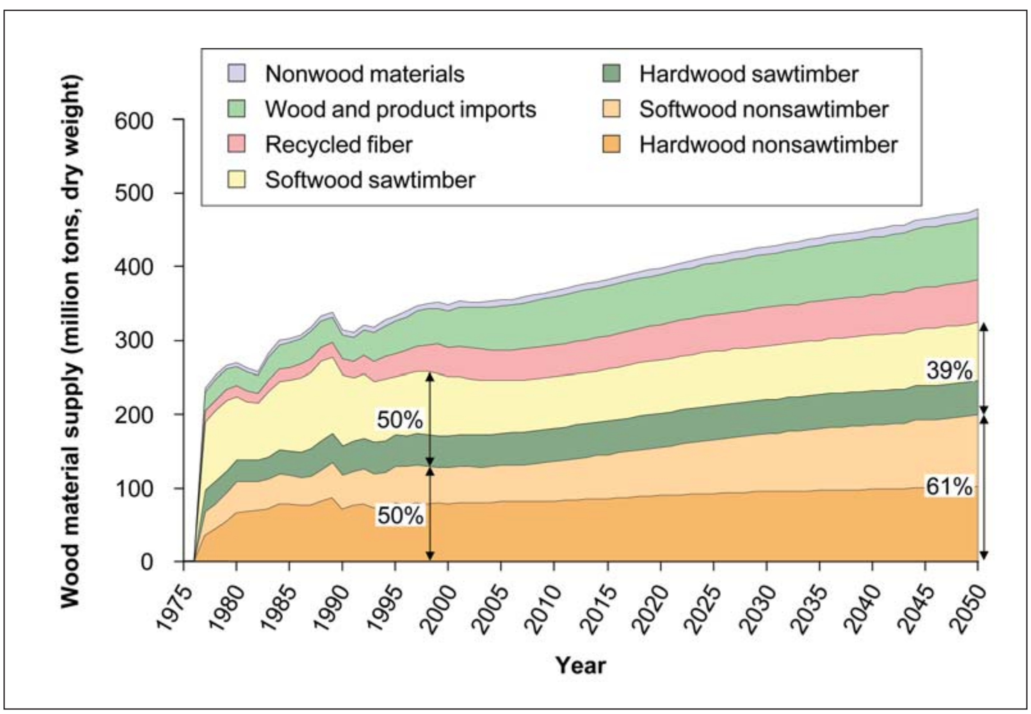

Figure 44—Material sources of U.S. forest product consumption and exports by timber type, 1975–98, with projections to 2050. Percentages are for sawtimber and nonsawtimber as a percentage of roundwood supply.

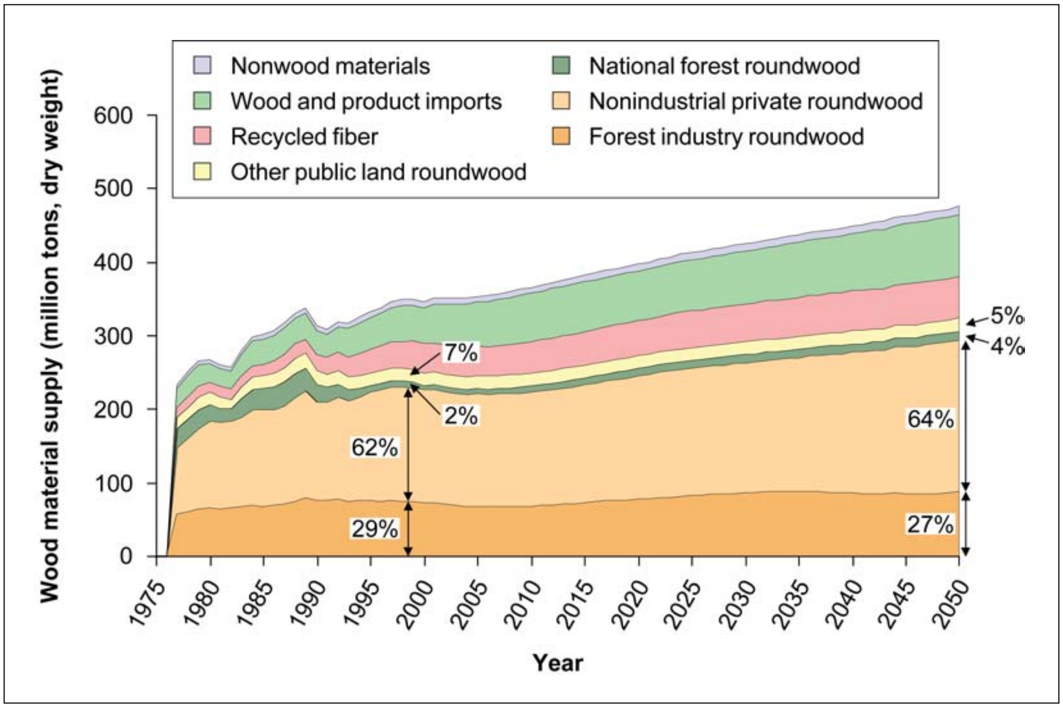

Figure 45a—Material sources of U.S. forest product consumption and exports by owner, 1975–98, with projections to 2050. Percentages are for sawtimber and nonsawtimber as a percentage of roundwood supply.

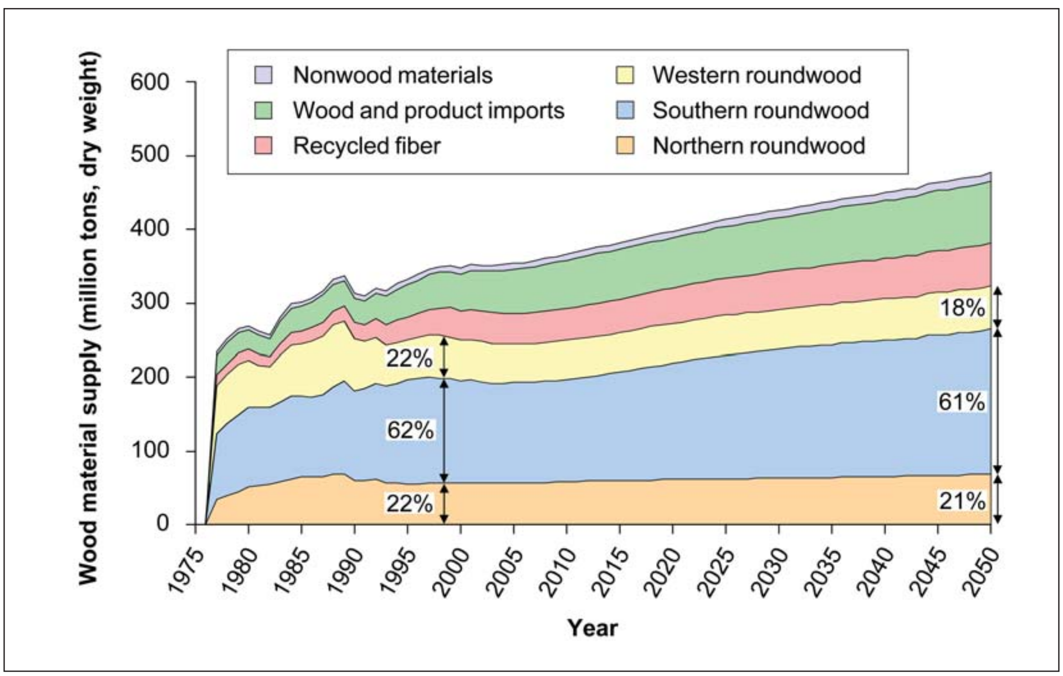

Figure 45b—Material sources of U.S. forest product consumption and exports by region, 1975–98, with projections to 2050. Percentages are for sawtimber and nonsawtimber as a percentage of roundwood supply.

- United States consumption of products per capita will remain about constant while U.S. roundwood harvest per capita decreases primarily owing to increased imports and, to a lesser degree, increased use of recovered paper (fig. 46).

Outputs—Outputs include forest products produced in the United States (for domestic use and export), forest product imports, log and chip exports, and wood energy use (includes roundwood, mill residue, and pulp liquor). Between 1998 and 2050, it is projected that output needs will increasingly be met by imports. But the rate of increase in imports over the next 50 years is slower than for the last 50 years.

- Product imports are projected to increase from 14 to 17 percent of outputs.
- The U.S. production for domestic use declines from 50 to 48 percent.
- Products for export decrease from 6 to 5 percent.
- Export of logs and chips declines from 4 to 2 percent.
- Wood for energy remains about 28 percent (fig. 41).

Consumption of wood, paper, and paperboard products is projected to increase from 223 to 310 million tons (0.6 percent per year) between 1998 and 2050. (In comparison, the United States consumed 138 million tons of steel and 113 million tons of cement in 1998.)

- Projected increase in product consumption is less than half the annual rate from 1965 to 1998.
- Product consumption came 78 percent from U.S. production in 1998; this share is projected to decline to 73 percent by 2050. The relative contribution of imports to consumption increases from 22 percent in 1998 to 27 percent in 2050 (fig. 42).

Total U.S. production (for domestic use and exports) is projected to increase 0.5 percent per year, from 174 million tons in 1998 to 227 million tons in 2050, whereas the increase rate was 1.5 percent per year over the prior 33 years.

- Total exports are projected to decline from 10 percent of production in 1998 to 8 percent in 2050 (fig. 41).
- The fastest growing component of production over the next 50 years is projected to be paper and paperboard (up 41 percent), followed by composite products (up 38 percent), and lumber and miscellaneous products (up 18 percent). However, paper and paperboard production will be declining temporarily in the next several years (fig. 43).
- The composition of production in 1998 was (1) paper and paperboard, 51 percent (54 percent by 2050), (2) lumber and miscellaneous products, 33 percent (30 percent in 2050), and (3) composites, 16 percent (16 percent in 2050). In 1965, these shares were 40 percent for paper, 49 percent for lumber, and 11 percent for composites.
- For lumber and miscellaneous products, softwood lumber accounts for most of the lumber increase over the next 50 years, from 35 to 42 million tons, while hardwood increases from 23 to 24 million tons. Composites increase from 29 to 40 million tons, with OSB accounting for much of the increase, from 7 to 17 million tons.

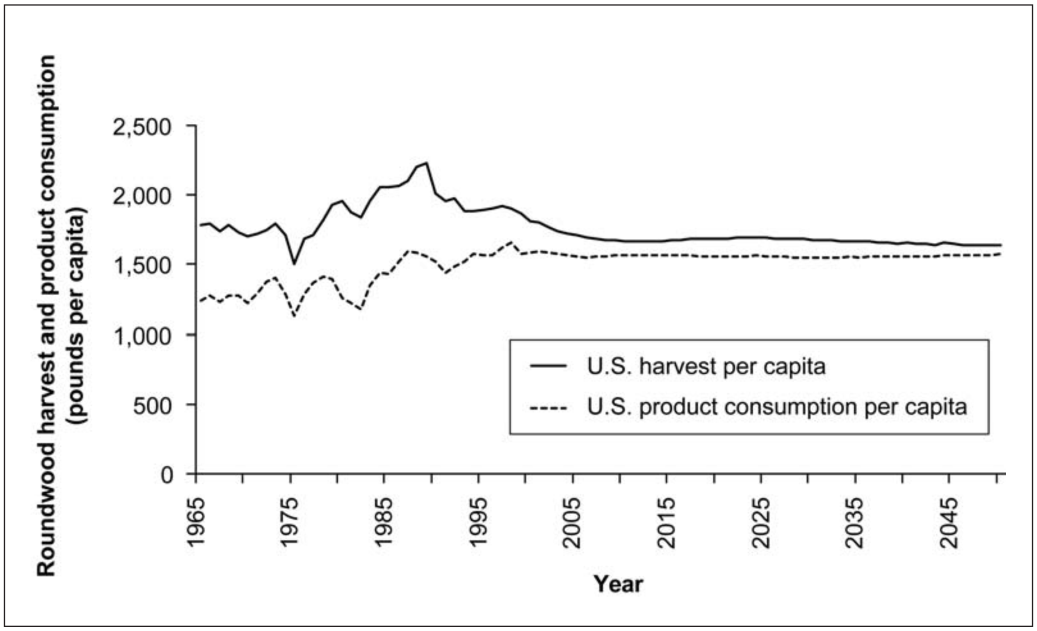

Figure 46—U.S. roundwood harvest and wood or paper product consumption per capita.

Effect on inputs of increasing paper and paperboard and OSB share of output—The increasing share of paper and paperboard and OSB production will increase the input share for small trees and recovered paper. The amount of wood mill residue available to make paper per ton of paper produced will decline with the decreasing share of lumber and increased efficiency of lumber production.

Inputs—Inputs include U.S. roundwood harvest, log and chip imports, forest product imports, recovered paper use, and nonwood fillers in products. Between 1998 and 2050, the relative role of U.S. roundwood harvest is projected to decrease.

- Roundwood harvest decreases from 73 to 68 percent of all inputs.
- Log, chip, and product imports increase from 14 to 18 percent of inputs.
- Recovered paper continues to increase from 10 to 12 percent of inputs.
- Roundwood has decreased notably since 1965 when it provided 85 percent of inputs (fig. 42).

United States roundwood harvest is projected to increase from 256 to 323 million tons between 1998 and 2050 (0.4 percent per year).

- This increase rate is down from 1.2 percent per year over the prior 33 years.
- United States roundwood harvest for fuelwood increases in share from 14 percent in 1998 to 17 percent in 2050.

Import of logs and chips is projected to increase from 0.7 to 1.5 million tons between 1998 and 2050 (1.5 percent per year), up from a decrease of 2.7 percent per year over the prior 33 years. The share of roundwood from imports increases from 0.3 to 0.5 percent.

The U.S. roundwood harvest increase of 67 million tons between 1998 and 2050 will come from the following sources:

- Mostly from the South (78 percent), compared with 18 and 4 percent from the North and West, respectively.
- Mostly from nonindustrial private lands (75 percent), compared with 19 and 6 percent from industry land and public land, respectively.
- All from nonsawtimber (nonsawtimber increase is 104 percent of the total, and sawtimber decreases by 4 percent of the total).
- Mostly from softwoods (59 percent, compared with 41 percent for hardwoods).

Industrial wood productivity—United States production of wood, paper, and paperboard products per unit of roundwood input (industrial roundwood) increased 35 percent in the past 50 years, but the rate of increase is projected to slow to 3 percent over the next 50 years.

- Production per unit of roundwood input has increased from 19.4 pounds of product per cubic foot of wood input in 1950 to 26.2 pounds per cubic foot in 1998 and is projected to increase to 27.0 pounds per cubic foot in 2050.
- Productivity increased between 1950 and 1998 owing to increased use of wood mill residue for products, increased use of recovered paper, and increased product output per unit of fiber input.
- The rate of increase is projected to slow over the next 50 years because (1) wood mill residues are now largely used for products rather than being burned or discarded and a greater shift from fuel use to product use is not expected, and (2) there will be relatively little increase in the rate of use of recovered paper. A greater shift toward using residue for products rather than fuel would increase industrial product output per unit of industrial roundwood input.
- Future advances will rely on increases in recycling of paper and solid wood, use of alternative fibers, and increased product (or product performance, for example, in housing) per unit of fiber input.

U.S. product consumption and U.S. roundwood harvest per capita—Per capita consumption is projected to remain about constant while U.S. roundwood harvest per capita declines. Per capita consumption is projected to remain at about 1,565 pounds per year between 1998 and 2050, up from 1,243 pounds per year in 1965 (fig. 46). United States roundwood use per capita (U.S. harvest + log and chip imports) decreases from 1,900 pounds in 1998 to 1,650 pounds in 2050 (64 cubic feet and 56 cubic feet, respectively), for a decrease of 0.3 percent per year, a reversal from a 0.2-percent-per-year increase between 1965 and 1998 (fig. 46). Consumption per capita can remain constant with declining roundwood harvest per capita primarily because of increased product and log and chip imports, a limited increase of product exports, and limited improvements in U.S. product output per unit of roundwood input (fig. 46).

Total roundwood use for consumption, production, and trade—Figure 47 displays estimates of total volume of timber harvest used to produce all forest products consumed in the United States (hardwood and softwood detail is shown in table 11). In this figure, the quantity of each class of product is converted to the equivalent volume of roundwood, derived from current harvest, that would be required for its manufacture.

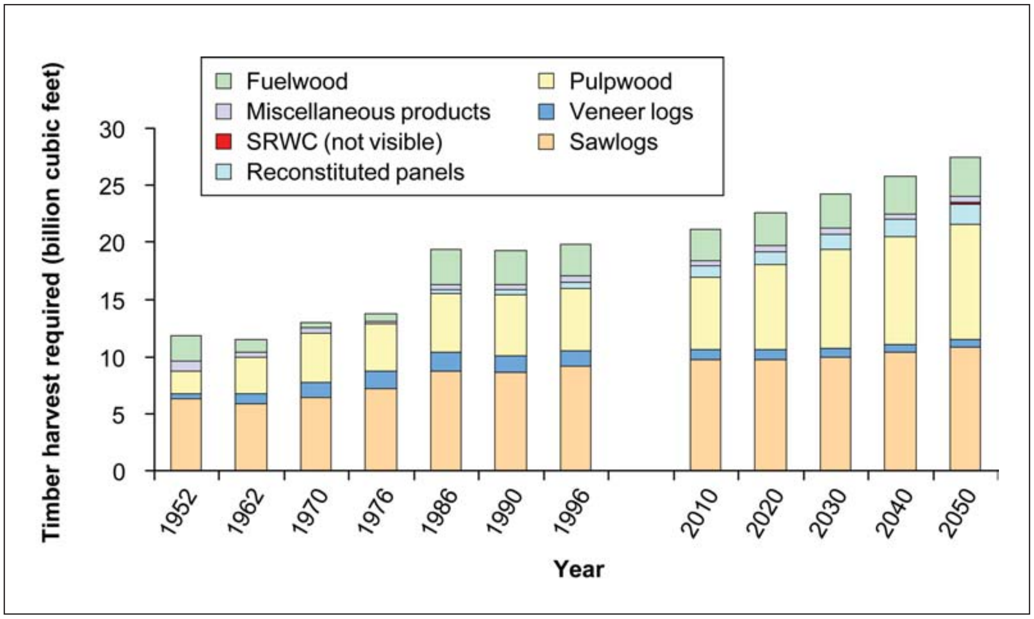

Figure 47—Timber harvest volumes required for U.S. production by category of product, with projections to 2050. SRWC is short-rotation wood crops for pulping.

The figure estimates "new" harvest from forests and from short-rotation woody crops grown on agricultural lands and does not include recovered wood and fiber. It does include the products consumed regardless of source, however, so roundwood that was used to make imports is part of the total. The roundwood that was used to make solid wood and paper imports is estimated by using U.S. conversion efficiencies.

In recent years, the United States has consumed close to 20 billion cubic feet of newly harvested wood per year for products made in the United States for domestic use and for products made in other countries and imported into the United States. (In addition, we harvest about 2.3 billion cubic feet of roundwood in the United States for exports.) Products made from sawlogs (lumber in its many forms) have traditionally been the largest component of roundwood consumption. They are also projected to remain a major group in the future but with limited growth until after 2030. Nonsawtimber harvested for pulpwood or reconstituted panels is the second largest consumption category at present. In the projection, nonsawtimber for pulpwood and reconstituted panels continues to show strong growth, with the largest increases in softwood species. After 2030, short-rotation woody crops from agricultural lands will be used to a small degree as an additional source of fiber for paper and paperboard. The only product class for which production volume contracts is veneer logs, owing to the decline in use of softwood plywood. In sum, over the 50-year projection period, total timber harvest from all sources (domestic and other countries) for domestically consumed products rises to 27.5 billion cubic feet, 40 percent above current levels.

The role of trade—Figures 48 and 49 indicate the sources of harvested timber from domestic forests, forests in other countries, and nonforest short-rotation woody crops (details are shown in table 12). Imports contribute to consumption but do not represent a draw on domestic forests. Exports are not part of domestic consumption but do require harvests from U.S. forests.

Table 11—Apparent roundwood consumption in the United States, by species group and product, 1952–96, with projections to 2050

	Historical							Projections				
Species group and product	**1952**	**1962**	**1970**	**1976**	**1986**	**1991**	**1996**	**2010**	**2020**	**2030**	**2040**	**2050**
	Billion cubic feet, roundwood equivalent											
Softwoods:												
Sawlogs[a]	5.0	4.8	5.0	5.6	7.0	6.0	7.0	7.7	7.6	7.8	8.1	8.6
Veneer logs	.2	.7	1.1	1.4	1.5	1.1	1.1	.6	.6	.5	.5	.5
Pulpwood[b]	2.4	2.6	3.3	2.9	3.2	3.5	3.3	3.7	4.5	5.5	6.2	6.9
Reconstituted panels[c]	0	0	0	0	.1	.1	.2	.6	.7	.8	.9	1.1
SRWC[d]	0	0	0	0	0	0	0	0	0	0	0	0
Miscellaneous products[e]	.3	.2	.2	.2	.3	.3	.3	.3	.3	.3	.3	.3
Fuelwood	.5	.2	.1	.1	.5	.5	.4	.6	.7	.7	.8	.8
Total softwoods	8.4	8.5	9.8	10.2	12.6	11.5	12.4	13.6	14.4	15.6	16.8	18.2
Hardwoods:												
Sawlogs[a]	1.1	1.0	1.5	1.4	1.8	1.8	2.1	2.0	2.1	2.2	2.2	2.3
Veneer logs	.2	.2	.2	.2	.2	.1	.2	.3	.3	.2	.2	.1
Pulpwood[b]	.3	.7	1.1	1.2	1.9	1.8	2.1	2.6	2.9	3.2	3.2	3.2
Reconstituted panels[c]	0	0	0	0	.2	.3	.4	.4	.5	.5	.6	.7
SRWC[d]	0	0	0	0	0	0	0	0	0	0	0	.1
Miscellaneous products[e]	.4	.2	.2	.1	.2	.3	.2	.2	.2	.2	.2	.2
Fuelwood	1.5	.9	.4	.5	2.6	2.5	2.3	2.1	2.2	2.3	2.5	2.6
Total hardwoods	3.5	3.1	3.4	3.4	6.9	6.8	7.2	7.6	8.2	8.6	8.9	9.3
All species:												
Sawlogs[a]	6.1	5.8	6.5	7.0	8.8	7.8	9.1	9.8	9.9	10.0	10.4	10.8
Veneer logs	.4	.9	1.3	1.6	1.8	1.3	1.3	.9	.8	.7	.7	.7
Pulpwood[b]	2.7	3.3	4.4	4.1	5.0	5.2	5.4	6.3	7.4	8.7	9.4	10.1
Reconstituted panels[c]	0	0	0	0	.3	.4	.6	1.0	1.2	1.3	1.5	1.8
SRWC (hardwood)[d]	0	0	0	0	0	0	0	0	0	0	0	.1
Miscellaneous products[e]	.7	.5	.4	.4	.5	.6	.5	.5	.5	.5	.5	.5
Fuelwood	2.0	1.1	.5	.6	3.1	3.0	2.7	2.7	2.8	3.0	3.2	3.5
Total	11.9	11.6	13.2	13.6	19.6	18.3	19.7	21.2	22.6	24.3	25.8	27.5

[a] Includes log exports.
[b] Includes both pulpwood and the pulpwood equivalent of the net trade of chips, pulp, paper, and board.
[c] Includes roundwood used in oriented strand board and particleboard manufacture.
[d] SRWC = short-rotation woody crop; includes only hardwoods in agriculture lands.
[e] Includes cooperage logs, poles, piling, fence posts, round mine timbers, box bolts, shingle bolts, and other miscellaneous items.
Source: Historical data: Howard 2001, Ulrich 1989.

Over the next 50 years, our projections suggest it is likely the United States will increase relative use of imported forest products versus U.S. roundwood harvest to meet U.S. consumption needs, although our projected consumption needs for 2040 are now estimated to be lower than we projected in 1993 (25.8 versus 26.5 billion cubic feet). The projected increase in imports relative to U.S. roundwood harvest is due, in part, to slower projected increase in available hardwood inventory and harvest in the South. Softwood harvest is projected to increase notably with increasing area and management intensity for plantations in the South leading to higher softwood harvest than shown in the 1993 assessment (16.8 versus 16.3 billion cubic feet) (Haynes et al. 1995).

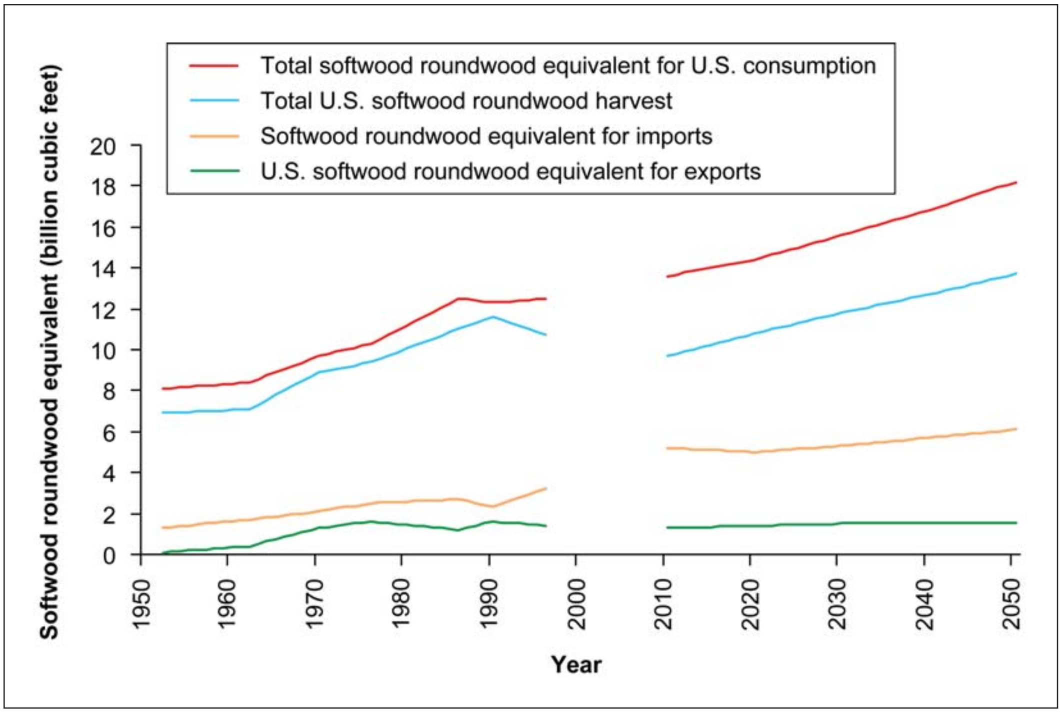

Figure 48—U.S. harvest and roundwood equivalents of imports, exports, and total consumption of softwood timber, with projections to 2050. Estimates of new harvest only, excluding recycled wood and fiber.

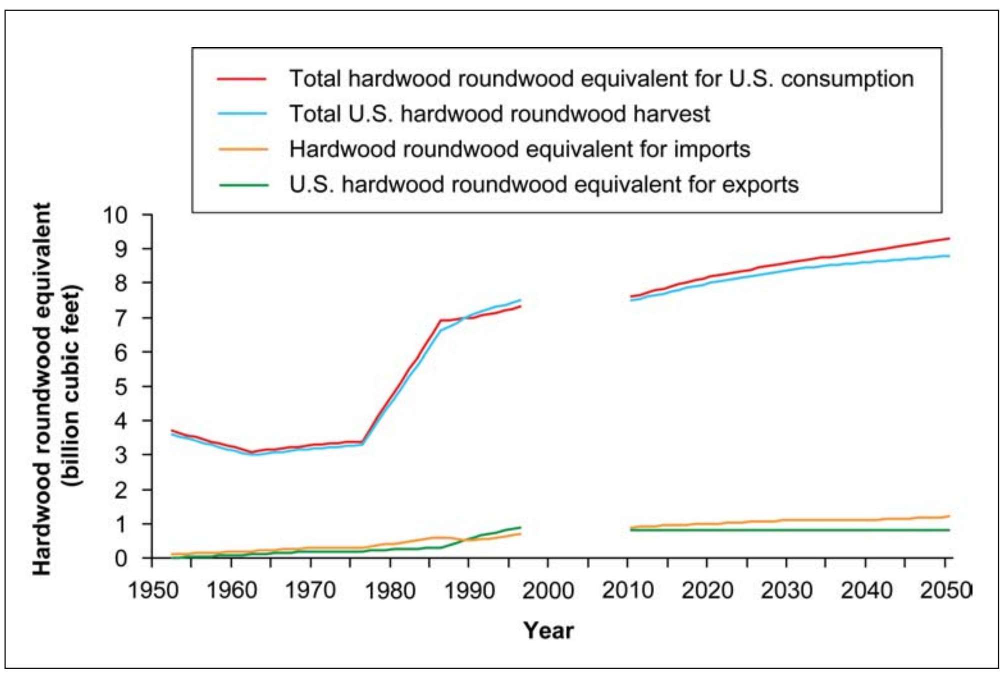

Figure 49—U.S. harvest and roundwood equivalents of imports, exports, and total consumption of hardwood timber, with projections to 2050. Estimates of new harvest only, excluding recycled wood and fiber.

Table 12—Apparent roundwood consumption, exports, imports, and harvests in the United States, by species group, 1952–96, with projections to 2050

Species group and product	Historical[a]							Projections				
	1952	1962	1970	1976	1986	1991	1996	2010	2020	2030	2040	2050
	Billion cubic feet											
Softwoods:												
Total consumption[b]	8.4	8.5	9.8	10.2	12.6	11.5	12.4	13.6	14.4	15.6	16.8	18.2
Exports	.2	.4	.9	1.0	1.2	1.7	1.4	1.3	1.4	1.5	1.5	1.5
Imports	1.3	1.7	1.5	1.8	2.8	2.3	3.2	5.2	5.0	5.3	5.7	6.1
SRWC[c]	0	0	0	0	0	0	0	0	0	0	0	0
Harvest	7.3	7.2	9.2	9.5	11.1	10.9	10.5	9.7	10.8	11.8	12.7	13.7
Hardwoods:												
Total consumption[b]	3.5	3.1	3.4	3.4	6.9	6.8	7.2	7.6	8.2	8.6	8.9	9.3
Export	0	.1	.1	.1	.3	.7	.9	.8	.8	.8	.8	.8
Imports	.1	.2	.4	.4	.6	.5	.7	.9	1.0	1.1	1.1	1.2
SRWC[c]	0	0	0	0	0	0	0	0	0	0	0	.1
Harvest	3.5	3.0	3.2	3.2	6.6	7.0	7.5	7.5	8.0	8.4	8.6	8.8
All species:												
Total consumption[b]	11.9	11.6	13.2	13.6	19.6	18.3	19.7	21.2	22.6	24.3	25.8	27.5
Exports	.2	.5	1.1	1.2	1.5	2.4	2.2	2.1	2.3	2.4	2.3	2.3
Imports	1.4	1.9	1.9	2.1	3.4	2.8	3.9	6.1	6.0	6.4	6.8	7.2
SRWC[c]	0	0	0	0	0	0	0	0	0	0	0	.1
Harvest	10.8	10.2	12.4	12.7	17.7	17.9	18.0	17.2	18.9	20.2	21.3	22.4

[a] Data are estimates of actual consumption and harvests; consequently, harvest data do not match similar data in table 13.
[b] Total demand for products converted to a roundwood equivalent basis.
[c] SRWC = short-rotation woody crop.
Source: Historical data: Howard 2001, Ulrich 1989.

The portion of U.S. consumption met from U.S. harvest decreased from 89 to 80 percent between 1952 and 1997 and is projected to decrease to 73 percent in 2050 (table 12).

Net imports of products to the United States as a portion of all world industrial roundwood harvest outside the United States are projected to increase from 5 percent in 1996 to about 8 percent in 2050.

In order for more of the softwood and hardwood roundwood needs to be met from domestic harvest, prices for stumpage and resulting products would need to be higher. Price increases would need to be substantially higher for softwood products and moderately higher for hardwood products to cover roundwood needs with domestic harvest and a redirecting of roundwood from export production (table 12) to the domestic market.

Sources of harvest—The volumes in figures 48 and 49 are termed **roundwood harvest** and come from all parts of the forest: dead and live trees, trees that have defects from disease or mechanical damage and those that do not, and trees of any size and any species. In later parts of this timber assessment, as we examine the effects of harvest on the forest inventory, we must differentiate between these various sources of harvest within the forest. The major source is termed the **growing stock** portion of the forest inventory. The growing stock includes only live trees of commercial species meeting minimum standards of quality and vigor that are at least 5 inches breast height diameter (d.b.h.). This is a useful subgroup of the inventory to consider as it represents the live merchantable portion of the forest and in the near term will be the source of virtually all the growth in the forest volume. The roundwood harvest thus comprises mostly growing-stock and some nongrowing-stock volume.

At the same time, the volume cut for products is not the only volume cut from the growing stock. The total cut from growing stock is termed **growing-stock removals** and comprises three parts: the growing-stock volume that is cut for products, plus the volume left on harvested sites in the form of logging slash and debris, plus the volume cut but not used for products as part of silvicultural activities or timberland clearing. Thus, dead and cull material is not included in growing-stock removals as it is not part of the growing stock, but dead and cull material may contribute to the total roundwood harvest. Figure 50 summarizes the relation between roundwood harvest and growing-stock removals.

In recent years, the United States has consumed close to 18 billion cubic feet per year of newly harvested roundwood of all types and from all geographic sources. Products made from sawlogs (lumber in its many forms) have traditionally been the largest component of consumption and are also projected to remain a major group in the future but with limited growth until after 2030. Pulpwood harvested from forests and used to make paper and paperboard products is the second largest consumption category at present. In the projection, pulpwood use continues to show strong growth, with the largest increases in softwood species. Short-rotation woody crops from agricultural lands remain a minor additional source of fiber for paper and paperboard. The only product class for which production volume contracts is veneer logs, owing to the decline in use of softwood plywood. In sum, over the 50-year projection period, total timber harvest from all sources for all products rises to 27.5 billion cubic feet, 39 percent above current levels.

Figures 48 and 49 examine the sources of harvested timber from domestic forests, forests in other countries, and nonforest short-rotation woody crops (details are shown in table 12). Imports contribute to consumption but do not represent a draw on domestic forests. Exports are not part of domestic consumption but do require harvests from U.S. forests. Adjusting for these cross-border flows, figure 48 indicates that the United States is a major net importer of softwood products (consumption exceeds domestic harvest). Current consumption of some 12.4 billion cubic feet per year (table 12) requires 10.5 billion cubic feet of harvest from domestic forests, more than 85 percent of consumption. By 2050, the absolute import-export gap will widen significantly, but domestic forests will still supply about 75 percent of softwood consumption. Total U.S. harvest of softwood timber in 2050 is projected at 13.7 billion cubic feet, an increase of about 3 billion cubic feet from 1996.

As shown in figure 49, the United States has been a modest net exporter of hardwood timber in the recent past, but exports fall below imports after 2010 in the projection. Total U.S. harvest of hardwood timber is projected to rise some 1.9 billion cubic feet between 1996 and 2050. Regional harvests of roundwood for softwood and hardwood are summarized in table 13.

Average diameters of trees harvested on private timberlands are shown in table 14 for the four assessment regions. For the most part, the trend in the size of trees is about stable for hardwoods and slightly declining for softwoods. The declines for softwoods, although modest, reflect the growing importance of plantations in the Pacific Northwest and the South.

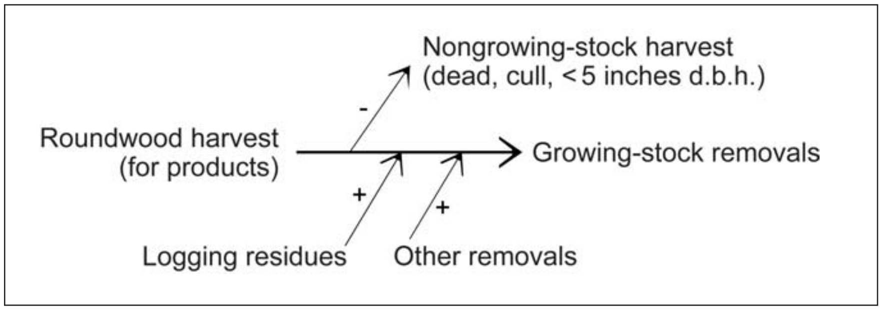

Figure 50—The relation between roundwood harvest and growing-stock removals.

Table 13—Timber harvests[a] from forest land in the contiguous states, by region, specified years 1952–96, with projections through 2050

Item	Historical							Projections				
	1952[b]	1962[b]	1970[b]	1976[b]	1986[b]	1991	1996	2010	2020	2030	2040	2050
	Billion cubic feet											
Softwoods:												
Northeast	0.48	0.37	0.39	0.43	0.57	0.74	0.62	0.56	0.50	0.48	0.49	0.50
North Central[c]	.17	.20	.17	.21	.23	.30	.33	.23	.26	.25	.26	.26
Southeast	1.65	1.40	1.67	1.70	2.23	2.26	2.63	3.00	3.66	4.08	4.15	4.23
South Central	1.21	1.16	2.01	2.26	2.68	3.21	3.48	3.28	3.64	4.29	5.02	5.63
Rocky Mountains—	.47	.61	.81	.84	.97	1.08	.85	.72	.76	.79	.83	.86
North Rocky Mountains	.31	.44	.57	.60	.66	.72	.57	.43	.44	.44	.46	.47
South Rocky Mountains	.16	.17	.24	.24	.31	.36	.28	.29	.33	.35	.38	.39
Pacific Northwest[d]—												
Pacific Northwest West[e]	1.85	2.01	2.50	2.66	3.00	2.48	1.73	1.52	1.59	1.59	1.56	1.59
Pacific Northwest East[e]	.38	.50	.49	.53	.57	.61	.39	.30	.34	.38	.41	.44
Pacific Southwest[f]	.68	.86	.87	.77	.75	.92	.66	.55	.60	.56	.57	.56
Total softwood	6.90	7.10	8.90	9.40	11.00	11.60	10.70	10.15	11.36	12.42	13.30	14.07
Hardwoods:												
Northeast	.55	.55	.60	.59	1.50	1.70	1.42	1.36	1.60	1.88	2.04	2.22
North Central	.98	.80	.83	.92	1.91	2.05	1.62	1.69	1.69	1.73	1.82	1.92
Southeast	.77	.62	.70	.73	1.34	1.31	1.46	1.73	1.82	1.83	1.80	1.73
South Central	1.27	.96	.98	.96	1.56	1.65	2.45	2.87	2.88	2.88	2.90	2.92
West	.03	.07	.10	.10	.29	.39	.55	.68	.65	.63	.62	.62
Total hardwood	3.60	3.00	3.20	3.30	6.60	7.10	7.50	8.34	8.65	8.95	9.18	9.40

Note—Data may not add to totals because of rounding.
[a] Harvest from all sources.
[b] Data are estimates of actual consumption or harvests and differ somewhat from the “trend” estimates shown in the preceding section on timber supplies.
[c] Includes the Great Plains States: Kansas, Nebraska, North Dakota, and eastern South Dakota.
[d] Excludes Alaska.
[e] Pacific Northwest West (western Oregon and western Washington) is also called the Douglas-fir subregion, and Pacific Northwest East (eastern Oregon and eastern Washington) is also called the ponderosa pine subregion.
[f] Excludes Hawaii.
Sources: Historical data: 1952–91 from 1993 RPA timber assessment update (Haynes et al. 1995).

Table 14—Average diameter[a] of timber harvested on private timberlands in the RPA timber assessment regions

	Pacific Coast		Rocky Mountains		North		South	
	Hardwood	Softwood	Hardwood	Softwood	Hardwood	Softwood	Hardwood	Softwood
				Inches				
1976	—	27.5	—	16.9	13.3	11.3	13.7	13.1
1986	16.6	18.7	18.9	9.6	14.2	12.0	12.4	9.9
1990	16.5	17.4	17.5	9.5	13.6	12.0	12.1	10.7
1997	16.1	16.1	9.7	10.3	14.2	11.3	11.0	9.6
2010	16.4	15.6	10.5	10.4	13.2	11.4	11.5	8.7
2030	16.8	15.2	11.0	11.3	13.8	10.7	11.6	8.6
2050	17.0	14.6	10.7	11.6	14.3	11.4	11.1	8.7

[a] Diameter measured at breast height.

The Stumpage Market

The stumpage market focuses on the interactions between timber harvested for use in products, the propensity of different landowners to respond to changes in stumpage prices, and changes in the growing-stock (trees over 5 inches d.b.h.) inventories.

Softwoods

Figure 51 contrasts removals from softwood growing stock by major U.S. regions. Projected removals in the South Central and Southeast continue to be the largest flows in the United States, rising from roughly 60 percent of softwood harvest in the late 1990s to nearly 70 percent by 2050. Over the next decade, however, softwood removals in the South-Central region decline, whereas those in the Southeast rise only in the last half of the decade. In the West and North, there are no dramatic projected changes in relative harvest levels. Harvest in the Pacific Northwest West, in the wake of major reductions in public harvests in the 1990s, is projected to stabilize. Components of harvest and underlying inventory developments in the three largest producing regions, Southeast, South Central, and Pacific Northwest West, are considered in the following sections.

South—In the Southeast, the limited growth in aggregate removals over the next decade shown in figure 51 results from partially offsetting movements in forest industry and nonindustrial private forest harvests, as illustrated in figure 52. In the projection, removals on forest industry lands drop below recent levels during the next decade to accommodate maturation of young stands. Rising softwood inventories on nonindustrial private forest lands enable a modest increase in nonindustrial private forest harvest. By 2010, forest industry inventory has increased enough to allow a resumption of harvest growth much like historical trends. Another cycle of this same sort occurs after 2030 with a decline in forest industry harvest and expansion in nonindustrial private forest cut.

Figure 53 shows the softwood growing-stock inventory volumes associated with the removals projected for the Southeast region. The slight decline in the inventory on forest industry lands in recent years is evident, whereas nonindustrial private forest inventory has recovered from a period of decline and begins an upward trend. Nonindustrial inventories rise between 2000 and 2040, indicating growth in excess of harvest, on average. After 2020, forest industry harvest and growth are in long-term balance, as indicated by the slowly oscillating inventory level.

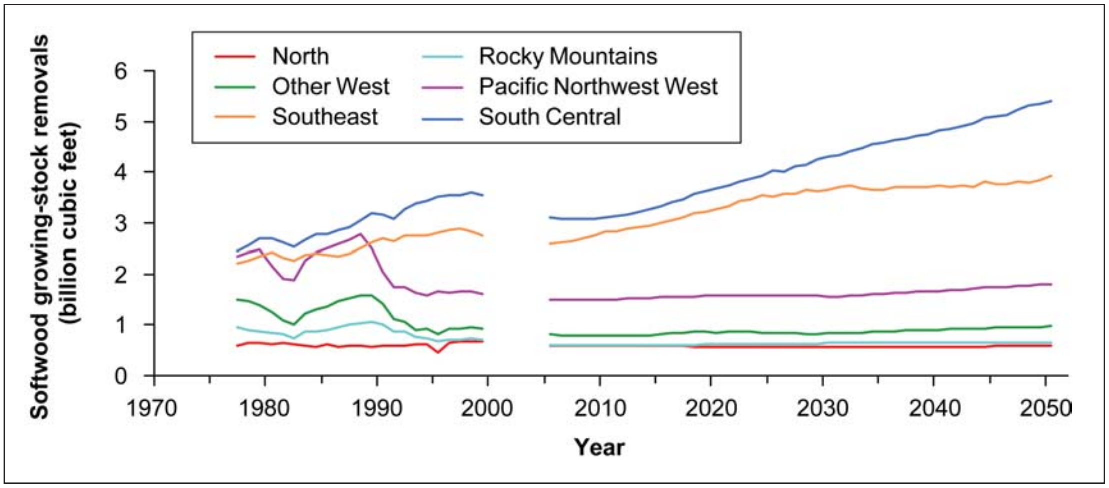

Figure 51—Softwood growing-stock removals by U.S. region, with projections to 2050. Historical values are estimates.

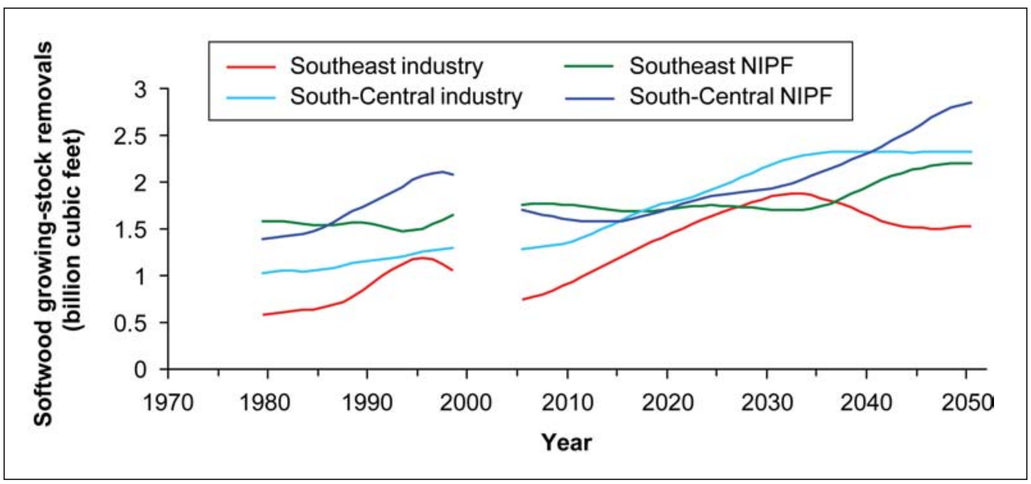

Figure 52—Southern softwood growing-stock removals by region and private owner, with projections to 2050. Historical values are estimates. NIPF = nonindustrial private forest.

In the South-Central region (fig. 52), it is the nonindustrial private forest ownership that faces near-term harvest restrictions, departing from the rising harvest trend of the past 35 years. The duration of the departure in the South-Central nonindustrial private forest is longer than was the case for Southeast forest industry, because the inventory limitation is somewhat more significant. Projected harvest falls until 2015, recovering to near current levels after 2035. From that point, harvest increases at a pace similar to that observed in the past. For forest industry lands, harvests continue to rise essentially along historical trends until 2035.

Softwood growing-stock inventories for the South-Central region are shown in figure 53. Forest industry inventory rises through the projection, although at a reduced rate after 2030. On nonindustrial private forest lands, total inventory rises after 2000, but only

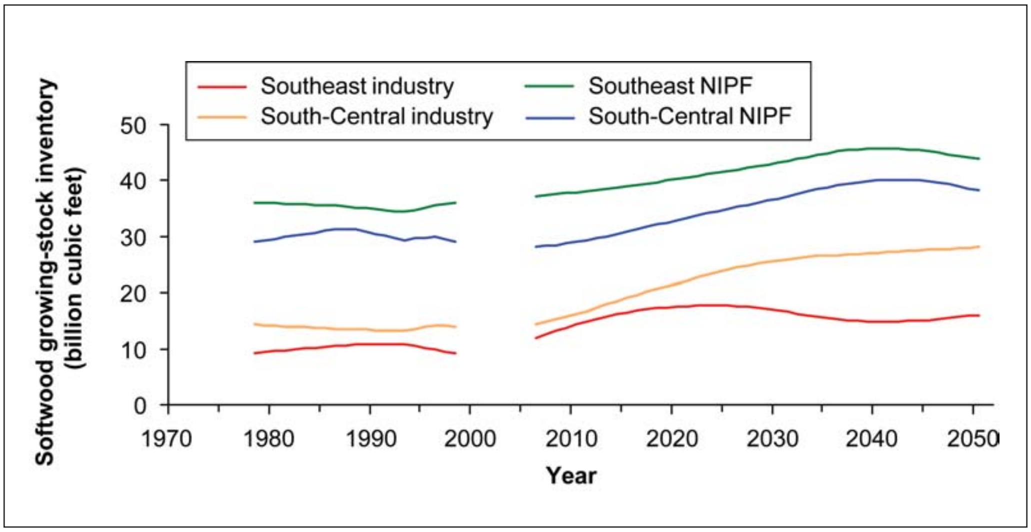

Figure 53—Southern softwood growing-stock inventory by region and private owner, with projections to 2050. Historical values are estimates. NIPF = nonindustrial private forest.

the "available" portion of this inventory[11] can actually be harvested. The available inventory (see detailed definition in chapter 2) is the volume in stands old enough to have sufficient merchantable timber to warrant a commercial harvest and that is not withheld from timber production. For South-Central nonindustrial private forest owners, continuing harvest at the levels of the late 1990s into the next decade would exhaust available inventory by 2005. Thus, some harvest reduction is required.

This can be seen more clearly in figure 54. Both the base case harvest and available inventory volume are falling from 1995 to 2005. The horizontal line in the figure indicates the level of the harvest in 1995 held constant in subsequent years. If the harvest after 1995 were held constant at the 1995 level, rather than falling as in the base case, the available volume would decline along the curve in the figure labeled "available inventory with constant 1995 cut." But by 2005, the constant 1995 harvest would exceed this available volume. Because harvest cannot exceed the available volume, it must fall below the 1995 level for some period after 1995.

A partial explanation of the harvest movements for Southern owners can be found in an examination of tree age-class distributions over time. As illustrated in figure 55 for softwood forest types, forest industry owners (combining South Central and Southeast) will realize a modest decline in the area with trees older than 30 years between 1995 and 2010. At the same time, they will experience a major expansion in area of the classes at or just above the age of minimum merchantability (about 20 to 25 years). This will provide the basis for major harvest expansion early in the projection. As illustrated by the curve for the year 2050, future age-class distributions will continue to yield large areas just passing the minimum merchantability threshold.

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[11] The available portion of the inventory is defined as that part of the inventory over the minimum merchantability and not assigned in the South to the reserve management class. (See the discussion on trends in timber inventory for an explanation of available inventories).

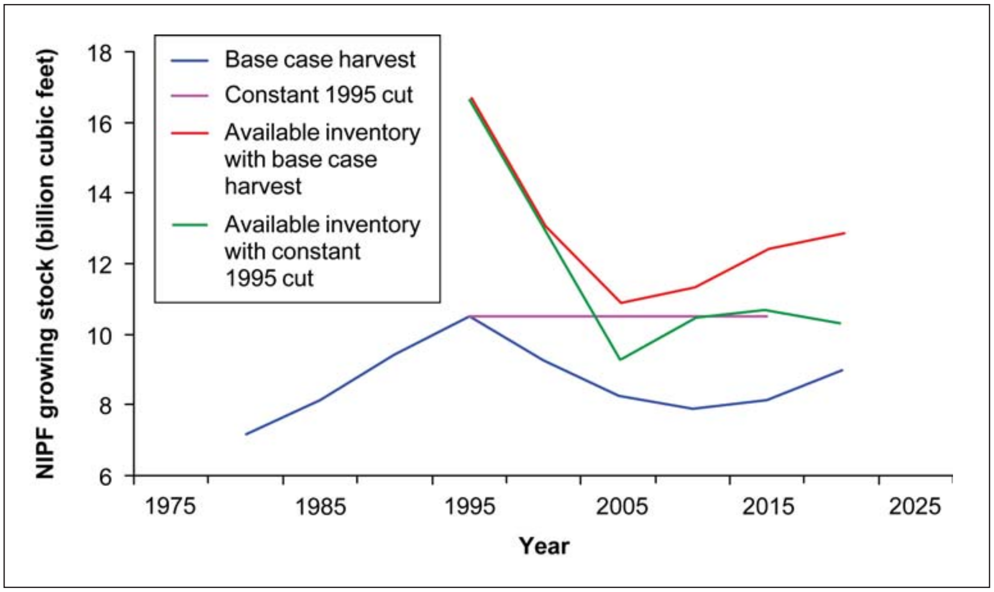

Figure 54—Detail of South-Central nonindustrial private forest (NIPF) available growing-stock inventory under projected cut and cut held constant at 1995–1999 level. Historical data are estimates.

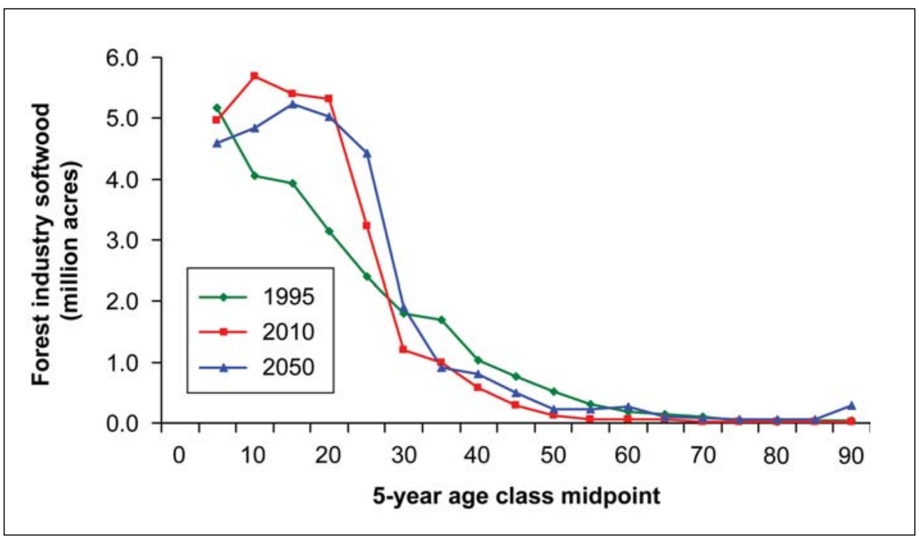

Figure 55—Distribution of area by age class of Southern forest industry, softwood types only.

Southern nonindustrial private forest ownerships also experience a contraction in the area of older stands between 1995 and 2010. The expansion in younger classes above the age of minimum merchantability (which is 25 to 35 years for this owner group) is relatively modest, however. As illustrated in figure 56, large areas of younger stands do exist (note, for example, the peak at age 20 in the 2010 distribution), which have not yet reached merchantability. As a result, harvest is restricted in the near term on these ownerships but can expand markedly after 2010. In later years of the projection (such

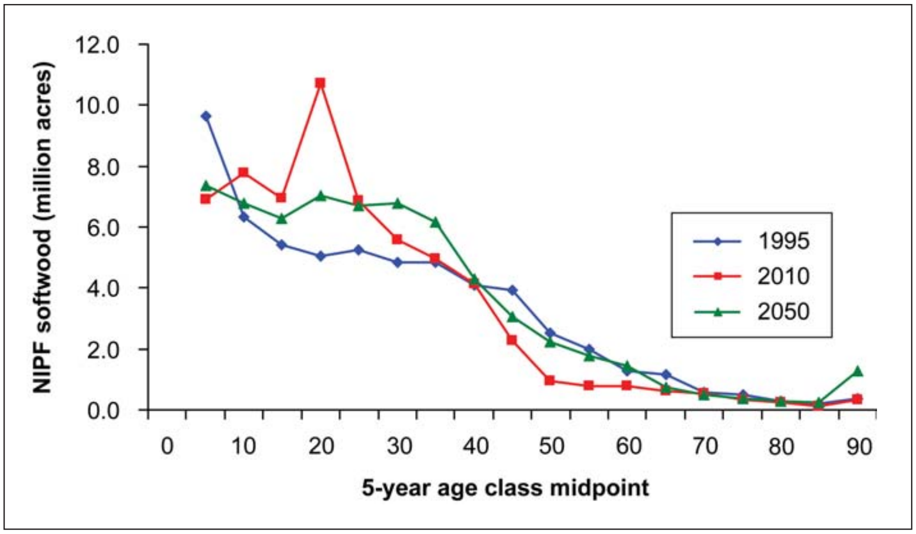

Figure 56—Distribution by age class of Southern nonindustrial private (NIPF), softwood types only.

as the 2050 curve in fig. 56), areas in older stands return to near 1995 levels, but overall, nonindustrial private forest softwood land area remains heavily concentrated in the younger classes.

Pacific Northwest West—In the Pacific Northwest West, forest industry harvest has declined steadily over the past three decades, as older stands of natural origin with high volumes per acre were converted to more intensively managed plantations. As shown in figure 57, this trend is not projected to continue beyond 2000. As large areas of young growth reach the age of minimum merchantability, growth will rise rapidly and harvest will stabilize. Nonindustrial owners face a similar inventory transition, and harvest is projected to grow slowly after 2005. On both forest industry and nonindustrial private forest ownerships, increments in harvest lag behind expansion in growth. As a result, Pacific Northwest West inventories are stable to rising through the projection. By 2050, projected inventories for both forest industry and nonindustrial private forest are more than 20 percent higher than current levels (fig. 58).

The age-class basis for stabilizing softwood harvest on forest industry ownerships in the Pacific Northwest West can be seen in figure 59. As was the case with the Southern age distributions, the Pacific Northwest West forest industry distribution has become more concentrated in the younger classes over the past several decades. This is the cause of the historical harvest decline, with falling volume available in the classes above the age of minimum merchantability (40 to 50 years in this region). As the 1990 distribution shifts to the right with time, however, larger areas will become available for harvest just at the minimum merchantability threshold. By 2010, the bulk of the inventory is restricted to the classes below minimum harvest age with limited variation in the volumes in each class. By 2050, the distribution in ages 50 and younger has become still more uniform.

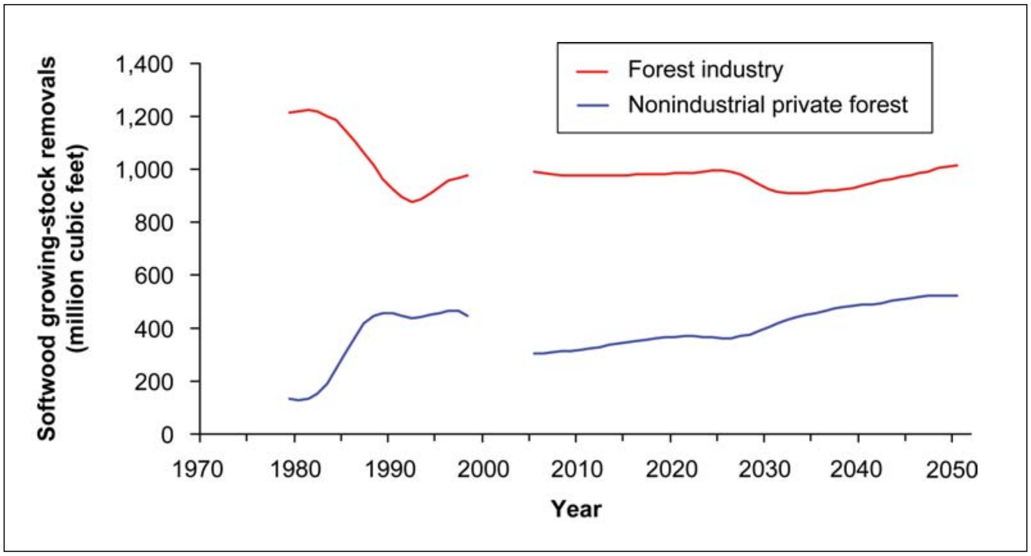

Figure 57—Pacific Northwest West softwood growing-stock removals by private ownership, with projections to 2050. Historical data are estimates.

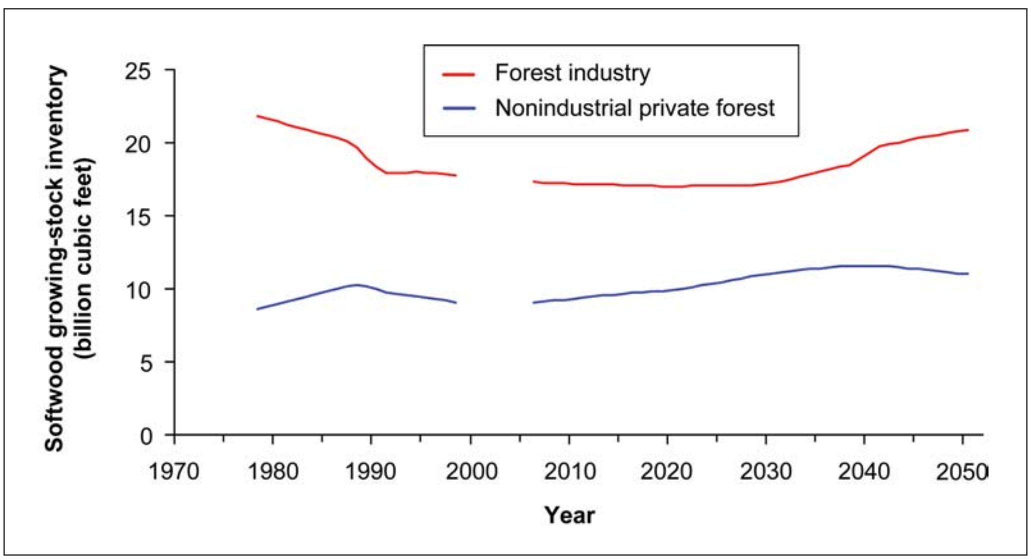

Figure 58—Pacific Northwest West softwood growing-stock inventory by private ownership, with projections to 2050. Historical data are estimates.

Hardwoods

Figure 60 shows removals of hardwood growing stock for the four major producing regions in the United States.[12] In the South, hardwood harvest has increased steadily over the past three decades as both sawtimber and pulpwood uses have grown. In the projection, harvest continues to rise, although at a reduced rate relative to the past. In the North, in contrast, growth in hardwood removals has slowed in recent years.

[12] Hardwood removals from all Western regions combined are less than 0.3 billion cubic feet per year.

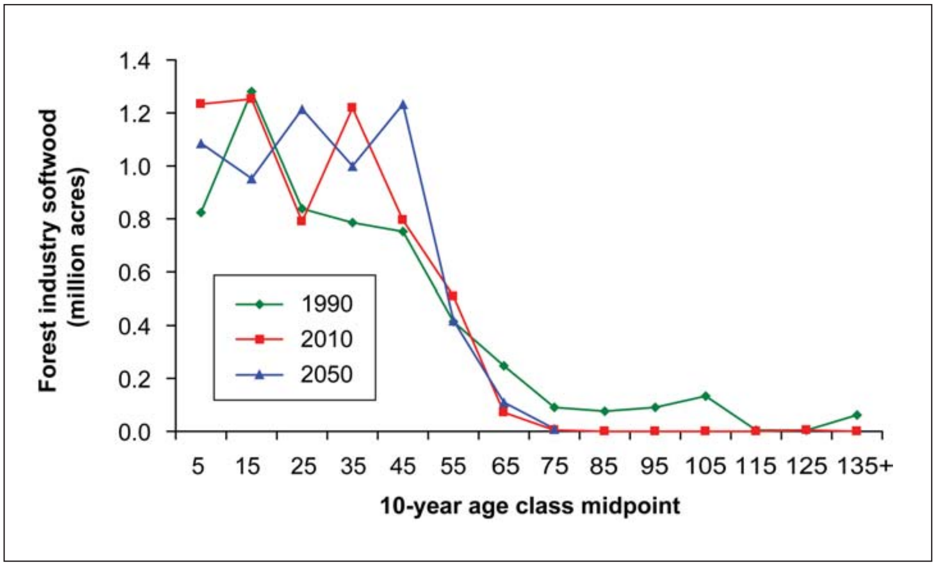

Figure 59—Distribution of area by age class of Pacific Northwest forest industry, softwood types only.

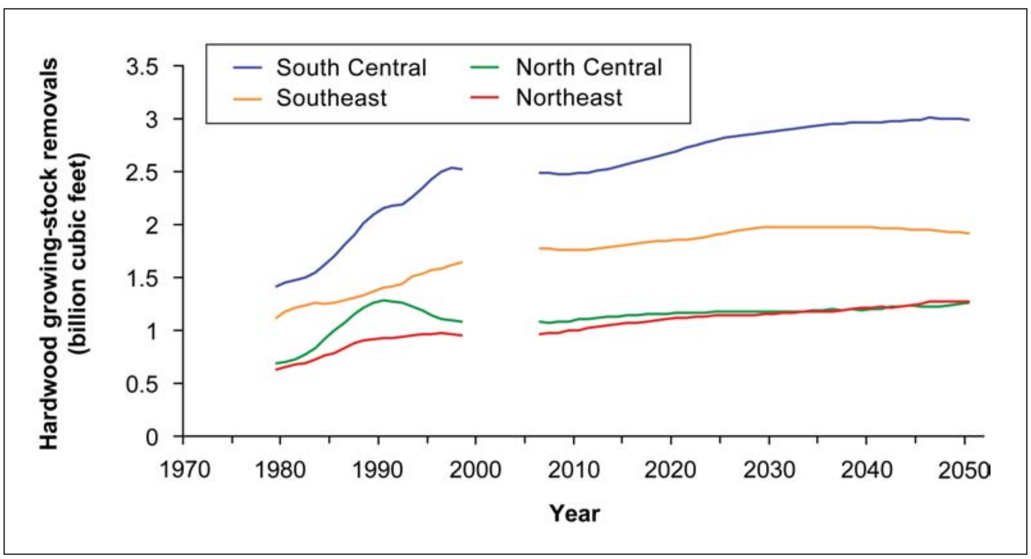

Figure 60—Hardwood growing-stock removals in eastern regions, with projections to 2050. Historical data are estimates.

Projected harvests show a resurgence of rapid growth in both the Northeast and North-Central regions. By 2050, hardwood removals in the Northeast are nearly 33 percent higher than current levels, while North-Central harvest is about 6 percent higher.

South—Figure 61 shows projected Southern hardwood removals by owner group. Harvest cycles but shows no trend on forest industry lands, while nonindustrial private forest owners will continue to increase harvest for some 30 years. The Southern hardwood inventory is large, but hardwood species have not been managed intensively even on

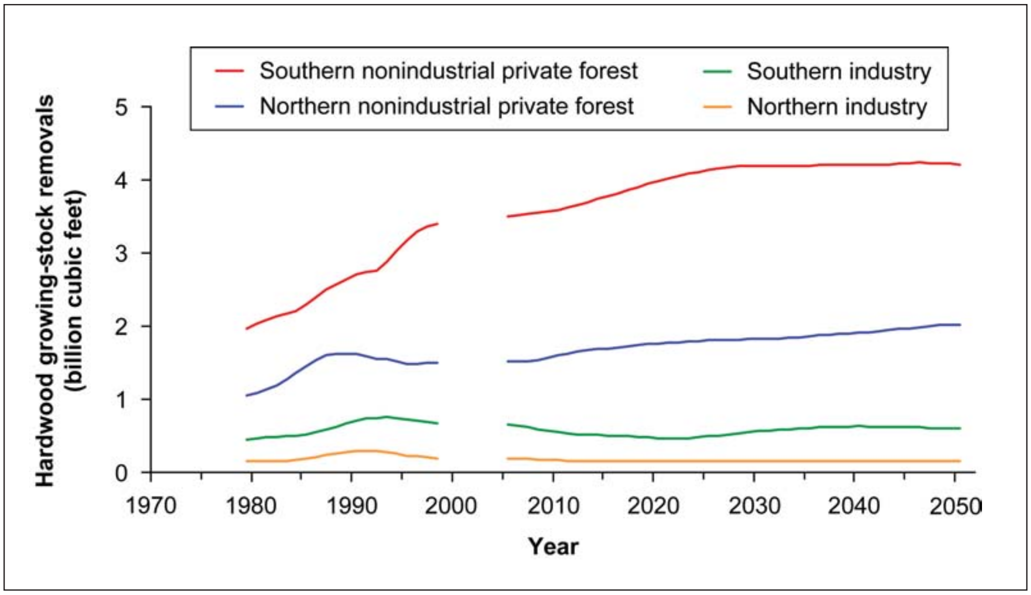

Figure 61—Eastern hardwood growing-stock removals by region and private owner, with projections to 2050. Historical data are estimates.

forest industry lands, and growth rates are relatively low.[13] At the same time, the base projection envisions continued conversion of some hardwood lands to softwood types and further loss of land to nonforest uses. Continued expansion of hardwood harvest on nonindustrial private forest lands eventually leads to harvest in excess of growth and declining inventories after 2010–15 as shown in figure 62.

North—Hardwood growth rates are no higher in the North than in the South, but harvests on forest industry and nonindustrial private forest lands there have been at or below growth for some time, and hardwood inventories have been stable or rising. In the base projection, driven by expansion in both sawtimber and pulpwood uses, harvests are expected to climb on nonindustrial private forest lands and to roughly stabilize on forest industry ownerships (fig. 61). Harvest will remain below growth on nonindustrial private forest, constrained by an array of forces. Owners are increasingly motivated by objectives other than timber harvest and revenue generation in managing their lands. This disinclination to harvest is related in part to fractionation of the land base, growing diversity of types of owners, and to the declining importance of timber harvest revenues in the income of forest landowners. As a result, nonindustrial private forest hardwood inventory will continue to rise (fig. 62). Industrial harvest will be at or just below growth, and inventory will rise slightly over the projection.

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[13] In 1997, hardwoods made up 64 percent of total Southern nonindustrial private forest growing-stock inventory, a volume 78 percent larger than the softwood component. On Southern forest industry lands, hardwoods accounted for only 40 percent of the total inventory. Total nonindustrial private forest hardwood inventory was some 131.5 billion cubic feet, whereas softwood inventory was 89.1 billion cubic feet. Softwood growth as a percentage of inventory on forest industry lands was some 8.3 percent per year and 5.3 percent on nonindustrial private forest, whereas hardwood growth rates were 3.4 and 3.3 percent on forest industry and nonindustrial private forest, respectively.

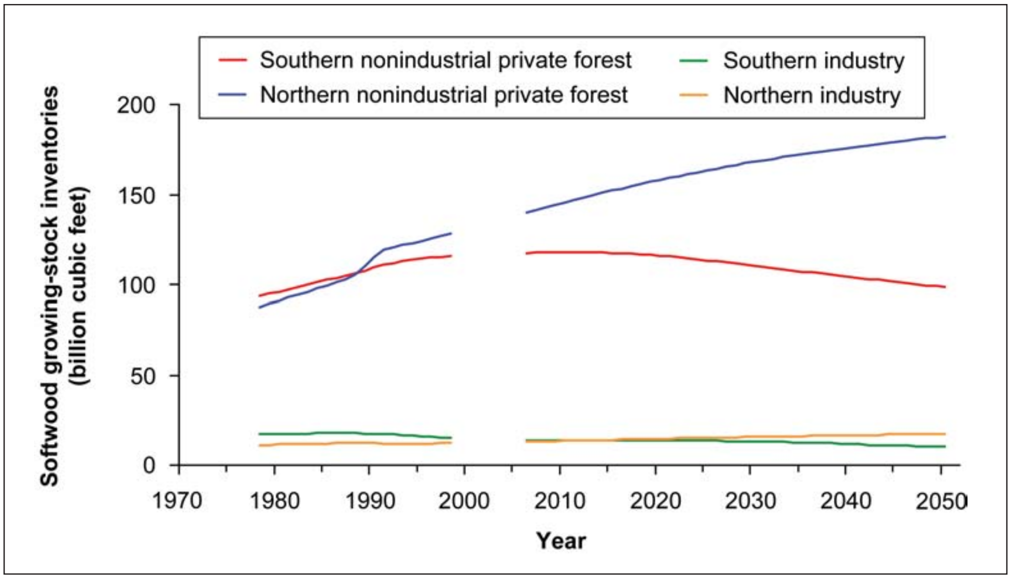

Figure 62—Eastern hardwood growing-stock inventories by region and private owner, with projections to 2050. Historical data are estimates.

Stumpage Prices

The timber assessment tracks four stumpage price measures: softwood sawtimber, hardwood sawtimber, softwood pulpwood, and hardwood pulpwood. Like other price series in the timber assessment, these are deflated and expressed in constant 1982 dollars. Prices for sawtimber are for Scribner log scale, whereas those for pulpwood are in cords.

Softwood sawtimber—Softwood sawtimber stumpage prices (table 15) in the United States have been highly volatile over the past three decades as illustrated in figure 63. This variability derives primarily from cycles in key end-use markets and shifts in timber supply acting either singly or in combination. The runup in prices to peaks in 1978–79 and the subsequent recessionary decline in the early 1980s provide an example of the former, whereas the large price runup and spike in 1993–94 arose both from a cyclical economic recovery and a sharp drop in public timber sales in the West. The historical portion of figure 63 also reveals an array of transitory and permanent differences between regional prices. Prices in the South and Pacific Northwest West alternately converge and diverge as production cost, timber supply, and output conditions change in the regions. Since the mid-1990s, they have been converging once again, as the effects of declining public timber supply in the West are worked out through reductions in solid wood processing capacity in the West and growth in lumber output in the South. Prices in the interior West and North have generally remained below those in the Pacific Northwest West and South owing to cost and product price differences.

In the projections, real softwood sawtimber prices in the South and Pacific Northwest West move around each other, as they have in the past, with a modest upward trend, but do not return to the levels observed in the 1970s and 1980s.[14] Prices in the interior West rise about 25 percent above recent peak levels, then roughly stabilize after 2020.

[14] Annual compound softwood stumpage price growth between levels in the late 1990s and 2050 is +0.2 percent in the Pacific Northwest West, +0.6 percent in the South, +0.4 percent in the North, and +1.0 percent in the interior West.

Table 15—Deflated (1982) stumpage prices[a] in the contiguous United States, by region, 1952–97, with projections to 2050

	Historical							Projections				
Region	**1952**	**1962**	**1970**	**1976**	**1986**	**1991**	**1997**	**2010**	**2020**	**2030**	**2040**	**2050**
	Price (dollars) per thousand board feet, Scribner log rule											
Sawtimber:												
Softwoods—												
North	89	62	53	51	37	57	108	94	104	114	125	136
South	130	82	120	142	119	109	228	294	305	299	311	316
Interior West[b]	47	31	55	95	64	96	108	156	184	176	180	182
Pacific Northwest West	55	63	104	155	99	224	299	280	291	279	305	339
	Price (dollars) per thousand board feet, international 1/4-inch scale											
Hardwoods—												
North	NA	62	70	75	110	110	214	210	218	223	229	238
South	NA	32	45	49	43	58	86	92	107	149	181	201
	Price (dollars) per cord											
Pulpwood:												
Softwoods—												
North	12	10	9	9	7	8	14	5	5	8	13	20
South	NA	18	17	15	13	15	21	13	11	9	13	15
Hardwoods—												
North	7	5	6	5	6	7	10	6	7	6	6	6
South	NA	5	5	4	3	6	13	4	4	9	19	25

NA = Not available.
[a] All prices deflated by all-commodity producer price index.
[b] Interior West includes the Rocky Mountains, Pacific Southwest (California), and Pacific Northwest East (eastern Oregon and Washington).
Sources: Historical data from U.S. Department of Agriculture, Forest Service Timber Cut and Sold reports on national forests (on file at individual Forest Service regional offices); Regional price reporting services, Sendak 1994.

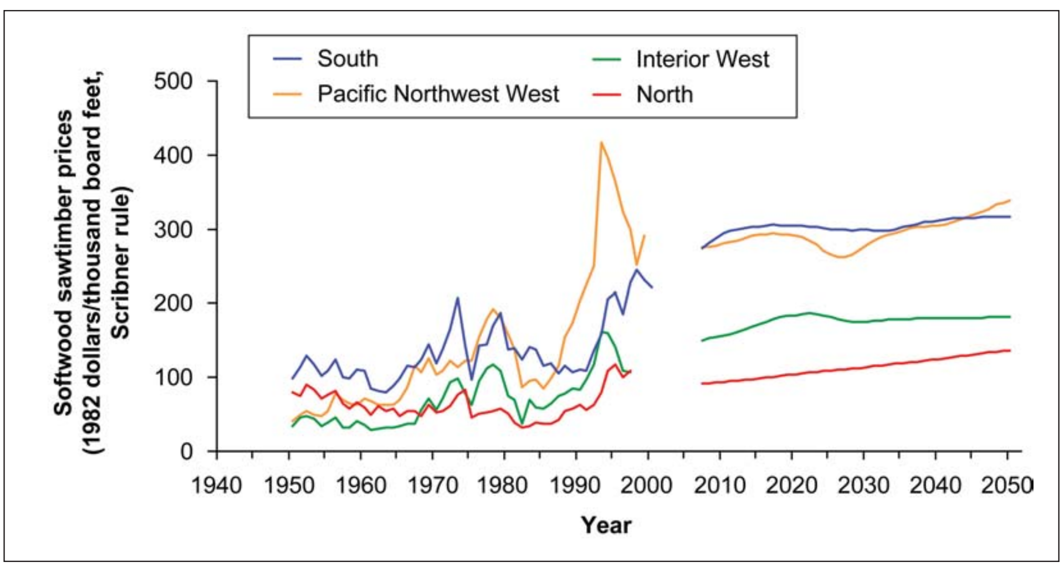

Figure 63—Softwood sawtimber stumpage prices in 1982 dollars per thousand board feet, Scribner log rule by major U.S. region, with projections to 2050.

Prices in the North show a steady trend, as growing demand brings them in line with the West and South. In effect, stumpage prices in all regions shifted up in the 1990s and remain at these higher levels in the projections. At the same time, trend growth in softwood sawtimber prices is limited in the long term because expansion in demand is largely offset by growth in domestic supply, product substitution, increased product imports, and reduced exports. Under these conditions, U.S. private softwood growing-stock inventory will rise in aggregate by 30 percent from recent levels. Softwood inventories in 2050 for all private region-owner groups in the base projection are at least as large as inventories in the late 1990s. Part of this expansion is a reflection of reduced interest in timber harvest on the nonindustrial private forest component of ownership, including the reservation of a growing area of nonindustrial private forest timberland from harvest.

Hardwood sawtimber—Hardwood sawtimber prices are shown in figure 64. The past two decades have seen a dramatic separation in market sawtimber prices between North and South, as Northern private supply conditions have tightened and quality differences between the regions have widened. This price gap narrows in the projections. As noted in the previous discussion, long-term supply-side conditions are expected to be less liberal in the hardwood sawtimber market than is likely to be the case for softwoods, particularly in the South. As a result, even modest increases in sawtimber harvest will generate some growth in real sawtimber stumpage prices.[15] In the North, price increases are relatively limited because of continued growth in Northern hardwood inventory and expanding stumpage supplies. Southern price growth is more rapid, in part because inventory on private ownerships declines slowly after 2010 and supply conditions become increasingly tight. By 2050, U.S. private hardwood growing-stock inventory rises in aggregate by 15 percent from recent levels. All private inventories in the North rise, offsetting reductions on all private owners in the South.

Softwood pulpwood—Softwood pulpwood prices in the South rose sharply during the late 1980s and into the 1990s (table 15) as all forms of softwood timber harvest expanded while timber inventory remained nearly stable. However, since 1997, real pulpwood stumpage prices for softwood in the South have collapsed, eliminating most of the gains in real prices that were observed in the period since the late 1980s. The base projections (fig. 65) suggest that real stumpage price levels of the mid-1990s will not be seen again throughout the projection period. By 2010, real stumpage prices for softwoods remain near to current levels (or levels typical of the late 1980s), then decline further by nearly 30 percent between 2015 and 2030, and then return to current (2001) levels by 2050. The downturn after 2010 reflects expanding timber growth and supply, as young stands mature on both industrial and nonindustrial private forest ownerships (see fig. 53). The increase after 2030 is a response to stabilizing inventories and tightening supply toward the end of the projection.

Prices have also grown in the North in the recent past, in response to shifting supply conditions on nonindustrial private forest lands where management objectives place less emphasis on timber harvest. In the projection, softwood pulpwood prices in the North follow a cycle roughly similar to that in the South, driven by cross-regional arbitrage in product prices and shifts in product output in response to wood costs. After 2030, the traditional North-South price gap disappears, and Northern prices finish the projection at levels somewhat above those of the South.

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[15] Annual compound hardwood stumpage price growth between levels of the late 1990s and 2050 is +0.2 percent in the North and +1.6 percent in the South.

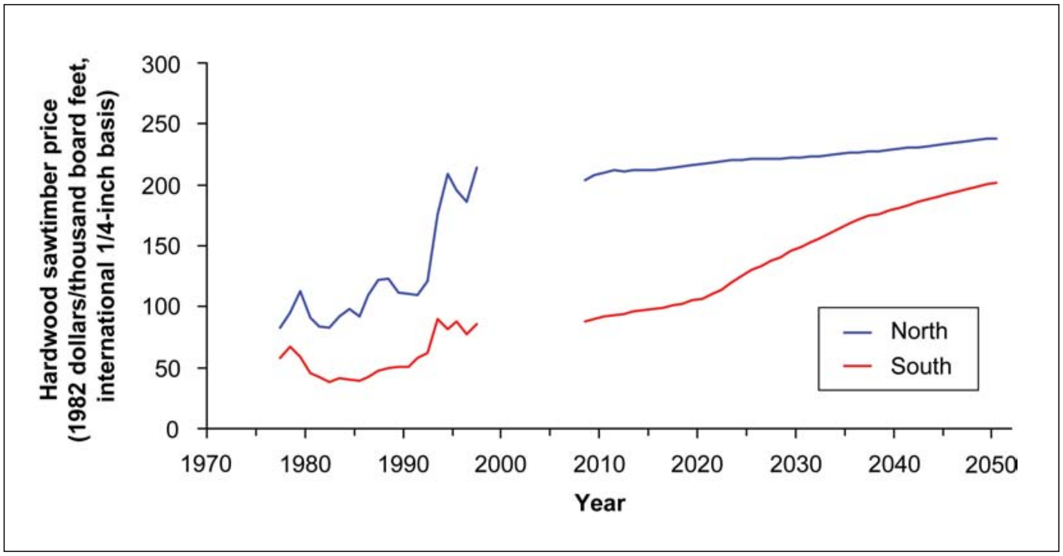

Figure 64—Hardwood sawtimber stumpage price for principal producing regions in 1982 dollars per thousand board feet, international 1/4-inch rule, with projections to 2050.

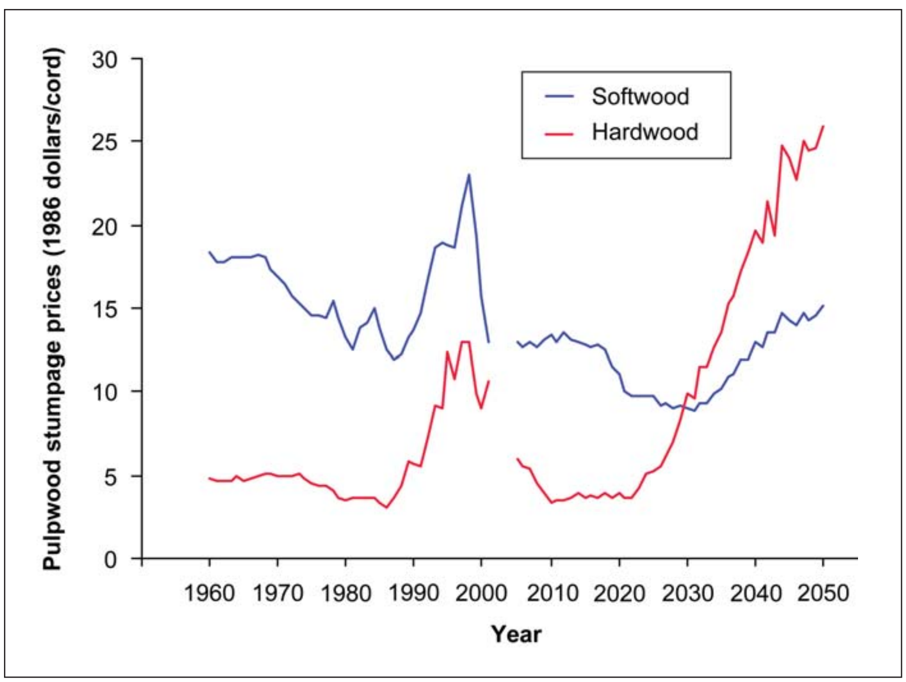

Figure 65—Real prices for Southern pulpwood stumpage, historical and projected (1986 dollars per cord).

Hardwood pulpwood—Hardwood pulpwood stumpage prices have also risen sharply in the recent past, as greater proportions of hardwood are used in pulp and paper production (table 15), but hardwood stumpage prices in the South have generally fallen since 1997. Moving into the future, real stumpage prices for hardwood are projected to remain at or below current levels for several decades in the South. After 2030, Southern hardwood stumpage prices are projected to increase and rise above softwoods on a price-per-unit-volume basis. Prices in the North fall from recent high levels and remain at historical levels for the full projection, reflecting liberal supplies from nonindustrial private forest lands in the face of major expansion in inventories (see fig. 62).

Trends in Timber Inventories

Rising timber harvests expected in the future will influence the rates of growth and levels of timber inventories and, in turn, be affected by these changes. Projections of harvest, growth, and inventory for private timberlands are shown in appendix tables 42 to 45. Similar projections for public timberlands are shown in appendix tables 34 to 37. Summaries for all owners and all regions are given in tables 16 and 17. Changes in inventories seen in these tables are the net result of reductions, owing to harvests and net changes in the forest base, and increments from growth. Growth, in turn, depends on the age structure of the forest resource (young stands have higher growth rates than older stands) and assumptions regarding trends in forest management and investment.[16] For the United States as a whole, total softwood inventories are projected to increase about 53 percent by 2050. This increase reflects the recent declines in harvests and stable growth on public timberlands, growth in excess of harvest on private timberlands, and slowing conversions of private forest land to other uses. Net softwood growth on private timberland increases after 2000 as a wave of young, rapidly growing stands moves upward through the inventory. The volume of U.S. hardwood inventories is also expected to increase, rising 28 percent by 2050. This increase will occur almost equally on public and private timberlands. Although overall hardwood growth is relatively stable, a major expansion in inventories in the North will offset a decline in the South.

The inventory volumes in tables 16 and 17 represent all inventories on timberlands and do not include timber inventories on lands that have been withdrawn from timber harvest by statute or administrative regulation (e.g., wilderness areas, national parks). These inventory volumes do, however, include areas likely to be inaccessible or inoperable under current (and expected) regulations. In the South, forest industry owners and state foresters were asked to estimate the percentage of timberland available for production. The unavailable timberland would perhaps reflect urban pressures, environmental concerns, or other landowner intentions. Here, unavailable areas are assigned to a management class that recognized their status.[17] It should be noted that because this area is identified as timberland, unless specifically stated, all summaries of area, inventory volume, and growth include these attributes from the unavailable management class.

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[16] Projected shifts in management investment were discussed in chapter 2.

[17] Note that the area change models account for some land shifts out of timber production with respect to primary land use. To reduce the likelihood of "double counting" the area moving out of timber production, the ATLAS management intensity shifts derived from the owner surveys were adjusted to reduce the area moving into the unavailable timberland class. Together, the subtractions from the timberland base and shifts to the ATLAS unavailable class would account for the total predicted change in availability represented by the landowner surveys.

Table 16—Softwood and hardwood timber removals, harvest, growth, and inventory in the United States, by region, 1952–97 with projections to 2050

	Historical							Projections				
Item	**1952**	**1962**	**1970**	**1976**	**1986**	**1991**	**1997**	**2010**	**2020**	**2030**	**2040**	**2050**
	Million cubic feet											
North:												
Softwoods—												
Removals	622	528	583	692	725	723	674	644	612	609	616	621
Harvest	596	501	549	636	908	940	825	817	786	790	806	818
Net annual growth	972	1,212	1,336	1,558	1,288	1,214	1,175	1,199	1,158	1,108	1,058	1,017
Inventory	27,053	33,661	38,817	43,850	47,618	50,977	49,376	56,742	61,201	65,206	68,480	71,532
Hardwoods—												
Removals	1,279	1,391	1,722	1,801	1,982	2,029	2,088	2,135	2,306	2,364	2,449	2,544
Harvest	1,381	1,329	1,465	1,502	3,190	3,684	2,713	3,070	3,341	3,639	3,869	4,113
Net annual growth	2,743	3,213	3,593	3,790	4,223	4,148	4,169	4,126	4,060	3,955	3,830	3,697
Inventory	76,695	94,627	106,867	119,158	142,420	156,142	164,905	195,597	212,565	226,549	238,029	247,573
South:												
Softwoods—												
Removals	3,122	2,823	3,674	4,437	5,740	5,840	6,481	5,921	6,972	7,966	8,537	9,206
Harvest	3,036	2,707	3,527	4,251	5,317	5,282	6,157	5,703	6,743	7,722	8,299	8,954
Net annual growth	3,641	4,699	5,644	6,314	5,500	5,100	5,892	7,519	8,195	8,670	8,925	8,777
Inventory	60,462	75,087	89,156	101,208	105,613	102,927	104,847	116,087	132,588	143,950	150,192	149,326
Hardwoods—												
Removals	2,731	2,832	2,344	2,241	2,958	3,086	3,630	4,247	4,581	4,848	4,954	4,921
Harvest	1,933	1,662	1,840	1,707	2,931	2,914	3,366	4,588	4,700	4,700	4,684	4,650
Net annual growth	3,040	3,394	4,282	5,009	4,488	4,731	4,877	4,781	4,527	4,434	4,474	4,465
Inventory	88,008	98,985	109,271	122,165	139,027	147,667	151,783	156,772	158,025	154,954	150,197	145,366
Rocky Mountains:[a]												
Softwoods—												
Removals	534	738	889	842	839	841	517	638	657	678	700	696
Harvest	497	684	812	773	876	996	612	781	825	864	902	912
Net annual growth	1,101	1,256	1,446	1,594	1,956	1,985	2,026	2,251	2,094	1,921	1,796	1,696
Inventory	87,545	93,222	94,275	95,111	100,298	101,487	114,682	133,311	148,578	162,265	174,359	185,255
Hardwoods—												
Removals	34	24	24	21	17	40	27	44	48	52	55	56
Harvest	10	13	12	4	30	14	44	92	98	103	110	113
Net annual growth	87	97	117	136	168	167	434	190	158	162	163	153
Inventory	5,074	5,595	6,034	6,138	7,681	8,863	9,360	6,004	6,317	6,537	6,702	6,815

Table 16—Softwood and hardwood timber removals, harvest, growth, and inventory in the United States, by region, 1952–97 with projections to 2050 (continued)

	Historical							Projections				
Item	**1952**	**1962**	**1970**	**1976**	**1986**	**1991**	**1997**	**2010**	**2020**	**2030**	**2040**	**2050**
						Million cubic feet						
Pacific Coast:												
Softwoods—												
Removals	3,484	3,514	4,039	4,024	4,057	3,460	2,451	2,431	2,537	2,502	2,681	2,847
Harvest	3,393	3,429	3,805	3,850	4,189	3,765	2,507	2,548	2,667	2,633	2,811	2,991
Net annual growth	2,021	2,444	2,904	3,034	3,777	3,673	4,460	4,779	4,791	4,863	4,955	4,894
Inventory	256,729	247,785	237,754	226,787	199,382	194,502	214,937	242,846	265,975	289,549	314,360	335,975
Hardwoods—												
Removals	43	77	115	125	115	142	118	340	314	290	271	257
Harvest	37	62	87	102	145	264	172	525	491	460	436	425
Net annual growth	304	389	485	486	681	604	597	643	645	638	638	643
Inventory	14,093	16,413	19,197	18,437	23,220	22,776	26,080	32,717	36,626	40,756	44,914	49,242
United States:												
Softwoods—												
Removals	7,762	7,603	9,185	9,995	11,362	10,864	10,123	9,633	10,778	11,756	12,534	13,371
Harvest	7,522	7,321	8,695	9,510	11,289	10,983	10,101	9,848	11,021	12,009	12,818	13,674
Net annual growth	7,734	9,611	11,338	12,501	12,521	11,973	13,553	15,748	16,237	16,562	16,733	16,385
Inventory	431,789	449,755	460,002	466,956	452,911	449,893	483,842	548,985	608,342	660,970	707,392	742,088
Hardwoods—												
Removals	4,087	4,330	4,208	4,191	5,083	5,299	5,866	6,796	7,283	7,590	7,768	7,818
Harvest	3,361	3,066	3,405	3,316	6,323	6,875	6,299	8,346	8,707	8,985	9,188	9,393
Net annual growth	6,175	7,095	8,478	9,423	9,561	9,650	10,086	9,740	9,389	9,190	9,106	8,959
Inventory	183,870	215,620	241,369	265,898	312,348	335,448	352,128	391,090	413,534	428,796	439,842	448,996

Note: Historical harvest data are estimates of the trend level of harvests and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data show the average volume that would be harvested given the assumptions of the study. Inventory data for 1952 and 1962 are as of December 31. Inventory data for 1970 and the projection years are as of January 1. Inventory data shown under 1976, 1986, 1991, and 1997 are as of January 1 of following year.

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

Source: For historical data, Powell et al. 1993; 1997 data from Smith et al. 2001.

Table 17—Softwood and hardwood timber removals, harvest, growth, and inventory in the United States, by ownership, 1952–97, with projections to 2050

	Historical							Projections				
Item	1952	1962	1970	1976	1986	1991	1997	2010	2020	2030	2040	2050
							Million cubic feet					
National forest:												
Softwoods—												
Removals	1,028	1,728	2,082	1,986	2,061	1,681	630	532	642	691	735	763
Harvest	961	1,635	1,918	1,867	2,153	1,789	712	542	682	732	778	816
Net annual growth	1,664	1,999	2,367	2,468	2,783	2,747	3,431	3,941	3,682	3,364	3,107	2,874
Inventory	204,437	213,696	211,927	208,099	186,313	185,574	222,326	267,241	300,033	329,252	355,061	377,980
Hardwoods—												
Removals	117	126	146	129	161	186	89	100	103	104	105	105
Harvest	100	97	123	101	166	197	122	115	119	122	125	125
Net annual growth	396	508	573	658	617	544	674	713	594	504	452	401
Inventory	13,556	17,207	19,721	21,567	25,107	25,641	30,087	36,722	42,322	46,667	50,317	53,463
Other public:												
Softwoods—												
Removals	429	568	750	851	858	616	561	556	556	555	555	554
Harvest	403	562	702	822	814	769	577	578	578	578	578	578
Net annual growth	730	961	1,113	1,191	1,371	1,130	1,208	1,279	1,333	1,366	1,398	1,431
Inventory	55,184	55,720	57,521	59,039	57,255	50,002	51,092	59,994	67,491	75,427	83,695	92,299
Hardwoods—												
Removals	141	150	199	225	223	327	386	424	431	430	428	427
Harvest	122	130	170	199	276	309	445	600	600	600	600	600
Net annual growth	492	634	749	840	978	834	841	771	763	776	811	810
Inventory	16,417	20,621	23,894	26,365	31,256	32,857	36,645	41,861	45,261	48,654	52,300	56,133
Forest industry:												
Softwoods—												
Removals	2,765	2,301	3,084	3,615	4,213	4,114	3,683	3,905	4,774	5,376	5,273	5,247
Harvest	2,796	2,289	2,896	3,417	4,221	4,134	3,623	3,986	4,812	5,366	5,247	5,223
Net annual growth	1,872	2,326	2,626	2,949	3,152	3,190	3,382	4,716	5,288	5,588	5,849	5,949
Inventory	77,439	76,094	75,433	74,526	72,753	70,957	66,261	68,126	76,552	81,438	86,041	92,986
Hardwoods—												
Removals	525	663	570	600	818	1,192	1,050	860	766	845	913	883
Harvest	421	434	488	473	1,025	1,120	1,069	1,246	1,084	983	952	919
Net annual growth	690	830	1,070	1,222	1,130	1,099	986	1,020	960	920	907	895
Inventory	20,373	25,425	29,381	32,313	35,311	34,806	33,526	32,497	34,037	35,501	35,776	35,880

Table 17—Softwood and hardwood timber removals, harvest, growth, and inventory in the United States, by ownership, 1952–97, with projections to 2050 (continued)

	Historical							Projections				
Item	**1952**	**1962**	**1970**	**1976**	**1986**	**1991**	**1997**	**2010**	**2020**	**2030**	**2040**	**2050**
						Million cubic feet						
Nonindustrial private forest:												
Softwoods—												
Removals	3,541	3,007	3,270	3,543	4,230	4,453	5,249	4,640	4,806	5,134	5,971	6,807
Harvest	3,362	2,836	3,179	3,403	4,102	4,291	5,188	4,742	4,949	5,334	6,214	7,057
Net annual growth	3,468	4,325	5,232	5,893	5,214	4,906	5,532	5,812	5,934	6,244	6,378	6,130
Inventory	94,729	104,245	115,121	125,292	136,590	143,360	144,163	153,624	164,265	174,852	182,595	178,823
Hardwoods—												
Removals	3,305	3,392	3,293	3,237	3,881	3,594	4,341	5,413	5,983	6,211	6,322	6,403
Harvest	2,718	2,405	2,624	2,543	4,856	5,249	4,663	6,385	6,904	7,281	7,511	7,750
Net annual growth	4,597	5,122	6,086	6,704	6,836	7,174	7,584	7,237	7,072	6,990	6,936	6,852
Inventory	133,524	152,367	168,373	185,653	220,674	242,144	251,870	280,009	291,913	297,974	301,449	303,521
United States:												
Softwoods—												
Removals	7,762	7,603	9,185	9,995	11,362	10,864	10,123	9,633	10,778	11,756	12,534	13,371
Harvest	7,522	7,321	8,695	9,510	11,289	10,983	10,101	9,848	11,021	12,009	12,818	13,674
Net annual growth	7,734	9,611	11,338	12,501	12,521	11,973	13,553	15,748	16,237	16,562	16,733	16,385
Inventory	431,789	449,755	460,002	466,956	452,911	449,893	483,842	548,985	608,342	660,970	707,392	742,088
Hardwoods—												
Removals	4,087	4,330	4,208	4,191	5,083	5,299	5,866	6,796	7,283	7,590	7,768	7,818
Harvest	3,361	3,066	3,405	3,316	6,323	6,875	6,299	8,346	8,707	8,985	9,188	9,393
Net annual growth	6,175	7,095	8,478	9,423	9,561	9,650	10,086	9,740	9,389	9,190	9,106	8,959
Inventory	183,870	215,620	241,369	265,898	312,348	335,448	352,128	391,090	413,534	428,796	439,842	448,996

Note: Historical harvest data are estimates of harvest trends and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data show the average volume that would be harvested given the assumptions of the study. Inventory data for 1952 and 1962 are as of December 31. Inventory data for 1970 and the projection years are as of January 1. Inventory data shown under 1976, 1986, 1991, and 1997 are as of January 1 of following year.

Source: For historical data, Powell et al. 1993; 1997 data from Smith et al. 2001.

Only timber removals are restricted from this class. As shown in the following tabulation, the impact is more severe on nonindustrial private forest ownerships, especially in the Southeast because of their higher proportion of hardwoods associated with both riparian and urban areas. For the South, nearly 7 percent of the timberland area (12.3 million acres) was assigned this status in 1995. The proportion is expected to double during the next 50 years, representing a growth of unavailable inventory from initially 17 billion cubic feet to nearly 50 billion cubic feet by 2050 (63 percent is hardwood area and volume).

Unavailable areas

Region	FI	NIPF
	Percent	
Southeast	5.8	10.8
South Central	3.4	5.1

Trends in inventory differ markedly between ownerships and are compounded by land area changes. In most regions, inventories on forest industry timberlands increase after 2000, and by 2010 are projected to exceed current levels. In the Northeast, Northern Rocky Mountain, and Pacific Southwest regions, forest industry inventories drop for several decades before they recover. The recovery, however, is in response to timber removals dropping by at least half, and in the case of the Pacific Southwest, forest industry softwood removals drop nearly 80 percent by 2050 (or 250 million cubic feet per year). For the United States as a whole, forest industry softwood inventories expand by about 40 percent (27 billion cubic feet), whereas nonindustrial private forest softwood inventories increase by 24 percent (35 billion cubic feet). This increase is largely from Southern inventories; not only do forest industry owners contribute to nearly three-fourths and nonindustrial private forest owners to almost half of these increases, in doing so they are able to support rising removals. Figure 66 shows in greater detail the increase in Southern private softwood inventory. The difference between total and available inventory is inventory that is too young to harvest (nonmerchantable) or inventory that is considered unavailable for harvest. As shown, the available growing-stock inventory initially drops in response to relatively high removals; at the same time removals are forced down, the results of past investments begin to push growth upward. As investment continues, we see a 40-year period where growth comfortably exceeds removals, allowing inventories to build. Near the end of the projection, removals catch up to growth, having expanded 57 percent since 2005. Over this period, the softwood inventory has added 56 percent, and most importantly, the available inventory has grown by over 80 percent while the unavailable class more than triples. This downturn of inventory at the end of the projection appears to signal what likely is the start of another cycle, during which we would expect removals to drop and then rebound as in the early part of the projection.

Projected trends in hardwood inventories present a somewhat different picture (see tables 16 and 17). Although public inventories also rise, nearly all the gain on private land is from nonindustrial private forest owners, in spite of a 48-percent increase in nonindustrial private forest removals. On a regional basis, the gains in inventory and removals are not evenly distributed. Removals in the North, representing a little less than one-third the U.S. total, rise about 22 percent, whereas the rise in hardwood inventory in the North accounts for about 86 percent of the U.S. gain. The Pacific Coast shows

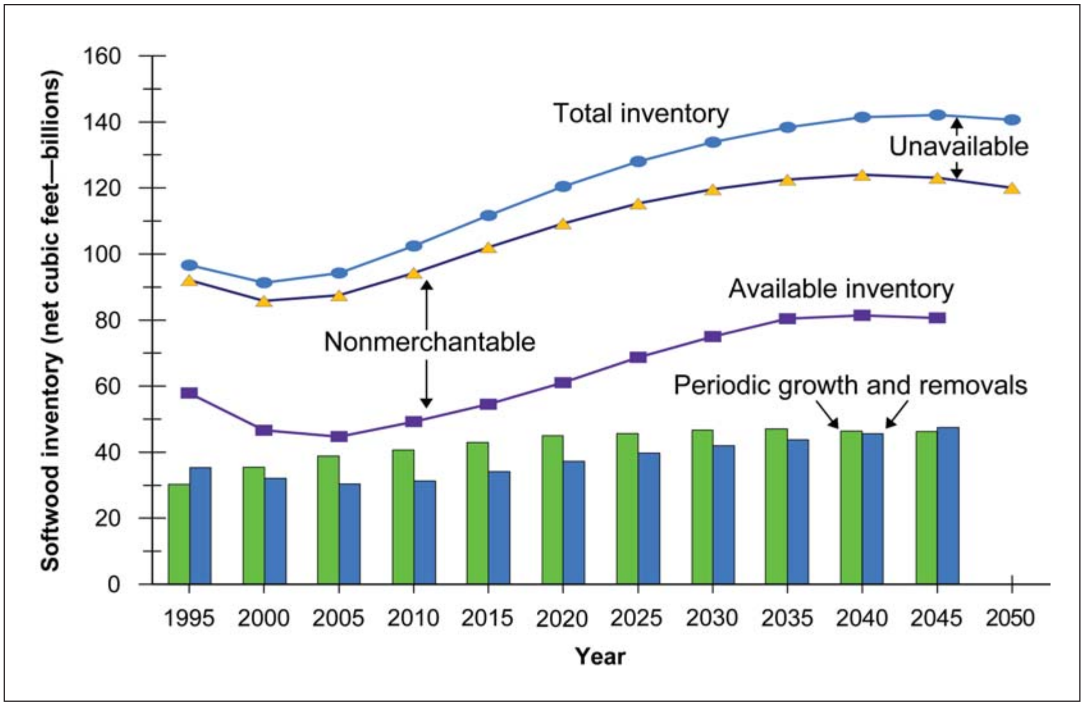

Figure 66—Components of the Southern softwood inventory projection for private timberlands.

increased hardwood inventory, but removals there account for less than 5 percent of the national total, and they decline over the projection. The Rocky Mountain and Southern regions both experience rising hardwood removals and declines of inventory. Like the Pacific Coast, the Rocky Mountain region is dominated by softwoods; it produces less than 1 percent of all hardwood removals. The largest hardwood producing region, the South, produces almost two-thirds of the domestic supply.

After 2020, the decline in Southern hardwood inventories accelerates, dropping 8 percent in 30 years. In part, this results from increased removals, which rise 36 percent by 2050. Coupled with harvesting, however, is a 12-percent loss of area supporting hardwoods, as many harvested acres are regenerated to softwood species (e.g., pine), while others are lost from the timberland base to agriculture, urban, or other uses. The nonindustrial private forest ownership is projected to lose the most hardwood area, 8 million acres, but this represents just 9 percent of nonindustrial private forest hardwood area. The areas of the two fiber categories by the two Southern landowner groups are:

	Hardwood		**Softwood**	
Owner	**1997**	**2050**	**1997**	**2050**
		Million acres		
FI	11.8	6.7	25.2	29.6
NIPF	85.2	77.3	58.0	63.4

Industry loses about 5 million acres, but at 43 percent, this represents a relatively much larger change. For industry, almost all of that loss is not a loss of timberland, but an investment in softwood plantations.

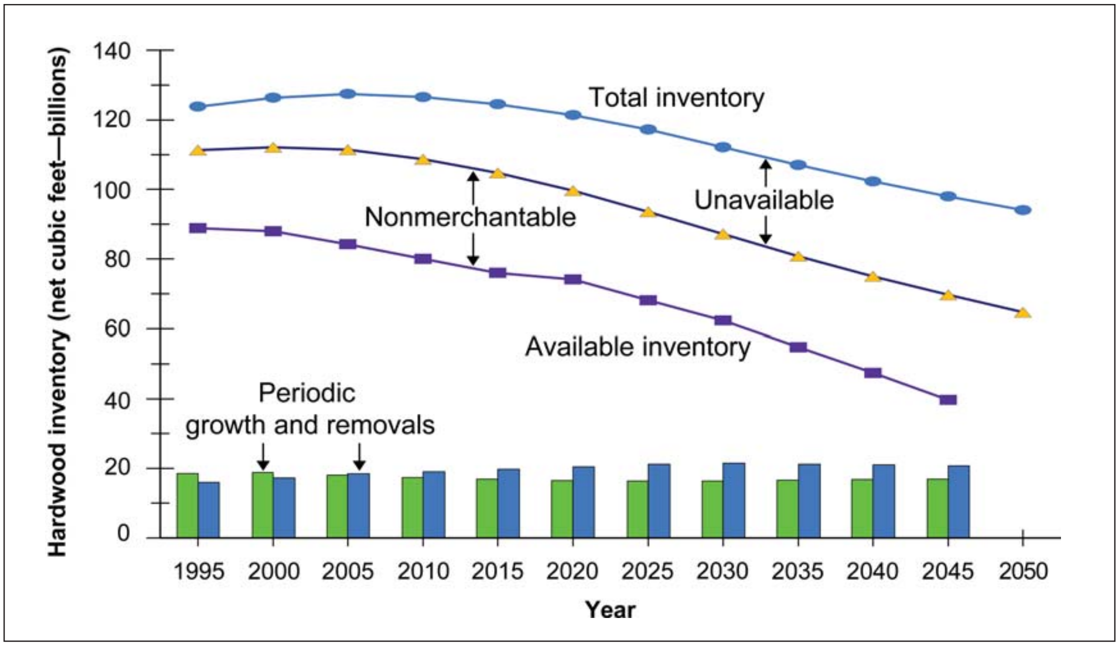

Figure 67—Components of the Southern hardwood inventory projection for private timberlands.

Figure 67 shows the projection for private hardwoods in the South. It is different than the softwood situation (fig. 66) in two ways. First, the unavailable class is relatively much larger for hardwoods, taking over a third of the difference between total and available inventory. This reflects the diversity of objectives among the Southern nonindustrial private forest ownership, which initially holds a dominant three-quarters of the Southern inventory and almost a third of all U.S. hardwood inventory. The second and most notable difference from softwoods is the projection of volume, and most importantly, available volume. Initially, the available hardwood volume is relatively much larger than removals, supporting room for an expansion of removals not seen for softwoods (fig. 66). Soon into the projection, however, removals do expand while growth declines, contributing to a situation where available volume plummets to about 45 percent of recent levels. By 2050, the area in the unavailable class has grown to represent 18 percent of the Southern hardwood area for both forest industry and nonindustrial private forest ownerships, and available inventory is rapidly approaching removals.

Regional shares for total softwood and hardwood harvest are shown in table 18. The data indicate that future growth in harvest will be coming mostly from the East. In the longer term, the Pacific Coast region continues to lose share of harvest in spite of modest increases in the Pacific Northwest West subregion. Finally, there is a modest shift between 1997 and 2050 substituting softwoods for hardwoods. This occurs primarily in pulpwood and in various reconstituted panel products.

Table 17 illustrates that nearly all the increase in timber harvest comes from nonindustrial private forest and forest industry ownerships. Supply from the national forests and from other public ownerships in all regions is determined by political and policy processes that are generally independent of market activity. These processes, and the harvests determined by them, are assumed to remain stable during the course of the base projection.

Table 18—Regional shares for total softwood and hardwood harvest

Area and type	1991	1997	2010	2030	2050
	Percentage of U.S. harvest				
Harvest region:					
North	26	21	22	21	22
South	48	55	58	59	60
Rocky Mountains	4	4	5	4	4
Pacific Coast	23	19	16	15	14
Harvest type:					
Hardwood	39	41	45	42	40
Softwood	61	59	55	58	60

Note: Data derived from table 16.

The ownership pattern of the increases in harvest differs between the hardwood and softwood sectors (table 17). The increase in softwood harvest is shared between the two types of private owners. Increases in hardwood harvest, on the other hand, are concentrated on the nonindustrial private forest ownership. This ownership held more than 71 percent of 1997 hardwood inventory and accounted for 72 percent of the hardwood harvest. By 2050, nonindustrial private forest harvest share is expected to increase to 83 percent. This increase is largely the result of declining harvests from forest industry lands owing to conversion of hardwood forest types to softwood plantations.

The base projections will entail important structural changes in the Nation's forest resources. Over the next five decades, the United States will continue to reduce its dependence on timber produced from the softwood forests of the Pacific Northwest, and harvest will increase on private forests in the South and to a lesser extent in the North. Pressures placed on forest owners in the West (both public and private) to maintain or increase nontimber outputs will be felt as increasing demands for harvest by owners and managers in the East. This will involve increased frequency and extent of harvesting disturbances on lands in the East and shifts in management activities. In addition, because forested lands in the East are less densely stocked (lower volumes per acre) than those in the West, the production of a given increment in volume will require the harvest of a larger area than would be the case in the West.

The base projection also envisions a significant shift toward more intensive management on private lands in all regions. These management activities include controlling the species composition of forest stands, use of genetically improved seed or planting stock, efforts to manage stand density, and shortening the average harvest age. In the South, for example, shifts to more intensive management and an increase in the rate of harvest will combine to reduce the area of natural pine stands on industrial lands. In their place will be pine plantations, many of which will employ genetically improved tree stock. These plantation forests will have a more balanced or uniform age-class structure than existing forests in the region, and few stands will be allowed to reach the age of the stands of natural origin that they replace. The age-class distributions of these forests will be increasingly compressed into classes at or below the age of minimum merchantability.

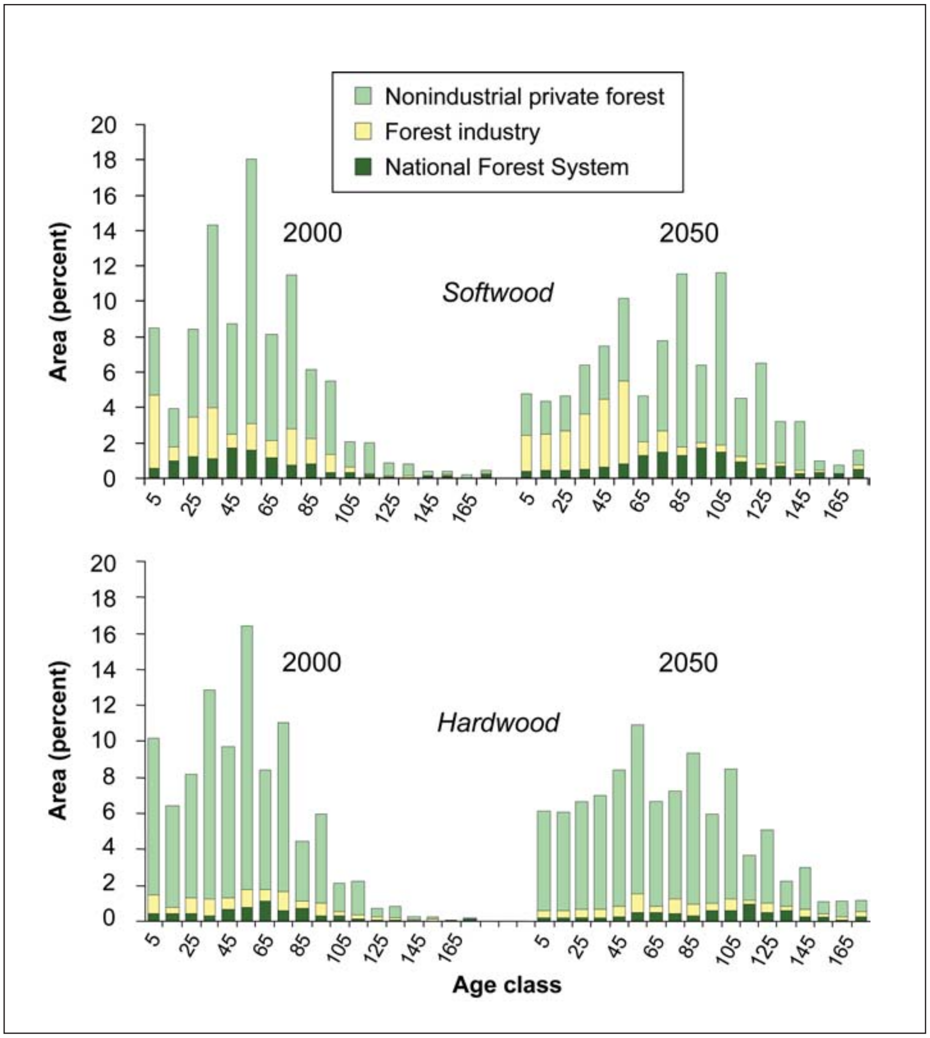

Figure 68—Age-class distribution for all softwood and hardwood forest types on timberland area for the Northern United States, by ownership.

The consequences of these shifts are evident in the changes expected in age-class structures across all ownerships in the North and South. Figure 68 shows the age-class structures for the North, progressive aging of especially the hardwood inventory, and the clear dominance of the nonindustrial private forest owners for both hardwoods and softwoods. It also shows that for the North, national forest lands play a slightly larger role in softwood inventories than for hardwoods. Figure 69 shows the age-class structure across all ownerships in the South. Because of the relative parity between growth and harvest, Southern inventory structures remain about the same over time except for an accumulation of hardwoods in the oldest age class (95 and older). The inventory structure for Southern softwoods reveals the concentration of forest industry lands in younger age classes (less than 25 years of age), whereas nonindustrial private forest lands are spread more evenly across a wider range of age classes. The inventory structure for Southern hardwoods reveals the same dominance of nonindustrial private forest owners as seen in the North.

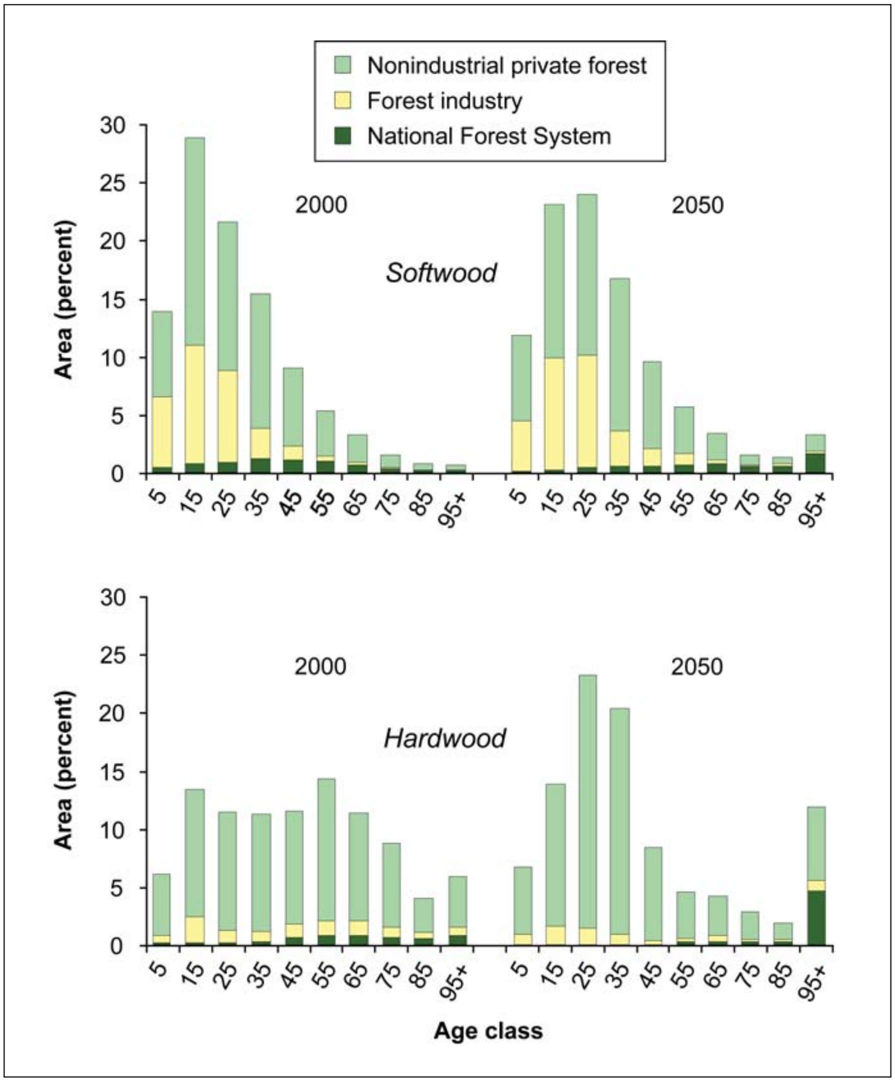

Figure 69—Age-class distribution for all softwood and hardwood forest types on timberland area for the Southern United States, by ownership.

The dependence of the hardwood sector on nonindustrial private forest lands (shown in both figs. 68 and 69) has important implications for timber supply, forest policy, and meeting criteria for sustainable forest management. The diversity of the nonindustrial private forest ownership and range of management goals complicate hardwood timber supply making it less predictable. That same diversity complicates policy and regulatory efforts. Finally, the diversity of management objectives held by numerous landowners makes it difficult to assess criteria for sustainability or to deal with forest certification.

In the West, the juxtaposition of large areas of public and private ownerships with radically different management regimes will produce forests with two distinct age structures. As illustrated in figure 70, there is a shift from the current roughly unimodal distribution of acres by age class to a bimodal distribution by 2050. This shift is the consequence of harvest reductions on public lands and increased harvests on more

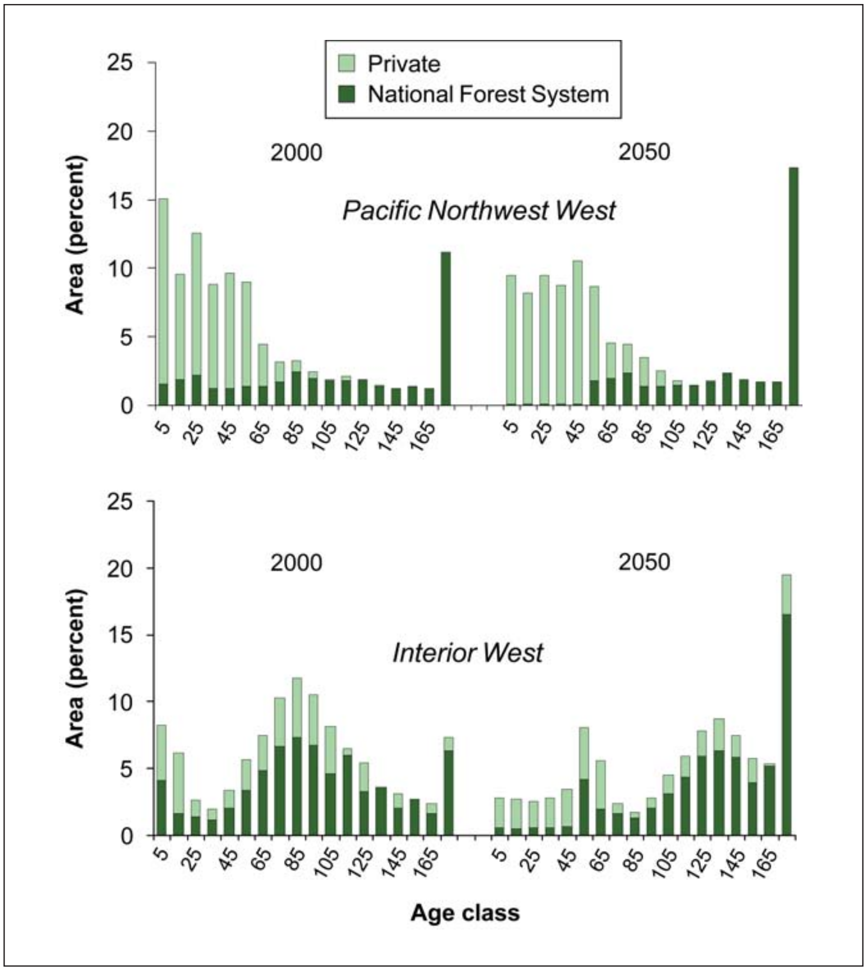

Figure 70—Age-class distribution for all forest types on timberland area for the Pacific Northwest West and Interior West, by ownership. Interior West data include the Rocky Mountains and Pacific Northwest East.

intensively managed private timberlands. By 2050, most of the young (less than 75 years old) timber is concentrated on private timberlands, there is a gap in midage stands (75 to 100 years old), and most public timberland is concentrated in age classes greater than 100 years with a significant part in ages 175 years and older. In the Pacific Northwest West, for example, there will be a gap by 2050 in the 70- to 100-year range. Most of the younger stands (≤60 years) will be on private land located typically at lower elevations, whereas older (≥100 years) stands will be on public land, typically in higher elevations and headwaters areas.

In recent years, the growth/harvest or growth/drain ratio has reemerged as one of many measures of the ability of a forested area to sustain harvest over time. An equivalent indicator, however, is the change in inventory, because a rising inventory corresponds to a growth/drain ratio greater than 1, a stable inventory to a ratio equal to 1, and a declining inventory to a ratio less than 1. Ratios of 1 or larger, i.e., stable or rising inventories, often are considered to be a minimum requirement of sustainable harvest. The difficulty with the growth/drain measure and other simple indexes is their application when a resource has multiple temporal, geographic, and quality dimensions. For example, in the national base projections, both harvest and inventory increase between 1997 and 2050, implying a growth/drain ratio greater than 1. But this aggregate assessment ignores potential variation in growth/drain ratios and resource conditions when examined at the regional, ownership, and forest-type levels; potential differences between quality categories such as sawlogs and pulpwood; and variations in growth/drain relations within the time interval from 1997 to 2050.

Tables 16 and 17 indicate that the U.S. timber resource will be continuously changing across all these dimensions over the base projection. In the aggregate, inventories will rise, but in the process, some regions will experience falling inventories, some forest types will decline in extent and volume, some ownership inventories will fall, larger size material will accumulate on some ownerships and smaller material on others, and over time these trends will not be uniform or steady in most cases. Whether or not this complex of divergent changes implies a sustainable outlook for the U.S. timber sector will require judgments about the relative importance of each of the various components and the incorporation of indicators of sustainability beyond simple inventory or growth/drain trends.

Selected Plantations

We see a future where investments in forest management increase the reliance on plantations to meet fiber needs. The projections show that investments act to boost production efficiency by increasing the volume of wood produced while decreasing the time necessary to produce it. Although the establishment of planted and managed stands occurs within all regions, we account for plantations only in the regions where we have developed the explicit management intensification models, for the production of softwood fiber.

In the timber assessment, we identified plantations on private lands as stands of trees in the Pacific Northwest and South that are regenerated under active management regimes. These are stands that receive an investment in growth-enhancing activities intended to increase wood production, activities such as the use of genetically superior seedlings[18] along with a combination of treatments such as site preparation, stocking control (precommercial thinning), and perhaps one or more applications of fertilizer. In the Pacific Northwest Douglas-fir subregion, these stands are composed of Douglas-fir and western hemlock; in the South these are stands within the forest type named “planted pine.” We acknowledge that these estimates are conservative as we are ignoring plantations in other regions and investments in other forest types.

At the start of the projection, these softwood plantations account for roughly 23 percent of all forest industry timberland and just 4 percent of all nonindustrial private forest timberland. Looking just at the area occupied by softwood forest types (table 19), these plantations make up 36 and 12 percent of the initial forest industry and nonindustrial private forest timberlands. Many of these plantations are relatively new and support young forests; standing inventory volume therefore accounts for a disproportionate 21 and 7 percent share of total forest industry and nonindustrial private forest softwood inventories. Softwood harvested from plantations (table 20) initially accounts for 19 percent of the total softwood volume harvested and 28 percent of the area harvested for softwoods. This indicates that initially, plantation yields on a per-acre basis are lower than yields on nonplantations. Two things account for this. First, the nonplantations are

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[18] We assume genetic improvements to be the results of tree breeding or hybridization, not genetic engineering.

Table 19—Area and volume in managed softwood plantations as compared to the area of all private timberland and to timberland classified as a softwood forest type

Year and owner	Managed plantations		All private timberland	All softwood types	
	Area	Volume	Area	Area	Volume
	Million acres	*Million cubic feet*	*Million acres*	*Million acres*	*Million cubic feet*
1990–95:					
Forest industry	15.7	14,898	67.5	44.0	65,885
Nonindustrial private forest	12.6	10,303	288.4	104.5	132,661
Total	28.3	25,201	355.9	148.4	198,546
2050:					
Forest industry	27.0	52,178	65.3	47.8	90,497
Nonindustrial private forest	18.8	28,347	280.6	103.9	168,282
Total	45.8	80,526	345.9	151.7	258,780

Table 20—Annual removals and area treated for harvesting, comparing selected plantations with total U.S. private timberland

Year and owner	Managed plantations		U.S. totals[a]		
	Area treated	Softwood volume removed	Area treated	Total volume removed	Softwood volume removed
	Million acres	*Million cubic feet*	*Million acres*	*Million cubic feet*	
1990–95:					
Forest industry	0.77	919	2.47	5,148	4,097
Nonindustrial private forest	.44	750	4.87	9,603	4,714
Total	1.21	1,669	7.34	14,751	8,881
2050:					
Forest industry	1.88	4,327	2.56	6,063	5,201
Nonindustrial private forest	1.00	2,570	5.72	12,693	6,326
Total	2.88	6,898	8.28	18,756	11,527

[a] Excludes Alaska.

composed of a combination of older (higher volume) natural stands and older nonmanaged planted stands. And second, it reflects the commercial thinning aspect of plantation management where initially almost half the area treated was for commercial thinning.

Over the course of the projection, plantations become more effective producers of fiber and provide a larger share of the harvest. Several factors account for this apparent efficiency. First, by the end of the projection, the number of acres in plantations increased by over 60 percent. This happened by the replanting following harvest of natural stands and the enrollment of nonforest land into managed forests. Generally, older, slower growing stands are being replaced with stands subject to enhanced growth technologies. Second, within plantations there is an upward trend in investment in intensive management practices, so a greater share of the plantation area is producing faster growing trees. And third, time has allowed the plantations established early in the projection to mature, supporting higher volumes.

Generally, harvest follows available inventory, and as shown in figure 71, the plantation share of softwood removals rises faster than total removals. The figure reflects the relatively large investments by the forest industry ownership as compared to nonindustrial private forest owners. In the final projection period, the area in plantations accounts for 30 percent of the private timberland area in softwood forest types, while plantation harvest volume accounts for 60 percent of softwood removals from all private timberland—or 54 percent of all softwood removals when the public owners are included. By 2050, the relation between the volume of harvest and area harvested has reversed itself such that the area of plantation harvest among the private softwood forest types is 57 percent of the total area harvested. In becoming the most efficient producers of softwood fiber, plantations have become the dominant source of domestic softwood supply among all ownerships.

Projections of Canadian Harvest

Public lands in Canada's provinces face an array of pressures to broaden the objectives for their management, to limit harvests to sustainable levels, and to provide land for native peoples.[19] As a result, AAC[20] has been falling in some provinces, and in the British Columbia Coast and Canadian Interior regions the actual or realized harvest has fallen as well (see footnote 5). This is, at present, a highly controversial issue in Canada, and the extent and timing of any future reductions in AAC and harvest are uncertain.

The base projection assumes that harvest restrictions will continue in western provinces and be enacted in eastern provinces within the next decade. In the projection, only softwood sawtimber is subject to specific limitations. Pulpwood harvest (which is more than

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[19] For a discussion of these issues, see Natural Resources Canada, Canadian Forest Service. 2000. The state of Canada's forests 1999–2000. Ottawa, ON. See especially pages 52–75.

[20] The allowable annual cut (AAC) is computed by provinces in Canada to specify the amount of timber that may be cut annually from provincial Crown lands. Each province computes its AACs differently. The AAC estimates shown in figure 72 were compiled by the Canadian Forest Service (CFS). They include estimates by CFS for federal and private lands (not included in the AACs for provincial Crown lands). The AACs for Ontario are quoted on an area basis and were converted by CFS to volumes. See http://nfdp.ccfm.org/cp95/text_e/sect2e.htm for details of historical AAC data presented in figure 72 and further discussion of AAC computation.

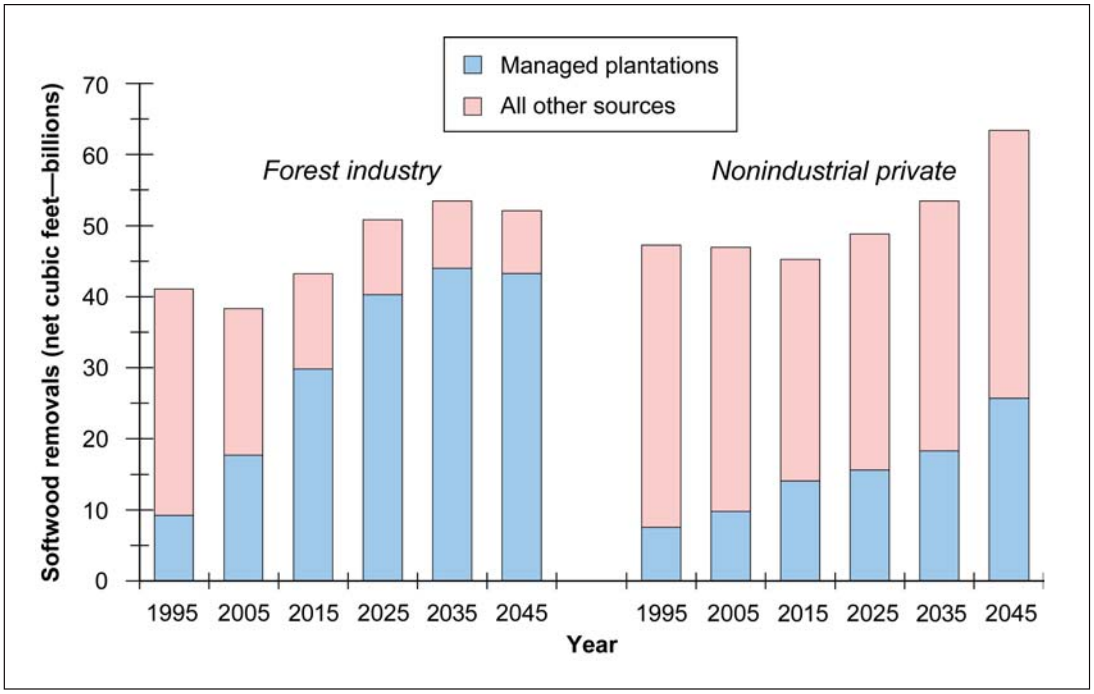

Figure 71—Periodic softwood removals projected by owner, managed plantations versus all other sources.

20 percent of the industrial harvest) and harvest for use in OSB production are not constrained. In the British Columbia Coast region, it is assumed that allowable softwood sawtimber harvest will continue its decline of the past decade and will rise no higher than 400 million cubic feet, approximately the level observed in 1997. In the Canadian Interior region, it was assumed that softwood sawtimber harvest between 2000 and 2010 will be allowed to rise no higher than the peak level observed in 1992 (some 2.0 billion cubic feet per year). From 2010 to 2020, this limit is reduced to the lowest harvest level observed in the decade of the 1990s (roughly 1.75 billion cubic feet per year) and remains there for the rest of the projection. In the Eastern Canadian region, where AACs are at present substantially higher than harvest, it was assumed that harvest would be allowed to increase no more than 15 percent above approximate 1999 levels (to about 2.6 billion cubic feet per year) in the period to 2010. Between 2010 and 2020, the limit falls back to roughly the average level observed during the 1990s (about 2.0 billion cubic feet per year).

Figure 72 and table 21 show estimates of Canada's industrial softwood harvest by sawtimber and pulpwood categories for the historical period 1970–96 and base case projections to 2050. Projected pulpwood harvest continues its slow, long-term declining trend. Sawtimber harvest falls after 2010 as a result of the assumed restrictions noted above.

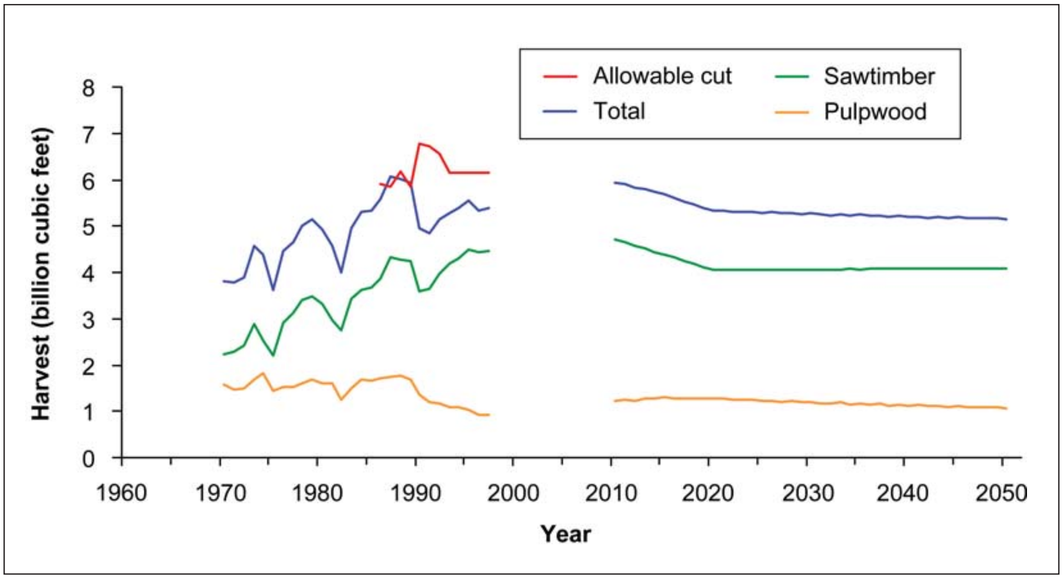

Figure 72—Sawtimber, pulpwood, and total harvest in Canada, with projections to 2050 and total annual allowable cut for recent years. Source for historical data: Canadian Forest Service, National Forestry Database.

Table 21—Projections of Canadian softwood harvest

Year	Total harvest	Sawtimber	Pulpwood	AAC[a]
		Million cubic feet		
1970	3,816	2,225	1,591	NA
1980	4,927	3,331	1,596	NA
1986	5,577	3,861	1,716	5,898
1990	4,946	3,586	1,360	6,780
1997	5,383	4,462	921	6,145
2010	5,936	4,714	1,222	NA
2020	5,325	4,057	1,268	NA
2030	5,269	4,064	1,206	NA
2040	5,186	4,074	1,112	NA
2050	5,151	4,078	1,073	NA

NA = not available.
[a] AAC = annual allowable cut.
Source: Historical data: National Forestry Database Program, Canadian Forest Service (1999).

Chapter 4: Alternative Futures[1]

Introduction

Since the 1983 RPA timber assessment supplement (Haynes and Adams 1985), timber assessments have contained sets of alternative projections or scenarios.[2] These alternatives have been designed to represent different views of the future derived from often divergent opinions about trends and conditions in the major determinants of supply and demand. Results from these alternatives, when compared to the base case, may help identify emerging problems or assess the potential effects of some proposed policy change. In the 1980s, for example, the RPA timber assessment and other studies developed numerous scenarios looking at the relations between changes in federal timber flows (largely in the West) and stumpage prices and private timber harvest levels in the United States (see Haynes 1990, Haynes and Adams 1985). When federal timber harvest in the Pacific Northwest declined in the early 1990s, the consequences (in terms of impacts on markets and on private lands in the West and South) were reasonably understood by policymakers and various interest groups because of this history of scenario planning.

In this fifth timber assessment, the initial scenario is the "base case" that has been discussed in detail in chapter 3. It represents a starting point, employing one view of the influences affecting supply and demand and assuming no fundamental changes in existing forest policies or environmental regulations. The various alternative future scenarios reflect differences in one or a few selected elements of the base case. Because the analysis derives from economic equilibrium models, changes in just one input variable can displace projected market equilibria and affect all projected output variables.

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[1] The authors for this chapter are Darius M. Adams, Peter J. Ince, Richard W. Haynes, Ralph J. Alig and John R. Mills.

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

Three groups of scenarios are examined in this timber assessment report.

1. Changes in timber supply. This group comprises four scenarios:
   a) Elimination of all national forest harvest in all regions and for all species and products.
   b) Increasing national forest harvest in the "interior West" regions to twice its level in the base case.
   c) Decreasing Canadian sawtimber harvest. In the base case, Canadian sawtimber harvest after 2010 is reduced to near the average levels of the 1985-95 period. In the lower harvest scenario, harvest after 2010 is reduced a further 20 percent to the levels of the late 1970s.
   d) Increasing nonindustrial private forest afforestation. An additional 6 million acres of agricultural land are afforested under a hypothetical public program, augmenting the timberland base in nonindustrial private forest ownership. Most of the afforested area comes as pine plantations in the South.
2. Reduced sawtimber demand—lower U.S. housing activity. The average size of new residential housing units remains constant from 2030 to 2050.
3. Reduced demand for paper—lower consumption of newsprint and printing and writing papers. Consumption of newsprint and printing and writing papers is reduced by 14 million tons by the year 2050. As a result, per capita U.S. paper and board consumption remains roughly stable in the projection at 750 pounds per person, approximately the 1999 level.

Changes in National Forest Harvest Level

Timber management has not always been the dominant management model for national forests. Until 1944, the national forests—including those in the Pacific Northwest—were largely managed with the goal of resource conservation while integrating the needs of specific user groups. At the end of World War II, leaders of the Forest Service rapidly increased harvest rates to support lumber and plywood production (see fig. 12). Public lands were recognized as the major remaining source of timber, and timber management the primary goal of national forests. Harvest during the 1950s in the Pacific Northwest equaled the harvest for all prior years. Expansion continued until the early 1960s, when increasingly complex and contentious demands on public lands led to countervailing pressures on Forest Service leaders. During the 1990s, management changes set in motion by habitat conservation requirements for the northern spotted owl in the Pacific Northwest West pushed harvests back to levels observed in the early 1950s. While there have been many proposals for further modifications of national forest harvests, two scenarios illustrate the range of recent discussions. First, there have been calls for a total elimination of national forest timber harvests (see, for example, Fairbanks and Green 2001, Niemi and Fifield 2000). Second, the perceived forest health crisis in the interior Western States has stimulated interest in the use of thinning as one means of restoring ecosystem process and function (and presumably forest health). Scenarios developed to examine these cases are shown in figure 73.

In the first case, all timber harvests on the national forests were halted effective in 2002. Results for a selection of price, production, and inventory measures are shown in table 22. In the second case, base-level timber harvests were doubled in the interior

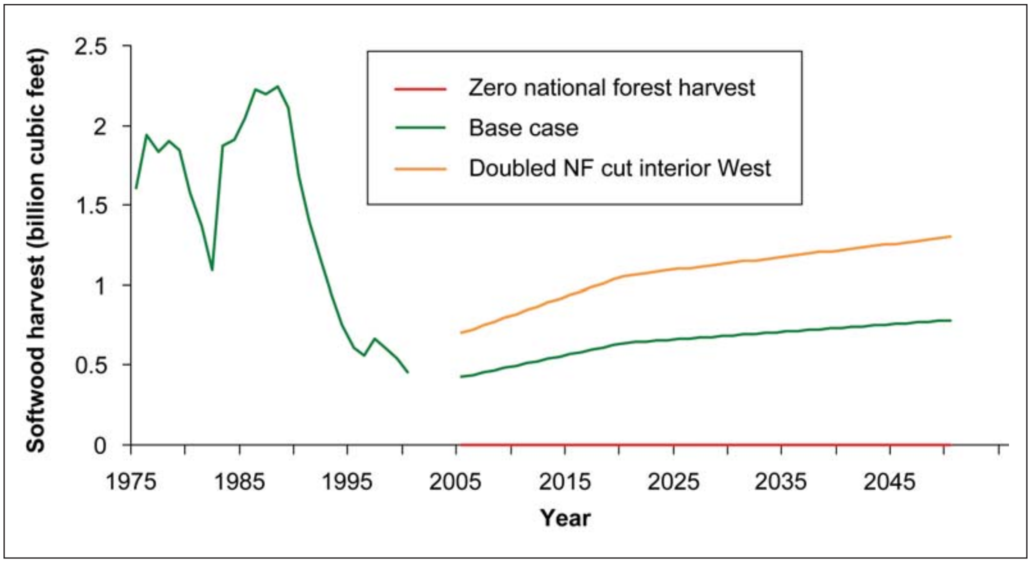

Figure 73—National forest softwood harvest in base, zero harvest, and doubled interior West harvest scenarios.

West (Pacific Northwest East, Pacific Southwest, Rocky Mountains) regions, assuming the same mix of sawtimber and pulpwood-size material as was harvested from these forests in the late 1980s and early 1990s. The zero cut scenario involves an average annual reduction in national forest softwood roundwood harvest of about 700 million cubic feet for the United States as a whole—about 6 percent of the U.S. average annual softwood harvest in the base case. Doubling cut on the interior West national forests would involve a 445-million-cubic-feet-per-year increase—about 4 percent of the U.S. average annual softwood harvest in the base case.

Both of these scenarios have their largest impacts on softwood solid wood markets and on softwood timber harvests in the West (see table 22). Eliminating harvests from the national forests reduces U.S. softwood lumber production by 2 to 7 percent and U.S. consumption by 1 to 2 percent.[3] Softwood lumber price effects increase gradually over time, about 9 percent by 2050, reflecting the low responsiveness (inelasticity) of demand for these products to changes in their prices. Softwood sawtimber and growing-stock harvests in the United States fall by less than the reduction in national forest harvest as private forest owners respond to increased stumpage prices. Reductions in national forest harvest in the West entail a shift in harvest to private lands in the East. Aggregate harvest falls in the West (because private lands there have a limited ability to increase harvest) and rises on private lands in the South. Private softwood growing-stock inventory falls below base levels by expanding percentages in all regions as the projection proceeds.

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[3] In the base case and all scenarios, Canadian sawtimber harvest is constrained by the bounds assumed and discussed in chapter 3. As a consequence, there is no upward response from Canadian softwood lumber imports in cases that restrict United States supplies. Further, although imports from non-Canadian sources are sensitive to price in the short term, a sustained price increase does not act to extend or augment the base-case supply assumptions. That is, the non-Canadian import supply curves do not shift from their base-case locations.

Table 22—Summary of scenarios: base case in absolute units, scenarios in percentage changes from the base

		Alternative scenarios					
Variable and year	Base case	Zero NF cut	Double NF harvest in interior West	Lower Canadian harvest	Lower housing	Increased NIPF[a] afforestation	Intelligent consumption
Softwood lumber production	*Million board feet*	*Percent*					
1999	36,674	0	0	0	0	0	0
2010	32,467	-2.1	1.4	0	0	0	0
2020	36,079	-3.3	1.6	6.0	0	.3	0
2030	37,444	-3.5	3.0	9.2	0	.8	0
2040	39,546	-5.8	2.4	10.2	-3.1	5.0	-.1
2050	43,310	-7.2	2.5	9.1	-5.5	85	-.1
Softwood lumber consumption	*Million board feet*	*Percent*					
1999	54,421	0	0	0	0	0	0
2010	56,289	-.7	.5	0	0	0	0
2020	57,889	-1.1	.6	-2.9	0	.1	0
2030	60,456	-1.1	.9	-2.1	0	.2	0
2040	64,621	-1.8	.8	-1.7	-3.0	1.5	0
2050	70,014	-2.3	.8	-1.7	-5.6	2.7	0
Softwood lumber imports	*Million board feet*	*Percent*					
1999	19,178	0	0	0	0	0	0
2010	25,322	1.2	-.8	0	0	0	0
2020	23,310	2.3	-1.1	-16.4	0	-.2	0
2030	24,511	2.5	-2.2	-19.3	0	-.6	0
2040	26,575	4.3	-1.7	-19.2	-2.6	-3.8	.1
2050	28,204	5.5	-1.8	-18.2	-5.4	-6.3	.1
Real softwood lumber price index	*1982 = 1.0*	*Percent*					
1999	1.559	0	0	0	0	0	
2010	1.460	3.8	-2.5	0	0	-.1	0
2020	1.703	4.6	-2.3	16.4	0	-.5	0
2030	1.661	4.9	-3.7	8.9	0	-1.4	.1
2040	1.872	6.8	-2.9	5.1	-5.1	-8.5	.1
2050	1.988	8.7	-3.0	5.4	-10.2	-13.3	.1

Table 22—Summary of scenarios: base case in absolute units, scenarios in percentage changes from the base (continued)

		Alternative scenarios					
Variable and year	Base case	Zero NF cut	Double NF harvest in interior West	Lower Canadian harvest	Lower housing	Increased NIPF[a] afforestation	Intelligent consumption
Real hardwood lumber price index	*1982 = 1.0*	*Percent*					
1999	1.410	0	0	0	0	0	
2010	1.592	.4	-.2	0	0	0	0
2020	1.709	.8	-.1	1.3	0	-.1	0
2030	1.756	.7	-.3	.7	0	-.1	0
2040	1.795	.8	-.2	.3	-.4	-.8	.1
2050	1.823	.9	-.2	.2	-1.1	-1.3	0
Real South softwood sawtimber harvest price	*1982 dollars/mbf[b]*	*Percent*					
1999	231	0	0	0	0	0	0
2010	294	3.6	-1.4	.8	0	-.3	0
2020	305	4.2	-.8	3.8	0	-3.6	0
2030	299	4.8	-2.2	4.7	-.4	-9.4	-.3
2040	311	7.4	-2.1	5.4	-2.4	-23.3	-.3
2050	316	8.2	-2.4	5.6	-4.3	-37.5	-.5
Real Pacific Northwest West softwood sawtimber harvest price	*1982 dollars/mbf[b]*	*Percent*					
1999	291	0	0	0	0	0	0
2010	280	11.9	-4.5	1.4	0	-.1	0
2020	291	15.9	-7.3	11.7	0	-1.0	0
2030	279	19.7	-4.9	4.0	-.5	-1.7	0
2040	305	17.0	-4.0	2.3	-2.7	-5.4	0
2050	339	11.9	-4.7	3.1	-7.1	-10.4	0
Real North hardwood sawtimber harvest price	*1982 dollars/mbf[b]*	*Percent*					
1997	214	0	0	0	0	0	0
2010	210	1.3	0	0	0	0	0
2020	218	1.2	-.1	.4	0	0	0
2030	223	1.0	-.2	.1	0	0	0
2040	229	.8	-.1	.1	-.1	-.1	0
2050	238	.6	-.1	0	-.1	.1	0

Table 22—Summary of scenarios: base case in absolute units, scenarios in percentage changes from the base (continued)

Variable and year	Base case	Alternative scenarios: Zero NF cut	Double NF harvest in interior West	Lower Canadian harvest	Lower housing	Increased NIPF[a] afforestation	Intelligent consumption
Real South hardwood sawtimber harvest price	*1982 dollars/mbf*[b]	*Percent*					
1997	86	0	0	0	0	0	0
2010	92	.9	-.1	0	0	-.1	0
2020	107	10.1	-.1	6.0	0	-.4	0
2030	149	5.2	-1.7	3.8	-.1	-.7	-.1
2040	181	3.0	-.6	1.1	-1.6	-2.8	-.2
2050	201	2.4	-.7	.5	-3.2	-4.2	-.1
North softwood growing-stock removal	*Million cubic feet*	*Percent*					
1999	706	0	0	0	0	0	0
2010	638	0	-.2	0	0	0	0
2020	606	-.4	-.2	.8	0	0	0
2030	603	-.9	-1.1	-.2	-.1	-.1	0
2040	611	-1.1	-.8	-.2	-.3	-.3	0
2050	616	-.8	-.8	0	-.5	-.5	0
South softwood growing-stock removal	*Million cubic feet*	*Percent*					
1999	6,281	0	0	0	0	0	0
2010	5,941	.3	-.4	0	0	0	0
2020	6,965	.5	-.4	3.0	0	.3	.5
2030	7,973	.2	-1.1	2.7	-1.2	1.3	-.8
2040	8,576	1.1	-1.7	3.6	-2.0	4.3	-1.4
2050	9,333	-.2	-2.3	1.3	-5.3	6.6	-2.4
West softwood growing-stock removal	*Million cubic feet*	*Percent*					
1999	3,243	0	0	0	0	0	0
2010	2,880	-4.7	3.6	0	0	0	0
2020	3,054	-6.7	3.7	3.4	0	-.1	0
2030	3,036	-8.2	5.2	5.9	0	-.4	0
2040	3,246	-14.2	5.3	4.7	-1.4	-1.7	0
2050	3,443	-16.6	5.9	4.2	-2.9	-3.1	0

Table 22—Summary of scenarios: base case in absolute units, scenarios in percentage changes from the base (continued)

Variable and year	Base case	Zero NF cut	Double NF harvest in interior West	Lower Canadian harvest	Lower housing	Increased NIPF[a] afforestation	Intelligent consumption
		Alternative scenarios					
North hardwood growing-stock removal	*Million cubic feet*	*Percent*					
1999	2,050	0	0	0	0	0	0
2010	2,094	.5	0	0	0	0	0
2020	2,287	-.3	-.2	.2	0	-.3	.5
2030	2,340	-1.5	-2.1	-.8	.5	-.2	.3
2040	2,417	-1.5	-3.0	.9	-.1	-.8	.2
2050	2,544	.2	-2.7	3.6	-1.6	-.4	-.7
South hardwood growing-stock removal	*Million cubic feet*	*Percent*					
1999	4,209	0	0	0	0	0	0
2010	4,220	0	-.1	0	0	0	0
2020	4,559	-.2	.2	2.4	0	.1	.3
2030	4,873	0	.3	1.0	-1.1	.2	-1.0
2040	4,952	-.6	.5	.4	-.3	-.6	-1.6
2050	4,906	-.8	-.9	-4.6	.7	-.5	-.4
U.S. softwood sawtimber harvest	*Million cubic feet*	*Percent*					
1999	6,373	0	0	0	0	0	0
2010	5,244	-1.8	1.2	0	0	0	0
2020	5,514	-2.7	1.5	4.7	0	.2	0
2030	5,555	-2.7	2.8	7.4	0	.7	0
2040	5,683	-4.5	2.3	8.4	-2.7	4.5	-.1
2050	5,978	-5.6	2.4	7.7	-4.9	7.6	-.1
U.S. softwood nonsawtimber harvest	*Million cubic feet*	*Percent*					
1999	3,954	0	0	0	0	0	0
2010	4,432	-.5	-.4	0	0	0	0
2020	5,333	-.6	-.1	.8	0	0	.6
2030	6,286	-1.4	-1.3	-.6	-1.5	.8	-.9
2040	7,009	-1.8	-1.5	-.7	-.7	.5	-1.7
2050	7,688	-3.4	-2.0	-2.8	-3.7	.1	-2.8

Table 22—Summary of scenarios: base case in absolute units, scenarios in percentage changes from the base (continued)

Variable and year	Base case	Alternative scenarios: Zero NF cut	Double NF harvest in interior West	Lower Canadian harvest	Lower housing	Increased NIPF[a] afforestation	Intelligent consumption
U.S. hardwood sawtimber harvest	*Million cubic feet*	*Percent*					
1999	2,668	0	0	0	0	0	0
2010	2,768	.1	-.1	0	0	0	0
2020	2,811	0	-.1	.5	0	0	0
2030	2,823	-.1	-.2	.3	0	0	0
2040	2,843	.1	-.1	.3	-.1	-.2	0
2050	2,862	.2	-.1	.3	-.3	-.4	0
U.S. hardwood nonsawtimber harvest	*Million cubic feet*	*Percent*					
1999	4,574	0	0	0	0	0	0
2010	4,746	.3	0	0	0	0	0
2020	5,215	-.3	.1	1.6	0	0	.4
2030	5,557	-.6	-.6	.2	-.6	.1	-.7
2040	5,757	-1.2	-.8	.5	-.2	-.7	-1.1
2050	5,920	-.6	-1.8	-1.6	0	-.3	-.6
North private softwood growing-stock inventory	*Million cubic feet*	*Percent*					
1999	38,042	0	0	0	0	0	0
2010	40,872	-.5	0	0	0	0	0
2020	43,292	-1.1	0	-.1	0	.1	0
2030	45,281	-1.6	.1	-.1	0	.1	0
2040	46,590	-1.9	.2	-.1	0	.2	0
2050	47,653	-2.2	.3	0	.1	.3	0
South private softwood growing-stock inventory	*Million cubic feet*	*Percent*					
1999	87,678	0	0	0	0	0	0
2010	97,414	-1.1	.1	0	0	.9	0
2020	112,311	-2.6	.5	-.9	0	6.5	0
2030	122,576	-4.1	.9	-3.1	.2	10.5	.1
2040	127,863	-5.6	1.6	-5.4	1.0	11.1	.3
2050	126,132	-7.5	2.8	-7.4	2.7	10.2	1.2

Table 22—Summary of scenarios: base case in absolute units, scenarios in percentage changes from the base (continued)

Variable and year	Base case	Alternative scenarios: Zero NF cut	Double NF harvest in interior West	Lower Canadian harvest	Lower housing	Increased NIPF[a] afforestation	Intelligent consumption
West private softwood growing-stock inventory	*Million cubic feet*	*Percent*					
1999	70,190	0	0	0	0	0	0
2010	70,186	-2.5	2.1	0	0	0	0
2020	71,518	-5.9	5.7	-.8	0	.1	0
2030	74,131	-9.7	9.8	-2.8	0	.7	0
2040	79,214	-9.9	12.8	-4.2	.2	1.5	0
2050	82,295	-10.9	16.5	-6.7	1.1	3.4	0
North private hardwood growing-stock inventory	*Million cubic feet*	*Percent*					
1999	141,486	0	0	0	0	0	0
2010	159,201	-.2	0	0	0	0	0
2020	172,834	-.5	.0	-.1	0	0	0
2030	183,983	-.7	.1	0	0	0	-.1
2040	192,773	-.7	.4	0	0	0	-.1
2050	199,660	-.8	.6	-.2	.1	.1	-.1
South private hardwood growing-stock inventory	*Million cubic feet*	*Percent*					
1999	130,980	0	0	0	0	0	0
2010	131,687	-.2	0	0	0	.1	0
2020	129,502	-.5	-.1	-.3	0	.5	0
2030	123,445	-.8	-.3	-1.3	.1	.9	0
2040	115,913	-1.1	-.6	-2.0	.3	1.2	.5
2050	108,562	-1.2	-.7	-2.1	.2	1.5	1.1
Real price index for paper	*1982 = 1.0*	*Percent*					
1999	1.005	0	0	0	0	0	0
2010	0.984	0	0	0	0	0	.1
2020	0.997	0	-.1	.4	0	-.2	-.1
2030	0.989	.4	.4	1.0	.5	.3	-.6
2040	0.985	.6	0	1.1	.4	.7	-.3
2050	1.003	-.3	-.8	-.4	-.6	-1.2	-1.9

Table 22—Summary of scenarios: base case in absolute units, scenarios in percentage changes from the base (continued)

Variable and year	Base case	Alternative scenarios: Zero NF cut	Double NF harvest in interior West	Lower Canadian harvest	Lower housing	Increased NIPF[a] afforestation	Intelligent consumption
Real price index for paperboard	*1982 = 1.0*			*Percent*			
1999	1.088	0	0	0	0	0	0
2010	1.146	0	.2	0	0	0	0
2020	1.172	-.1	-.6	.8	0	0	.6
2030	1.150	.1	-.5	1.0	.5	-.7	-.5
2040	1.152	.9	-.1	2.2	.6	.5	.9
2050	1.170	1.7	1.2	2.2	-1.0	-1.6	.1
Real Southern softwood pulpwood price	*1982 dollars/cord*			*Percent*			
1999	19.36	0	0	0	0	0	0
2010	13.14	-1.5	.7	0	0	-.2	0
2020	11.00	1.1	3.6	7.2	0	-7.2	1.8
2030	9.11	4.4	5.2	15.7	.7	-19.5	-5.4
2040	12.66	10.1	6.7	23.1	8.3	-23.4	-2.7
2050	14.69	14.0	6.9	28.8	-3.3	-26.2	-9.4
Real Southern hardwood pulpwood price	*1982 dollars/cord*			*Percent*			
1999	12.40	0	0	0	0	0	0
2010	3.76	3.1	-.3	0	0	0	0
2020	3.78	7.3	.9	44.8	0	-2.5	6.2
2030	9.29	12.9	9.1	32.3	-7.5	-3.9	-8.3
2040	19.15	1.0	9.3	32.1	-5.9	-5.2	-24.2
2050	25.04	4.2	6.2	-2.0	-7.6	-14.8	-15.0
U.S. paper production	*Million tons*			*Percent*			
1999	45	0	0	0	0	0	0
2010	44	0	.1	0	0	0	0
2020	50	0	1.2	4.5	0	.1	.2
2030	53	1.0	3.3	4.2	-2.3	-.1	-2.1
2040	55	1.1	4.6	3.8	-1.6	-1.0	-4.4
2050	57	1.2	5.1	3.3	-1.3	1.7	-6.9

Table 22—Summary of scenarios: base case in absolute units, scenarios in percentage changes from the base (continued)

Variable and year	Base case	Alternative scenarios: Zero NF cut	Double NF harvest in interior West	Lower Canadian harvest	Lower housing	Increased NIPF[a] afforestation	Intelligent consumption
U.S. paperboard production	*Million tons*	*Percent*					
1999	52	0	0	0	0	0	0
2010	53	0	0	0	0	0	0
2020	60	1.0	.6	.1	0	.3	.5
2030	68	-.7	-.7	.2	-.5	.8	-1.1
2040	73	-1.7	-.9	.2	.1	1.1	-.5
2050	79	-2.0	-1.3	-.8	-1.7	1.0	-2.2
U.S. softwood pulpwood harvest	*Million cubic feet*	*Percent*					
1999	3,420	0	0	0	0	0	0
2010	3,806	-.5	.2	0	0	0	0
2020	4,673	-.9	-.3	1.0	0	.1	.7
2030	5,496	-.9	-.7	.6	-1.7	.8	-1.1
2040	6,169	-1.8	-.7	.1	-.8	.6	-1.9
2050	6,772	-3.5	-1.7	-2.6	-3.9	.2	-3.1
U.S. hardwood pulpwood harvest	*Million cubic feet*	*Percent*					
1999	2,718	0	0	0	0	0	0
2010	2,634	.5	.1	0	0	0	0
2020	3,003	0	.6	3.1	0	-.1	.7
2030	3,246	-.9	-.9	.3	-1.1	.2	-1.1
2040	3,299	-2.0	-1.6	.8	-.4	-1.2	-1.9
2050	3,283	-1.1	-3.0	-3.0	.1	-.6	-1.1
U.S. wastepaper recovery rate		*Percent*					
1999	.447	0	0	0	0	0	0
2010	.496	0	0	0	0	0	0
2020	.498	-.1	.1	-.1	0	0	1.5
2030	.498	-.4	.2	0	.1	-.3	4.9
2040	.498	-.6	.7	.5	.1	.3	6.4
2050	.497	-.1	1.3	.6	.5	.8	6.4

[a] NIPF = nonindustrial private forest.
[b] 1982 dollars per thousand board feet.

Doubling harvest on national forests in the interior West shifts markets in the opposite direction compared to the zero national forest cut scenario. Softwood lumber output rises, prices of both lumber and softwood sawtimber stumpage fall, public harvest is substituted for private, and private inventories rise relative to the base case. The relative responses to the harvest increase are not symmetric to those for the harvest reduction scenario both because the sizes of the public cut changes differ and because the demand and supply relations in regional and national markets do not exhibit symmetric responses to public supply increments and decrements. For example, private harvest in the West can move readily in a downward direction in response to a price decline (as in the cut-doubling scenario), but limited merchantable inventory prevents it from rising in a proportional fashion when prices increase (as in the zero-cut case).

The alternative projection explicitly incorporating fire-induced mortality, discussed in chapter 2, impacted national forest inventories, but did not impact harvest flows. If, however, high levels of fire lead to higher levels of salvage harvesting, there would be market impacts similar to those shown under the scenario of doubled national forest harvest in the West. In the cases where this additional mortality is salvaged, softwood lumber outputs would be increased. In those regions, this would push stumpage prices slightly lower, leading to small increases in privately held inventory and a small decrease in softwood lumber imports.

Reflecting the limited role of national forest harvests in pulpwood supply, these scenarios generally have less marked impacts on the pulp and paper sector. Paper and paperboard price changes are mixed but generally rise under zero national forest harvest and fall for the doubling interior national forest harvest case.

Lower Canadian Harvest

As noted in chapter 3, there is some uncertainty about future prospects for Canadian timber harvest. Although the assumptions made in the base case are reasonable given current policies and recent trends, future developments are highly uncertain. In this scenario, we examine a case in which harvest restrictions are more severe than the base case. Canadian softwood sawtimber harvest falls by an additional 20 percent relative to base levels in 2020 (see fig. 74). This amounts to a reduction in Canadian sawtimber harvest of some 830 million cubic feet per year, relative to the base, after 2020.

This alternative acts as a constraint on softwood sawtimber supply to U.S. markets not unlike the zero national forest harvest scenario. As a result, prices and volumes in the solid wood sector and timber markets respond as described for that scenario. Softwood lumber imports from Canada decline by about 35 percent, raising softwood lumber prices, lowering U.S. consumption, and stimulating U.S. production and imports from non-Canadian sources. Demand for U.S. sawtimber rises, increasing stumpage prices and harvest on private lands and reducing inventory in the long term. The largest sawtimber stumpage impacts are in the West and South, where softwood lumber production is concentrated. Impacts in the pulp and paper sector are small compared to the solid wood sector, although pulpwood prices tend to be somewhat more sensitive. In addition, some measures of activity in the sector move in opposite directions from the zero National Forest cut case (also a supply-reduction scenario). This reflects changes in residue supplies in Canada that accompany a reduction in softwood lumber production and the associated impacts on Canadian paper and paperboard output and trade with the United States.

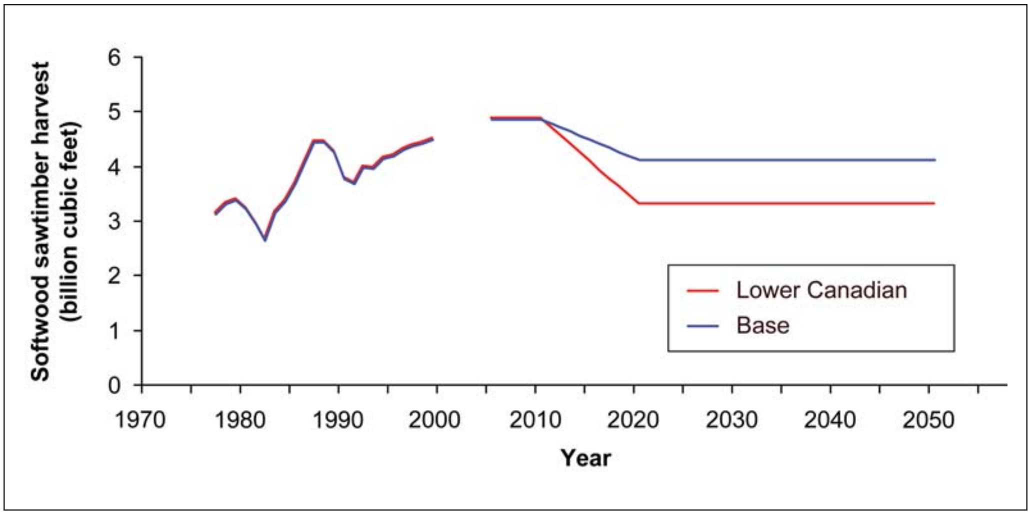

Figure 74—Canadian softwood sawtimber harvest in base and lower harvest scenario.

Results of this simulation are comparable to findings for similar scenarios in past RPA timber assessments (see, for example, Haynes et al. 1995) and reemphasize that the United States and Canadian forest sectors are closely linked. Changes in one country quickly transmit price and production signals through North American products markets, affecting producers, consumers, and timberland owners in both countries. Canadian timber supply changes do have direct effects on U.S. markets, and the size of these impacts may rival or exceed those of domestic market shifts under appropriate circumstances.

Increased Nonindustrial Private Afforestation

Nonindustrial private forest ownerships include large areas of land suitable for both agricultural and forest uses. Over the past 50 years, these lands have been the primary source of fluctuations in private timberland area, with uses shifting to agriculture in some periods and back to forestry in others. Public programs, such as the Soil Bank in the late 1950s and the Conservation Reserve Program in the late 1980s and early 1990s, have attempted to return some of these lands (with highly erodible soils) to forest cover by means of afforestation subsidies. This scenario examines a hypothetical program designed to afforest 6 million acres of marginal nonindustrial private forest agricultural land over the next decade. The program would be aimed at all regions, but the largest part of the additional timberland area would come in the South (90 percent). The remainder would occur in the Pacific Northwest West, North-Central, and Northeast regions. Based on experiences with past afforestation programs, most of the converted area would be planted to softwood species (Hernandez and Moulton 1999). For this projection, we assumed pines would be planted in the South and North, whereas Douglas-fir is planted in the Pacific Northwest. Apart from regeneration, the management of these lands would be of relatively low intensity given the limited importance of forest production in the objectives of most nonindustrial private forest owners.

In this scenario, newly afforested southern pine stands receive less investment than average and are managed under a “custodial” regime. Once established, treatment is similar to natural pine stands. We assumed that 10 percent of the stands would be subject to a pulpwood thinning followed by a mix of final and partial harvests. Two percent were placed in an unavailable class, counted as inventory but not subject to harvest. The remaining stands were eligible for final harvest beginning at an age 5 years older than similar managed plantation stands. Because we assumed these efforts would be occurring on former agricultural lands, the growth response was based on the high site-class category. Outside the South, the management treatment was comparable to the average nonindustrial private forest timberland acre in the base case. Because the minimum harvest ages in the Northeast and Pacific Northwest were greater than 40 years in the simulation, no additions to available softwood fiber were seen before 2050. In the North-Central region, a small amount of fiber became available in the last decade, whereas with the shorter rotation ages in the South, some additional fiber first became available in 2025.

In the projection, an additional 3.6 million acres were afforested in the South-Central region, representing 29 percent of the nonindustrial private forest planted pine acres. This was 9 percent of the South-Central nonindustrial private forest area classified as a softwood forest type. In the Southeast, 1.8 million additional acres were afforested, representing 15 percent of the area in planted pine and 6 percent of the area classified as softwoods. Because these acres are managed on a custodial basis, they produce less than their proportionate share of softwood fiber among planted pine acres. Between 2040 and 2050, the afforested acres in the South-Central and Southeast regions contribute 14 and 10 percent, respectively, of the softwood volume harvested from planted stands, and 7 and 6 percent of all softwood removals from the nonindustrial private forest ownership. This is less than their share of plantation area but about the same as their proportion of all softwood types.

In the South, increased afforestation would expand growth and raise the inventory above base-case levels. Inventory increments over the base reach their maximum in 2030, when the increase in South-Central nonindustrial private forest softwood is nearly 20 percent, and the gain in the Southeast is almost 9 percent. These are large impacts given that the overall increase in timberland area is just 4.4 and 3.1 percent in the South Central and Southeast, respectively. The large changes are due to our assumption that former agricultural land would produce growth rates associated with the higher site-productivity classes. As nonindustrial private forest harvest increases in response to additional available volume and stumpage prices decline, some harvest shifts away from forest industry owners. As a result, industrial inventories rise relative to the base as the projection progresses. Greater removals also serve to reduce the difference between base and scenario inventories for nonindustrial private forest owners after 2030.

In the Pacific Northwest, the scenario did not produce any additional volume available for harvesting by 2050, but inventory did rise. Timberland area in the nonindustrial private forest ownership was up 9 percent (400,000 acres), and by 2050, nonindustrial private forest softwood inventory volume was 15 percent higher than the base. Part of this response is attributable to lower stumpage prices in the South pulling away some processing capacity and associated timber demand. This is reflected in a 3-percent increase in forest industry inventory over the base.

The afforestation area increase predicted in the North was much smaller. It represented less than 0.1 percent of all nonindustrial private forest timberland (100,000 acres) in that region. Softwood inventories ended the projection just 0.3 percent above the base.

The market impacts of expanded timber growth, inventory, and ultimately harvest are shown in table 22. Both sawtimber and pulpwood stumpage prices decline and softwood lumber output and consumption rise, while lumber prices and lumber imports fall. Inventory and output expansion are greatest in the South and displace some production in the West. Responses in the pulp and paper sector are mixed. Pulpwood harvest generally rises for both softwoods and hardwoods but not in all years. Paper and paperboard output rise, again excepting a few years, with the largest gains in paperboard. Because the impacts of added timberland occur gradually as newly regenerated areas grow, all the market effects are delayed and rise toward the end of the projection.

Lower Housing Activity

Projections of housing construction activity developed in past RPA timber assessments have always spawned controversy, with some groups arguing that they were too high and others that they were too conservative. Development of the housing models used in the timber assessment (see discussion in chapter 2) was stimulated in part by a debate that started nearly 20 years ago. At that time, housing projections were driven largely by demographics (see, for example, Marcin 1972) and provided limited explanation for the major housing cycle observed in the 1980s. Concerns about the treatment of housing unit replacements and rapid increases in expenditures for residential repair and alteration during this same period generated additional controversy and impetus to seek alternative modeling methods.

This scenario examines the sensitivity of the projections to both a lower level of housing activity and to a change originating on the demand side of the solid wood products market. In the base housing projections (app. table 27), there is a period of relatively rapid increase in average unit size after 2030 spurred by continued growth in household income. In this alternative scenario, this increase is eliminated, and average unit size is held constant for all unit types. Household expenditures on housing stock continue to rise but are assumed to be directed toward other attributes of the housing unit rather than its size (this might include built-in electronics, special recreational or health facilities, etc.). The impact on total floor area of new residential construction is illustrated in figure 75. By 2050, the floor area of new residential construction is lower by some 1.4 million square feet per year, more than 23 percent below the base case. And because the most rapid growth in base-case house size during this period comes in single-family units, the impacts on materials consumption in residential construction will be disproportionately large.

As noted in chapter 3, new residential construction is one of the primary drivers of solid wood demand. The simulated decline in housing construction reduces demand for softwood lumber (by nearly 6 percent in 2050, see table 22) and structural panels and to a much lesser extent for certain classes of hardwood lumber. Lumber prices fall, together with the demand for softwood sawtimber stumpage and sawtimber stumpage prices. Softwood sawtimber harvest falls, and softwood inventories rise relative to the base, especially late in the projection period. Impacts in the paper and board sector are modest. With lower solid wood output there is less softwood residue generated, higher softwood pulpwood prices, lower pulpwood harvest, and higher recycling rates. Prices of paper and paperboard rise except in the last decade of the projection. Substitution of softwoods for hardwoods in pulping leads to a reduction in hardwood pulpwood harvest and price.

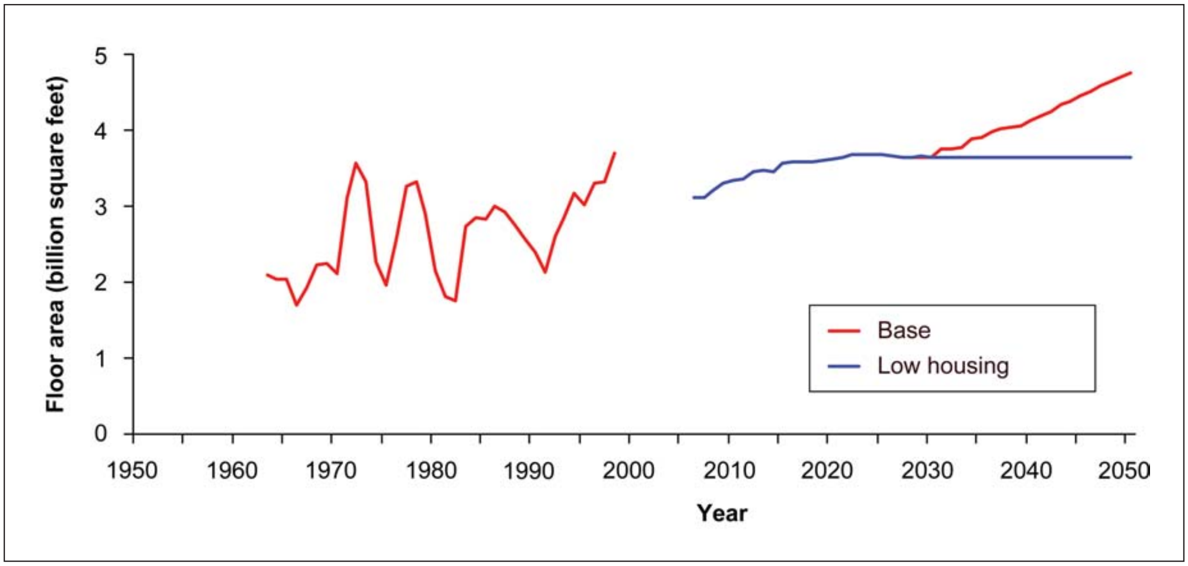

Figure 75—Total floor area of new residential housing construction in the United States in base case and lower housing scenario.

Reduced Consumption of Paper and Paperboard—Intelligent Consumption

In a recent report, the Intelligent Consumption Project concluded that, "Supporting the expanding world population at anything approaching current U.S. per capita consumption rates will impose a substantially increased burden on the world's ecological systems. Reduced consumption of wood and wood products is an important response to this state of affairs" (Strigel and Meine 2001). Other groups have similarly called for reductions in consumption of wood and wood products, notably focusing on trends in U.S. paper consumption. The United States has the highest per capita paper and paperboard consumption in the world, peaking at around 750 pounds recently in 1999, and currently at around 700 pounds (Strigel and Meine 2001). The baseline RPA projections indicate that the current recession in the pulp and paper sector will be reversed, and eventually paper and paperboard consumption will climb above recent peak levels and reach approximately 830 pounds per capita by the year 2050. This assessment projects a much more modest increase in per capita paper and paperboard consumption than do past RPA assessments, but nevertheless consumption is still projected to increase in the long run.

This alternative scenario posits a different future, one in which per capita consumption gradually recedes in the long run. The scenario is based on the possibility that consumers of newsprint and printing and writing paper could seek to obtain greater use of electronic media in the future in substitution for print media, thereby reducing consumption of communication grades of paper. The scenario is implemented in the partial equilibrium supply-demand analysis by imposing significant reductions in projected demands for printing and writing paper and newsprint after the year 2010. Such future reductions in demand growth could occur as a result of increased substitution of electronic media for print media, with no change in the macroeconomic outlook for U.S. population or GDP growth.

In the base case, domestic demands for paper and paperboard are projected to recover from the current recession, with total consumption in 2010 projected to be slightly higher than the recent historical peak of 1999. Consumption is projected to gradually increase over the projection period, approaching 160 million tons by 2050. In the alternative scenario, U.S. paper and paperboard consumption is projected to reach only 145 million tons by 2050. The overall reduction in consumption amounts to about 14 million tons per year by 2050, with reductions in consumption of printing and writing paper and newsprint from 2010 to 2050. The U.S. demands for paper and paperboard have been decelerating over the past two decades. Consumption has been declining on a per capita basis for some product grades such as newsprint and kraft paper, while per capita consumption of other product grades continues to increase. In the alternative scenario, per capita consumption of paper is projected to gradually decline after 2010, dropping from over 400 pounds per capita to around 320 pounds per capita by 2050. This leads to a relatively "flat" projected trend in total paper and paperboard consumption per capita, close to 750 pounds per capita.

The U.S. trade balance in paper and paperboard commodities has deteriorated in recent years along with an overall increase in the U.S. manufacturing trade deficit, owing in part to a strong U.S. dollar and overseas capacity expansion. With only a modest projected decline in the U.S. dollar value and continued expansion in overseas production capacity, imports of paper and paperboard in the base case are projected to continue increasing in the decades ahead, whereas U.S. exports are projected to experience little growth. In the alternative scenario, reduced consumption of printing and writing paper and newsprint beyond 2010 is associated with reduced imports of those commodities, an overall reduction in annual imports of about 7 million tons by 2050. Thus about half of the reduction in domestic consumption translates into reduced imports. In addition, there is a small increase in projected exports, as reduced consumption results in excess domestic production capacity.

As illustrated in table 22, declining demand for paper leads to reductions in paper and paperboard production (paperboard output declines, but it gains a slightly higher share of total output) and an increase in the rate of use of recovered paper. Reduced paperboard output derives from higher paperboard imports from Canada and an overall reduction in the recycled fiber supply so critical to many types of paperboard products. Overall paper prices decline as a result, but there is some increase in price of paperboard as supplies of recycled fibers shrink and costs rise. Both softwood and hardwood pulpwood harvests drop together with pulpwood stumpage prices. Private inventory changes are minimal. Impacts in the solid wood sector are also small.

Discussion

It is difficult to rank the various scenarios based solely on comparison of their absolute or proportional impacts because the extent of the policy or trend shift that underlies each scenario is essentially arbitrary. The reduced Canadian sawtimber harvest case, for example, has some of the largest impacts of any of the scenarios. Yet the 20-percent harvest reduction assumed in the scenario is only one possible view of the future. A smaller reduction would correspondingly reduce the impacts of the case. Thus, there is no firm basis for asserting that one type of shift is more "important" or significant than another. Useful generalizations about the scenarios can be made, however, by examining some of the broader characteristics of their impacts. These generalizations include differences in regional and product impacts and in the timing of changes induced by the scenarios in prices and volumes.

There is a difference among the scenarios in the extent to which changes originating in one sector spill over into other sectors. The four scenarios whose initial changes are related primarily to the solid wood and sawtimber sector (the national forest harvest changes, lower Canadian harvest, and lower housing cases) all have their largest impacts on aspects of the solid wood market and sawtimber (see table 22). At the same time, they produce smaller but noteworthy shifts in pulpwood markets and other parts of the paper and board sector. The intelligent consumption scenario directly relating to the paper and board sector, in contrast, has significant impacts in that sector but only modest effects on the solid wood and sawtimber stumpage markets. The increased nonindustrial private forest afforestation scenario, because it impacts long-term sawtimber and pulpwood supplies, produces changes in both sectors although the largest are for sawtimber. The solid wood/sawtimber sector is related to paper and board via the quantities of residues produced in solid wood processing (which are substitutes for pulpwood and other types of fiber) and the prices of sawtimber stumpage (which represents an output alternative to pulpwood for timber producers). The paper and paperboard sector, in turn, is linked to solid wood/sawtimber through the prices received for residues (determined together with other fiber prices) and the prices of pulpwood stumpage. Scenario results illustrate an asymmetry in responses of markets within the forest sector. Changes originating on the sawtimber side may produce some shifts in the pulpwood sector, but changes in the paper and paperboard sector may have only muted impacts on solid wood.

These same groups of scenarios also differ in the regional concentrations of their impacts. The national forest cases have major impacts in the West. The other solid wood/sawtimber cases have large impacts both in the West and East. Changes resulting from the paper and board scenario are somewhat bigger in the East. This reflects, of course, the geographic concentrations of the two industries and of the harvest of timber from the national forests. National forest harvest comes mostly from Western regions, Western industry is predominantly solid wood-producing, and sawtimber is the primary product of Western forests. Paper and board production is heavily concentrated in Eastern regions, but the largest part of U.S. solid wood processing (since the early 1990s) also occurs in the East, and pulpwood represents a significant portion of the timber harvested in Eastern forests.

With regard to the timing of impacts observed in the scenarios, it is clear that the onset of changes is governed in part by the conditions of the cases; the low housing case does not change until 2030, the lower Canadian harvest scenario does not reach full impact until 2020. Changes in other cases arise before 2010. Shifts beyond the onset period are also linked in part to the form of the scenario. For example, the low housing, increased nonindustrial private forest afforestation and intelligent consumption scenarios show rising impacts for many measures as the projections proceed. These scenarios all involve significant departures from trends in the base case. The rising trend in floor area in the later years of the base case is replaced by a future of constant floor area construction. Base case trends in nonindustrial private forest timberland area are replaced by a more rapid rate of accumulation. The intelligent consumption case reduces the strong consumption growth of certain paper products. As a result, impacts measured relative to the base get bigger over time as conditions driving the scenarios depart further and further from the base.

Two of the scenarios (low housing and intelligent consumption) deal with examples of demand contraction, and the results serve to illustrate some general characteristics of the responses of forest products markets to demand changes.

- Prices and quantities in the initially impacted forest products markets (i.e., solid wood or paper) decline.
- Use of wood and fiber inputs in production of these commodities declines. The sawtimber input to solid wood products clearly drops in the low-housing case (see table 22). Total fiber input to paper and paperboard production also falls in the intelligent consumption scenario after initial trade adjustments are complete in 2020.
- Roundwood and fiber prices fall.
- Timber inventories rise as a result of lower harvests during at least some portion of the projection period. These changes will be small in percentage terms, as the inventory is large relative to harvest and growth and is slow to change.

Shifts would be in the opposite direction, although not necessarily symmetric in size, in scenarios of augmented demand.

Chapter 5: Management Implications[1]

Introduction

In this chapter we consider in greater detail the findings of the various projections as they relate to a number of contemporary issues facing the forest sector. These include (1) stumpage prices for softwoods (this discussion also includes a review of assessment price projections over the past 20 years to provide context for the current forecasts), (2) forest fragmentation, (3) sustainable forest management, (4) trends in forest diversity and structure, (5) the question of whether Southern timberlands can provide the bulk of harvest increases, (6) forest health, (7) globalization and its effect on the forestry sector, and (8) disaggregation of projections.

Softwood Stumpage Price Projections

The base projection shows relatively limited growth in prices for softwood stumpage in the major producing regions. Sawtimber stumpage prices rise at less than 0.5 percent per year in the projection after 2010 in the South and Pacific Northwest West, while softwood pulpwood stumpage shows a strong cycle but no trend in the South. In terms of underlying changes in softwood stumpage markets, demands for both sawtimber and pulpwood expand markedly in the projection, but supplies, albeit from different sources, keep pace and limit any price growth. In addition, increased dependence on global product markets helps limit U.S. stumpage price growth. Slow price growth represents a sharp break from the experience of the past decade. But the unusual conditions of demand and supply that lead to rapid price growth in the recent past have changed, and price growth is expected to moderate as a result. At the same time, prices will not fall back to levels observed in earlier decades. Softwood stumpage prices have taken another, essentially permanent, step upward just as they have in many similar periods in the past. And although the timber assessment projection of modest long-term price growth is noteworthy in contrast to recent history, it is not a new result. Timber assessment reports since 1989 have projected slower growth in softwood timber prices beginning in the 2000–10 period based on essentially the same fundamental vision of future markets.

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[1] The authors for this chapter are Darius M. Adams, Richard W. Haynes, Brett J. Butler, Ralph J. Alig, Kenneth E. Skog, John R. Mills, Peter J. Ince, David J. Brooks, and Xiaoping Zhou.

Demand-Supply Basis for Limited Price Growth

In future sawtimber stumpage markets, conditions that retard price growth will differ in the periods before and after 2015. In the near term, demand differs markedly across sawtimber products. Lumber use remains near recent peak levels. In contrast, consumption of softwood plywood and miscellaneous products declines, freeing some sawtimber supply for lumber use. As a result, total U.S. consumption of softwood sawtimber is nearly unchanged between 1996 and 2020. At the same time, U.S. sawtimber harvest continues the lengthy decline begun in the late 1980s, reaching its nadir in about 2015. Reductions in the past have been concentrated in the West but will occur in parts of the South as well over the 2000–10 period (see table 13). As noted in chapter 3, domestic harvest limitations in this period derive largely from imbalances in the age-class structures of private forest ownerships. The primary offset for declining domestic supply during this period will be continued growth in softwood lumber imports both from eastern Canada and non-Canadian sources.

Beyond 2015, U.S. demand for softwood sawtimber products increases once again (reaching 9.4 billion cubic feet by 2050), owing entirely to growth in lumber use. With the growth of large areas of young timber above the minimum merchantability threshold, harvest after 2010–15 will expand rapidly in parts of the South and stabilize in the Pacific Northwest West. The net effects on supply will be partially offset by reductions in sawtimber harvest in Canada, but the upward price pressures of these limitations will be overcome by growing Southern output after 2020 and continued growth in imports from non-Canadian sources.

Unlike sawtimber demand, some growth is anticipated in the first portion of the projection in net U.S. demand for softwood pulpwood (it rises from 3.5 to 4.3 billion cubic feet between 1996 and 2010). During this period, softwood pulpwood use associated with rapidly rising consumption of oriented strand board (OSB) augments growth in paper and paperboard consumption. The U.S. softwood pulpwood supply, just as the sawtimber supply, faces near-term limits, particularly in the South. As a result, imports of pulp, paper, and paperboard rise markedly in this period. The effect is to keep pulpwood prices near the low levels of the late 1990s until 2015. In later years, pulpwood demand for paper and paperboard and OSB grows steadily (total U.S. demand for pulpwood reaches nearly 8.0 billion cubic feet by 2050). At the same time, pulpwood harvest in the South expands markedly (for the same reasons noted above for sawtimber). The initial impact is to push prices downward until about 2025 to levels somewhat below the lows of the late 1980s. At this point, softwood harvest begins to approach growth on key Southern ownerships, and supply tightens. Prices turn upward and finish the projection near early 1990s levels in the South. On nonindustrial lands in the North, reluctance to harvest because of higher opportunity costs pushes prices steadily upward in that region after the 2025 trough.

Projections in Historical Context

The historical record suggests that real softwood sawtimber prices both in the Pacific Northwest West and the South have moved upward episodically, with periods of increase interspersed among periods of relative stability or even decline, in a step-like fashion (see fig. 76). The timing of upward shifts has corresponded to major changes in resource or market conditions. Prices moved up sharply following the removal of price controls after World War II and the advent of the post-World War II housing boom. Prices shifted upward again in the late 1960s and early 1970s as the log export market became a significant source of demand and housing activity shifted up to a

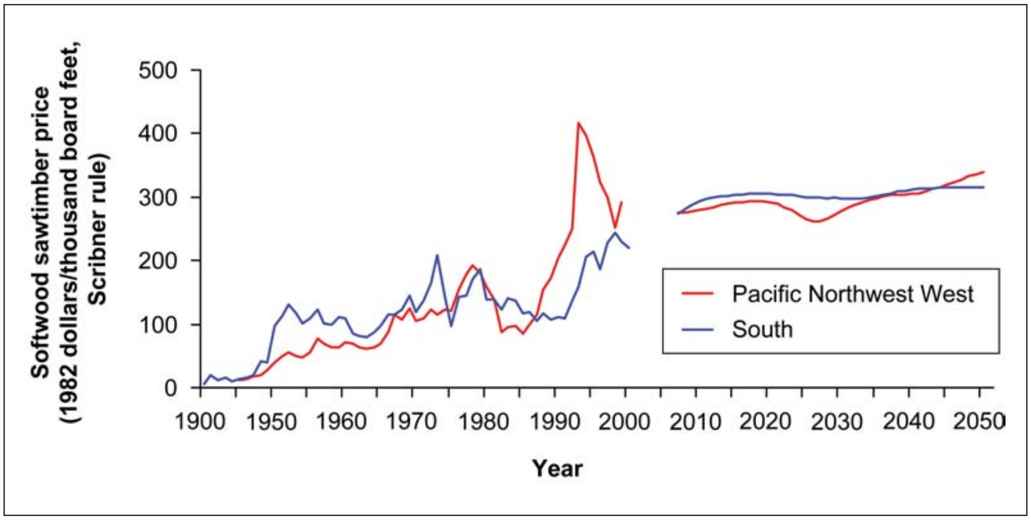

Figure 76—Softwood sawtimber stumpage prices in the Pacific Northwest West and South, with projections to 2050.

steadily higher average level.[2] The most recent increase began in 1990 spurred by reductions in Western public timber harvest, a further upward shift in housing activity, and restrictions in the availability of timber from Canada (both the limitation of harvests in western provinces and the softwood lumber import quota system have been important). Although some of these elements could be transitory with changing public policies, under the constant policy assumptions of the base projection the price shift is permanent.

Unlike sawtimber markets, the markets for pulpwood are not subject to the variations induced by housing activity. Demand for paper and board is dispersed across all sectors of the economy and moves closely with broad indicators of general economic activity such as gross domestic product (GDP). As illustrated in figure 77 for the South, pulpwood stumpage prices also are somewhat less volatile than sawtimber prices in the short run. Over longer periods, however, they still show pronounced multiyear cycles, driven by the interplay of regional production capacity and periods of varying growth in the timber resource and pulpwood supply.

The early development and expansion of paper and board production in the South drew up prices through the late 1950s (including a small upward shift with the elimination of World War II price controls). Stable prices during the 1960s reflected the dramatic growth in the softwood forest resource and expansion of pulpwood supply to meet the needs of the growing industry (harvest increased by nearly 60 percent during this decade while softwood inventory expanded by approximately 23 percent).

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[2] With the movement of the “baby boom” generation into the housing market, the average annual floor area of new conventional residential construction shifted from 1.81 billion square feet in the 1950–69 period to 2.38 billion square feet during 1970–89. The average rate of construction shifted once again during the decade of the 1990s to 2.61 billion square feet.

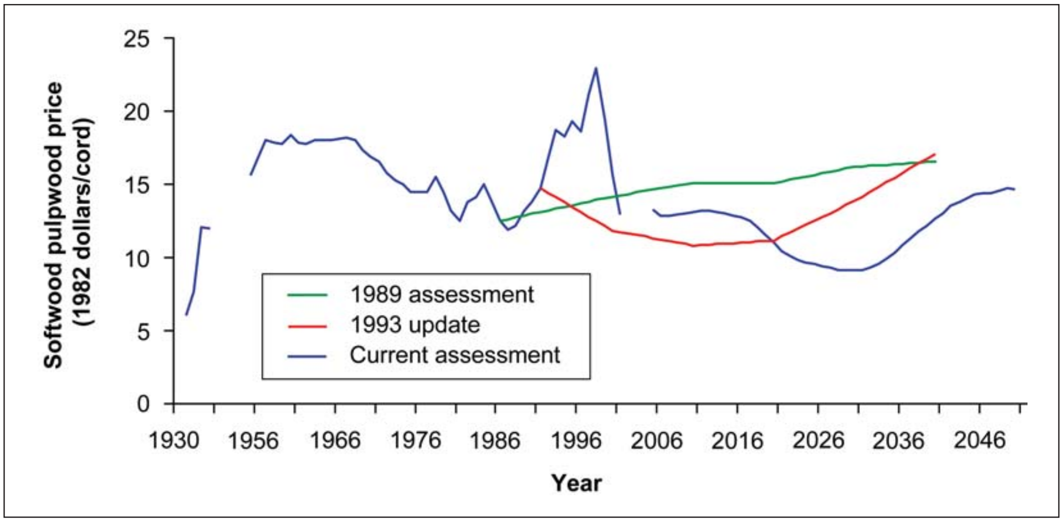

Figure 77—Softwood pulpwood stumpage price in the South, with projections from current and past RPA timber assessments.

The downward price trend in the 1970s and early 1980s accompanied a period of somewhat slower growth in the regional industry but continued expansion in timber inventory and stumpage supply and growing use of hardwood fiber. Prices jumped again in the 1990s in response to the same public harvest, housing demand, and lumber import restrictions that affected the sawtimber market, increasing competition for wood of all types in the South. The base projection shows another major pulpwood price cycle. As discussed above, the same forces of markedly rising timber growth and expanding stumpage supply are at work in this future cycle as they have been over the past four decades.

Current Versus Past Assessment Projections

As illustrated in figures 78 and 79, timber assessment softwood sawtimber stumpage price forecasts since 1989 have all envisioned declining growth in prices after 2010. In earlier projections completed in 1979 and 1983, however, sawtimber prices rose steadily. Pulpwood prices have been projected only in the most recent assessments. The 1989 RPA timber assessment forecast a slow rise in Southern pulpwood prices to near 1960s levels by 2040, whereas the 1993 RPA timber assessment update showed a shallow cycle returning to the same 2040 levels as the 1989 projection (see fig. 77).

For sawtimber, the differences between the rising trend projections in 1979–83 and more recent projections result primarily from changes in the methods used to project the private forest inventory. Earlier models represented the inventory on a diameter-class basis and projected growth by shifting trees from one diameter class to the next. In long-term projections, it was assumed that the diameter growth rates observed in the historical inventory data would remain the same in the future. In retrospect, the resulting aggregate growth projections, particularly for forest industry lands, were extremely conservative, leading to sharply lower inventory projections and stable or contracting sawtimber supply over the projection. Because demand forecasts did not differ greatly from those of later assessments, the result was rising price projections.

The effects of more realistic estimates of inventory growth can be seen in a simulation experiment conducted in the 1979 RPA timber assessment (labeled “1979-INT” in figs. 78 and 79). In this analysis, diameter growth rates were adjusted upward to reflect a

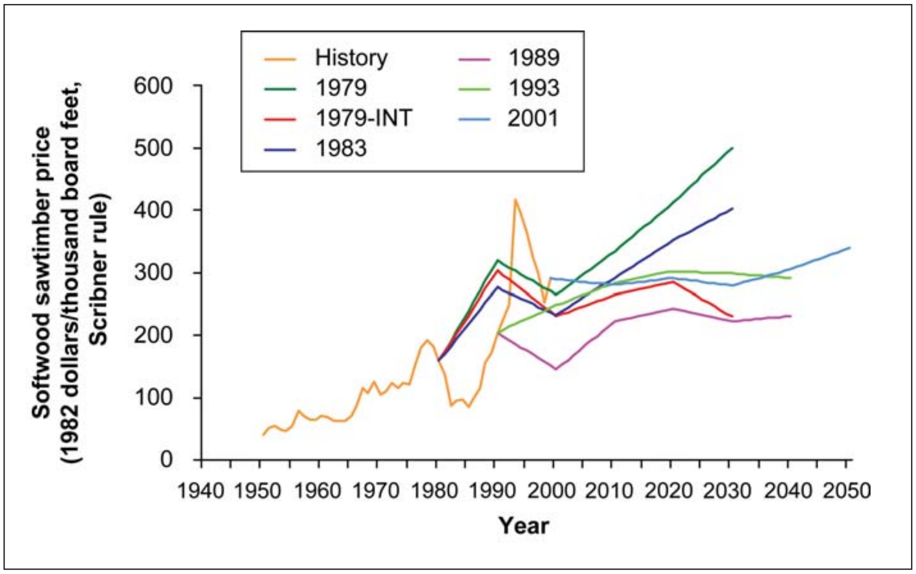

Figure 78—Softwood sawtimber stumpage prices in the Pacific Northwest West, with projections from the five timber assessments. 1979-INT = Intensive land management (1979 alternative run).

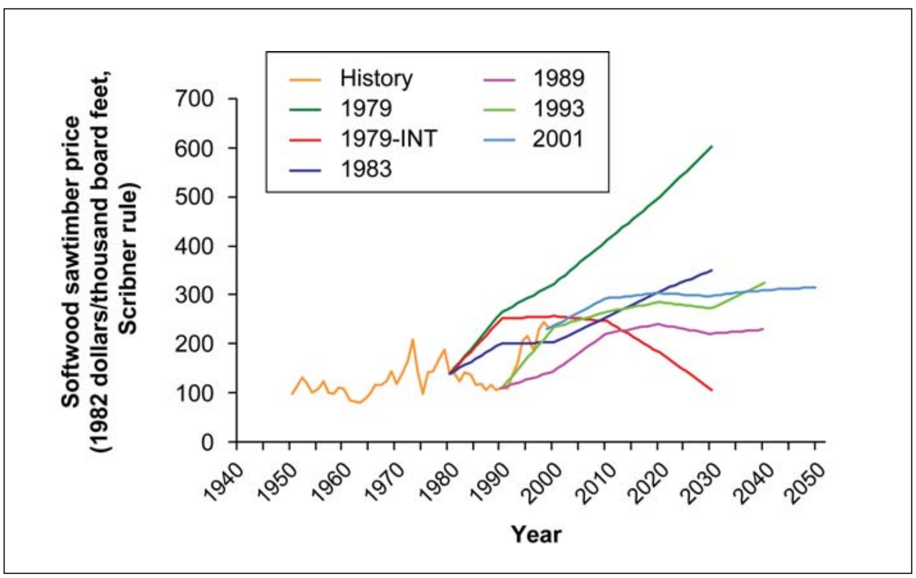

Figure 79—Softwood sawtimber stumpage prices in the South, with projections from five timber assessments. 1979-INT = Intensive land management (1979 alternative run).

scenario of active investment in forest management (see Adams et al. 1982 for details). The result, in both the Pacific Northwest West and South, is stable to declining prices 10 years into the projection. At least until 2020, this projection is much closer to the current timber assessment base than the static investment and growth scenario of the 1979 base.

Forest Fragmentation

Preliminary findings from the timber assessment indicate that approximately 15 to 20 million acres of U.S. forest land could be converted to urban and developed uses over the next 50 years. Such land use conversions could result from residential development in forested landscapes, as the U.S. population grows by another 126 million people. Particularly rapid growth rates are expected in the key timber supply regions of the South and Pacific Northwest. Forest fragmentation (see “What is Forest Fragmentation?” section) resulting from changing land use and land cover patterns is becoming an increasingly important topic in the United States, as concerns are being raised about habitat protection, timber supply, and myriad other issues. Although some wildlife species need the edge areas present in fragmented forested areas, forest fragmentation presents potential unfavorable consequences, such as loss of biodiversity, increased populations of invasive and nonnative species, changes in biotic and abiotic environments, changing landowner objectives, and decreased or more costly natural resource availability as in the case of timber management. Forest fragmentation is receiving increased attention, but there is relatively little national data and few macroscale analyses on the topic. The absence of a standard definition for fragmentation is part of the challenge. In the following sections, we discuss definitional issues, causes of forest fragmentation, and the timber assessment findings relative to fragmentation.

What Is Forest Fragmentation?

Definitions of forest fragmentation appear to differ across disciplines and are influenced by the questions or policy issues of interest. For example, it is equally valid to discuss the fragmentation of forest vegetation as it is to discuss the fragmentation of ownership of the land (e.g., parcelization). Fragmented forests may occur naturally across the landscape (such as the Great Basin, Nevada), or such a pattern may be a result of human activities. A dichotomy in forest fragmentation definitions is between treatment of fragmentation as a process or as a pattern (Alig et al. 2000). Various spatial indices of landscape structure used to quantify fragmentation have ranged from (1) comparisons among old-growth and managed forests and associated rates of disturbances and changes in patterns over time in managed forests to (2) evaluating land use and landscape change over time. Such indices and associated statistics cannot provide a definitive threshold for identifying a fragmented landscape. They only provide a means for comparing the relative degree of fragmentation to other landscapes or of the same landscape at different periods (Alig et al. 2000).

Some of the common terms used in discussions of fragmentation include edge, core or interior habitat, and interspersion. The borders or perimeters between different land uses or land covers are known as “edges.” The core area is the area that is not influenced by neighboring land uses or land covers; i.e., the area of the patch minus the area that is influenced by edges. Interspersion is a description of the juxtaposition of landscape elements and is often calculated as the probability of adjacency between categories (e.g., Turner 1989). The terms associated with forest fragmentation emphasize the focus of a particular study question and its scale. For example, harvesting of forests may lead to age-class fragmentation, but the underlying forest base has not been fragmented if natural or human-caused reforestation follows the timber harvest.

What Causes Forest Fragmentation?

Forest fragmentation can result from disturbances that are initiated by natural elements or humans. Often, human and natural agents or elements interact to either enhance or lessen the resulting fragmentation effects. A significant difference between human-caused and natural fragmentation is that human actions are often more frequent (e.g., Butler and Alig, n.d), less random, and more permanent than natural processes. Natural fragmentation processes include fire, wind, and flooding.

Human actions that cause fragmentation include land use conversions, changing ownership patterns, and other disturbances, such as timber harvesting. Some of the timber harvesting is on forest land that is being cut for the last time in preparation for development. Further, the process of forest fragmentation is generally not random. In the case of urban development, land is converted by persons with specific needs and individual preferences for land with certain characteristics (such as, accessibility, tree cover, septic suitability, slope, etc.). Similarly, when forest land is converted for agriculture use, specific areas with agricultural potential are targeted. Along with land use conversions, changing landowner demographics are having notable effects on forest fragmentation and parcelization, and on the ability of fragmented landscapes to provide specific amenities. Because forest harvesting is most often followed by reforestation (Smith et al. 2001), effects of such age-class fragmentation are often not as severe in the longer term as, for example, conversion of forests to other land uses such as urban development.

Results from the Current Timber Assessment

For the timber assessment, preliminary projections of area changes for land use, land cover, and forest ownership (Alig et al., n.d.) are relevant elements in an analysis of forest fragmentation. Population changes are a major determinant of future timberland area (e.g., Mauldin et al. 1999a). The area change projections consider afforestation, deforestation, reforestation, and successional processes. The first two of these also involve land use changes, so the land use and land cover projections are interrelated.

The 126-million-person increase in U.S. population by 2050 is accompanied by a 76-million increase in the number of households. In the past, each additional household consumed about 1 acre of land. These projections lead to about 40 million acres of total rural land being converted to urban/developed uses by 2050. If historical trends continue,[3] 15 to 20 million acres of this land could come from forests. Population growth is projected to be strongest in the South and West, regions that contain the Nation’s key timber supply areas. In the South and West, for example, where urban growth is above the national average (nationally, urban areas doubled in size between 1942 and 1992 [Alig et al. 1999]), expansion of urban and agricultural areas is acting to fragment some forests.

In addition to the area of forests lost to urbanization and sprawl, population growth is likely to add to the fragmentation and parcelization (i.e., breaking up of large holdings into small holdings, which some also call fractionalization) of croplands and forest lands. This has two effects. First, it could reduce the amount of economically harvestable area, as owners of smaller forests or woodlots may decide not to harvest. Although a specific area may still be in forest cover, the small size of a holding may adversely affect the economics of commodity harvests in some cases (Row 1978). Decreasing average tract size for nonindustrial private forest timberlands is already a reality. In 1994, the average noncorporate individual owner had 24 acres (Birch 1996). This number is projected to decrease to 17 acres by 2010 (Sampson and DeCoster 1997). At the same time, a consolidation of larger land holdings is occurring. The average area of the land holdings of large forest owners (i.e., holding more than 500 acres) increased from 2,500 acres per ownership in 1978 to 2,600 acres in 1994 (Birch 1996).

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[3] Approximately 40 percent of rural lands converted to urban/developed uses between 1982 and 1992 came from forested areas (USDA NRCS 2001).

The second effect associated with fragmentation is change in the values and perceptions of the forest landowners. These new rural immigrants sometimes have attitudes toward the land and land management that contrast with the attitudes of the original residents who often have more conservation and utilitarian oriented views of natural resources.

The nonindustrial private forest ownership (1) has historically been subject to the largest and most frequent land use changes of any owner group, (2) has a heterogeneous owner composition, and (3) has notable variation in size of forest holdings and management intensities within and across regions (Alig 1990). Although some speculate that forest fragmentation may significantly reduce timber supply from the nonindustrial private forest land, the historical trend indicates that the net outcome of the many forces operating on the ownership has been a fairly steady supply of timber at an aggregate level. The percentage of U.S. timberland harvest from the nonindustrial private forest ownership has gone from 57 to 60 percent between 1952 and 1997. Further, the percentage of nonindustrial private forest harvest relative to total timber inventory has changed little over that period, at about 2.6 to 2.7 percent. At the same time, nonindustrial private forest timberland area decreased by 5 percent between 1952 and 1997, with increased productivity per acre owing in part to increases in pine plantation area (Alig et al. 1999). As discussed elsewhere (e.g., Kline et al. 2000, Londo 2000, Schmidt and McWilliams 2000), trends in nonindustrial private forest timberland area and timber supply impacts can differ by region. For example, private timberlands in the North are increasing in average stand size, stocking, and age (Schmidt and McWilliams 2000). In contrast, Sampson (2000) points out that forests in the South are increasingly impacted by parcelization, higher road densities, and increased clearing and conversion for homes and other land use.

Few studies have examined the impacts of urbanization and forest fragmentation on timber harvest and timber supply. In an empirical analysis, Barlow et al. (1998) found that the proximity of urban development and higher population densities are correlated with reduced rates of timber harvest on private timberlands in the South. Wear et al. (1999) found that higher population densities are correlated with a reduced likelihood that private timberlands are managed for commercial timber production. Alig and Healy (1987), Munn et al. (2002), and Wear et al. (1999) suggest that increasing population densities may reduce private forest investment as forest owners anticipate continued population growth and eventual conversion of their forest land to urban and developed uses. In chapter 2, we described adjustments of timber inventories in the timber assessment to reflect their “availability,” a process intended to reflect impacts from increased population densities on the landscape. Estimates of inventories that may be withheld were based on surveys of state foresters in the South (see chapter 2).

The land use and land ownership dynamics discussed above are important components of fragmentation. Measurement of the spatial component of land use can add additional information. Specifically, patterns related to the amount of edge and interior habitat and the arrangement or interspersion of landscape elements are important for a spatially explicit understanding of changing land use dynamics. Alig et al. (2000) analyzed fragmentation at the national scale by using coarse-resolution data (1-km minimum resolution). These data are not fine enough to supply information about local dynamics or patterns, but developing indexes from the data is useful for creating maps of fragmentation. These combined indices of the ratio of edge to interior habitats and interspersion were summarized at the county level, calculated from the forest type groups map of the United States produced by the U.S. Forest Service with 1-km resolution advanced very high resolution radiometer (AVHRR) data and other information (Powell et al. 1993, Zhu and Evans 1994). The resulting (static) map of composite indices indicates relatively more forest fragmentation in the Midwest, southern Florida, and parts of the Great Plains, some owing to natural forest fragmentation (Alig et al. 2000). By contrast, the upper Lake States region, portions of Maine, and parts of the Pacific Northwest are examples of regions with relatively lower fragmentation indexes. Some native forests have been converted to agricultural and urban uses, notably in the Eastern and Midwestern United States.

What Are the Critical Issues?

There are several dimensions to fragmentation that have emerged as critical issues. First, there are concerns that changes in land use and land cover alter both the spatial pattern and distribution of habitats and create new habitats that are intensively used by humans. Second, there is a greater interest in looking at consequences (both intended and unintended) of various policies (e.g., policies such as extensive public investments in improved automobile transportation systems) in terms of their impacts on land use. Third, there is the consequence of more houses, streets, parking lots, malls, and office buildings (DeCoster 2000). At the same time, we have added forest area either through plantations as part of overall afforestation or where forests have regrown on abandoned agricultural lands.

Discussions of fragmentation are hindered by limited data. Work is needed to better understand forest fragmentation, its extent, location, and rate of change. Better documentation of forest fragmentation requires developing a long-term database (Alig 2000) and improving methods for projecting the distribution of people over the national landscape. There is also a need to develop a standardized terminology. Fragmentation and parcelization are often used interchangeably but often have different meanings in application. Forest fragmentation, as proposed in one definition, includes land use conversion where conversion of forests to nonforest increases the edge areas relative to core forest areas. Parcelization, in contrast, is ownership-related. Others speak of fragmentation with regard to area changes for forest cover where species compositions are altered, or where timber harvests have led to age-class fragmentation.

Sustainable Forest Management

The United States is committed to using the criteria and indicators in the Santiago Declaration of the Montreal Process[4] to assess the sustainability of forest management in the United States. These criteria provide a broad basis for discussing forest management organized around 67 indicators of resource, economic, and social conditions grouped into seven broad criteria.

The timber assessment results provide a number of both direct and proxy measures for some of these indicators. The three criteria we discuss provide information on values we hold for conservation of biological diversity (hereafter, biodiversity conservation), maintenance of productive capacity of forest ecosystems (hereafter, maintenance of productive capacity), and maintenance and enhancement of long-term multiple socioeconomic benefits to meet the needs of societies (hereafter, maintenance of socioeconomic benefits).

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[4] For more information on the Montreal Process see http://www.mpci.org/home_e.html. For a list of the criteria and indicators see http://www.mpci.org/whatis/criteria_e.html.

We provide a section with a synthesis of national information for indicators under the three criteria, a section with detailed information by region, and a section with a synthesis of regional information.

Synthesis of National Trends and Projections for Selected Indicators

Aggregate national trend data and projections for indicators are shown in table 23.

Direct measures are:

- Extent of area by forest type (percentage of timberland in softwood types).
- Area of timberland.
- Total growing stock.
- Ratio of removals to net growth.
- Consumption of wood products.
- Roundwood harvest overseas for net imports as a percentage of all roundwood needed for U.S. consumption.

Indirect or proxy measures are:

- Average diameter of private timber stands (for extent of area by age class or successional stage).
- Annual area harvested (as a measure of fragmentation of the land base).
- Harvest volume (as a proxy for wood product production).

The data were developed by aggregating regional data and are shown as indices computed by dividing each value by the 1952 value for that series (1976 for extent of older stands). The exceptions are the ratio of removals to growth, the softwood proportion of total inventory, and the roundwood equivalent[5] for net imports versus consumption.

With the timber assessment data, the discussion of sustainability can be developed by comparing biodiversity conservation and maintenance of productive criteria changes with changes in criteria for maintenance of socioeconomic benefits over time.

- Data in table 23 show that there have been changes in many of the biodiversity conservation and maintenance of productive capacity criteria indicators over the historical period, but these aggregate changes have slowed in the recent past.
- During this same period, socioeconomic benefits increased as measured by increasing harvest, suggesting there may have been a tradeoff between changing ecological conditions and economic growth.
- As there have been slowing changes in biodiversity conservation and maintenance of productive capacity criteria, there has also been a shift to meet more of our consumption needs from imports. This suggests a second tradeoff of lowered harvest and attendant effects in the United States for increased harvest and attendant effects in other countries.
- Slower declines in the biodiversity conservation and maintenance of productive capacity measures in recent years may suggest that improving forest management and increased productivity of forest lands have helped reduce the extent of the tradeoff between ecological conditions and harvest in some cases. For example,

[5] Roundwood equivalent is the amount of roundwood needed to make the products in the United States.

Table 23—Selected sustainability indicators for the United States (indexes equal to 100 in base year unless otherwise noted)

	Biodiversity conservation			Maintenance of productive capacity			Maintenance of socioeconomic benefits	
Year	Extent of softwood area	Extent of older stands	Fragmentation	Area of timberland	Total growing-stock inventory	Ratio of growth to harvest	Total harvest	Consumption from domestic supply
	Percent	*Index*	*Index*	*Index*	*Index*	*Percent*	*Index*	*Percent*
1952	70		100	100	100	128	100	89
1962	68		89	99	108	161	95	84
1970	66		97	97	114	164	111	86
1976	64	100	96	95	119	171	118	84
1986	59	76	124	96	124	125	162	82
1991	57	74	124	99	128	121	164	85
2000	58	67	110	99	136	144	151	80
2010	58	66	108	98	153	140	167	71
2020	60	65	107	97	166	130	181	73
2030	61	65	106	97	177	123	193	73
2040	62	65	105	96	186	117	202	74
2050	62	65	105	96	193	110	212	73

Source: Computed from tables 5, 12, 14, 16, and 17.

increases in average stocking levels have helped to reduce the area harvested for a given volume removed (hence reducing the fragmentation measure), and there has been a slowing in the shift from softwoods to hardwoods.

Although past movement in some of the biodiversity conservation and maintenance of productive capacity criteria indicators could be interpreted as undesirable, the projection indicates approaching stability for a number of indicators at the national level.

- Harvest area (fragmentation) falls slowly with waves of new stands reaching maturity, primarily in the South. Harvest rises, but growth remains above harvest, and inventory expands.
- Although aggregate area, age, and fragmentation indicators tend to stabilize, there are projected harvest increases, and growth remains above removals but by a decreasing margin.
- To provide for increasing consumption, projections suggest there will be an increasing proportion of harvest needs that will be met by harvest in other countries. The relative shift of harvest needs to other countries will, over time, have an effect, from lowered U.S. harvest, on many indicators under other criteria.

These results suggest that, at the national level, the future sustainability debate might be framed more in terms of balancing domestic environmental gains, U.S. economic development, and effects of imports in changing forestry and forest industry in other countries, rather than the traditional “U.S. economy or U.S. environment” confrontation. At the same time, these national indexes hide significant regional and owner-level tradeoffs: for example, most of the increase in softwood inventories comes in the West, but nearly all of the increases in softwood harvest come in the South; Southern hardwood harvest exceeds growth after 2010 while Northern hardwood inventories grow markedly above current levels. Clearly, conclusions about sustainability can differ at different geographic scales.

Regional Detail in Trends and Projections for Selected Indicators

This section provides rationale for why selected indicators are important for understanding sustainability of forest management (Montreal Process Technical Advisory Committee 2000), historical trends, and current status of the indicators in the Forest Service 2000 RPA Assessment of Forest and Range Lands (USDA FS 2001), and projections from this timber assessment.

The projections used here are based on numerous assumptions (including assumptions about increased imports of forest products) that become less certain as we move further into the future and to greater levels of regional and ownership detail. They should be taken as only one of several plausible internally consistent pathways for these indicators.

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

Extent of forest area by forest type relative to total forest area—This indicator is intended to be a monitor of overall U.S. trends in forest coverage (by type), ecological processes, and viable populations of species that are dependent on a contiguous ecosystem or ecosystems of a certain minimum size. Each forest type is considered to represent a separate ecosystem, and is itself composed of a variety of ecosystem components. If sufficient area of each forest type is not maintained, these ecosystems become vulnerable to loss from fires, hurricanes or typhoons, disease, and other disasters.

Since 1920, forest land area has remained relatively stable at approximately one-third of the total U.S. land area.

Projections suggest forest land area and timberland area will decline 5.5 percent and 3.0 percent, or 23.2 and 14.8 million acres, respectively, by 2050. Half of the forest area loss is in the Pacific Coast region and one-third is in the South (table 5).

In the East, area has increased in loblolly-short leaf pine, oak-gum-cypress, oak-hickory, and maple-beech-birch. In the West, area has increased for Douglas-fir, hemlock-Sitka spruce, redwood, other softwoods, pinyon-juniper, and hardwoods. In Alaska, area has declined for hardwoods, the area of fir-spruce has increased, and the area of hemlock-Sitka spruce has remained constant.

Projections suggest forest cover types in the South will shift away from area in upland hardwoods and toward planted pine. Area is stable for oak-pine and lowland hardwoods, and there is slight decline in the area of natural pine (fig. 3).

Forest cover types in the Pacific Northwest West are projected to shift slightly toward more area in Douglas-fir and less in red alder. Areas for other hardwoods, other softwoods, and hemlock-Sitka spruce are relatively stable (fig. 4).

Extent of forest area by forest type and by age class or successional class—Many species are wholly or partly dependent on a particular successional stage. Therefore, all normally occurring successional stages should be present with sufficient area to support these species. Ecological processes and the species associated with those processes within a forest ecosystem or forest type are often associated with vegetative structure. It should be noted that some forest types are predominantly composed of stands of uneven age or otherwise difficult to ascribe to particular age classes. Forest type and forest age are important determinants of timber growth and yield, the occurrence of game animals, other nontimber forest products, and the forest's aesthetic and recreational values.

In the East, there has been an increase in the area of forest types that are representative of later stages of succession; some 71 percent of timberland is classed as having a stand age more than 40 years. Area with sawtimber was 30 percent in 1952 and 46 percent in 1997. Eastern forests are still younger than those prior to European settlement. The representation of some seral stages and forest types will likely decrease with an increase in area in later seral stages.

In the West, average stand age is older than in the East. In 1997, 64 percent of timberlands were classed as sawtimber size.

This timber assessment projects area by stand-age category for private land and national forest land rather than by timber size categories used above. So for the discussion below, look primarily at the projected trend in area in sawtimber (young, mature, and old mature seral stages; see app. tables 49 and 50) between 2000 and 2050 rather than comparing projected percentage of area to historical percentages above.

Generally, projections suggest an increasing proportion of area of timberland with sawtimber-size trees with the exception that sawtimber area proportion is projected to decrease for private hardwood timberland in the South.

National forests will continue to have a higher proportion of sawtimber acres than private lands for both hardwoods and softwoods. For 2050, the proportions of sawtimber acres for softwood and hardwood forest types, respectively, are as follows:

Percentage of timberland acres that classify as sawtimber (based on seral stages) projected for 2050

Forest sector	Softwood forest	Hardwood forest
	Percent	
National forest:		
West	97	100
South	93	100
North	77	89
Private land:		
West	66	71
South	63	65
North	79	73

Projections suggest that for private lands in the East (the North and South), area in sawtimber will increase from 64 percent in 2000 to 68 percent by 2050 (app. table 49), but this masks differences between species and subregions. The percentage of sawtimber increases in the North for both hardwood and softwood—62 to 73 percent, and 65 to 79 percent, respectively—but for the South, the percentage of sawtimber area decreases for hardwood from 74 to 65 percent, and increases for softwood from 56 to 63 percent.

Projections suggest that for the private lands in the West, area in sawtimber will increase from 63 to 66 percent between 2000 and 2050, including both hardwoods and softwoods (app. table 49). For national forest lands in the West, area in sawtimber will increase from 87 to 97 percent of timberland between 2000 and 2050, including both hardwoods and softwoods (app. table 50). For national forest lands in the East, area in sawtimber will increase from 79 to 93 percent of timberland between 2000 and 2050, including both hardwoods and softwoods (app. table 50).

Maintenance of productive capacity of forest ecosystems—Many human populations depend on forests directly or indirectly for a variety of extractive and nonextractive goods and services. Opportunities to provide goods and services sustainably are clearly linked to the productive capacity of forests. If the productive capacity of forests is exceeded, there is the risk of ecosystem decline. For forests to continue to function, it is necessary to maintain the presence of the forest itself, to understand the levels of goods and services now provided, and to determine levels that are likely to be sustainable.

Area of forest land and net area of forest land available for timber production—This indicator provides information fundamental to calculating the timber-producing capacity of existing forests. It shows how much land is available for timber production compared with the total forest area. The difference between total area and net area demonstrates that some forests are not going to be harvested for a variety of reasons.

Some 504 million acres, or 67 percent of total forest land area, is classed as timberland–forest area that is capable of producing 20 cubic feet per acre per year of industrial wood and that is not withdrawn from timber harvest by statute or administrative regulation (Smith et al. 2001). Timberland area has consistently amounted to about two-thirds of U.S. forest land area since the 1950s.

Timberland area is projected to decline 2.9 percent (or 14.8 million acres) from 504 to 489 million acres between 1997 and 2050. This is a somewhat larger decrease than over the past 50 years (5.1 million acres). About three-fifths of the projected decrease is in the North and one-fifth each in the South and Pacific Coast (table 5). Timberland will remain about two-thirds of total forest area.

Total growing stock of both merchantable and nonmerchantable tree species on forest land available for timber production—Growing stock is a fundamental element in determining the productive capacity of the area identified by the indicator, extent of forest area by forest type and by age class or successional class. Knowledge of growing stock and how it changes is central to considerations of a sustainable use of wood products by industry. In addition, knowledge of the growth rates of forests may assist with the interpretation of this indicator and of the forest ecosystem health criterion.

The volume of hardwood growing-stock inventory on timberland generally increased for the Nation as a whole and across ownerships from 1952 through 1997 (by 192 percent), with the exception of a decrease since 1986 in inventories on forest industry lands. This may be due to conversion from hardwood to softwood stands (tables 16 and 17).

The volume of softwood growing stock increased from 1952 through 1977, declined through 1991, then increased through 1997. Between 1952 and 1997, inventory increased continuously on national forest and other public lands (220 percent for each) (table 17).

Projections suggest hardwood growing-stock inventory will increase 23 percent between 1997 and 2050. Half of the increase will be on nonindustrial private land, 30 percent on national forest land, and 20 percent on other public land. Hardwood volume on forest industry land, overall, stays steady. Volumes increase continuously in the North and Pacific Coast, and decline in the South after 2020 (tables 16 and 17).

Projections suggest softwood growing-stock inventory will increase 56 percent between 1997 and 2050. Inventory increases on all regions and for all ownerships (fig. 80). About half of the increase is on national forest land, one-quarter on nonindustrial private land, 15 percent on other private land, and 8 percent on forest industry land (table 17).

Projections suggest average annual growing-stock growth rates per acre for softwoods on private lands will increase most in the South and West between 2000 and 2050; 67 to 94 cubic feet per acre and 63 to 71 cubic feet per acre, respectively. These rates are almost twice the static average growth rate for the North—about 37 cubic feet per acre (computed from the inventory and area data summarized in app. tables 30–33, 42, 44, and 49).

- Growth rates will be highest and increase substantially for forest industry plantations in the South and Pacific Northwest West, from 112 to 174 cubic feet per acre, and 167 to 201 cubic feet per acre, respectively.
- Growth rates for plantations on nonindustrial lands in the South and Pacific Northwest West also increase from 100 to 120 cubic feet per acre and 128 to 182 cubic feet per acre, respectively.

Plantations of softwood species will play an important role in future domestic harvest expansion. By 2050, 54 percent of total U.S. softwood growing-stock removals will come from plantations in private ownership. These plantations will occupy 30 percent of the U.S. private softwood timberland base, 13 percent of the total private timberland base (including softwoods and hardwoods), and 9 percent of the total U.S. timberland base (all owners and species) (table 19, app. tables 49 and 50).

Projections suggest average growth rates per acre for softwoods on national forest lands will decline in the North, South, and West between 2000 and 2050 as more timber reaches older age classes (app. tables 34 and 50).

- In the North, the growth rate declines from 36 to 24 cubic feet per acre.
- In the South, growth rate declines from 41 to 27 cubic feet per acre.
- In the West, growth rate declines from 46 to 41 cubic feet per acre.

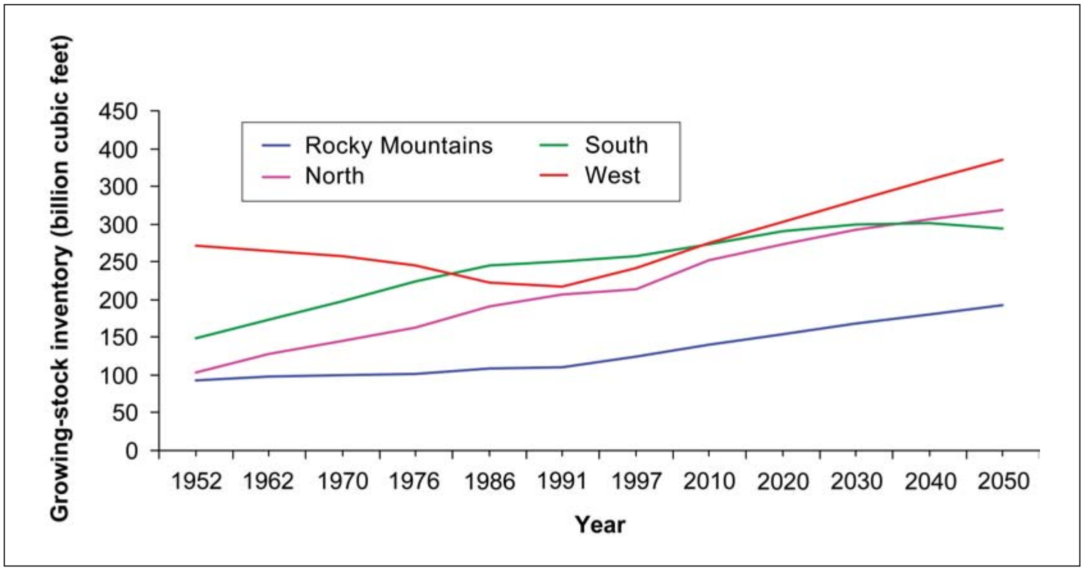

Figure 80—Total growing-stock inventory for the United States by region, with projections to 2050.

Projections suggest average growth rates per acre for hardwoods on private land will increase in the South from 42 to 59 cubic feet per acre, remain stable in the North at about 34 cubic feet per acre, and decline in the West from 87 to 78 cubic feet per acre (app. tables 43, 45, and 49).

The area and growing stock of plantations of native and exotic species—This indicator is a measure of the degree to which forest management agencies and organizations are establishing plantations in response to increasing demand for forest products. The provision of forest products from intensively managed plantations may impact biodiversity and demands for services from native, or natural, forests. The use of both native and exotic species in plantation management may enhance the potential range and quantity of goods and services available from the forest sector but, under certain circumstances, may produce unintended environmental effects.

The planted forest area in the East in 1997 was 40.1 million acres or about 10.4 percent of all forest land in the East. About three-fourths of the area is southern pines.

The planted forest area in the West is currently about 13.6 million acres. Planted trees are often used to supplement natural regeneration, and after about 5 years, it is difficult to differentiate planted from natural areas.

Projections suggest that the area in managed softwood plantations in both the East and West (a portion of all planted forest areas) will increase from 28 to 45 million acres between 1995 and 2050 and to 16 to 18 percent of all softwood timberland area by 2050 (tables 5, 19, app. table 49). In 2050, about 86 percent of private softwood plantation area is in the South.

For private land softwood plantations in the South, the annual growth rate in 2000 is twice the growth rate of nonplantation softwoods in the South–130 versus 60 cubic feet per acre. By 2050, the plantation growth rate is projected to be 2.5 times the nonplantation softwood forest rate.

For private land softwood plantations in the Pacific Northwest West, the annual growth rate in 2000 is 1.3 times the growth rate of nonplantation softwoods in the Pacific Northwest West—162 versus 120 cubic feet per acre. By 2050, the plantation growth rate is projected to be 1.7 times the nonplantation softwood forest rate.

Annual removals of wood products compared to the volume determined to be sustainable—This indicator is intended to compare actual harvest against the sustainable level of harvesting permitted by forest management plans as a measure of the forest's ability to maintain its productive capacity over time.

Given that forest management planning methods in the United States differ by individual owners, it is not possible to provide numbers on the sustainable level of harvest permitted by such plans for the United States as a whole. As a substitute, we look at growth-to-removal ratio for growing stock on timberland. A notion of sustainable production would at least require an overall ratio, and ratios for regions, of one or more in the long run.

Watching the size and change in this ratio has many shortcomings as a measure of sustainability. It does not indicate amount or change in biodiversity, size of trees, or forest types. Changes need to be evaluated over longer periods. Short-term increases may be due to changes in market conditions rather than changes in growth patterns. Short-term decreases may be due to shifts in forests to acceptable structures with lower inventory. There may be cycles in the ratio owing to nonuniformity of age distributions, with growth increasing in a certain area as a greater proportion of trees reach more productive age classes, or conversely, decreasing when a greater proportion of trees are in less productive age classes.

For the Nation as a whole, growth-to-removal ratio was higher in 1997 than in 1952 for both softwoods and hardwoods, with increases from 1.0 to 1.3 for softwoods and 1.5 to 1.7 for hardwoods. Projections suggest the ratios will decline by 2050 to 1.2 for both softwoods and hardwoods.

Projections indicate that, generally, the ratio will be lower in 2050 than in 1997 for softwood and hardwood groups in all regions. The ratio will still be 1.0 or above in 2050 for all regions and species except for 0.9 for hardwoods in the South. Within each region, the pattern of change in the ratio differs widely by ownership and species (table 24).

Projections indicate changes for private land softwoods in the South with the ratio increasing from 0.9 to 1.2 as plantations mature then declining to 0.9 as they shift to lower growth, younger age classes by 2050. The runup in the ratio is greater for nonindustrial lands than for forest industry lands. The ratio for public lands remains high but decreases as growth rate decreases on maturing timber.

Projections indicate continuing ratios about 1.0 for private land hardwoods overall in the South through 2030 but about 0.7 for forest industry land. By 2050, the overall ratio decreases to 0.8. The hardwood ratio for public land in the South remains high.

Projections indicate that ratios for the North will remain well above 1.0 for both hardwoods and softwoods and will be increasing for industry land and for softwoods on other public land.

Projections indicate that ratios for the West will remain well above 1.0 for both hardwoods and softwoods. The ratio is increasing for forest industry lands generally and for softwoods on other private land. The ratio is highest, although declining, for softwoods and hardwoods on national forest land, 4.6 and 16.0, respectively, in 2050.

Table 24—Projected growth-to-removal ratios for growing-stock timber in 2050 and direction of change since 1997

	Softwoods					Hardwoods				
Area	Forest industry	Non-industrial	National forest	Other public	All	Forest industry	Non-industrial	National forest	Other public	All
North	3.3+	1.6-	2.2-	3.6+	1.6-	1.8+	1.2-	2.5s	1.4s	1.5-
South	.9s	.8-	1.3s	1.3+	1.0+	.7s	.8-	2.7+	1.3+	.9-
West	1.1+	1.3-	4.6-	3.0+	1.9+	1.8-	1.9-	16.0-	2.1-	2.5-
United States	1.1+	.9-	3.8-	2.6+	1.2-	1.0-	1.0-	3.8-	1.9-	1.2-

Note: s = same level as 1997.
Source: Tables 16, 17, 34–37, 42–45.

Maintenance and enhancement of long-term socioeconomic benefits—

Value and volume of wood and wood products production, including value added through downstream processing—This indicator measures the size and economic health of the wood products sector by identifying trends in the value and volume of wood and wood products production and allowing comparison of those trends against management objectives.

Value and volume of wood and wood products are a coarse indicator of wood and wood products sector health and ability to maintain certain timber values for forest land that could aid in maintaining or enhancing forest conditions.

This assessment provides information on production volumes, which are part of this indicator—production of roundwood (U.S. timber harvest) and production of wood and paper products. We also provide information on the trend in value of production as indicated, in part, by the trend in prices for roundwood and for primary products. The contribution of roundwood harvest differs by region and size of timber harvested, and the contribution of wood and paper products production varies by region, type of product, and amount of product exported.

In general, U.S. production of roundwood (U.S. timber harvest) increased steadily between 1952 and 1997—by 34 and 87 percent, respectively, for softwood and hardwood. Projections indicate softwood harvest will decline in the near term through 2010 then increase through 2050 for an overall increase of 35 percent. Hardwood harvest will increase at a lower rate than during the last 50 years, by 49 percent through 2050 (table 16).

Softwood harvest remains concentrated in the West and South, about 86 percent of all harvest, but the share from the South increased from 1950 to 1997, and continues to 2050, 41, 61, and 65 percent, respectively.

Hardwood harvest remains concentrated in the North and South, with the West gaining a 6-percent share by 2050. In the North and South, shares are roughly stable between 1997 and 2050, with 44 and 50 percent, respectively in 2050.

The projected portion of U.S. roundwood harvest that is exported as logs or chips decreases from 6 to 3 percent between 1997 and 2050.

Production of wood and paper products will increase more than roundwood harvest, 30 percent versus 24 percent between 1997 and 2050, owing to increasing use of recovered paper, fillers, and adhesives in products. The component of production with the largest increase over the next 50 years is projected to be paper and paperboard (up 41 percent), followed by composite products (38 percent), and lumber and miscellaneous products (up 18 percent). Paper and paperboard production, however, is projected to decline temporarily in the next several years (fig. 43).

The value of wood harvested will be determined in part by its end uses. Virtually all of the projected increase in harvest is in nonsawtimber trees—trees used for oriented strand board (OSB) or paper and paperboard. The price for hardwood and softwood pulpwood (nonsawtimber) is projected to decline somewhat from the 1997 level in the South and remain similar to 1980s levels for up to three decades, then increases (table 15). This price trend is due to:

- A projected decrease in demand for paper and paperboard in the near term.
- An increase in imports of market pulp, paper, and paperboard.
- Limited growth in paper and paperboard exports.
- Continued increases in paper recycling.
- Continued availability of domestic nonsawtimber-sized trees.

The value of softwood sawtimber as indicated by stumpage price is projected to increase most in the South and West, about 70 percent through 2050. This is a somewhat greater increase overall than the last 50 years. Hardwood sawtimber stumpage price is projected to increase more slowly, 10 and 33 percent in the North and South, respectively, through 2050. This is a much slower increase than for the last 50 years (table 15).

Supply and consumption of wood and wood products, including consumption per capita—This indicator measures the demand and extent to which the supply of wood and wood products meets the needs for domestic consumption. A measure of consumption per capita might reflect a cultural affinity to wood products, the level of disposable income, the price or availability of wood products and their substitutes, or the efficacy of conservation, recycling, and reuse measures. High per capita consumption levels may also put pressures on forest resources.

In general, U.S. consumption of wood and paper products is projected to increase more slowly in the future, but it will still increase faster than U.S. timber harvest. Increases in paper and wood recycling and import of products will allow consumption to increase faster than harvest.

Consumption of wood and paper products is projected to increase from 223 to 310 million tons, or 39 percent, between 1998 and 2050. In comparison, the United States consumed 138 million tons of steel and 113 million tons of cement in 1998. This projected increase is less than half the annual rate of increase from 1965 to 1998.

United States roundwood harvest to meet domestic and export demands is projected to increase from 18.0 to 22.4 billion cubic feet, or 24 percent, over the next 50 years. This is less than one-third the annual rate of the past 44 years. Our current projections for roundwood harvest and roundwood for exports for 2040 are less than amounts we projected in 1993. Exports of wood and paper products stay near 2.2 billion cubic feet roundwood equivalent (see footnote 5) and shift from 12 to 10 percent of total harvest through 2050.

The portion of U.S. consumption met from U.S. harvest decreased from 89 to 80 percent between 1952 and 1997 and is projected to decrease to 73 percent in 2050 (table 12).[6]

Net imports of products to the United States as a portion of all industrial roundwood harvest outside the United States are projected to increase from 5 percent in 1996 to about 8 percent in 2050. As noted in chapter 3, the expected increase in imports of manufactured products to the United States is expected to come from managed forests and plantations in Europe, Latin America, and Asia (see footnote 5). Total exports from the United States are expected to be relatively stable.

Projected wood and paper products consumption per capita stays about the same, averaging 1,565 pounds per year between 1998 and 2050, up from 1,243 pounds per year in 1965 (fig. 46).

Projected U.S. roundwood harvest per capita decreases from 64 to 56 cubic feet per capita. This is down from 76 cubic feet per capita in 1952.

Roundwood harvest per capita has declined and is projected to continue to decline, while consumption per capita remains stable owing to increased imports, lower exports, and increased efficiency of roundwood use measured by product output per unit of roundwood input.

Increased roundwood use efficiency has been a key factor in decreasing roundwood consumption with an efficiency increase of 35 percent between 1950 and 1998. The increase has been due primarily to increased paper recycling and increased use of wood residue for products. Efficiency increases are projected to slow over the next 50 years with slower increases in recycling and use of residue for products. Further efficiency gains are possible, however, by decreasing wood and paper product used per unit of end use such as housing or packaging, or by increasing solid wood recycling.

Synthesis of Regional Trends and Projections for Selected Indicators

Projections suggest U.S. consumption of wood and paper products will continue to increase per capita while the share from U.S. production decreases. The U.S. roundwood harvest, although increasing, will decline somewhat per capita but will remain above the average level of other developed countries.

As in the past, U.S. imports and exports will influence wood and fiber use in the United States and in other countries. The portion of U.S. consumption met from U.S. harvest continues to decrease—from 89 to 80 percent between 1952 and 1997 to 73 percent in 2050.

Roundwood harvest increase in the United States will be in nonsawtimber trees whose value per cubic foot is projected to remain stable or decline somewhat for the next several decades but increase by 2050. Value per unit of softwood sawtimber is projected to increase somewhat faster than during the last 50 years and hardwood sawtimber somewhat slower than during the last 50 years.

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[6] Imports and exports are expressed in roundwood equivalents. For 1996 we have 100 × (18.0 - 2.2)/19.7 = 80 percent. For 2050 we have 100 × (22.4 - 2.3)/27.5 = 73 percent (data are from table 12).

The potential effects of harvest and the ability to sustain harvest on forest land as indicated by growth-to-removal ratios differ widely. The ratio is projected to remain above 1.0 through 2050 for most combinations of region, species, and ownerships. Two exceptions are for forest industry and nonindustrial private lands in the South. For private land softwoods, the ratio increases from 0.9 to 1.2 between 1997 and 2010 as plantations mature, then declines to 0.9 as harvest increases and plantation area shifts to lower growth, younger age classes by 2050. For private land hardwoods in the South overall, the ratio is above 1.0 through 2030 but decreases to 0.8 by 2050.

The capability to support high levels of harvest is focused on the same lands that are closest to a growth-to-removal ratio of 1.0–private lands, particularly plantations, in the South. Private lands in the Pacific Northwest also have high productivity. Growth rates will be highest and increase substantially for forest industry plantations in the South and Pacific Northwest West where growth will increase from 112 to 174 cubic feet per acre, and 167 to 201 cubic feet per acre, respectively. Growth rates for plantations on nonindustrial lands in the South and Pacific Northwest West will be from 100 to 120 cubic feet per acre and 128 to 182 cubic feet per acre, respectively.

Because of the high growth-to-removal ratio for softwood, inventory will increase most on national forest lands. Softwood growing-stock inventory will increase 56 percent between 1997 and 2050. Inventory increases in all regions and for all ownerships. About 60 percent of the increase is on national forest land, 14 percent on nonindustrial private land, 16 percent on other public land, and 10 percent on forest industry land.

The combined effects of growth and removals will influence shifts in proportion of acres in various forest types and seral stages. Forest types will remain relatively stable with the exception that forest cover types in the South will shift away from upland hardwoods and toward planted pine. Generally, projections suggest an increasing proportion of timberland area in older seral stages (sawtimber-size trees) with the exception that sawtimber area proportion is projected to decrease for private softwood timberland in the South. The highest proportion of acres in older seral stages will be on national forest land in all regions, followed by private land in the North.

Synthesis of National Trends and Projections for Selected Indicators

Aggregate trend data and projections for indicators for these criteria are shown in table 23 at the national level.

Trends in Diversity and Structure

The base projections were presented in chapter 3 as were the various implications for inventory volumes and growth. Although these measures have important impacts on timber markets, they are only some of the conditions for the broader considerations of sustainable forest management. This section examines the implications of the base projections for trends in diversity of forest types and structure. Both of these variables are cited as important components in broad-scale measures of ecosystem condition and change.[7]

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[7] See the National Research Council report (2000) for a discussion about broad-scale ecological measures and Haynes and Quigley (2001) for an example where broad-scale measures were used to examine the consequences of land management actions.

The discussion about sustainable forest management represents a broadening of the goals for forest management and raises questions about the compatibility of timber production with other goals such as biodiversity or ecological integrity. At the same time, advocates within the environmental community are articulating an agenda for effective conservation of private U.S. forests. Such an agenda includes efforts to reduce timberland loss, increase reforestation of former timberlands, reduce parcelization of larger forest properties, increase forest age, reassemble forest landscapes through joint stewardship opportunities, and expand access to the capital and resources needed for stewardship (Best and Wayburn 2001). Many of these concerns evolved with the increases in harvest levels since World War II that have led to the loss of older stands and their associated benefits for habitat, recreation, and spiritual values. These changes have yielded concerns that increases in forest management and harvest have simplified forest types and structures. Inventory structure in this usage refers to the relative abundance of different size classes of stands within a forest.

First, concern about the structure of the inventory reflects notions that there is value in maintaining a diverse range of different stages of forest development.[8] Popular literature often suggests we are seeing a progressive decrease in amount of older seral stages and an increase in the younger seral stages. The data for public and private lands are shown in appendix tables 49 and 50, and summarized in tables 25 and 26. They reveal a more complex story but one much like that revealed in figures 68 through 70. For much of the country, we are seeing an aging of the forests and an accumulation of acres in the older seral stages as production shifts to fewer acres. This is especially true in the both the West and the North. In the South, however, there is a shift from older hardwood stands to younger softwood stands because of forest management decisions. From another perspective, the data in table 14 imply that much of the change in seral stage probably occured before 1986 when the average diameter of harvested timber fell, especially in the West. From 1976 to 1986, the transition from natural to managed stands occurred in both the South and Pacific Northwest West, reducing the size of trees for final harvest. These trends are now expected (as shown in tables 25 and 26) to be relatively stable.

Another cited concern is the lack of diversity associated with managed forests. Most U.S. regions, however, are expected to maintain their current diversity of timber types over the next five decades (fig. 81). The highest diversity (number) of types is in the Pacific Northwest East (PNWE). Some of the lowest relative diversity is for softwood and hardwood types in the Pacific Northwest West, for softwood types in the Great Plains, and for hardwood types in the South. Changes are expected in current levels of diversity of forest types for hardwood types in the South Central and softwood types in the Great Plains and northern Rocky Mountains. In these regions, timberland area lost or type conversions result in less abundance of some timber types in the future relative to the mid-1990s.

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[8] Forest development is often described as a progression through a series of relatively transitory communities representing ecological succession from bare ground to climax stages. In contemporary usage, this development is often described in five stages: seedlings, poles and saplings, young, mature, and old mature (see glossary for definitions).

Table 25—Diversity indexes for private timberlands

	Region									
		North Central								
Year	Northeast	Lake States	Plains States	Southeast	South Central	Northern Rockies	Southern Rockies	Pacific Southwest	Pacific Northwest West[a]	Pacific Northwest East[a]
					Seral stage diversity					
2000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2010	.968	1.006	.990	.980	1.050	.928	.964	.996	.947	.973
2020	.980	.993	.987	.937	1.032	.876	.980	.939	.951	.963
2030	1.008	1.006	.994	.960	1.035	.871	.948	.955	.955	1.014
2040	.960	1.013	.997	.970	1.038	.902	.998	1.036	.981	1.069
2050	1.027	1.022	1.012	.950	1.022	.857	1.029	1.050	.988	1.065
					Type diversity					
2000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2010	.994	.992	.995	.993	.888	.978	.658	1.000	.980	.991
2020	.989	.987	1.002	.991	.820	.958	.650	1.000	.978	.986
2030	.981	.983	1.003	.988	.781	.940	.643	.999	.981	.983
2040	.974	.979	1.006	.984	.768	.918	.637	.999	.986	.989
2050	.970	.976	1.011	.983	.768	.901	.630	1.002	.988	.985
					Seral x type diversity					
2000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2010	.977	.996	.992	.994	1.029	.952	.990	1.008	.965	.990
2020	.981	.991	.995	.971	1.022	.914	.968	.964	.963	.979
2030	.988	.991	1.001	.977	1.032	.886	.934	.943	.950	.989
2040	.943	.999	1.006	.977	1.039	.899	.960	.990	.953	1.016
2050	.991	1.004	1.017	.975	1.036	.862	.969	.976	.965	1.001

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

Table 26—Diversity indexes for national forest timberlands

	Region									
		North Central								
Year	Northeast	Lake States	Plains States	Southeast	South Central	Northern Rockies	Southern Rockies	Pacific Southwest	Pacific Northwest West[a]	Pacific Northwest East[a]
					Seral stage diversity					
2000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2010	.836	.972	.976	.908	.934	.937	.908	.932	.910	.941
2020	.808	.950	.966	.767	.920	.895	.867	.934	.878	.926
2030	.786	.905	.886	.706	.961	.890	.863	.897	.825	.915
2040	.824	.888	.915	.662	.931	.827	.846	.756	.740	.870
2050	.761	.890	.928	.635	.878	.828	.821	.716	.711	.863
					Type diversity					
2000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2010	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2020	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2030	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2040	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2050	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
					Seral x type diversity					
2000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2010	.919	.984	.979	.946	.977	.969	.962	.977	.954	.972
2020	.904	.979	.969	.868	.962	.949	.947	.977	.937	.965
2030	.897	.961	.929	.825	.976	.945	.943	.969	.911	.960
2040	.926	.949	.941	.794	.938	.913	.938	.932	.871	.939
2050	.894	.951	.949	.791	.914	.915	.930	.915	.857	.936

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

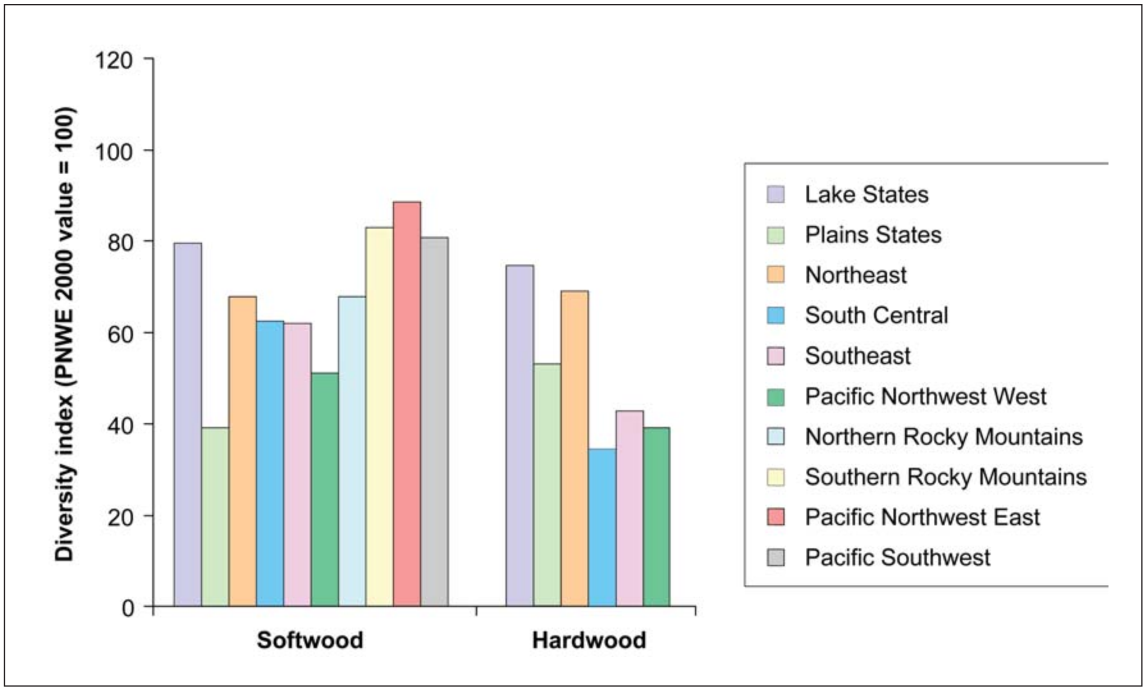

Figure 81—Diversity index for private lands by region and species for 2000.

Diversity of forest type and seral stage can be combined and represented as a single index. These results are shown in the bottom part of tables 25 and 26. In general, the results show remarkable stability in forest conditions for the next 50 years. In many ways this reflects the dynamic nature of forested ecosystems where regrowth, increasing productivity, and harvest all help balance ecosystem conditions.

Some of the biggest changes are expected to be on public timberlands. There, declines in the combined indexes reflect shifts in seral stages toward older stands and a diminishment in the proportion of stands in young seral stages. For example, in the West, currently 24 percent of the area is in late-seral conditions, but by 2050 this proportion rises to 53 percent with most of the change coming from a reduction of acres in the younger and midseral stages (see app. table 50 for details).

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

This broad-scale view of relative stability of ecological conditions takes a strategic view of what is happening but ignores the impact of these issues at the local or individual owner scale. These results, as well as the earlier results, point out that the

United States is well on its way to having large parts of the timberland base managed either in some type of reserve status or in a custodial fashion while remaining exploitable forests are managed more intensively. Where this issue is being discussed in other major softwood producing areas (see Verkaik and Nabuurs 2000), policy decisions about the management of public lands (for greater emphasis on habitat conservation strategies) and the collective decisions of private timberland owners have already placed the United States on this policy trajectory.

Can Southern Timberlands Provide the Bulk of U.S. Softwood Timber Harvest?

Table 16 suggests that the largest part of projected increases in domestic softwood removals will come from private timberlands in the South. Figure 48 in chapter 3, shows that both the consumption and harvest of softwood timber are projected to rise steeply in the last 30 years of the projection. Hardwood consumption also rises, but at a slower rate (fig. 49). Figures 51 and 60 show the importance of the South in supplying both softwood and hardwood fiber.

The harvest increase in the South is particularly dramatic, increasing by more than 40 percent for softwoods and 20 percent for hardwoods, and is attributed to a combination of available inventories and market forces. As discussed in chapters 2 and 3, investment by private landowners increases available softwood inventories by pushing up the rate of growth and hence the yield volume per unit of area harvested. In the face of expanding inventory and limited growth in stumpage prices, wood processing capacity follows inventory and expands to use the available resource.

In the context of privately owned timberland, the South is the largest timber production region in terms of both area and volume. With 37 million acres of industrial timberland, the South has almost four times the area devoted to timber production as does the Pacific Northwest West, and more than twice that of the North. The South supports a broad nonindustrial base, again the largest, with significant area managed for timber under miscellaneous corporate ownership and a significant number of acres leased to industry.

When comparing regions as measured by the percentage of inventory removed annually, the South supports the highest harvesting intensity. Figure 82 shows that the South is initially 1 percentage point above the Pacific Coast[9] (about a 25-percent difference), and while the other regions decline or remain relatively stable, this ratio for the South trends upward. This level of harvest is supported by a relatively high growth-to-inventory percentage as shown in figure 83. So although harvest is high relative to other regions, growth is replacing stands at a comparable rate. Where the growth rate exceeds the removals rate, inventories will build; when removals exceed growth, inventories fall. The projected growth rate in the South rises initially and remains fairly constant (at 5.1 percent), but after 2010 the removals rate begins to rise and exceed the growth rate near 2035.

If we put these ratios together and compare growth to removals (fig. 84), we can quickly determine the net effect on inventories. Initially, the Pacific Coast and South have the lowest ratios, just less than 1.0, meaning removals are slightly exceeding growth resulting in an inventory drop. In the South, as harvest falls in response to less available inventory, a wave of growth occurs on young stands, and the ratio rises above 1.0 as inventories begin to build. As they mature, harvest rises to use the newly

[9] For figures 82, 83, and 84 the Pacific Coast = Pacific Southwest and Pacific Northwest West; elsewhere Pacific Coast = Pacific Northwest and Pacific Southwest.

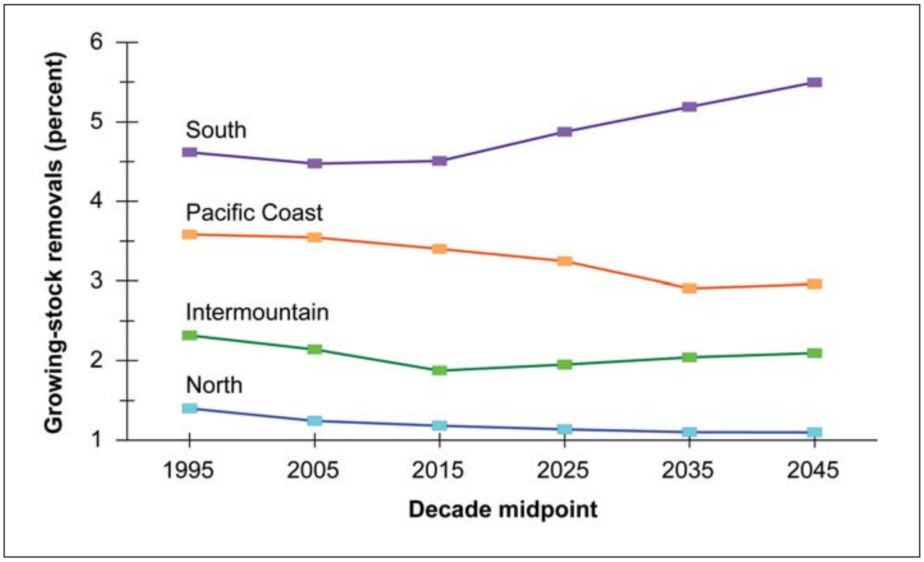

Figure 82—Annual removals as a percentage of growing-stock inventory on private timberland, by region and decade. Pacific Coast includes Pacific Southwest and Pacific Northwest West; Intermountain includes Pacific Northwest East and Rocky Mountains.

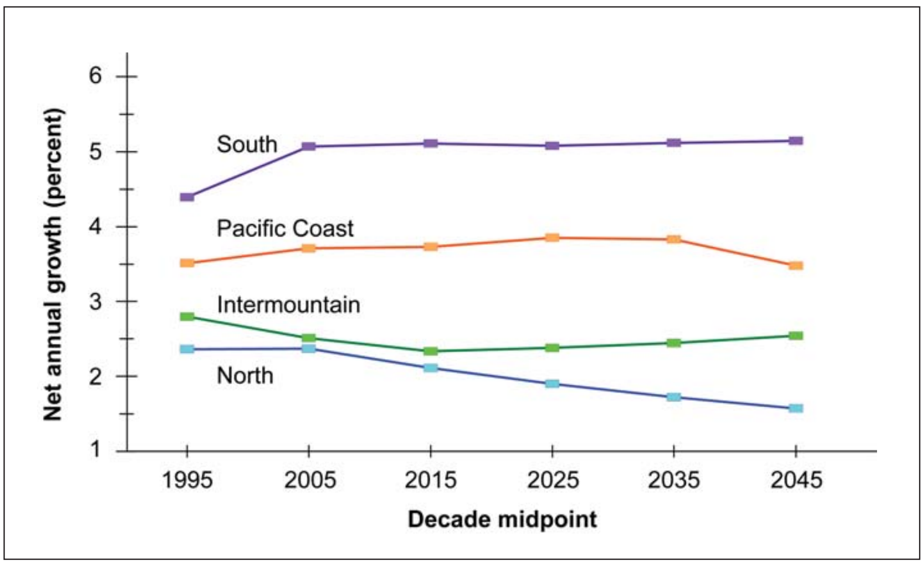

Figure 83—Net annual growth as a percentage of growing-stock inventory on private timberland, by region and decade. Pacific Coast includes Pacific Southwest and Pacific Northwest West; Intermountain includes Pacific Northwest East and Rocky Mountains.

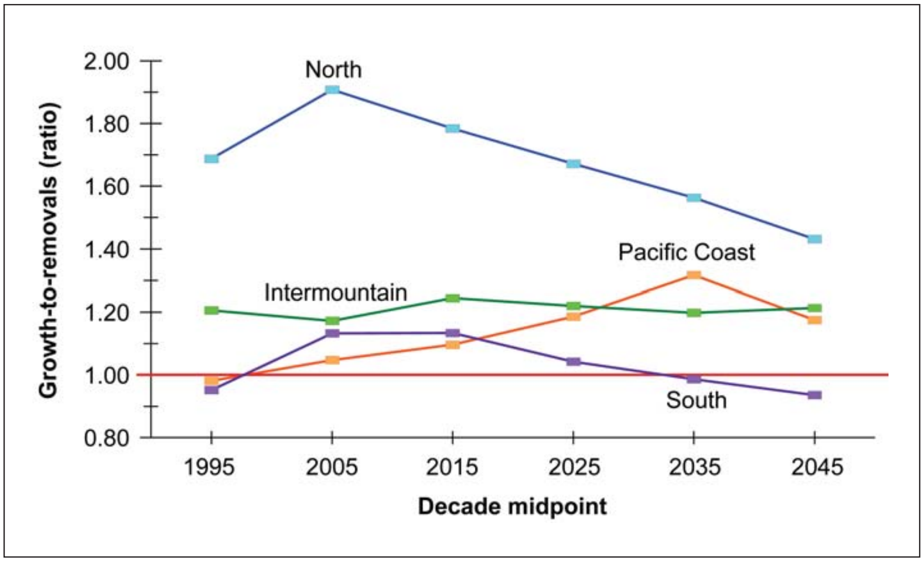

Figure 84—The projected ratio of growing-stock growth to removals on private timberland, by region and decade. Pacific Coast includes Pacific Southwest and Pacific Northwest West; Intermountain includes Pacific Northwest East and Rocky Mountains.

available inventories, eventually increasing faster than the increase in growth, and by 2035, the ratio approaches and drops below 1.0 signaling a downward trend in the inventory cycle. Total inventory is still up 11 percent from start of the projection in 1995. As figures 66 and 67 have shown, softwoods and hardwoods have different trajectories; by 2035, a 40-percent gain in softwood volume overshadows an 8-percent decline in hardwood inventories. The longer term outlook in other regions is for growth to exceed removals, perhaps indicating long-term balance between removals and inventories, or possibly a consistent underutilization of the available resource.

Hidden in the Southern softwood projections is the continuation of a cycle of growing and maturing inventories followed by periods of increased harvests and stable-to-declining inventories resulting from shifts in the age-class structures on private land (see figs. 55, 56, 66, and 69). After each period of increased harvest is a bulge of the area in young age classes. The subsequent generation of pine is managed with higher efficiency in terms of improved planting stock and effective practices that increase yields and retain a greater proportion of planted pine acres. As these inventories mature, removals can increase.

The hardwood situation is different; inventories do not appear to be following the same cycle as for softwoods. The growth-to-removals ratio by fiber type (fig. 85) shows hardwood removals exceeding growth early in the projection. As the projection proceeds, hardwood removals remain relatively high, increasing 20 percent by 2050 while inventories drop. As investment dollars are focused on softwoods, there is a 13-percent loss of area supporting hardwoods, much of it regenerated with higher valued stands of pine—lowering the potential for available hardwood fiber. Figure 67 shows that, over time, a greater share of hardwood area becomes unavailable for timber production. As figure 60 indicates, however, hardwood removals are expanding in the North, and as the high growth-to-removals ratio implies, they could potentially expand further. With a fall in volume, prices rise and nonindustrial private forest harvests increase as higher prices promote additional volume to become “available.” This would

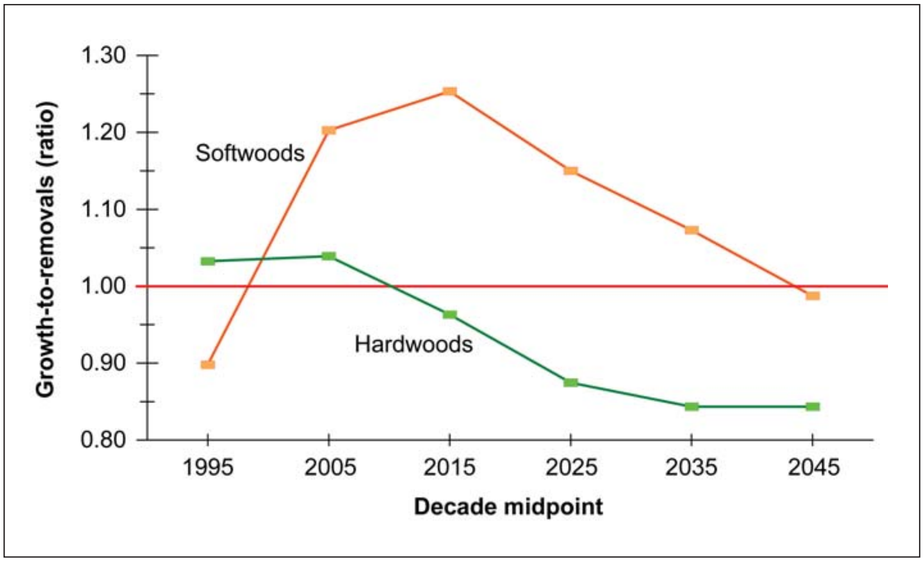

Figure 85—The projected ratio of growing-stock growth to removals on private timberland in the South, by fiber type and decade.

be a short-term source of supply, however, because after 2050 there would be a reduction of capacity, with consumption shifting to additional hardwood volume in the form of both short-rotation production on agricultural land and imports.

A key assumption underlying the softwood projections was that after 2015, private timberland owners would reduce the rate that area was enrolled into more intensive management as they perceived the implications of essentially constant stumpage prices (shown in table 15). This assumption recognizes that perceptions of future returns to forest investments do change landowner propensities for investments; if investment rates had been held to their initial values, the additional inventory volume would have resulted in declining real stumpage. When the projection begins in 1995, owners face increasing prices and reductions in harvest over the first decade. Investment levels are high, but after investments made in the 1990s pay off in higher yields and bigger inventories, prices level off, reducing the incentive to enroll additional acres under the highest, most expensive, management regimes. As discussed in chapter 2 (see figs. 9 to 11), the greatest increase in the upper levels of investment will have occurred by 2025. Inventories will have risen while prices remain level, and many acres then will remain under medium and low investment levels until 2035 when a tightening in supplies boosts investment in strategies to further increase growth and yield.

Still, the South becomes the dominant source of softwood fiber and home to most of the forest products industry. This industry depends on a highly productive resource base that in itself depends on high levels of investment. Much of this management is designed to produce sawtimber and wood fiber on relatively short rotations that lead to frequent harvest activity and relative parity between growth and harvest. The cycle will likely continue as harvests adjust to changes in available inventory and investment boosts future fiber output in hopes of raising sustainable production, perhaps buffering what we see as the downward part of the cycle.

Western Forest Health and Small-Log Markets

The forests of the interior West face unique forest health and fire hazard issues that have been compounded by federal, state, and local efforts to suppress or limit forest fires since the early 1900s. These efforts have, ironically, added to the natural accumulation of forest fuels, particularly smaller diameter trees or brush that might otherwise have been cleared by periodic wildfires. This set of conditions significantly departs from the historical or "natural" conditions, especially on public lands (Hann et al. 1997). Recently, public attention has focused on strategies to reduce the risks of wildfire while at the same time restoring forest conditions in the interior West. Key in these strategies is the consideration of thinning forest stands on public lands to remove excessive accumulation of smaller diameter timber. In this discussion, small-diameter timber or logs are from stands whose average diameter is roughly 8 inches in an area where sawtimber is conventionally thought of as starting at 11 inches in diameter.

The timber assessment provides information about the likelihood that there will be markets for the types of material resulting from thinning operations undertaken to support restoration strategies. There are three aspects to consider: production capacity sufficient to process large volumes of thinning material; the scale of the forest health problem; and whether this small timber can be sold by using existing timber sale mechanisms.

Production Capacity

The interior West can be characterized by the predominance of the softwood lumber industry. In 2000, the softwood lumber industry consumed 830 million cubic feet of logs to produce nearly 5.8 billion board feet of lumber and 485 million cubic feet of residues. Various other types of processing, including the pulp and paper industry, use about 1 billion cubic feet of roundwood and residues. Product technologies that use pulpwood have the greatest potential for profit and use the largest volumes of small-diameter timber. In the West, there are also many smaller enterprises that use some small-diameter timber, such as small-log sawmills, log cabin manufacturers, and wooden pole and post producers, along with various other types of smaller scale wood-based enterprises. The volume of small-diameter timber that is projected to be used by such enterprises is, however, relatively small.

Pulpwood consumption in the interior West has fallen since the mid-1980s as processing capacity has adjusted to higher cost federal timber associated with declining public harvests. There have been notable declines in regional production capacity for products such as wood pulp and OSB owing to declining relative profitability. Expanding these types of production capacity requires large capital investments, and exposure to uncertain pulpwood supply is undoubtedly a risk factor that inhibits new mill investments. Lack of investment will have profound implications for opportunities to commercially thin large volumes of small-diameter timber to restore the health of forest ecosystems in the region.

The base projections show the Western United States will continue to recede in relative importance in terms of pulpwood supply and demand. Projections show modest increase in regional OSB capacity in the West and continued pulpwood exports, but total regional pulpwood supply and demand is projected to remain at approximately 1 billion cubic feet, about half of that in the form of residues from softwood lumber production.

Scale of the Forest Health Problem

Little recognition has been given to the magnitude of the market impact and market challenge presented by the option of thinning large volumes of timber on public lands (see figs. 86A and 86B for an estimate of the increase in federal inventories for the Rocky Mountain region). There is no assurance that there will be a future match between volumes of small logs that can be produced by thinning operations on public lands and the actual market demand or production capacity to use such timber. A reasonable estimate of the volume of small-diameter timber that could be removed through thinning operations on public lands in the West can be calculated assuming a small fraction of this timber is thinned annually. There are no firm estimates of timber that ultimately may be removed by thinning operations on public lands in the West, but a figure of 1 billion cubic feet per year (1,000 cubic feet per acre times 1 million acres per year) is a reasonable estimate and is a small fraction of the timber volume that needs to be thinned in the West. One billion cubic feet of wood is roughly equivalent to the current total consumption of all 28 wood pulp mills in the Western United States (including both roundwood and residues). Thinning and removal for market of an additional 1 billion cubic feet of pulpwood per year would require an additional 30 to 35 pulp mills. In terms of OSB mills, 1 billion cubic feet of pulpwood per year is a sufficient volume of wood supply for about 50 modern OSB plants. In both cases, the number of these mills has been declining since the early 1990s, and no increase is projected.

Some sawmills in the region already are focused on utilization of small logs. Data from the Western Wood Products Association (see WWPA 1999) indicate that the number of sawmills in the Western United States has declined precipitously over the past decade from over 500 sawmills in 1990 to only around 300 by 1999, with the greatest loss coming in small sawmills (those with less than 20 million board feet of production capacity). One billion cubic feet of small-log material would be sufficient to provide annual raw material input for at least 250 small sawmills (assuming an average lumber production capacity of 20 million board feet per year). In addition, any increase in lumber production also increases residue production offering further utilization challenges.

A key question is how to improve the investment environment. Considerations include a predictable supply of relatively consistent material and working with the industry and communities to develop processing capabilities for the available materials that can be marketed in a competitive environment.

Can Small-Timber Sales Be Sold?

The third aspect of thinning Western forests is how to design and offer federal timber sales with a high likelihood of being sold. Looking at fiber and saw log prices for northeastern Oregon, we estimate that in 1997 (a year with relatively low fiber-log prices), sales needed to have 68 percent sawtimber (that is, logs over 11 inches) to be break-even sales (see Haynes 1999). The sawtimber also needs to be green, as wood recovery from dead timber is generally poor (Lowell et al. 1992). In general, sawtimber and chip markets do not necessarily move in parallel. Typically, chip prices have gone up in the West when lumber, sawtimber, and residue production declined, or when export markets have increased. However, Western chip prices have generally declined in the 1990s in association with declining wood pulp and OSB capacity in the West. It would seem likely that any substantial expansion of the supply of chip logs or pulpwood from thinning on public lands would further depress markets for chips and small logs in the West, making it even less economical to sell small-diameter timber.

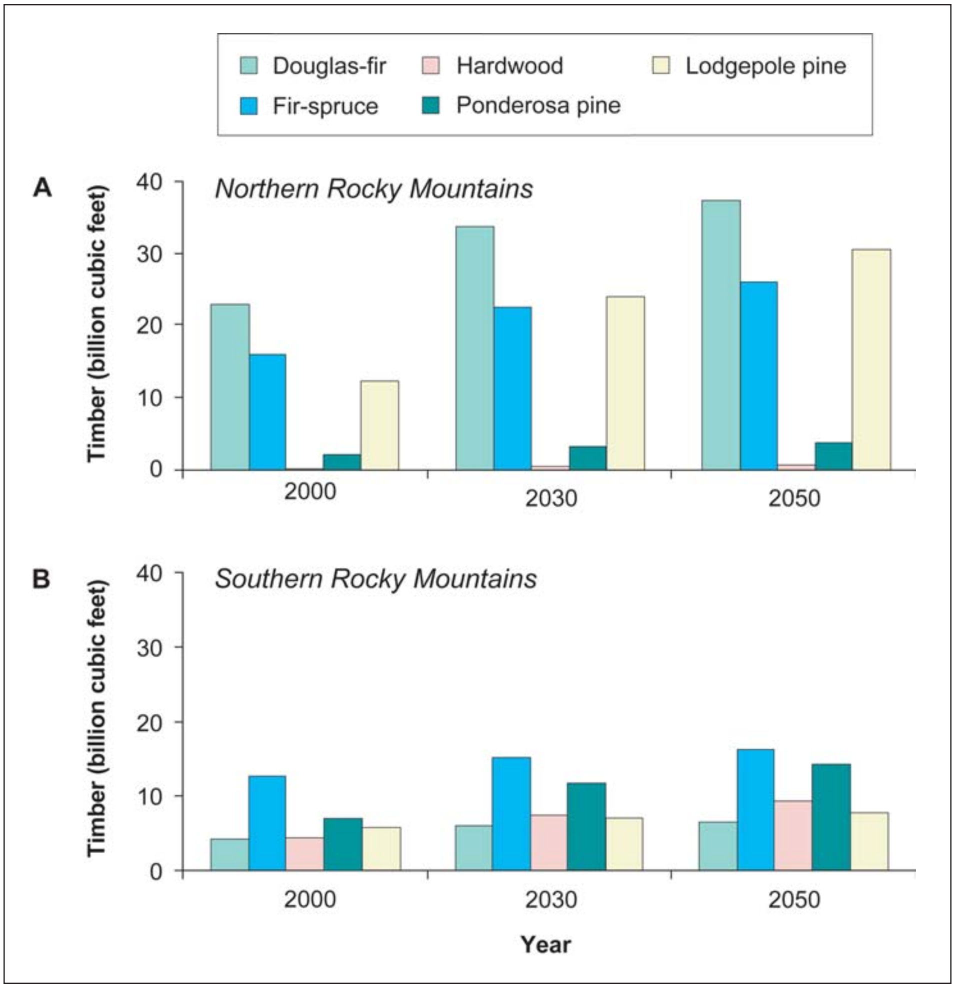

Figure 86—Projected National Forest System timber volumes in Northern Rocky Mountains and Southern Rocky Mountains by type, for the years 2000, 2030, 2050.

Complex International Links

Countries are linked through trade in commodities and services, through cross-border investment, and through a variety of formal international agreements and intergovernmental processes. In the last decade of the 20th century, the extent and the complexity of these international links increased, as did their interactions with broad-scale trends such as technological, political, and environmental change (fig. 87). As a consequence, the management and policy implications of the outlook for domestic resources are broadly set in an international context.

The commodity trade dimension of this interdependence and its importance to the U.S. forest sector have been recognized for some time. Forest products trade, along with the implications of resource conditions and demand and supply trends in other countries have been addressed in each of the previous RPA timber assessments. The projections in this timber assessment describe a future in which U.S. forest sector and forest products markets remain closely linked to the rest of the world through commodity trade. Although this projection is similar to previous RPA timber assessments, in many respects, the level of import dependence and trend differ from previous assessments.

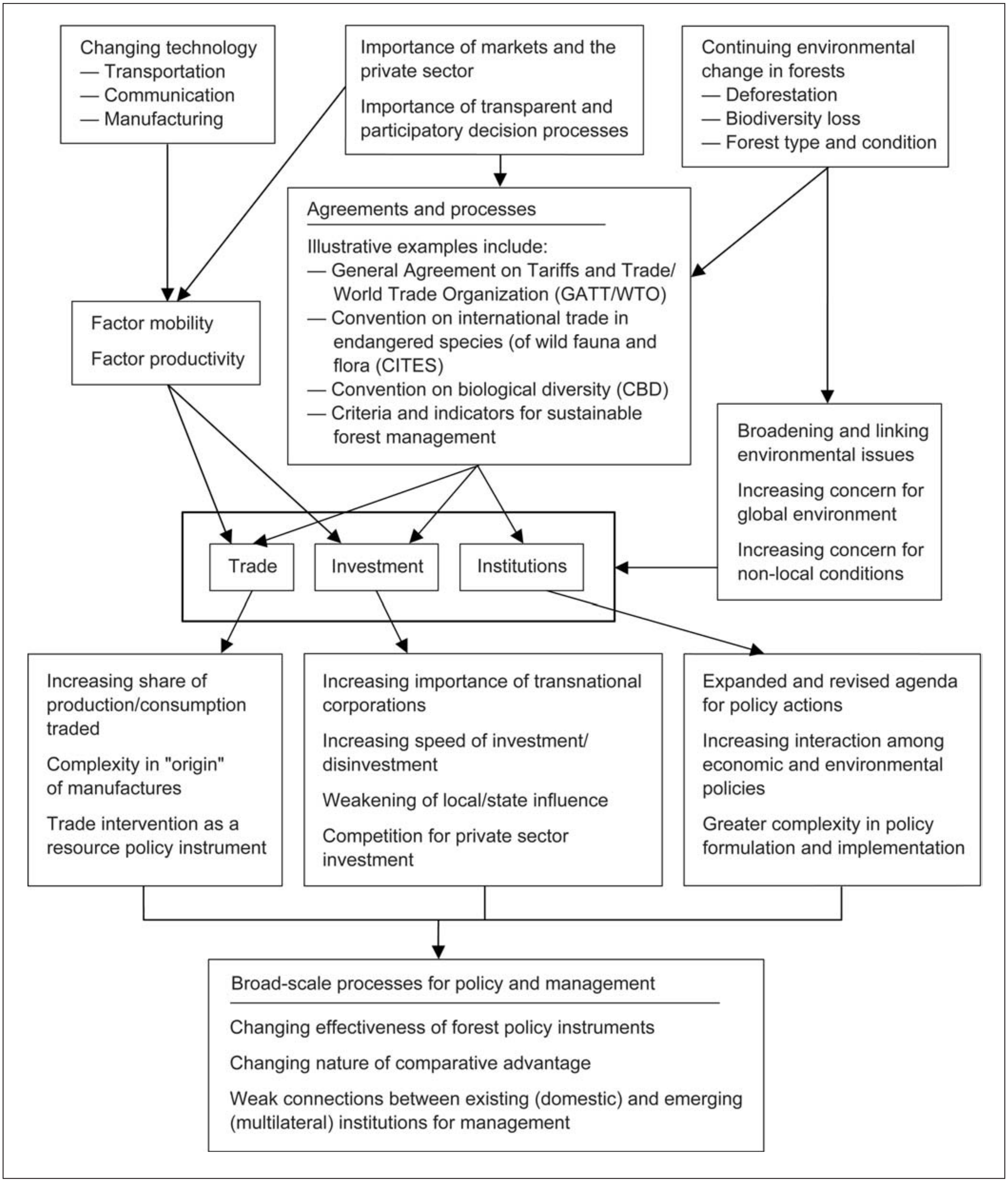

Figure 87—Global issues affecting the forest sector.

Sustained economic growth in the 1990s contributed to increasing U.S. dependence on forest products imports. We expect this trend to continue in the short term (10 to 15 years) as U.S. demand continues to grow, and opportunities for expanded domestic production are limited. Over the longer term (beyond 2015), U.S. dependence on imports is projected to decrease as domestic production expands. Throughout the projection period, international markets are expected to continue to be important to U.S. producers, although in the aggregate, the share of U.S. production exported is expected to remain below the level reached in the early 1990s (more than 15 percent). In some of the alternative futures, the magnitude and composition of U.S. forest products trade change, but all of the alternatives describe a future in which trade plays an important role.

One immediate implication of this outlook is that trade policies and trade-related agreements will affect the U.S. forest sector. Given the importance of trade[10] and interaction with domestic markets, trade agreements (especially those targeting forest products) may have broad consequences for domestic resources that extend beyond trade flows. For example, domestic prices and trade agreements may influence patterns of resource production and management. The nature and the magnitude of trade and effects of trade policy on domestic resources are likely to vary. Unanticipated and unintended interactions with "traditional" resource policies and management objectives may be among the most significant consequences of the increasing role of trade in the U.S. forest sector.

Prospective extensions of recent multilateral trade agreements (such as the Uruguay Round of the General Agreement on Tariffs and Trade) appear likely to have only a small effect on the overall level of U.S. timber harvest and trade (Brooks et al. 2001). However, historical and prospective future tariff reductions do affect patterns of trade (trading partners) and the structure of trade (generally encouraging increasing trade in manufactures as compared to trade in raw material). Therefore, these projections imply that consideration of the possible effects of trade policies must be an explicit component of forest sector policies. Nontariff trade policies (such as phytosanitary agreements and standards) may be considerably more important than tariff rates in terms of their long-term consequences for domestic resources.

As compared to further tariff reductions, a development with greater implications for resource management and policy is the explicit consideration of environmental consequences in trade agreements. Although "environmental review" of trade agreements is a relatively new development,[11] recognition of the links between trade and environment, and the possible use of trade policies as an instrument of environmental policy are not new (see Tomberlin et al. 1998 for a review). For the U.S. forest sector, the current Softwood Lumber Agreement (SLA) with Canada provides a clear example of a trade policy that interacts with domestic forest policies. The SLA is the most recent response to a long-standing debate that reflects the interdependence of lumber producers and consumers within North America. The current debate has added forest policy, forest management, and environmental considerations to a dispute that once was more narrowly focused on a comparison of timber prices and production costs.

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[10] In the late 1990s, imports accounted for more than 25 percent of U.S. consumption of forest products (roundwood equivalent).

[11] Executive Order 13141 ("Environmental Review of Trade Agreements") was signed in November 1999 (see 63 Fed. Reg. 63169 November 18, 1999).

Commodity trade is now only one among a number of ways in which producers, consumers, resource managers, and policymakers must consider the international context of their decisions. Integration of national economies—and therefore natural resource conditions—also takes place through foreign investment and through firms that operate in multiple countries (multinational corporations). Foreign direct investment abroad by U.S. forest industries averaged more than $10 billion per year throughout the 1990s (see http://www/bea.doc.gov). During the same period, there was evidence of increasing foreign investment in forests and timber-based manufacturing facilities in the United States. Although it is widely argued that domestic and international economic growth depends on a willingness to accept continuing international economic integration, it is also increasingly acknowledged that effective domestic policies and institutions are needed to ensure that unintended consequences (notably environmental and social) can be anticipated and mitigated.

Among the implications—and challenges—for forest policies and management are the possible weakening of local influence over manufacturing and management decisions, increases in the speed and magnitude of change (for example, in capital flows), and shifts in patterns of comparative advantage brought about by reductions in barriers to investment. The effect of economic integration on environmental standards and performance is a subject of continuing debate. Nevertheless, forest policy goals, processes, and tools that were effective in an era of locally owned firms are unlikely to be equally effective addressing more complex and more remote patterns of ownership and management.

In addition to international economic integration, there has been a broadening of management and policy issues, and a linking of policy processes across national boundaries. Both developments have been motivated, in part, by increasing concern for the global environment and the role of forests in sustaining environmental services (such as carbon sequestration and maintaining biodiversity). In the 1990s, a number of multilateral environmental agreements (MEAs) were signed that address forest-related issues and have implications for domestic policies and management.[12] Often the scope and magnitude of implications for domestic management are not based on the breadth of the issue addressed or the degree of formality of the agreement. An example of this is the extent to which the use of criteria and indicators (and, specifically the Montreal Process criteria and indicators) has become inextricably linked to sustainable management, even at lower spatial scales never intended by the original, informal, intergovernmental process.

The interdependence of the U.S. forest sector with other countries—through trade, investment, and international agreements and policy processes—is likely to expand and become increasingly complex. However, few of the domestic institutions and processes that have historically provided effective management of U.S. natural resources have fully taken into account these new circumstances. Therefore, among the emerging challenges is the need to modify forest policy and management goals, processes, and methods to reflect greater and more complex international interaction.

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[12] See Wisdom, Harold; Brooks, David. 2000. International agreements and forest management. Manuscript on file with: Human and Natural Resources Interactions Program, Forestry Sciences Laboratory, P.O. Box 3890, Portland, OR 97208.

Disaggregating the Projections

The projections of forest inventories start with measurements obtained from a set of permanent ground plots established on timberland in each state. Each plot, and associated data describing the forest, is identified by its specific ground location. In the process of developing resource projections, the data are aggregated upward from hundreds of thousands of tree records, to thousands of plots, to the level we have traditionally found useful in assessments, that being nine multistate regions. However, given the evolution toward faster computers, the availability of geographic information system tools, and the popularity of colorful visual displays, we think it is relevant to display the projections visually—showing them in a geographic context. We developed a model that allows us to aggregate the plot data up to any scale while disaggregating the regional solution downward to smaller scales. The projections presented in this section were made with a version of aggregate timberland assessment system (ATLAS)[13] configured to project and track county-level inventories, and to do so consistent with the regional modeling framework.

This process did require the disaggregation of regional data accounting for timber removals and land area change. Algorithms were developed to allocate regional components of change to county inventories by using the same rules applied in the regional projections. A key assumption in this process has to do with the apportioning of removals from the TAMM/NAPAP/ATLAS (timber assessment market model/North American pulp and paper model) solution among counties. In this case, the share of removals volume allocated to a particular county depended, in accordance with the allocation parameters, on the proportional share of available volume within the county. Area loss and gain also originally were derived at the regional level and allocated among counties with rules compatible with those in the aggregate model. These projections may not be accurate for a particular county. When added together, however, the resulting county-level growth, removals, and inventory matched the results projected with the region-level model.

What these projections show is a way of looking “inside the box” to see the consequences of the various assumptions when they are linked back to the landscape. The county-level model shows where the wood was assumed to come from, where the projected investment in plantations occurs, and where growth and removals are in or out of balance. These assumptions are implicit in the regional solution; now we have a way to view the result at the county level.

A set of county-level maps are shown in figures 88 through 92. Figures 88 and 89 show the current distribution of timber inventories on private and on national forest[14] timberlands. These maps illustrate the spatial extent of forests in the United States and some of the differences and similarities between public and private timberlands. The volume classes represent a relative weight assigned to each county that is based on the average of all timberland in the county, irrespective of county size. The highest averages are concentrated in the Eastern and Pacific States.

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[13] This modified version of ATLAS (known as ATLAS-T) developed by using SAS (Version 6.12, SAS Institute) is compatible with the main version but has the added flexibility of aggregating inventory at multiple scales.

[14] As a caution, the display of national forest timberlands is incomplete for the states of Arizona, California, Colorado, Idaho, Nevada, New Mexico, South Dakota, and Wyoming. Missing data are attributed to inventory plots that were not coded with county identifier.

Figure 90 shows the projected average removals on private timberlands over the next five decades. Counties along the coast in the South and Pacific Northwest account for most of the timber harvested. In these regions, industrial owners were assumed to be investing in management practices aimed at increasing wood production efficiency. The counties with higher levels of removals have attributes favorable for wood production (better site productivity, favorable mix of available stands, concentration of timber-oriented ownerships). Finally, figures 91 and 92 show the growing-stock change on private and national forest timberlands. In most cases, inventory accumulates on the national forests where net growth exceeds removals, whereas private timberland inventory accumulates in areas where harvesting is relatively light (for example, the Northeast and North-Central States). In the major timber-producing areas, such as the coastal counties in the South and Pacific Northwest, the pattern is more mixed with higher removal levels offsetting some of the inventory accumulation. Figures 91 and 92 show that the South dominates fiber production but that the distribution of harvest differs across the region with the heaviest removals in the coastal plain and the areas along the Alabama-Mississippi and Louisiana-Arkansas-Texas borders. These areas are likely to support softwood plantations. The yellow and purple counties in Kentucky and Tennessee represent the projected removal of hardwood volume and a reduction of the hardwood inventory. Harvests in the North, which produces proportionally more nonsawtimber, are spread more evenly across the region.

Do these maps reveal any particular problems that could be alleviated with early actions? Perhaps the most prominent concern revealed in these figures is on figure 91, which shows a drop in the hardwood resource of Kentucky, Tennessee, and a little along the Mississippi River. But as we know from tables 16 and 17, the decline in hardwoods is more than offset by an increase in softwood volume, making the net inventory change in this region positive. These figures show where the resources are and that within regions, inventory change is uneven.

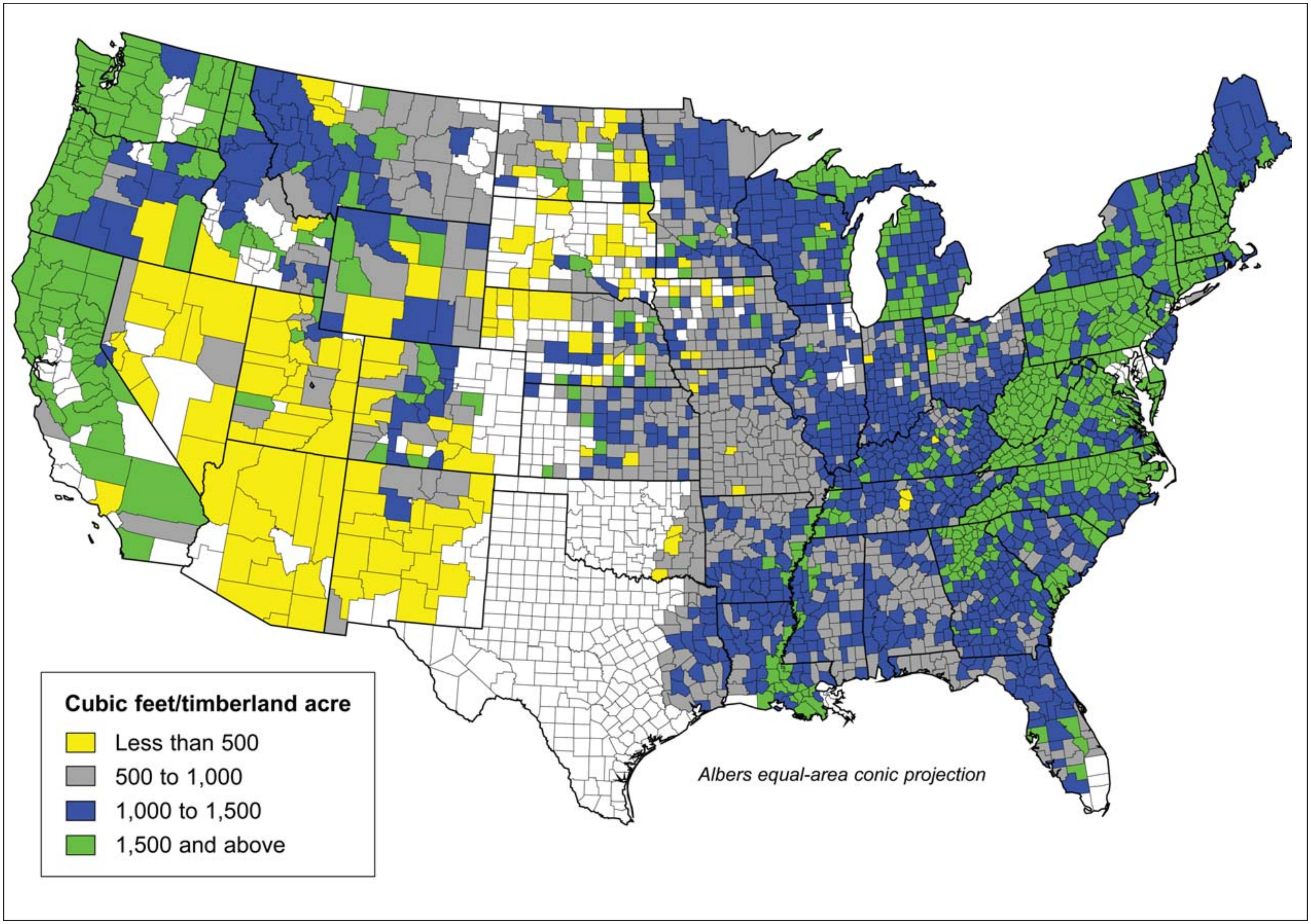

Figure 88—Distribution of timberland inventory on private land in 2000 showing average volumes by county.

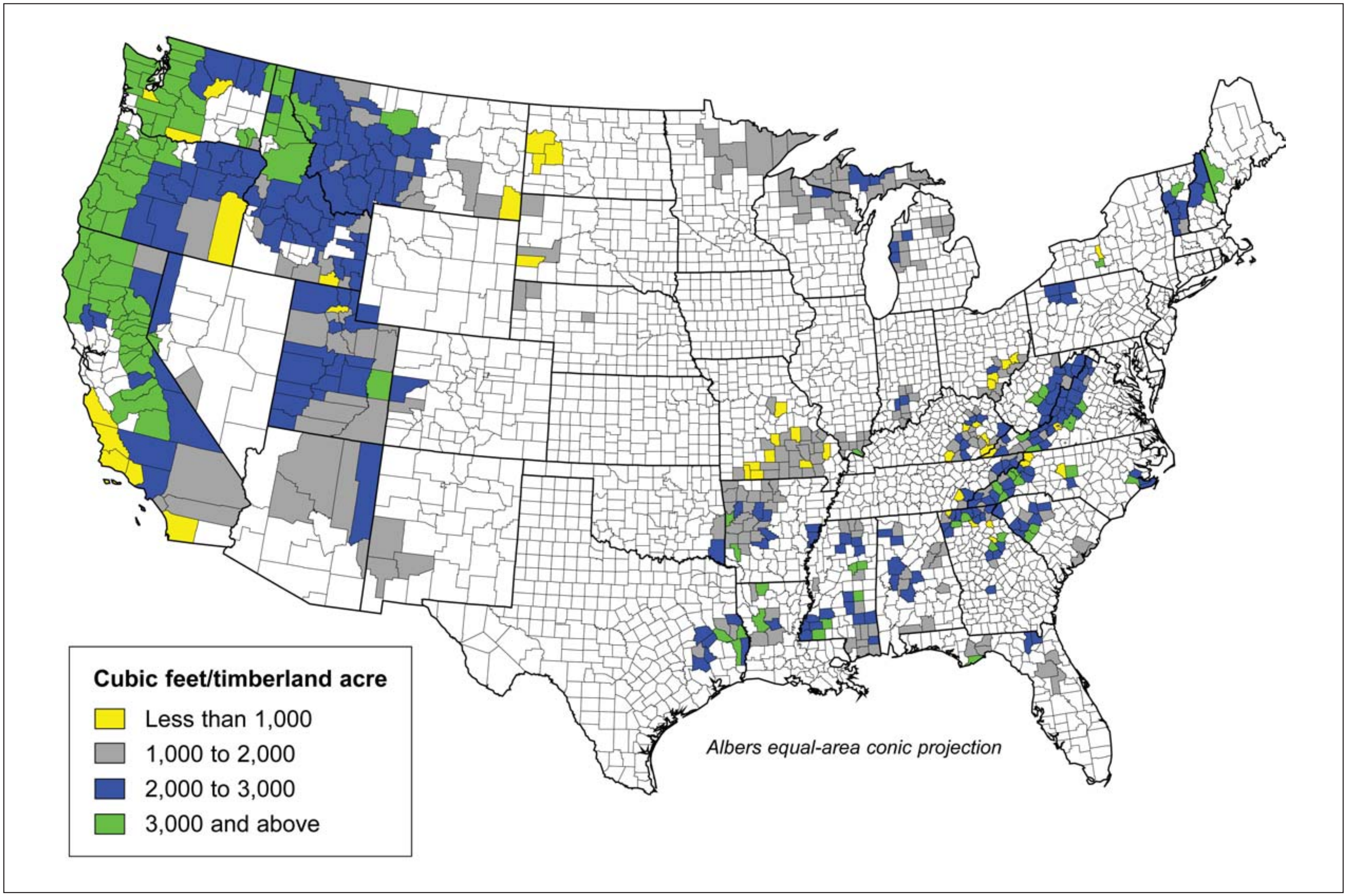

Figure 89—Distribution of timberland inventory on national forest lands in 2000 showing average volumes by county. Arizona, California, Colorado, Idaho, Nevada, New Mexico, South Dakota, and Wyoming are missing county codes for some of the data.

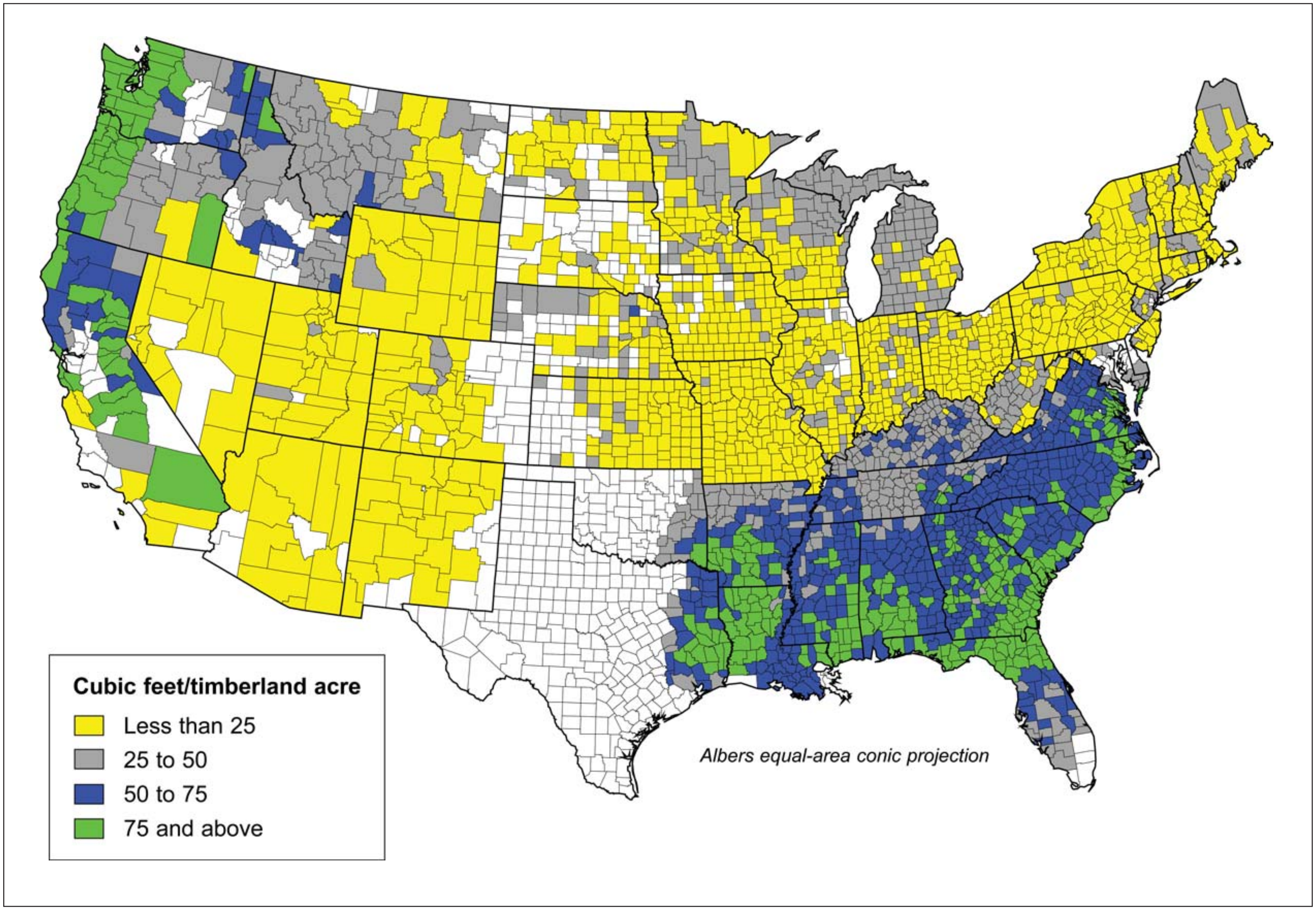

Figure 90—Average annual volume removals from private timberland, 2000 to 2050, by county.

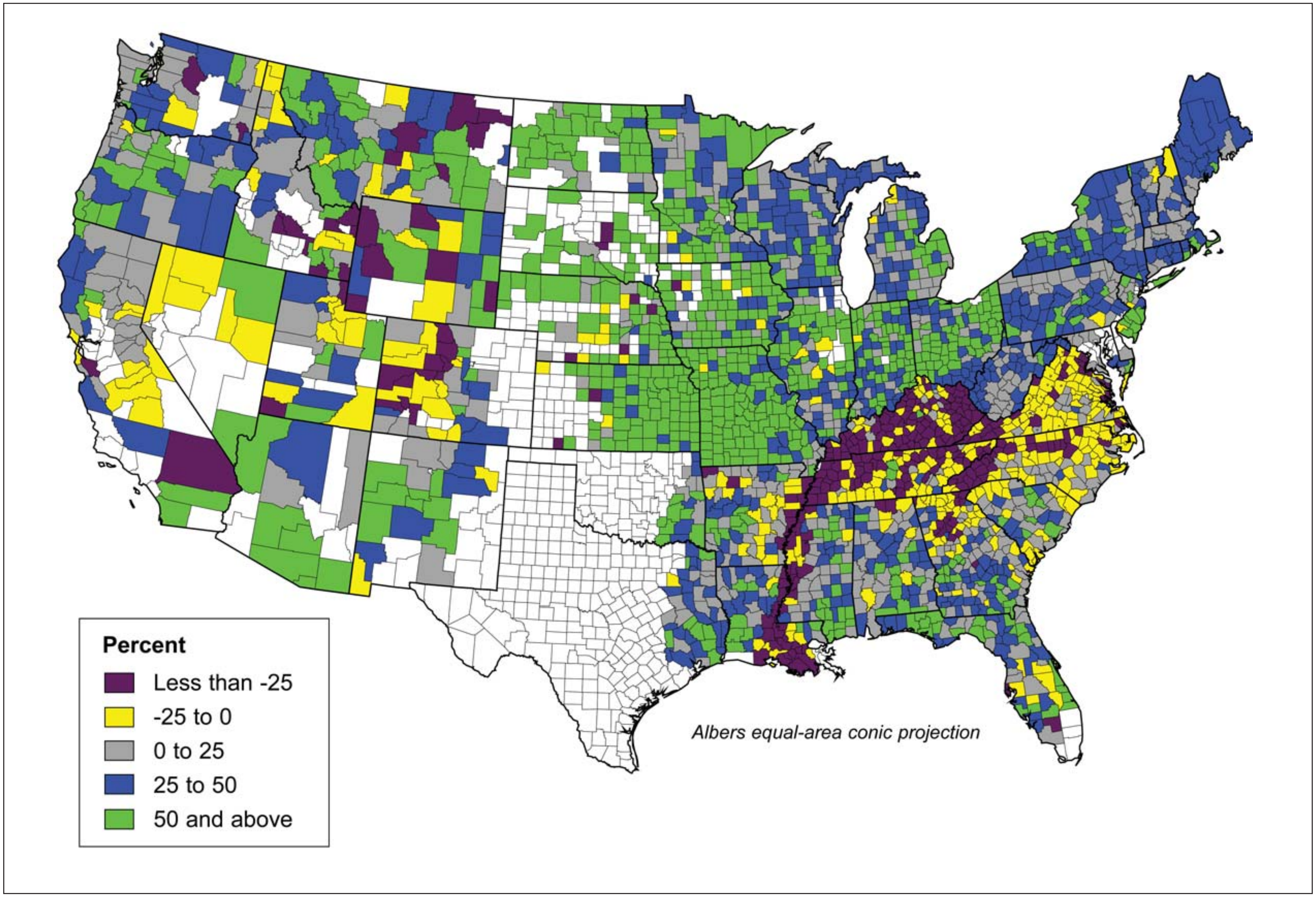

Figure 91—Volume change as percentage of growing-stock inventory on private timberland, 2000 to 2050, by county.

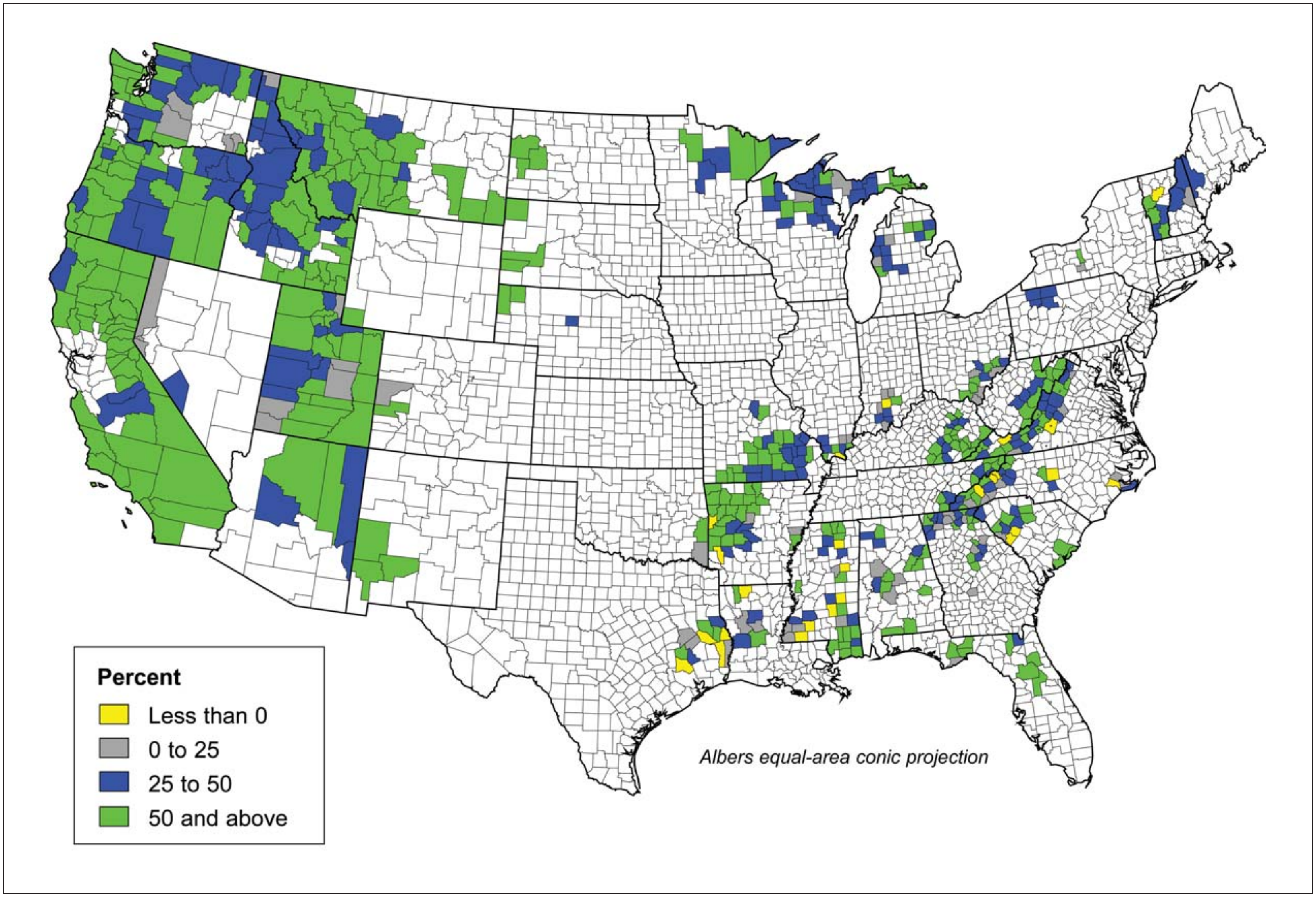

Figure 92—Volume change as percentage of growing-stock inventory on national forest timberland, 2000 to 2050, by county. Arizona, California, Colorado, Idaho, Nevada, New Mexico, South Dakota, and Wyoming are missing county codes for some of the data.

Chapter 6: Summary, Conclusions, and Implications[1]

Introduction

In entering upon a consideration of the points of inquiry specified in the law under which this report is made, it is not deemed necessary to present facts tending to show the importance of a suitable supply and proper distribution of woodlands in the country, nor to urge the necessity of forest products for the supply of these materials for the daily wants of life, and the manifold uses to which they are applied in the arts. It is believed that no differences of opinion could arise as to the close dependence of our national welfare and individual comfort upon the maintenance of these supplies of wood and wood-products, or upon the importance of having a sufficient amount within a convenient distance, at moderate prices, through an indefinite period of coming time.

— *F. B. Hough,* Report Upon Forestry, *1878*

The Role of the RPA Timber Assessment

In the middle of the 19th century, George Perkins Marsh documented the transformation of the environment as a feature of human history. Marsh (1864) also described the central role played by forests—especially the clearing of forests—in human development. The broad-scale and long-term perspective that Marsh brought to analysis of environmental change has been credited with an influential role in the rise of the conservation movement in the early 20th century, and as an intellectual precursor of the environmental movement of the mid to late 20th century.

Reference to documents now well over a century old is helpful in an effort to look decades into the future, and encourages us to recognize that the lens through which we view—and therefore judge—transformations of the environment changes from generation to generation. This change in perspective is both inevitable and positive. Goals for natural resource management in the early 21st century are diverse and include an emphasis on maintaining the integrity[2] of ecological systems while seeking

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[1] The authors for this chapter are David J. Brooks, Darius M. Adams, Richard W. Haynes, and Kenneth E. Skog.

[2] Ecosystems are said to have "integrity" when they have their native components (plants, animals, and other organisms) and processes (such as growth and reproduction) intact.

to provide goods and services for current consumption. Recognition of the value in balancing present needs with preservation of future options is reflected in public debate as well as in formal, intergovernmental agreements (e.g., United Nations 1992, World Commission on Environment and Development 1987). Success in this effort requires careful and explicit consideration of prospective management of land and forest resources by a diverse set of owners, changes in biological systems, and changes in the levels and patterns of demand for goods and services derived from these systems.

The role of this assessment is to provide early indications of trends and prospective outcomes for the forests and forest sector of the United States. In its description of possible future pathways for U.S. forests, and supply and demand for forest products, this assessment joins a collection of studies that now span more than 100 years. Formal, congressional interest in forest sector studies dates back to a request for a report on forestry in the late 19th century (Hough 1878). General concern over forest conditions and interest in the outlook for forest resource availability can be traced back to European settlement in the 17th century.

Broadly, the challenge for resource managers is to develop and implement strategies that provide the range of goods and services expected from forests. In the last decade, “sustainable management” has been increasingly advocated as a standard for resource management. As is the case with “sustainable development” (see United Nations 1992), this is an attractive but vague goal. It is important to recognize, in addition, that any operative definition of “sustainability” will be a reflection of values—and therefore is subject to change. Although there is a necessary biophysical component in the range of possible choices, biophysical information, alone, is not sufficient to determine whether forests are sustainably managed. That question can only be definitively answered in hindsight, and with reference to what is to be sustained, and for whom. The timber assessment describes a significant part of the context for developing these management strategies.

Acknowledging the inevitability of change in the forested landscape and in the standards used to judge those changes presents particular challenges for forest management and policy. The importance of forests (in social, environmental, and economic terms), the relatively long period between management actions and final consequences, and the accelerating pace of social and technological change are elements of these challenges. In its effort to identify likely economic and ecological outcomes of forest management practices and production and consumption trends, this timber assessment is designed to contribute to dialogue and debate by informing perceptions of the future.

Markets and Forest Management

This timber assessment focuses on markets and market processes in its approach to providing context. Markets have played, and can be expected to continue to play, a central role in shaping the forested landscape of the United States. Markets for timber and forest products are, therefore, an integral component of forest management. Opportunities to sell a variety of goods and services can be one of the most powerful incentives to use management practices that sustain a diversity of forest conditions and outputs. Markets also are a widely preferred mechanism for revealing the value of specific outputs, and an important source of information on the relative importance of management alternatives.

Forest product markets are dynamic and, at times, volatile. This is neither a profound observation, nor is it unique to the forest sector. Nevertheless, the implications of these characteristics of markets are easily and often overlooked in discussions of forest management and policy. This assessment covers about 100 years—nearly 50 years of historical data and a projection 50 years into the future. Over this time span, most markets undergo substantial change. Comparing current patterns and levels of U.S. consumption, production, and trade in forest products to those at the beginning of the 20th century provides ample evidence of the type and the magnitude of change that can be expected over an extended period. Market dynamics, including changes in the mix of products and the technologies used to manufacture them, affect demand for timber raw material.

The magnitude and speed of change in forest products markets, especially response to business cycles (as illustrated in fig.1 price panel), is often greater than expected or recognized by resource managers or policymakers. As a result, market-based "disturbance" events, such as economic recessions, the introduction of new technologies or products, the opening of new markets, or shifts in exchange rates often have unanticipated effects on forests that are an order of magnitude greater than those resulting from endemic biophysical processes. In the baseline analysis, and through scenarios, this assessment provides a quantitative basis for examining potential developments in forest products markets and their effects on forests.

The importance of the broad-scale economic outlook is a long-standing theme of forestry outlook studies, and this assessment rests on a similar observation. This timber assessment also emphasizes, however, the importance of both international as well as domestic economic conditions as factors in the outlook for U.S. resources. Over the past few decades, international economic conditions have had an increasing effect on both producers and consumers of forest products. For example, the effects of exchange rates and patterns of international economic growth are obvious in U.S. forest products trade. Less obvious, perhaps, are the cumulative effects that international economic integration ("globalization") has on domestic markets and, as a consequence, on domestic resources. In many respects, therefore, international linkages (including, but not limited to commodity trade) are unavoidable and important elements of discussions of "sustainable" resource management.

Highlights of the Projections

Trends in Consumption and Production of Forest Products

United States consumption of forest products will continue to increase over the next 50 years, but the rate of increase will be slower than over the last 50 years. Rising consumption will be accompanied by increases in U.S. timber harvest; rising log, chip, and product imports; and greater use of recovered paper. The composition of both production and consumption will change. Pulp and paper products will account for a larger share, the relative importance of composite products will remain steady, and the importance of lumber will decline. Per capita consumption of U.S. forest products will remain static, whereas per capita U.S. timber harvest will decline.

Price Growth

Over the next 50 years, prices of most major classes of forest products will continue along their recent historical trends. Commodities whose consumption will grow most rapidly, including oriented strand board (OSB) and paper and paperboard, will realize the slowest price growth rates, and price levels will remain well below the peaks observed in the 1980s and 1990s. Lumber, in contrast, will experience slower rates of consumption growth but more rapid price growth, and prices are expected to surpass the peak levels observed in the 1990s. Plywood prices are expected to remain stable at the recent historically high levels.

Softwood sawtimber stumpage prices are projected to increase over the next 50 years, but at a rate (0.6 percent per year) considerably below that of the past 50 years (1.9 percent per year). Prices for small-diameter softwood logs (in the West) and softwood pulpwood (in the East) are projected to remain at or below current levels until the last 20 years of the projection. The projected price of sawtimber in the South is a notable exception to the overall projection of moderate price increases: the price is projected to rise as a result of limited availability.

Changes in Harvest and Inventory

Over the next 50 years, most of the increase in the Nation's timber harvest will occur in the East and especially on nonindustrial lands in the South. United States timber harvest is expected to increase 24 percent by 2050; harvest of softwoods will increase 30 percent, and harvest of hardwoods will increase by 17 percent. Virtually all of the increase will be used for manufacturing paper, paperboard, and composite products.

Plantations of softwood species will play an important role in future domestic harvest expansion. By 2050, 54 percent of total U.S. softwood growing-stock removals will come from plantations in private ownership. These plantations will occupy 30 percent of the U.S. private softwood timberland base, 13 percent of the total private timberland base (including softwoods and hardwoods), and 9 percent of the total U.S. timberland base (all owners and species).

Timber inventories will increase over the next 50 years. Softwood timber inventories will rise on all ownerships in all regions by 53 percent for the United States as a whole; softwood inventories on public lands alone will rise by more than 70 percent. Hardwood inventories, almost entirely in private forests, will increase by 27 percent. Increases in inventories in the North will offset reductions in the South.

Over the next 50 years, the species composition of U.S. forests will shift toward softwoods in the South and toward hardwoods in the North, but remain largely unchanged in other regions. The changes in species composition are not large (measured in terms of the percentage of total area in each region). By 2050, the age structure of forests managed on an even-age basis will be similar to current conditions on private lands but shift toward older age classes on public lands. Diversity indexes that combine information on both age and forest types exhibit limited change over the period of the projection for the United States as a whole.

All of these changes in resource conditions are influenced by the trade assumptions. Without increased imports of softwood lumber and pulp, timber inventories would be lower and trees generally smaller in size. The type of diversity indexes would likely be less stable than described in these projections.

Forest Products Trade

The United States will continue to rank among the world's leading importers and exporters of forest products. Although domestic production will continue to account for most U.S. consumption, the share of total consumption met by imports will rise from 20 percent today to 26 percent by 2050. These projections assume that the U.S. dollar will retain its strength relative to other currencies. The trade, consumption, production, and resource projections of this assessment would change if there were significant changes in the exchange value of the U.S. dollar, or in other factors affecting international trade.

Imports from non-Canadian sources will account for the bulk of import growth. Canada's share of U.S. softwood lumber consumption is expected to decline from just over 35 percent in 2010 to 25 percent by 2050; the share of imports from other

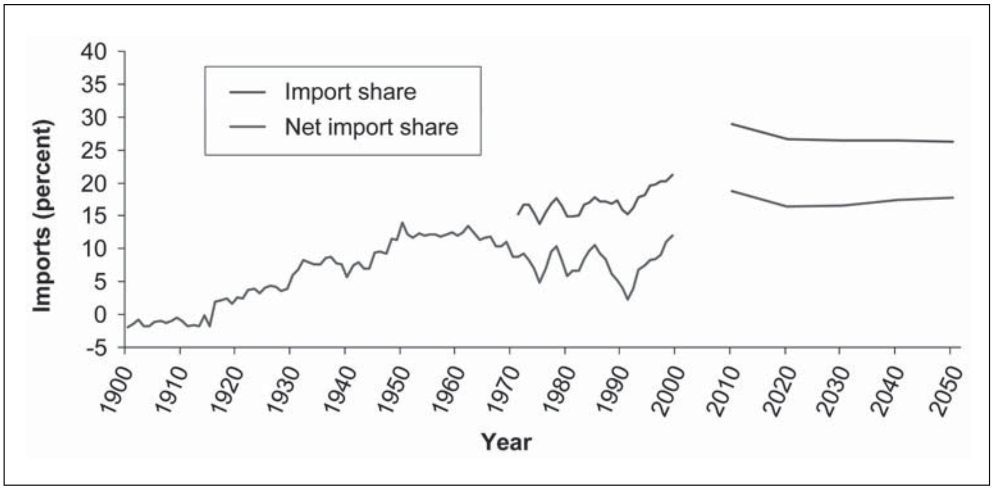

Figure 93—Total imports and net imports as a percentage of all consumption in the United States (based on roundwood equivalent volume).

countries is expected to increase to 15 percent. The Canadian import share of U.S. paper and paperboard consumption is expected to decrease from 14 percent in 2000 to 12 percent by 2050, while non-Canadian sources, which provide about 3 percent today, will account for 10 percent of consumption by 2050.

Emergent Lessons

- The United States will become increasingly dependent on imports as our forest products consumption expands in the future. Our relative import dependence has risen in the past, and the magnitude of the anticipated increase is small compared to trends over the past 100 years. The projected level of net import dependence (19 percent by 2050) is, however, higher than we have experienced in the past (fig. 93). Because of the importance of trade, specifically imports, the United States will have reason for increasing interest in the forest resource and forest industry policies of trading partners and all nations.
- Based on the projected broad-scale measures of forest resource condition,[3] we do not expect to see large or dramatic changes in U.S. forest conditions over the next 50 years, even as harvest rises. There will continue to be adjustments in the extent of certain forest types (expanding in some regions and contracting in others), shifts in age-class structures (some continuous and some transitory), an accumulation of older stands on public lands in the West, and an array of other variations, but most are expected to be gradual and not large relative to historical experience over the past 50 years. This does not suggest that deliberations on issues of forest protection, stewardship, and the adequacy of forest-based environmental services are moot; but these discussions and debates do not need to proceed in an atmosphere of impending crisis based on fiber scarcity or large-scale ecological change.
- In the South, demand for solid wood and fiber is expected to continue to rise in the future. In the case of hardwoods, the increase in demand surpasses growth and ultimately lowers inventories. In the case of softwoods, the increase in demand is

[3] The measures include the aggregate timber inventory, stand age (or size), forest type, and a Shannon-Weaver diversity index that combines age and type.

more than met with a combination of maturing young timber stands and intensification of management that leads to expanding growth that more than offsets increase in harvest.

Hardwood forest types in the South, on the other hand, have the lowest rates of timber growth, the least intensive forms of management, and expected declines in the area available for timber production. The knowledge of intensive hardwood culture is limited, and silvicultural activities in hardwood stands are complex owing to the diversity of trees and forest types. To date, silvicultural research has emphasized softwood stand management, even as the share of hardwoods in total harvest has been rising. Although inventories are decreasing and there is an increase in harvest, fiber prices are projected to remain low for several decades and would not tend to support intensified management. In addition most of the Southern hardwood forests are in small parcels, held by nonindustrial private owners with various objectives. It will be difficult to design and implement programs to increase the extent and intensity of hardwood management. Finally, the area of hardwood types is expected to decline 7 percent (15.4 million acres) over the projection through conversion to other types (predominantly softwoods), losses to urban and developed uses, and reservations for nontimber purposes.

- These projections suggest a future in which recent concerns about the broad-scale consequences of increasing production from hardwood forests, such as loss of understory plants, noncommercial tree species, and wildlife habitat will continue or intensify. We project that there will be greater pressure for timber production in the hardwood forests of the South, and relatively less in the hardwood forests of the North. Among the assumptions of the baseline projection is, however, the continued withdrawal of some Southern hardwood forests from availability for timber production. We assume that the owners of these forests may have long-term objectives other than timber production, including habitat protection and biodiversity conservation. By 2050, this “reserved” forest area accumulates to 14.9 million acres. This area is relatively large (amounting to 18 percent of the private hardwood timberland, and 8.4 percent of all private timberland in the South), and this may temper some concerns about increasing production on remaining hardwood forests. Nevertheless, the hardwood forests of the East, although extensive and highly productive, cannot be expected to sustain high levels of timber production and, at the same time, retain the current scale and distribution of native flora and fauna.
- A continuation of current policies is an assumption of this analysis; as a consequence, private lands are the suppliers of virtually all future increases in harvest in the United States, and there is a limited contribution to timber supplies from public timberland. It is expected that a larger portion of private timberland will be shifted into more intensive management as a result. Even so, more than three-fourths of the private land base will remain in native forest types with little or no active management. Our projection envisions the development of a mixed pattern of management on private lands with some areas used intensively for wood production while most of the land base is used for timber production at a lower level of intensity, or for provision of nonwood outputs and services. The potential value of this diversity in management objectives and resource conditions has been advocated by some as a goal for domestic forest policy (see, for example, Binkley 1999, Sample 2001, Victor and Ausubel 2000).

Implications for Policy and Management

In the past 50 years, policies to ensure timber supplies—either through public timber harvests or incentives to private owners or managers—have been central elements of the forest policies of the United States. The focus on forest management as a means of ensuring future timber supplies has been motivated by a perceived need to forestall “gaps” between demand and supply (especially for softwoods) or, in economic terms, projected increases in real prices for timber and forest products.

Our projections of future conditions in U.S. markets and forests suggest an opportunity to change this emphasis. In the next 50 years, forest products and timber markets in the United States are expected to produce a balance between demand for timber and timber supply, satisfied at the national scale by higher dependence on imports. Market conditions will differ, however, by region. The management decisions of private owners and the productivity of intensively managed forests are expected to play a central role in these developments. Projected market conditions also are dependent, in no small measure, on a continuation—and an extension—of the degree to which the United States is linked to the rest of the world through trade in forest products.

It is an open question, however, whether these prospective trends are consistent with evolving—and with future—social preferences for the role of forests in supplying both commodities and environmental services. No matter what role timber supply has in forest policy debates, these projections suggest a number of key guideposts for future deliberations.

Regional Distribution of Economic and Social Benefits and Ecological Change

Patterns of forest ownership, along with broad differences in management objectives, lead to accumulating timber inventories in the West on public lands, and increased timber production and more intensive management in the East on private lands. For more than 100 years, the United States has benefitted from the scale and diversity of resources within its borders, and forest-based industries that have been mobile. Shifts in the regional locus of timber production, including greater reliance on timber production in other countries, have occurred in the past few decades, and this sets the stage for expected patterns of production over the next decades. Regional differences in patterns of timber production and, for example, habitat conservation, are likely to result in differences in the type and distribution of economic, social, and ecological benefits of U.S. forests. To date, however, there has been relatively little success reaching any consensus related to these differences.

Economic and Social Benefits of Noncommodity Objectives

As the work of George Marsh (1864) illustrates, recognition of the ecological consequences of human development has a long history. For much of the 20th century, forest policy in the United States was attentive to the need to strike a balance between production of raw material for industry and consumers, and interest in conservation and preservation of flora and fauna. The associated public and policy debates are evolving from “jobs vs. the environment” to a richer, more complex set of issues. However we are still in the early days of understanding and effectively framing the issues associated with the interaction of resource management policies and social and economic policies. This assessment projects a future in which a relatively small portion of the Nation’s timberland base produces a significant share of timber raw material requirements. This concentration of timber production has been underway for several decades, but its effects on ecological outputs (both short term and longer term, and at the local, regional, and national scale) are still evolving.

Increasing Attention to Intersectoral Interaction

Among the simple, but difficult lessons of the environmental movement of the 1970s is the observation that "everything is connected to everything else." This can be applied to the policy environment in the same manner as it has been used for the natural environment. In both cases, the observation is descriptive and therefore contains only a caution; there are no embedded, normative conclusions that can be drawn. In the recent past, and for the prospective future, however, we can expect to experience increasing interaction between policies or policy objectives to the extent that they are narrowly framed. For forests, examples of broad policy topics that interact include trade, biodiversity, technology, energy, climate, and agriculture. In the United States (and in many other countries), there is an imperfect interaction among the policy processes and communities of interest for each of these broad topics. The result may be policies that appear well conceived in a narrow (sectoral) context, but are unsustainable in the broader context. The baseline projection of this assessment assumes a continuation of current policies—in all sectors—and therefore does not consider the prospect of significant, cross-sectoral interactions.

Adapting to Change

Finally, both forest policy and forest management face challenges anticipating and adapting to social, economic, and technological change whose frequency and magnitude are often inconsistent with the response of biophysical systems to management actions. This assessment describes a number of significant changes that have already affected forest management and policy, and a future in which these continue. Examples include the importance of imports and the role of non-Canadian regions as a source of consumption, and the shift toward shorter rotations and intensive forest management. Among the challenges of forest management and policy is the need to recognize changes that have already taken place and to adapt current and future plans accordingly.

Glossary

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Industrial wood—All commercial roundwood products except fuelwood.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Nonsawtimber—Timber that is not used by sawmills or veneer mills, but is used in the manufacture of pulp, paper, OSB, various nonstructural panels, or used for fuelwood.

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

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

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

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

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

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

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

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

Overrun—The difference between the greater volume actually sawn and the lesser estimated log scale volume.

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

Plantation—See managed plantation.

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

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

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

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

Private ownerships:

> **Forest industry (FI)**—An ownership class of private lands owned by companies that grow timber for industrial use and own wood processing facilities.
>
> **Nonindustrial private forest (NIPF**)—An ownership class of private lands where the owner does not operate wood-use plants. This includes lands owned by operators of farms, lands owned by private individuals, and lands owned by private corporations.
>
> **Native American**—(a) Lands held in trust by the United States or states for Native American tribes or individual Native Americans. (b) Lands owned in fee by Native American tribes whether subject to federal or state restrictions against alienation or not. Since 1990, these lands are grouped with other private lands in the NIPF ownership group.

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

Public ownerships:

> **Federal**—An ownership class of public lands owned by the U.S. Government.
>
> **National forest**—An ownership class of federal lands, designated by Executive order or statute as national forests or purchase units, and other lands under the administration of the Forest Service including experimental areas and Bankhead-Jones Title III lands.
>
> **Bureau of Land Management (BLM)**—An ownership class of federal lands administered by the Bureau of Land Management, U.S. Department of the Interior.
>
> **County and municipal**—An ownership class of public lands owned by counties or local public agencies, or lands leased by these governmental units for more than 50 years.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

	Hardwood	Softwood
	Age classes	
North	75 to 135	55 to 135
South	60 to 75	40 to 75
West	65 to 135	85 to 135

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

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

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

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

> **High sites**—Land capable of growing at least 85 cubic feet of wood per acre per year.
>
> **Medium sites**—Land capable of growing 50 to 85 cubic feet of wood per acre per year.
>
> **Low sites**—Land capable of growing 20 to 49 cubic feet of wood per acre per year.

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

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

Sound dead—The net volume in salable dead trees.

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

Stumpage—Standing timber (trees) in the forest.

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

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

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

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

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

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

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

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

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

Species List

Common Name	Scientific Name
Alpine fir (Subalpine fir)	*Abies lasiocarpa* (Hook.) Nutt.
Apache pine	*Pinus engelmannii* Carr.
Arizona pine	*Pinus ponderosa* var. *arizonica* (Engelm.) Shaw
Ash	*Fraxinus* spp.
Aspen	*Populus* spp.
Balsam fir	*Abies balsamea* (L.) Mill.
Balsam poplar	*Populus balsamifera* L.
Basswood	*Tilia* spp.
Beech	*Fagus* spp.
Birch	*Betula* spp
Blackgum (Black tupelo)	*Nyssa sylvatica* Marsh. var. *sylvatica*
Black walnut	*Juglans nigra* L.
Chestnut oak	*Quercus muehlenbergii* Engelm.
Chihuahua pine	*Pinus* (associates with Apache pine)

Colorado blue spruce	*Picea pungens* Engelm.
Cottonwood	*Populus* spp.
Cypress	*Taxodium* spp.
Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
Eastern white pine	*Pinus strobus* L.
Elm	*Ulmus* spp.
Engelmann spruce	*Picea engelmannii* Parry ex Engelm
Eucalyptus	*Eucalyptus* spp.
Grand fir	*Abies grandis* (Dougl. ex D. Don) Lindl.
Gray birch (yellow birch)	*Betula alleghaniensis* Britton
Gum	*Liquidambar* spp.
Hackberry	*Celtis occidentalis* L.
Hemlock	*Tsuga* spp.
Hickory	*Carya* spp.
Incense-cedar	*Libocedrus decurrens* Torr.
Jack pine	*Pinus banksiana* Lamb.
Jeffrey pine	*Pinus jeffreyi* Grev. & Balf.
Juniper	*Juniperus* spp.
Larch	*Larix* spp.
Limber pine	*Pinus flexilis* James
Loblolly pine	*Pinus taeda* L.
Lodgepole pine	*Pinus contorta* Dougl. ex Loud.
Longleaf pine	*Pinus palustris* Mill.
Maple	*Acer* spp.
Mountain hemlock	*Tsuga mertensiana* (Bong.) Carr.
Oak	*Quercus* spp.
Overcup oak	*Quercus lyrata* Walt.
Paper birch	*Betula papyrifera* Marsh.
Pinyon	*Pinus edulis* Engelm.
Ponderosa pine	*Pinus ponderosa* Dougl. ex Laws
Post oak	*Quercus stellata* Wangenh.
Red alder	*Alnus rubra* Bong.
Red pine	*Pinus resinosa* Ait.
Redwood	*Sequoia sempervirens* (D. Don) Endl.
Scrub oak	*Quercus laevis* Walt.
Shortleaf pine	*Pinus echinata* Mill.
Silver fir (Pacific silver fir)	*Abies amabilis* Dougl. ex Forbes
Sitka spruce	*Picea sitchensis* (Bong.) Carr.
Slash pine	*Pinus elliottii* Engelm.
Sugar pine	*Pinus lambertiana* Dougl.
Sweetgum	*Liquidambar styraciflua* L.
Sycamore	*Platanus occidentalis* L.
Tamarack	*Larix laricina* (Du Roi) K. Koch
Tanoak	*Lithocarpus densiflorus* (Hook. & Arn.) Rehd.
True firs	*Abies* spp.
Tupelo	*Nyssa* spp.
Western hemlock	*Tsuga heterophylla* (Raf.) Sarg.
Western redcedar	*Thuja plicata* Donn ex D. Don
Western white pine	*Pinus monticola* Dougl. ex D. Don
White-cedar	*Chamaecyparis thyoides* (L.) B.S.P.

White fir	*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.
White pine	See western white pine
Willow	*Salix* spp.
Yellow-poplar	*Liriodendron tulipifera* L.

Source: Burns and Honkala 1990a, 1990b.

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Equivalents

When you know	Multiply by:	To find:
Inches	2.54	Centimeters
Feet	.304	Meters
Square feet	.092	Square meters
Cubic feet*	.2	Board feet
Cubic feet	.028	Cubic meters
Acres	.405	Hectares (ha)
Cubic feet per acre	.07	Cubic meters per hectare
Pounds	.454	Kilograms
Tons	.907	Metric tonnes

* For the purposes of this report, we used 5 board feet per cubic foot (log scale), but the actual conversion varies widely by region depending on type of log scale used and the physical characteristics of the timber (diameter, length, taper, defect).

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Appendix

Table 27—Projections of number of households, new housing units, and average size of new units

Year	Households	New housing units: Total	New housing units: Single family	New housing units: Multiple family	New housing units: Mobile home[a]	Average size per new unit: Single family	Average size per new unit: Multiple family	Average size per new unit: Mobile home[a]
	Millions					*Square feet*		
1963	55.2	1.754	1.012	0.591	0.151	1,377	877	622
1970	62.9	1.835	.813	.621	.401	1,500	956	732
1980	79.1	1.526	.852	.440	.234	1,740	979	1,050
1981	82.4	1.313	.705	.379	.229	1,720	980	1,015
1982	83.5	1.296	.663	.399	.234	1,710	990	1,000
1983	83.6	1.981	1.068	.635	.278	1,725	942	1,035
1984	85.4	2.038	1.084	.666	.288	1,780	914	1,060
1985	86.8	2.025	1.072	.670	.283	1,785	922	1,080
1986	88.5	2.061	1.179	.626	.256	1,825	911	1,110
1987	89.5	1.859	1.146	.474	.239	1,905	980	1,140
1988	91.1	1.712	1.081	.407	.224	1,995	990	1,175
1989	92.8	1.577	1.002	.372	.203	2,035	1,000	1,195
1990	93.2	1.388	.895	.298	.195	2,080	1,005	1,205
1991	94.3	1.188	.840	.174	.174	2,075	1,020	1,225
1992	95.7	1.412	1.030	.170	.212	2,095	1,040	1,255
1993	96.4	1.531	1.126	.162	.243	2,095	1,065	1,295
1994	97.1	1.748	1.198	.259	.291	2,100	1,035	1,335
1995	99.0	1.673	1.076	.278	.319	2,095	1,080	1,360
1996	99.6	1.815	1.161	.316	.338	2,120	1,070	1,385
1997	101.0	1.810	1.134	.340	.336	2,150	1,095	1,420
1998	102.5	1.991	1.271	.346	.374	2,190	1,065	1,455
2010	122.1	1.757	1.078	.352	.327	2,261	1,110	1,555
2020	138.5	1.880	1.187	.337	.356	2,259	1,114	1,581
2030	154.2	1.911	1.168	.376	.367	2,258	1,119	1,586
2040	166.9	2.101	1.317	.415	.369	2,316	1,123	1,670
2050	178.1	2.151	1.362	.407	.382	2,587	1,209	1,946

[a] Mobile home placements.

Sources: Historical Data: Council of Economic Advisors 2000, except for mobile homes. Mobile home data from Department of Commerce, Bureau of the Census, http://www.census.gov/ftp/pub/const/www/mhsindex.html; projections: Montgomery 2001.

Table 28—Projections of major determinants of solid wood products demand

Year	Residential upkeep and improvements	Value of nonresidential construction	Index of manufacturing	Pallets[a]
	Billion 1987 dollars	*Billion 1992 dollars*	*1992 = 100*	*Millions*
1963	39.2		39.5	72
1970	46.8	239.1	54.8	126
1980	59.0	253.0	75.5	258
1981	54.7	256.6	76.7	252
1982	51.3	253.6	72.1	228
1983	55.9	236.9	76.3	258
1984	76.5	265.9	83.8	304
1985	86.1	291.8	85.7	335
1986	93.9	282.7	88.1	373
1987	93.0	279.0	92.8	419
1988	96.1	280.6	97.1	466
1989	92.3	286.6	99.0	505
1990	95.2	291.0	98.5	536
1991	86.9	268.6	96.2	541
1992	90.9	264.3	100.0	566
1993	90.7	260.6	103.7	536
1994	91.5	262.6	109.9	501
1995	84.5	275.7	115.7	411
1996	86.0	286.5	121.4	360
1997	85.9	298.4	130.8	400
1998	85.5	305.5	138.2	406
1999	NA[b]		144.8	
2010	118.9	330.4	196.2	451
2020	138.5	362.1	238.6	485
2030	147.0	397.9	285.7	495
2040	165.9	437.9	339.9	480
2050	187.8	461.3	405.5	480

[a] 1985–91 pallet data revised, 1992–98 Forest Service estimates of production.
[b] Residential repair and alteration data not available for 1999 in same format as earlier years owing to revisions in data collection.
Source: Historical data: U.S. Department of Commerce (expenditures on residential upkeep and improvement; value of nonresidential construction); Board of Governors of the Federal Reserve System (index of manufacturing production); U.S. Department of Agriculture, Forest Service (pallet production). All on file with: Dave McKeever, USDA Forest Service, Forest Products Laboratory, One Gifford Pinchot Drive, Madison, WI 53726-2398.

Table 29—Fuelwood consumed[a] in the United States, by species group and source, in 1986 and 1996 with projections to 2050

	Roundwood			Growing stock		
Year	Total	Hardwood	Softwood	Total	Hardwood	Softwood
			Billion cubic feet			
Northeast:						
1986	0.98	0.89	0.09	0.13	0.12	0.01
1996	.47	.42	.05	.06	.06	.01
2010	.55	.49	.06	.07	.07	.01
2020	.58	.51	.07	.08	.07	.01
2030	.61	.53	.08	.08	.07	.01
2040	.65	.57	.08	.09	.08	.01
2050	.70	.61	.09	.09	.08	.01
North Central:[b]						
1986	0.79	0.75	0.04	0.11	0.10	0.01
1996	.38	.36	.02	.07	.06	.01
2010	.44	.43	.02	.08	.07	.01
2020	.46	.44	.02	.08	.08	.01
2030	.49	.46	.02	.09	.08	.01
2040	.52	.49	.02	.09	.09	.01
2050	.56	.53	.03	.10	.09	.01
South:						
1986	0.75	0.69	0.05	0.32	0.29	0.03
1996	.95	.84	.11	.51	.45	.06
2010	1.12	.99	.13	.60	.53	.08
2020	1.18	1.03	.15	.63	.55	.08
2030	1.24	1.08	.16	.67	.57	.09
2040	1.33	1.15	.17	.71	.61	.10
2050	1.42	1.24	.19	.76	.66	.11
Rocky Mountains:[c]						
1986	0.16	0.08	0.08	0.01	0.01	0.01
1996	.18	.07	.11	.01	0	0
2010	.21	.09	.13	.01	.01	0
2020	.23	.09	.14	.01	.01	0
2030	.25	.10	.16	.01	.01	0
2040	.27	.10	.17	.01	.01	0
2050	.29	.11	.18	.01	.01	.01

Table 29—Fuelwood consumed[a] in the United States, by species group and source, in 1986 and 1996 with projections to 2050 (continued)

	Roundwood			Growing stock		
Year	**Total**	**Hardwood**	**Softwood**	**Total**	**Hardwood**	**Softwood**
			Billion cubic feet			
Pacific Coast:						
1986	0.44	0.15	0.28	0.22	0.07	0.15
1996	.30	.10	.20	.14	.04	.10
2010	.36	.12	.24	.17	.05	.12
2020	.39	.12	.27	.18	.05	.14
2030	.42	.13	.30	.20	.05	.15
2040	.45	.14	.32	.21	.05	.16
2050	.49	.14	.34	.23	.06	.17
United States:[d]						
1986	3.11	2.57	0.55	0.80	0.59	0.21
1996	2.28	1.79	.49	.79	.61	.18
2010	2.69	2.11	.58	.93	.72	.21
2020	2.85	2.20	.65	.99	.75	.24
2030	3.02	2.30	.71	1.05	.78	.26
2040	3.22	2.45	.77	1.12	.84	.28
2050	3.46	2.63	.83	1.20	.90	.30

Note: Data may not add to totals because of rounding.
[a] Excludes logging residue used for fuel.
[b] Includes North Dakota, Nebraska, and Kansas.
[c] Excludes North Dakota, Nebraska, and Kansas.
[d] Excludes Alaska and Hawaii.
Source: Historical data: Smith et al. 2001, Waddell 1989.

Table 30—Area of forest land and timberland in the North, by ownership and region, 1953–97, with projections to 2050

	Historical					Projections				
Ownership and region	**1953**	**1963**	**1977[a]**	**1987[a]**	**1997**	**2010**	**2020**	**2030**	**2040**	**2050**
	Million acres									
Forest land:										
Northeast	76.6	81.6	84.3	85.3	85.5	86.0	85.8	84.7	83.4	82.3
North Central	84.2	84.2	79.9	80.2	84.8	86.0	85.2	83.9	82.7	81.4
Total forest land	160.8	165.7	164.2	165.5	170.3	172.1	171.0	168.6	166.2	163.8
Timberland:										
Northeast—										
Public	7.3	7.5	8.2	9.6	9.6	9.6	9.6	9.6	9.6	9.6
Forest industry	10.1	10.1	12.8	12.6	11.0	10.9	10.9	10.7	10.5	10.4
NIPF[b]	55.6	60.3	57.5	57.7	58.3	58.2	57.6	56.6	55.3	54.4
Total Northeast	73.0	77.9	78.6	79.8	78.9	78.7	78.1	76.8	75.5	74.4
North Central—										
Public	21.9	20.9	20.3	20.4	22.6	22.6	22.6	22.6	22.6	22.6
Forest industry	3.6	3.6	4.7	4.4	3.8	3.7	3.7	3.6	3.6	3.5
NIPF[b]	55.8	54.2	49.9	49.8	54.1	54.3	53.5	52.5	51.4	50.4
Total North Central	81.2	78.7	74.9	74.6	80.5	80.7	79.8	78.8	77.6	76.6
North—										
Public	29.1	28.4	28.6	30.0	32.2	32.2	32.2	32.2	32.2	32.2
Forest industry	13.7	13.7	17.5	16.9	14.8	14.6	14.6	14.3	14.1	13.9
NIPF[b]	111.4	114.5	107.4	107.5	112.4	112.5	111.1	109.1	106.7	104.8
Total timberland	154.3	156.6	153.4	154.4	159.4	159.4	157.9	155.6	153.1	151.0

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] American Indian and Alaska Native lands 1953–2050 are now included in nonindustrial private forest (NIPF); in past reports they were shown in public lands.
Source: Alig et al., n.d.; Smith et al. 2001.

Table 31—Area of forest land and timberland in the South, by ownership and region, 1953–97, with projections to 2050

	Historical					Projections				
Ownership and region	**1953**	**1963**	**1977**[a]	**1987**[a]	**1997**	**2010**	**2020**	**2030**	**2040**	**2050**
					Million acres					
Forest land:										
Southeast	93.0	94.7	90.5	88.6	88.7	87.5	86.6	85.6	84.8	83.9
South Central	133.1	133.7	126.6	122.6	125.4	125.7	126.0	126.2	126.4	126.6
Total forest land	226.0	228.4	217.0	211.1	214.1	213.2	212.6	211.8	211.2	210.5
Timberland:										
Southeast—										
Public	7.9	8.2	8.5	9.1	9.4	9.4	9.4	9.4	9.4	9.4
Forest industry	13.9	14.8	15.3	16.6	14.5	14.2	13.9	13.7	13.5	13.5
NIPF[b]	67.2	68.0	64.0	59.5	60.9	60.1	59.4	59.2	58.4	57.6
Total Southeast	89.1	91.0	87.8	85.1	84.8	83.7	82.7	82.2	81.3	80.5
South Central—										
Public	9.6	9.6	10.0	10.9	11.5	11.5	11.5	11.5	11.5	11.5
Forest industry	17.9	18.8	21.5	21.4	22.5	22.6	22.7	22.7	22.7	22.8
NIPF[b]	88.1	89.3	80.3	79.8	82.2	82.5	82.7	82.9	83.0	83.1
Total South Central	115.5	117.7	111.8	112.1	116.3	116.6	116.9	117.1	117.2	117.3
South—										
Public	17.4	17.8	18.4	19.9	20.9	20.9	20.9	20.9	20.9	20.9
Forest industry	31.8	33.6	36.9	38.0	37.0	36.8	36.6	36.4	36.3	36.3
NIPF[b]	155.3	157.3	144.3	139.4	143.2	142.6	142.1	142.0	141.4	140.7
Total timberland	204.5	208.7	199.6	197.3	201.1	200.3	199.6	199.3	198.6	197.8

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. Includes Kentucky in addition to the 12 states examined in "The South's Fourth Forest" (USDA FS 1988).
[a] Data were revised after the 1989 RPA tables were developed.
[b] American Indian and Alaska Native lands 1953–2050 are now included in nonindustrial private forest (NIPF); in past reports they were shown in public lands.
Source: Alig et al., n.d.; Smith et al. 2001.

Table 32—Area of forest land and timberland in the Rocky Mountains and Great Plains, by ownership and region, 1953–97, with projections to 2050

	Historical					Projections				
Ownership and region	**1953**	**1963**	**1977[a]**	**1987[a]**	**1997**	**2010**	**2020**	**2030**	**2040**	**2050**
	Million acres									
Forest land:										
Great Plains	5.2	4.8	4.5	4.2	4.8	5.1	4.9	4.7	4.5	4.3
Intermountain	136.3	135.6	133.7	135.4	138.4	139.3	139.3	139.1	138.6	138.1
Total forest land	141.6	140.4	138.2	139.6	143.2	144.3	144.2	143.8	143.2	142.5
Timberland:										
Great Plains–										
Public	1.2	1.2	1.2	1.1	1.3	1.3	1.3	1.3	1.3	1.3
Forest industry	.02	.02	.02	.02	0	0	0	0	0	0
NIPF[b]	2.8	2.6	2.4	2.4	3.1	3.3	3.3	3.2	3.0	2.9
Total Great Plains	4.0	3.8	3.7	3.5	4.3	4.6	4.5	4.4	4.3	4.2
Intermountain—										
Public	45.3	45.8	39.4	40.3	48.6	48.6	48.6	48.6	48.6	48.6
Forestindustry	2.2	2.2	2.1	2.9	2.9	3.0	3.0	3.0	3.0	3.0
NIPF[b]	15.1	15.0	15.0	14.4	15.1	15.2	15.2	15.2	15.2	15.1
Total Intermountain	62.6	63.1	56.5	57.6	66.7	66.8	66.8	66.8	66.7	66.7
Rocky Mountains—										
Public	46.5	47.0	40.6	41.4	49.9	49.9	49.9	49.9	49.9	49.9
Forest industry	2.3	2.2	2.1	3.0	2.9	3.0	3.0	3.0	3.0	3.0
NIPF[b]	17.9	17.6	17.5	16.8	18.2	18.5	18.5	18.4	18.2	18.0
Total timberland	66.6	66.9	60.2	61.1	71.0	71.4	71.3	71.2	71.0	70.9

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. Includes the States of North Dakota, South Dakota, Nebraska, and Kansas, in addition to the Rocky Mountain states.
[a] Data were revised after the 1989 RPA tables were developed.
[b] American Indian and Alaska Native lands 1953–2050 are now included in nonindustrial private forest (NIPF); in past reports they were shown in public lands.
Source: Alig et al., n.d.; Smith et al. 2001.

Table 33—Area of forest land and timberland in the Pacific Coast region, by ownership and region, 1953–97, with projections to 2050

Ownership and region	Historical 1953	1963	1977[a]	1987[a]	1997	Projections 2010	2020	2030	2040	2050
	Million acres									
Forest land:										
Alaska	129.1	129.1	129.1	129.0	127.4	126.1	125.1	124.1	123.1	122.1
Pacific Northwest	54.1	53.8	53.0	51.3	51.6	50.9	50.4	49.9	49.3	48.8
Pacific Southwest	44.5	44.5	42.1	41.1	40.3	39.3	38.5	37.7	36.9	36.2
Total forest land	227.8	227.4	224.2	221.5	219.3	216.3	213.9	211.6	209.4	207.1
Timberland:										
Alaska—										
Public	20.1	19.7	19.2	9.6	8.6	8.6	8.6	8.6	8.6	8.6
Forest industry	0	0	0	0	0	0	0	0	0	0
NIPF[b]	.3	.4	.6	6.2	3.8	3.3	3.0	2.9	2.8	2.8
Total Alaska	20.3	20.1	19.7	15.8	12.4	11.9	11.7	11.5	11.4	11.4
Pacific Northwest—										
Public	22.9	23.4	22.4	22.1	23.6	23.6	23.6	23.6	23.6	23.6
Forest industry	9.0	9.4	9.8	9.7	9.1	8.9	8.9	8.8	8.8	8.8
NIPF[b]	12.9	11.7	9.9	8.6	8.5	8.2	8.0	7.9	7.9	7.8
Total Pacific Northwest	44.9	44.5	42.1	40.3	41.2	40.7	40.5	40.3	40.2	40.2
Pacific Southwest[c]—										
Public	9.4	9.8	9.0	9.5	10.9	10.9	10.9	10.9	10.9	10.9
Forest industry	2.2	2.4	2.7	2.8	3.0	3.1	3.1	3.1	3.1	3.0
NIPF[b]	6.6	6.0	5.6	5.2	4.8	4.4	4.2	4.1	3.9	3.9
Total Pacific Southwest	18.2	18.3	17.3	17.4	18.7	18.4	18.2	18.0	17.9	17.7
Pacific Coast—										
Public	52.4	52.9	50.5	41.2	43.0	43.0	43.0	43.0	43.0	43.0
Forest industry	11.2	11.9	12.5	12.5	12.1	12.0	12.0	11.9	11.9	11.8
NIPF[b]	19.8	18.1	16.0	19.9	17.1	15.9	15.3	14.9	14.6	14.5
Total timberland	83.4	82.9	79.1	73.5	72.2	71.0	70.3	69.9	69.6	69.3

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] American Indian and Alaska Native lands 1953–2050 are now included in nonindustrial private forest (NIPF); in past reports they were shown in public lands.
[c] Hawaii is included in the Pacific Southwest.
Source: Alig et al., n.d.; Smith et al. 2001.

Table 34—Softwood removals, harvest, growth, and inventory for the national forest timberlands, 1952–97, with projections to 2050

Item and region	Historical							Projections				
	1952	1962	1970	1976	1986	1991	1997	2010	2020	2030	2040	2050
	Million cubic feet											
Northeast:												
Removals	3	3	3	3	6	5	5	4	4	5	4	5
Harvest	3	3	3	2	6	7	6	6	7	7	7	7
Net annual growth	13	15	16	18	19	17	14	12	11	11	10	10
Inventory	459	532	637	636	678	723	782	1,044	1,118	1,184	1,243	1,297
North Central:												
Removals	22	30	28	34	26	48	25	26	27	28	28	29
Harvest	24	28	34	32	29	56	28	26	28	29	30	31
Net annual growth	57	73	75	98	118	84	94	76	70	60	57	57
Inventory	1,336	1,988	2,170	2,542	3,270	3,216	3,578	4,560	5,046	5,451	5,766	6,058
Southeast:												
Removals	15	28	35	67	74	59	47	28	35	36	36	36
Harvest	14	27	33	61	59	54	45	26	34	34	34	34
Net annual growth	80	90	129	137	94	50	57	99	70	54	49	47
Inventory	2,074	2,243	2,705	2,946	2,848	2,826	2,991	4,116	4,627	4,879	5,030	5,147
South Central:												
Removals	145	94	156	181	174	169	139	77	93	94	93	93
Harvest	141	90	147	174	163	163	132	72	92	93	93	93
Net annual growth	211	336	314	245	231	174	192	155	132	124	121	114
Inventory	3,123	4,874	4,952	5,670	6,466	6,013	6,396	7,501	8,054	8,383	8,672	8,908
Rocky Mountains:[a]												
Removals	229	412	524	463	468	389	130	142	172	183	193	200
Harvest	218	387	480	426	465	425	186	147	187	199	210	219
Net annual growth	689	776	905	1,044	1,296	1,285	1,274	1,597	1,465	1,273	1,101	955
Inventory	58,013	62,979	63,825	65,081	70,832	71,657	84,993	103,127	117,191	129,510	139,863	148,486
Pacific Southwest:[b]												
Removals	117	263	378	306	334	314	96	108	132	139	145	148
Harvest	89	216	346	286	347	336	117	108	141	148	153	158
Net annual growth	162	186	338	364	422	463	616	642	648	648	638	628
Inventory	29,590	29,391	28,694	28,073	27,213	31,448	29,539	36,765	42,055	47,197	52,244	57,137
Pacific Northwest West:[c]												
Removals	364	567	530	525	538	266	66	49	63	74	86	94
Harvest	361	586	489	511	659	297	73	46	61	73	85	95
Net annual growth	180	197	240	227	320	320	778	898	848	782	740	692
Inventory	47,584	47,704	45,478	44,088	33,607	33,621	51,399	62,799	71,103	78,727	85,640	92,011

Table 34—Softwood removals, harvest, growth, and inventory for the national forest timberlands, 1952–97, with projections to 2050 (continued)

	Historical							Projections				
Item and region	1952	1962	1970	1976	1986	1991	1997	2010	2020	2030	2040	2050
	Million cubic feet											
Pacific Northwest East:[c]												
Removals	121	256	314	313	387	330	72	68	87	103	120	130
Harvest	100	232	286	292	378	352	83	66	87	104	121	135
Net annual growth	261	310	329	312	269	269	320	377	352	327	306	288
Inventory	23,408	25,757	25,911	23,649	17,331	17,338	23,915	28,039	30,992	33,517	35,642	37,418
Alaska:												
Removals	13	75	114	95	54	99	51	29	29	29	29	29
Harvest	11	66	100	83	47	99	43	44	44	44	44	44
Net annual growth	10	16	20	23	15	85	85	85	85	85	85	85
Inventory	38,850	38,228	37,555	35,414	24,068	18,733	18,733	19,290	19,847	20,404	20,961	21,518
United States:												
Removals	1,028	1,728	2,082	1,986	2,061	1,681	630	532	642	691	735	763
Harvest	961	1,635	1,918	1,867	2,153	1,789	712	542	682	732	778	816
Net annual growth	1,664	1,999	2,367	2,468	2,783	2,747	3,431	3,941	3,682	3,364	3,107	2,874
Inventory	204,437	213,696	211,927	208,099	186,313	185,574	222,326	267,241	300,033	329,252	355,061	377,980

[a] Rocky Mountains region historical data include the Great Plains States. For projections, western South Dakota is in Rocky Mountains; eastern South Dakota and other Great Plains States are in the North-Central region.
[b] Pacific Southwest excludes Hawaii.
[c] Pacific Northwest West (western Oregon and western Washington) is also called the Douglas-fir subregion, and Pacific Northwest East (eastern Oregon and eastern Washington) is also called the ponderosa pine subregion.
Sources: For historical data Powell et al. 1993; 1997 data from Smith et al. 2001; projections from Mills and Zhou 2003.

Table 35—Hardwood removals, harvest, growth, and inventory for the national forest timberlands, 1952–97, with projections to 2050

	Historical							Projections				
Item and region	1952	1962	1970	1976	1986	1991	1997	2010	2020	2030	2040	2050
							Million cubic feet					
Northeast:												
Removals	10	11	19	29	13	22	16	8	10	10	11	10
Harvest	9	9	15	21	26	42	19	14	15	15	15	16
Net annual growth	69	88	105	117	131	88	68	60	57	54	50	47
Inventory	1,983	2,580	3,007	3,749	4,074	3,711	3,696	4,237	4,743	5,203	5,629	6,015
North Central:												
Removals	28	35	46	49	53	61	64	44	45	46	47	47
Harvest	32	34	40	43	76	95	68	60	63	64	66	66
Net annual growth	112	141	140	159	154	123	139	165	137	112	104	100
Inventory	2,482	3,491	3,994	4,483	5,470	5,228	6,281	7,932	8,925	9,609	10,200	10,741
Southeast:												
Removals	12	18	26	21	14	13	51	8	10	10	10	10
Harvest	9	11	17	15	14	11	47	9	9	9	9	9
Net annual growth	73	86	122	141	139	114	105	110	78	53	39	31
Inventory	2,784	3,335	3,511	4,679	5,503	5,565	5,773	7,397	8,213	8,743	9,094	9,338
South Central:												
Removals	61	52	36	26	34	36	56	24	29	30	30	30
Harvest	41	29	32	18	35	37	52	23	24	24	24	24
Net annual growth	67	111	122	144	135	147	144	147	134	115	88	64
Inventory	1,785	2,793	3,947	3,576	4,502	4,959	5,249	7,073	8,213	9,152	9,867	10,304
West:[a]												
Removals	6	11	19	5	45	54	11	7	8	9	9	9
Harvest[b]	9	14	19	4	16	12	32	7	9	9	10	10
Net annual growth	74	82	85	97	58	71	218	193	156	144	145	142
Inventory	4,522	5,008	5,262	5,080	5,558	6,178	8,790	10,902	12,653	14,099	15,459	16,812
United States:												
Removals	117	126	146	130	160	186	198	91	102	104	106	106
Harvest	100	97	123	101	166	197	217	114	119	122	124	125
Net annual growth	396	508	573	658	617	544	674	675	561	478	426	384
Inventory	13,556	17,207	19,721	21,567	25,107	25,641	29,789	37,541	42,747	46,806	50,249	53,210

[a] West excludes Hawaii. The 1997 increase in growth data is due to Rocky Mountain changes in inventory procedures.
[b] 1991 West harvest value has been corrected.
Sources: For historical data, Powell et al. 1993; 1997 data from Smith et al. 2001; projections from Mills and Zhou 2003.

Table 36—Softwood removals, harvest, growth, and inventory for other public timberlands, 1952–97, with projections to 2050

	Historical							Projections				
Item and region	**1952**	**1962**	**1970**	**1976**	**1986**	**1991**[a]	**1997**	**2010**	**2020**	**2030**	**2040**	**2050**
						Million cubic feet						
Northeast:												
Removals	7	6	9	14	16	13	13	10	9	9	9	9
Harvest	7	5	7	13	18	21	20	14	14	14	14	14
Net annual growth	27	32	37	49	54	52	61	71	79	83	88	93
Inventory	885	1,044	1,275	1,555	2,496	2,307	2,797	3,505	4,160	4,881	5,651	6,468
North Central:												
Removals	35	39	43	48	33	29	71	60	60	60	59	59
Harvest	33	35	38	41	43	37	74	65	65	65	65	65
Net annual growth	92	120	126	142	168	134	141	141	141	141	140	140
Inventory	2,162	2,943	3,237	3,728	4,840	4,945	5,272	6,254	7,063	7,874	8,683	9,491
Southeast:												
Removals	52	45	71	80	120	114	112	81	81	81	81	81
Harvest	51	43	69	88	100	106	109	78	78	78	78	78
Net annual growth	70	84	126	149	148	132	145	142	140	140	140	140
Inventory	1,584	2,089	2,278	2,770	3,639	3,765	4,452	5,052	5,654	6,244	6,835	7,427
South Central:												
Removals	43	32	38	51	74	79	61	69	69	69	69	69
Harvest	30	30	32	51	64	77	57	65	65	65	65	65
Net annual growth	56	58	78	71	55	52	66	63	61	61	60	60
Inventory	780	824	1,225	1,340	1,458	1,876	1,951	1,950	1,885	1,807	1,725	1,640
Rocky Mountains:[b]												
Removals	79	86	86	93	76	108	49	104	104	105	105	104
Harvest	72	78	78	85	79	173	54	118	118	118	118	118
Net annual growth	119	141	162	162	220	171	168	169	170	170	170	170
Inventory	9,923	10,147	10,399	10,429	11,094	8,352	8,427	9,623	10,275	10,930	11,584	12,239
Pacific Southwest:[c]												
Removals	5	18	27	24	15	11	23	11	11	12	12	12
Harvest	3	16	26	22	12	13	24	12	12	12	12	12
Net annual growth	14	14	14	14	25	24	29	30	31	32	32	33
Inventory	1,892	1,435	1,150	1,108	1,245	953	1,323	1,484	1,676	1,875	2,079	2,289
Pacific Northwest West:[d]												
Removals	155	274	359	439	419	226	159	164	164	164	164	164
Harvest	158	290	343	428	418	258	163	167	167	167	167	167
Net annual growth	193	316	356	371	495	388	491	479	541	575	600	625
Inventory	20,085	19,787	19,610	19,161	19,576	16,218	19,243	23,372	27,142	31,253	35,612	40,220

Table 36—Softwood removals, harvest, growth, and inventory for other public timberlands, 1952–97, with projections to 2050 (continued)

	Historical							Projections				
Item and region	**1952**	**1962**	**1970**	**1976**	**1986**	**1991[a]**	**1997**	**2010**	**2020**	**2030**	**2040**	**2050**
							Million cubic feet					
Pacific Northwest East:[d]												
Removals	52	64	103	96	102	34	67	54	54	54	54	54
Harvest	48	61	97	89	77	81	73	56	56	56	56	56
Net annual growth	66	88	91	96	139	109	67	143	130	124	127	130
Inventory	7,792	6,536	6,483	6,748	7,027	5,821	2,537	3,187	3,701	4,261	4,856	5,485
Alaska:												
Removals	1	4	14	6	3	3	3	3	3	3	3	3
Harvest	1	4	12	5	3	3	3	3	3	3	3	3
Net annual growth	93	108	123	137	67	68	40	40	40	40	40	40
Inventory	10,081	10,915	11,864	12,200	5,880	5,765	5,090	5,567	5,934	6,301	6,670	7,040
United States:												
Removals	429	568	750	851	858	616	561	556	556	555	555	554
Harvest	403	562	702	822	814	769	577	578	578	578	578	578
Net annual growth	730	961	1,113	1,191	1,371	1,130	1,208	1,279	1,333	1,366	1,398	1,431
Inventory	55,184	55,720	57,521	59,039	57,255	50,002	51,092	59,994	67,491	75,427	83,695	92,299

Note: Data for 1952–1986 contain American Indian and Alaska Native lands; in 1991 American Indian and Alaska Native lands transferred to nonindustrial private forest.
Note: Historical harvest data are estimates of harvest trends and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data show the average volume that would be harvested given the assumptions of the study. Inventory data for 1952 and 1962 are as of December 31. Inventory data for 1970 and the projection years are as of January 1. Inventory data shown under 1976, 1987, 1991, and 1997 are as of January 1 of following year.
[a] Pacific Northwest West and Pacific Northwest East 1991 inventory and growth calculated based on 1986 Pacific Northwest total fractions of inventory and growth.
[b] Rocky Mountains region historical data (excluding harvest) include the Great Plains States. For projections, western South Dakota is in the Rocky Mountains region; eastern South Dakota and other Great Plains States are in North-Central region.
[c] Pacific Southwest excludes Hawaii.
[d] Pacific Northwest West (western Oregon and western Washington) is also called the Douglas-fir subregion, and Pacific Northwest East (eastern Oregon and eastern Washington) is also called the ponderosa pine subregion.
Sources: For historical data, Powell et al. 1993; 1997 data from Smith et al. 2001.

Table 37—Hardwood removals, harvest, growth, and inventory for other public timberlands, 1952–97 with projections to 2050

Item and region	Historical 1952	1962	1970	1976	1986	1991	1997	Projections 2010	2020	2030	2040	2050
						Million cubic feet						
Northeast:												
Removals	24	30	37	30	28	70	45	105	109	108	106	107
Harvest	23	26	28	23	23	62	92	170	170	170	170	170
Net annual growth	142	182	210	238	265	200	151	188	186	182	176	172
Inventory	3,803	4,838	5,697	6,478	9,110	9,333	10,158	11,381	12,179	12,936	13,656	14,327
North Central:												
Removals	44	55	77	87	74	154	231	195	197	195	193	191
Harvest	45	51	70	72	81	117	249	284	284	284	284	284
Net annual growth	213	270	278	304	341	270	237	277	276	276	279	286
Inventory	4,583	6,619	7,649	8,343	10,112	10,193	11,430	11,998	12,807	13,611	14,448	15,355
Southeast:												
Removals	15	16	29	34	36	35	39	33	33	33	33	32
Harvest	12	10	20	31	62	30	34	30	30	30	30	30
Net annual growth	27	32	55	71	86	88	100	87	82	85	99	99
Inventory	845	1,155	1,547	1,992	3,006	3,359	4,062	4,812	5,331	5,838	6,432	7,102
South Central:												
Removals	50	40	35	52	62	44	53	37	38	38	38	38
Harvest	33	36	36	53	66	56	49	30	30	30	30	30
Net annual growth	55	71	90	109	101	128	181	102	98	111	132	132
Inventory	1,365	1,750	2,106	2,401	3,307	4,552	4,956	6,208	6,831	7,499	8,340	9,284
Rocky Mountains:[a]												
Removals	2	4	3	2	2	1	2	4	4	4	4	4
Harvest	2	2	1	1	1	2	3	5	5	5	5	5
Net annual growth	8	9	10	11	27	17	45	11	11	10	8	8
Inventory	566	624	670	682	974	689	823	1,143	1,212	1,278	1,326	1,367
Pacific Southwest:[b]												
Removals	1	2	2	2	1	1	1	1	1	1	1	1
Harvest	1	1	1	2	1	2	1	3	3	3	3	3
Net annual growth	6	5	7	7	16	13	5	5	5	4	4	4
Inventory	218	190	263	283	554	407	440	493	533	568	597	627
Pacific Northwest:												
Removals	5	3	13	15	15	20	13	47	48	50	51	52
Harvest	6	4	10	13	36	35	14	76	76	76	76	76
Net annual growth	34	58	92	93	88	63	74	41	44	46	51	47
Inventory	1,135	1,584	2,089	2,322	2,442	2,573	2,846	3,202	3,149	3,109	3,092	3,066

Table 37—Hardwood removals, harvest, growth, and inventory for other public timberlands, 1952–97 with projections to 2050 (continued)

	Historical							Projections				
Item and region	**1952**	**1962**	**1970**	**1976**	**1986**	**1991**	**1997**	**2010**	**2020**	**2030**	**2040**	**2050**
	Million cubic feet											
Alaska:												
Removals	([c])	([c])	3	3	5	2	1	1	1	1	1	1
Harvest	([c])	([c])	4	4	6	6	2	2	2	2	2	2
Net annual growth	7	7	7	7	55	55	49	61	61	61	61	61
Inventory	3,902	3,861	3,873	3,864	1,751	1,751	1,930	2,624	3,220	3,815	4,410	5,005
United States:												
Removals	141	150	199	225	223	327	386	424	431	430	428	427
Harvest	122	130	170	199	276	309	445	600	600	600	600	600
Net annual growth	492	634	749	840	978	834	841	771	763	776	811	810
Inventory	16,417	20,621	23,894	26,365	31,256	32,857	36,645	41,861	45,261	48,654	52,300	56,133

Note: Data for 1952–86 contain American Indian and Alaska Native lands; in 1991 American Indian and Alaska Native lands transferred to nonindustrial private forest (NIPF).
Note: Historical harvest data are estimates of harvest trends and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data show the average volume that would be harvested given the assumptions of the study. Inventory data for 1952 and 1962 are as of December 31. Inventory data for 1970 and the projection years are as of January 1. Inventory data shown under 1976, 1987, 1991, and 1997 are as of January 1 of following year.
[a] Rocky Mountains region historical data (excluding harvest) include the Great Plains States. For projections, western South Dakota is in the Rocky Mountains, eastern South Dakota and other Great Plains States are in the North-Central region. The 1997 increase in growth data is due to changes in inventory procedures.
[b] Pacific Southwest excludes Hawaii.
[c] Less than 0.5 million cubic feet.
Sources: For historical data, Powell et al. 1993; 1997 data from Smith et al. 2001.

Table 38—Population and lumber consumption in the United States, per capita and by end use, 1962–98, with projections to 2050

			Lumber consumption						
				End use					
Year	Population	Per capita use	Total	New housing	Residential upkeep and improvements	New nonresidential construction	Manufacturing	Packing and shipping	All other
	Thousands	*Board feet*	*Billion board feet*						
1962[a]	186,500	209	39.1	14.1	4.3	4.2	4.5	4.5	7.3
1970	205,100	199	40.7	14.0	5.0	4.7	4.7	5.7	6.7
1976	218,000	202	44.1	18.3	6.3	4.5	4.9	5.9	4.3
1986	240,700	238	57.4	20.8	15.4	5.3	6.1	5.9	3.8
1996	265,500	231	61.3	19.8	15.3	4.9	7.9	6.4	7.0
1998	270,509	237	64.2	22.2	14.1	5.4	8.4	7.2	6.9
2010	298,026	228	67.9	16.7	22.4	6.0	7.9	7.7	7.1
2020	323,052	217	70.0	17.3	23.6	6.2	8.0	8.0	7.0
2030	347,209	210	72.9	17.0	25.1	6.6	8.1	8.1	8.0
2040	370,290	209	77.3	19.0	27.1	7.0	8.2	7.9	8.1
2050	394,241	211	83.0	21.5	29.1	7.3	8.5	7.8	8.8

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

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

Source: Historical data: McKeever 2002.

Table 39—Lumber consumption, imports, exports, and production in the United States, 1962–98, with projections to 2050

	Consumption			Imports			Exports			Production		
Year	Total	Softwood lumber	Hardwood lumber	Total	Softwood lumber [a]	Hardwood lumber	Total	Softwood lumber [a]	Hardwood lumber	Total	Softwood lumber	Hardwood lumber
						Billion board feet						
1962 [b]	39.1	30.8	8.3	4.9	4.6	0.3	0.8	0.6	0.1	34.9	26.8	8.1
1970	40.7	32.2	8.5	6.1	5.8	.3	1.2	1.1	.1	35.9	27.5	8.3
1976	44.1	36.0	8.0	8.2	8.0	.3	1.8	1.6	.2	37.7	29.7	8.0
1986	57.4	47.1	10.2	14.0	13.8	.3	2.4	1.9	.5	45.7	35.3	10.5
1996	61.3	49.5	11.8	18.4	18.0	.4	2.9	1.8	1.1	45.8	33.3	12.5
1998	64.2	52.0	12.2	19.0	18.5	.5	2.2	1.1	1.1	47.4	34.7	12.7
2010	67.9	56.3	11.6	25.7	25.3	.4	3.0	1.5	1.5	45.2	32.5	12.7
2020	70.0	57.9	12.1	23.7	25.3	.4	3.0	1.5	1.5	49.3	36.1	13.2
2030	72.8	60.4	12.4	24.9	24.5	.4	3.0	1.5	1.5	50.9	37.4	13.5
2040	77.3	64.6	12.7	27.0	26.6	.4	3.0	1.5	1.5	53.3	39.5	13.8
2050	83.0	70.0	13.0	28.6	28.2	.4	3.0	1.5	1.5	57.4	43.3	14.1

Note: Data may not add to totals because of rounding.
[a] Includes small volumes of mixed species not classified as softwoods or hardwood.
[b] Historical data 1962–86 updated to reflect revisions in new housing and residential repair and alterations.
Source: Historical data: McKeever 2002.

Table 40—Lumber production in the contiguous United States, by softwoods and hardwoods and region, 1952–96, with projections to 2050

Species group and region	Historical							Projections				
	1952	1962	1970	1976	1986	1991	1997	2010	2020	2030	2040	2050
	Billion board feet, lumber tally											
Softwoods:												
Northeast	1.3	0.8	0.6	0.8	1.4	1.5	1.4	1.6	1.5	1.6	1.6	1.7
North Central[a]	.4	.3	.3	.4	.3	.3	.5	.4	.4	.4	.4	.4
Southeast	5.2	2.7	2.9	3.4	5.3	5.6	6.7	7.3	7.8	6.8	4.6	4.8
South Central	3.6	3.2	4.3	4.6	6.2	6.4	8.7	7.8	8.9	11.5	13.7	15.1
Rocky Mountains—	2.5	3.6	4.3	4.5	4.6	4.9	3.6	3.1	3.3	3.4	3.5	3.6
Northern Rockies	1.6	2.8	3.0	3.1	3.4	3.5	3.1	2.3	2.4	2.4	2.4	2.4
Southern Rockies	.9	1.0	1.2	1.2	1.3	1.3	0.5	.8	.9	1.0	1.1	1.2
Pacific Northwest[b]—												
Westside[c]	10.3	8.6	7.6	8.5	9.3	9.0	7.4	8.3	9.6	9.9	11.3	12.8
Eastside[c]	2.3	2.4	2.4	2.7	2.8	2.9	1.5	1.4	1.8	2.3	2.8	3.4
Pacific Southwest[d]	4.6	5.0	5.2	4.8	5.2	5.3	3.4	2.7	2.8	1.6	1.6	1.6
Total U.S. softwoods	30.2	26.8	27.5	29.7	35.3	35.8	33.3	32.5	36.1	37.4	39.5	43.3
Hardwoods:												
Northeast	.9	1.3	1.6	1.9	2.3	2.7	3.1	3.3	3.5	3.7	3.9	4.1
North Central[a]	2.4	1.5	1.7	2.6	3.2	3.7	3.1	3.0	3.1	3.2	3.3	3.5
Southeast	1.6	1.9	2.0	1.4	2.0	2.6	2.2	2.3	2.4	2.5	2.5	2.6
South Central	2.3	3.3	2.9	1.8	2.7	2.9	3.5	3.6	3.7	3.6	3.5	3.4
West	0	.1	.1	.2	.2	.3	.5	.5	.5	.5	.5	.5
Total U.S. hardwoods	7.2	8.1	8.3	8.0	10.5	12.3	12.5	12.7	13.2	13.5	13.8	14.1

Note: Data may not add to totals because of rounding.
[a] Includes Great Plains.
[b] Excludes Alaska.
[c] Pacific Northwest West (western Oregon and western Washington) is also called the Douglas-fir subregion, and Pacific Northwest East (eastern Oregon and eastern Washington) is also called the ponderosa pine subregion.
[d] Excludes Hawaii.
Source: Historical data for softwoods WWPA 1992–98, AF&PA 1991–2001, USDC 1958–96; for hardwoods AF&PA 1991–2001, USDC 1958–96, Luppold and Dempsey 1989.

Table 41—Population and structural panel consumption in the United States, per capita, by panel type and end use, 1962–98, with projections to 2050

				Panel type		End use					
Year	Population	Per capita use	Total use	Softwood plywood	OSB/wafer-board	New housing	Residential upkeep and improvements	New non-residential construction	Manu-facturing	Packaging and shipping	All other
	Thousands	*Square feet*	*Billion square feet (3/8-inch basis)*								
1962	186,500	51	9.5	9.5	(E)[a]	3.9	1.7	1.7	0.7	0.2	1.3
1970	205,100	69	14.2	14.3	(E)[a]	5.9	2.3	1.9	.9	.3	3.0
1976	218,000	82	17.8	17.7	(E)[a]	8.7	3.2	1.9	1.1	.3	2.6
1986	240,700	107	25.7	21.6	4.2	11.8	7.1	3.1	1.8	.4	1.7
1996	265,500	119	31.6	18.1	13.6	17.0	7.5	2.5	3.2	.5	.8
1998	270,509	129	34.8	17.2	17.6	19.4	7.3	2.9	3.7	.6	.8
2010	298,026	124	36.9	11.5	25.5	18.7	8.9	3.0	3.5	1.3	1.4
2020	323,052	122	39.5	10.3	29.3	19.5	9.4	3.3	3.9	1.9	1.6
2030	347,209	118	40.9	9.9	31.0	18.6	10.0	3.7	4.3	2.6	1.6
2040	370,290	121	44.9	9.9	35.0	20.0	10.8	4.2	4.9	3.6	1.4
2050	394,241	129	50.8	9.9	40.9	21.8	11.8	4.5	5.6	4.8	2.4

Note: Data may not add to totals because of rounding.
[a] (E) = less than 50 million square feet.
Source: Historical data: McKeever 2002.

Table 42—Softwood removals, harvest, growth, and inventory on forest industry timberlands[a] in the contiguous United States, 1952–97, with projections to 2050

	Historical							Projections				
Item	1952	1962	1970	1976	1986	1991	1997	2010	2020	2030	2040	2050
						Million cubic feet						
Northeast:												
Removals	105	92	138	182	273	317	118	160	118	103	95	90
Harvest	99	87	128	168	356	381	144	235	183	159	144	136
Net annual growth	179	236	339	377	188	188	65	140	139	138	135	131
Inventory	5,246	6,427	9,753	10,824	9,191	9,608	5,803	4,848	4,800	5,042	5,358	5,715
North Central:[a]												
Removals	34	23	28	33	37	31	32	17	19	19	20	21
Harvest	30	22	25	28	41	52	34	19	21	21	22	23
Net annual growth	43	44	63	55	50	42	35	45	48	51	50	52
Inventory	917	1,314	1,521	1,690	1,653	1,664	1,426	1,832	2,114	2,420	2,703	3,006
Southeast:												
Removals	325	262	458	518	821	870	961	937	1,457	1,854	1,632	1,530
Harvest	318	252	430	473	740	747	923	927	1,439	1,835	1,613	1,509
Net annual growth	375	411	558	688	725	761	890	1,449	1,517	1,547	1,655	1,684
Inventory	6,803	7,809	8,670	9,142	10,717	10,750	10,231	14,402	17,540	16,826	14,882	16,078
South Central:												
Removals	494	341	564	898	1,088	1,271	1,259	1,370	1,788	2,186	2,318	2,329
Harvest	484	328	530	893	1,045	1,096	1,196	1,312	1,709	2,083	2,212	2,232
Net annual growth	707	971	889	894	829	924	1,135	1,704	2,207	2,399	2,427	2,424
Inventory	9,738	13,087	13,501	14,430	13,515	13,306	14,231	16,088	21,581	25,779	27,129	28,113
Rocky Mountains:												
Removals	99	130	186	177	158	172	154	108	85	90	86	80
Harvest	128	145	138	115	178	198	152	114	92	98	95	88
Net annual growth	79	92	103	105	125	127	126	103	103	120	146	167
Inventory	6,767	6,447	5,939	5,156	5,343	4,815	4,773	3,466	3,513	3,802	4,347	5,166
Pacific Southwest:												
Removals	456	449	318	344	435	401	357	242	230	101	78	65
Harvest	393	385	294	321	452	452	371	269	259	118	91	77
Net annual growth	90	108	135	139	205	244	247	204	187	196	218	233
Inventory	11,268	9,639	8,244	7,457	7,918	9,051	8,592	6,434	5,844	5,913	7,193	8,785
Pacific Northwest West:[b]												
Removals	1,150	909	1,272	1,302	1,222	901	657	976	984	926	937	1,014
Harvest	1,244	976	1,234	1,268	1,244	1,106	643	1,006	1,010	950	957	1,034
Net annual growth	337	393	455	606	915	806	799	952	964	1,005	1,074	1,107
Inventory	32,725	27,399	23,767	21,978	20,137	17,921	17,648	17,179	16,998	17,182	19,551	20,875

Table 42—Softwood removals, harvest, growth, and inventory on forest industry timberlands[a] in the contiguous United States, 1952–97, with projections to 2050 (continued)

	Historical							Projections				
Item	**1952**	**1962**	**1970**	**1976**	**1986**	**1991**	**1997**	**2010**	**2020**	**2030**	**2040**	**2050**
						Million cubic feet						
Pacific Northwest East:[b]												
Removals	103	95	120	162	179	151	144	96	93	97	108	118
Harvest	100	94	117	151	166	100	160	104	100	103	113	124
Net annual growth	62	71	84	85	115	98	85	120	123	132	143	151
Inventory	3,975	3,972	4,038	3,849	4,279	3,842	3,557	3,877	4,163	4,475	4,878	5,248
United States:												
Removals	2,765	2,301	3,084	3,615	4,213	4,114	3,683	3,905	4,774	5,376	5,273	5,247
Harvest	2,796	2,289	2,896	3,417	4,221	4,134	3,623	3,986	4,812	5,366	5,247	5,223
Net annual growth	1,872	2,326	2,626	2,949	3,152	3,190	3,382	4,716	5,288	5,588	5,849	5,949
Inventory	77,439	76,094	75,433	74,526	72,753	70,957	66,261	68,126	76,552	81,438	86,041	92,986

Note: Historical harvest data are estimates of the harvest trends and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data show the average volume that would be harvested given the assumptions of the study. Inventory data for 1952 and 1962 are as of December 31. Inventory data for 1970 and the projection years are as of January 1. Inventory data shown under 1976, 1987, 1991, and 1997 are as of January 1 of following year.

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

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

Source: For historical data, Powell et al. 1993; 1997 data Smith et al. 2001.

Table 43—Hardwood removals, harvest, growth, and inventory on forest industry timberlands[a] in the contiguous United States, 1952–97, with projections to 2050

	Historical							Projections				
Item	1952	1962	1970	1976	1986	1991	1997	2010	2020	2030	2040	2050
						Million cubic feet						
Northeast:												
Removals	47	51	91	121	110	256	158	109	108	108	107	108
Harvest	44	45	69	89	216	253	199	164	130	122	118	121
Net annual growth	129	156	193	226	230	233	196	217	212	206	199	190
Inventory	4,742	5,554	6,819	7,636	8,835	9,090	8,700	10,054	11,019	11,912	12,735	13,469
North Central:[a]												
Removls	74	45	64	69	142	119	105	57	48	48	48	49
Harvest	73	41	57	55	201	258	113	108	95	94	94	94
Net annual growth	99	100	118	118	105	89	86	81	78	71	64	65
Inventory	2,048	2,673	3,129	3,376	3,430	3,620	3,274	3,398	3,622	3,772	3,833	3,935
Southeast:												
Removals	169	158	161	147	185	286	285	194	160	189	230	208
Harvest	127	96	108	107	176	185	257	233	204	185	202	191
Net annual growth	171	174	230	259	246	216	191	179	160	148	149	147
Inventory	5,588	6,220	7,248	7,542	8,157	7,423	6,857	5,013	4,781	4,676	3,984	3,202
South Central:												
Removals	211	375	202	213	322	480	454	358	314	370	400	395
Harvest	157	227	213	184	323	342	430	482	403	334	291	266
Net annual growth	203	285	379	453	348	395	358	370	335	314	312	315
Inventory	5,656	7,753	8,086	9,661	9,594	9,531	9,488	8,678	8,719	8,518	7,717	6,889
Rocky Mountains:[b]												
Removals	3	6	3	3	11	1	3	29	33	36	39	40
Harvest	0	0	1	1	27	0	3	72	77	82	89	92
Net annual growth	2	2	2	2	1	1	8	1	1	1	1	1
Inventory	103	101	100	64	33	33	31	24	22	24	27	32
Pacific Southwest:												
Removals	3	4	5	4	4	11	5	18	16	15	14	14
Harvest	2	3	3	3	24	12	25	49	50	51	53	54
Net annual growth	11	15	24	19	46	54	45	52	53	54	57	56
Inventory	336	449	717	679	1,374	1,634	1,701	2,052	2,396	2,760	3,153	3,564
Pacific Northwest:												
Removals	18	24	44	44	44	39	40	95	87	80	74	70
Harvest	18	22	37	34	57	71	42	138	126	114	105	100
Net annual growth	75	98	124	145	154	111	101	120	121	126	125	121
Inventory	1,900	2,675	3,282	3,355	3,888	3,475	3,475	3,280	3,480	3,839	4,329	4,789

Table 43—Hardwood removals, harvest, growth, and inventory on forest industry timberlands[a] in the contiguous United States, 1952–97, with projections to 2050 (continued)

	Historical							Projections				
Item	**1952**	**1962**	**1970**	**1976**	**1986**	**1991**	**1997**	**2010**	**2020**	**2030**	**2040**	**2050**
						Million cubic feet						
United States:												
Removals	525	663	570	600	818	1,192	1,050	860	766	845	913	883
Harvest	421	434	488	473	1,025	1,120	1,069	1,246	1,084	983	952	919
Net annual growth	690	830	1,070	1,222	1,130	1,099	986	1,020	960	920	907	895
Inventory	20,373	25,425	29,381	32,313	35,311	34,806	33,526	32,497	34,037	35,501	35,776	35,880

Note: Historical harvest data are estimates of the harvest trends and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data show the average volume that would be harvested given the assumptions of the study. Inventory data for 1952 and 1962 are as of December 31. Inventory data for 1970 and the projection years are as of January 1. Inventory data shown under 1976, 1987, 1991, and 1997 are as of January 1 of following year.

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

[b] 1997 increase in growth data is due to changes in inventory procedures.

Source: For historical, data Powell et al. 1993; 1997 data Smith et al. 2001.

Table 44—Softwood removals, harvest, growth, and inventory on nonindustrial private forest (NIPF) timberlands, 1952–97, with projections to 2050

	Historical							Projections				
Item	**1952**	**1962**	**1970**	**1976**	**1986**	**1991**	**1997**	**2010**	**2020**	**2030**	**2040**	**2050**
						Million cubic feet						
Northeast:												
Removals	358	274	263	300	226	162	278	215	214	225	238	246
Harvest	338	258	244	278	296	258	375	285	291	315	341	358
Net annual growth	433	539	510	623	441	457	508	443	408	380	349	318
Inventory	13,438	16,031	16,214	17,976	19,244	20,942	21,563	24,242	25,602	26,440	26,748	26,845
North Central:[a]												
Removals	59	61	72	79	109	117	132	151	161	162	163	162
Harvest	62	63	70	74	119	125	144	166	177	180	182	183
Net annual growth	128	152	170	196	250	240	257	271	261	245	228	216
Inventory	2,610	3,382	4,010	4,899	6,246	7,572	8,155	10,458	11,297	11,914	12,328	12,651
Southeast:												
Removals	1,444	1,234	1,235	1,365	1,821	1,730	1,826	1,758	1,717	1,710	1,977	2,210
Harvest	1,414	1,189	1,157	1,247	1,640	1,456	1,741	1,677	1,644	1,653	1,947	2,183
Net annual growth	1,349	1,567	1,882	2,130	1,656	1,435	1,688	1,968	2,002	2,067	2,011	1,924
Inventory	25,087	28,033	32,179	36,150	35,415	34,590	34,187	37,963	40,298	43,217	45,805	43,810
South Central:												
Removals	606	787	1,117	1,278	1,569	1,548	2,072	1,600	1,732	1,937	2,332	2,859
Harvest	584	748	1,129	1,264	1,507	1,583	1,995	1,545	1,682	1,882	2,257	2,759
Net annual growth	792	1,182	1,668	2,000	1,762	1,572	1,719	1,939	2,066	2,278	2,462	2,385
Inventory	11,273	16,128	23,646	28,760	31,555	29,801	30,408	29,015	32,949	36,815	40,113	38,203
Rocky Mountains:												
Removals	127	111	93	109	137	173	184	284	295	301	317	313
Harvest	79	74	118	147	154	200	221	401	428	449	480	486
Net annual growth	213	247	276	283	315	402	458	382	355	357	379	404
Inventory	12,842	13,649	14,112	14,445	13,029	16,663	16,489	17,095	17,599	18,022	18,564	19,364
Pacific Southwest:												
Removals	542	271	178	145	34	105	145	152	163	209	245	262
Harvest	468	230	163	136	35	59	164	169	183	245	288	311
Net annual growth	178	192	211	197	238	205	270	226	207	203	207	203
Inventory	15,256	12,900	9,608	9,337	9,931	8,679	9,717	10,696	11,078	11,307	10,958	10,412
Pacific Northwest West:[b]												
Removals	302	201	259	200	203	377	305	322	369	408	490	525
Harvest	317	207	245	195	232	427	298	332	378	418	500	535
Net annual growth	265	308	358	340	409	411	404	385	432	511	541	475
Inventory	9,510	9,520	10,304	8,458	10,171	11,145	10,336	10,057	10,858	12,199	13,000	12,604

Table 44—Softwood removals, harvest, growth, and inventory on nonindustrial private forest (NIPF) timberlands, 1952–97, with projections to 2050 (continued)

	Historical							Projections				
Item	1952	1962	1970	1976	1986	1991	1997	2010	2020	2030	2040	2050
	Million cubic feet											
Pacific Northwest East:[b]												
Removals	103	68	49	65	70	108	183	99	126	154	181	201
Harvest	100	67	48	60	65	61	198	106	134	162	190	210
Net annual growth	109	136	148	121	122	164	217	187	191	191	191	193
Inventory	4,495	4,319	4,725	4,604	3,896	7,322	7,321	9,147	9,958	10,492	10,810	10,848
Alaska:[c]												
Removals	([d])	([d])	4	2	61	133	123	58	29	29	29	29
Harvest	([d])	([d])	5	2	54	123	93	60	30	30	30	30
Net annual growth	1	2	2	3	21	19	11	11	11	11	11	11
Inventory	218	283	323	663	7,103	6,646	5,987	4,951	4,626	4,446	4,266	4,086
United States:												
Removals	3,541	3,007	3,270	3,543	4,230	4,453	5,249	4,640	4,806	5,134	5,971	6,807
Harvest	3,362	2,836	3,179	3,403	4,102	4,291	5,188	4,742	4,949	5,334	6,214	7,057
Net annual growth	3,468	4,325	5,232	5,893	5,214	4,906	5,532	5,812	5,934	6,244	6,378	6,130
Inventory	94,729	104,245	115,121	125,292	136,590	143,360	144,163	153,624	164,265	174,852	182,595	178,823

Note: Historical harvest data are estimates of the harvest trends and differ somewhat from the estimates of actual consumption shown in some tables For the projection years, the data show the average volume that would be harvested given the assumptions of the study. Inventory data for 1952 and 1962 are as of December 31. Inventory data for 1970 and the projection years are as of January 1. Inventory data shown under 1976, 1987, 1991, and 1997 are as of January 1 of following year.

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

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

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

[d] Less than 0.5 million cubic feet.

Source: For historical data, Powell et al. 1993; 1997 data Smith et al. 2001.

Table 45—Hardwood removals, harvest, growth, and inventory on nonindustrial private forest (NIPF) timberlands, 1952–97, with projections to 2050

	Historical							Projections				
Item	**1952**	**1962**	**1970**	**1976**	**1986**	**1991**	**1997**	**2010**	**2020**	**2030**	**2040**	**2050**
	Million cubic feet											
Northeast:												
Removals	424	503	591	623	630	472	643	784	895	932	981	1,053
Harvest	404	438	448	462	1,241	1,315	999	1,016	1,323	1,578	1,746	1,883
Net annual growth	1,018	1,296	1,465	1,491	1,620	1,857	1,767	1,485	1,483	1,476	1,443	1,394
Inventory	32,669	39,863	44,751	49,457	58,505	66,086	67,680	80,263	86,094	90,559	93,828	96,395
North Central:[a]												
Removals	629	661	797	793	932	875	857	826	890	912	950	973
Harvest	751	685	738	737	1,326	1,542	1,079	1,253	1,262	1,312	1,376	1,480
Net annual growth	961	980	1,084	1,137	1,377	1,288	1,525	1,651	1,630	1,577	1,513	1,441
Inventory	24,385	29,009	31,821	35,636	42,884	48,881	53,655	66,700	73,478	79,288	84,098	87,761
Southeast:												
Removals	817	861	843	801	1,096	1,049	1,138	1,526	1,665	1,738	1,703	1,678
Harvest	617	523	566	586	1,043	1,053	1,035	1,457	1,580	1,600	1,547	1,507
Net annual growth	1,020	1,175	1,439	1,715	1,633	1,526	1,559	1,539	1,455	1,459	1,471	1,492
Inventory	32,316	36,288	40,583	46,478	51,487	52,594	54,432	55,250	53,637	50,860	48,159	46,007
South Central:												
Removals	1,396	1,313	1,012	948	1,208	1,143	1,633	2,065	2,337	2,446	2,517	2,537
Harvest	937	730	848	713	1,212	1,171	1,535	2,322	2,420	2,487	2,550	2,592
Net annual growth	1,424	1,459	1,845	2,117	1,800	2,116	2,239	2,212	2,153	2,123	2,160	2,171
Inventory	37,669	39,691	42,243	45,836	53,471	59,684	60,699	62,795	62,426	59,465	56,139	52,562
Rocky Mountains:[b]												
Removals	27	18	18	17	7	19	20	38	41	44	47	48
Harvest	1	1	1	1	17	9	29	83	89	94	100	103
Net annual growth	46	51	57	60	84	102	284	49	42	41	41	42
Inventory	2,251	2,412	2,600	2,720	3,462	4,245	4,971	2,942	2,907	2,838	2,751	2,657
Pacific Southwest:												
Removals	4	7	10	8	1	3	2	31	26	22	19	17
Harvest	2	4	7	7	8	32	14	61	59	58	58	58
Net annual growth	29	30	40	36	95	84	80	93	89	83	78	72
Inventory	998	1,050	1,562	1,598	3,352	2,992	4,208	5,068	5,646	6,226	6,599	6,914
Pacific Northwest:												
Removals	8	29	22	47	7	30	46	141	126	113	101	94
Harvest	6	24	16	37	9	95	51	189	168	149	133	124
Net annual growth	99	131	156	148	189	163	150	165	170	173	162	163
Inventory	3,197	3,972	4,711	3,807	5,201	5,350	5,185	5,576	5,876	6,378	6,915	7,560

Table 45—Hardwood removals, harvest, growth, and inventory on nonindustrial private forest (NIPF) timberlands, 1952–97, with projections to 2050 (continued)

	Historical							Projections				
Item	**1952**	**1962**	**1970**	**1976**	**1986**	**1991**	**1997**	**2010**	**2020**	**2030**	**2040**	**2050**
						Million cubic feet						
Alaska:[c]												
Removals	([d])	([d])	([d])	([d])	([d])	3	3	3	3	3	3	3
Harvest	([d])	([d])	([d])	([d])	([d])	3	3	3	3	3	3	3
Net annual growth	([d])	([d])	([d])	([d])	38	38	21	43	50	58	68	79
Inventory	39	82	102	121	2,312	2,312	1,040	1,415	1,850	2,360	2,960	3,665
United States:												
Removals	3,305	3,392	3,293	3,237	3,881	3,594	4,341	5,413	5,983	6,211	6,322	6,403
Harvest	2,718	2,405	2,624	2,543	4,856	5,249	4,663	6,385	6,904	7,281	7,511	7,750
Net annual growth	4,597	5,122	6,086	6,704	6,836	7,174	7,625	7,237	7,072	6,990	6,936	6,852
Inventory	133,524	152,367	168,373	185,653	220,674	242,144	251,870	280,009	291,913	297,974	301,449	303,521

Note: Historical harvest data are estimates of the harvest trends and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data show the average volume that would be harvested given the assumptions of the study. Inventory data for 1952 and 1962 are as of December 31. Inventory data for 1970 and the projection years are as of January 1. Inventory data shown under 1976, 1987, 1991, and 1997 are as of January 1 of following year.

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

[b] 1997 increase in growth data is due to changes in Rocky Mountain inventory procedures.

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

[d] Less than 0.5 million cubic feet.

Source: For historical data, Powell et al. 1993; 1997 data Smith et al. 2001.

Table 46—Structural panel consumption, imports, exports, and production in the United States, 1962–98, with projections to 2050

Year	Consumption			Imports			Exports			Production		
	Total	Softwood plywood	OSB/ waferboard	Total	Softwood plywood	OSB/ waferboard	Total	Softwood plywood	OSB/ waferboard	Total	Softwood plywood[a]	OSB/ waferboard
	Billion square feet (3/8-inch basis)											
1962	9.5	9.5	([b])	([b])	([b])	([b])	([b])	([b])	([b])	9.5	9.5	([b])
1970	14.2	14.2	([b])	([b])	([b])	([b])	0.1	0.1	([b])	14.3	14.3	([b])
1976	17.8	17.7	0.1	([b])	([b])	([b])	.7	.7	([b])	18.5	18.4	0.1
1986	25.7	21.6	4.2	0.8	0.1	0.7	.6	.6	([b])	25.6	22.0	3.5
1996	31.6	18.0	13.6	4.5	.1	4.4	1.4	1.2	.2	28.5	19.2	9.3
1998	34.8	17.2	17.6	6.7	.2	6.5	.9	.8	.1	29.0	17.8	11.2
2010	36.9	11.5	25.5	10.3	.1	10.3	1.0	1.0	([b])	27.6	12.4	15.2
2020	39.5	10.3	29.3	10.7	.1	10.6	1.0	1.0	([b])	29.9	11.2	18.7
2030	40.9	9.9	31.0	10.4	.1	10.3	1.0	1.0	([b])	31.5	10.8	20.7
2040	44.9	9.9	35.0	11.0	.2	10.8	1.0	1.0	([b])	34.9	10.8	24.2
2050	50.8	9.9	40.9	13.2	.2	13.0	1.0	1.0	([b])	38.7	10.8	27.9

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

[a] Includes production from both domestic and imported species.

[b] Less than 50 million square feet.

Table 47—Structural panel production in the contiguous United States by region, 1962–96, with projections to 2050

Species group and region	Historical					Projections				
	1962	1970	1976	1986	1996	2010	2020	2030	2040	2050
	Billion square feet (3/8-inch basis)									
Softwoods:										
Northeast	0	0	0.1	0.6	1.0	2.7	3.8	4.5	5.2	6.2
North Central[a]	0	0	.1	1.7	3.0	4.0	4.8	5.3	6.0	7.2
Southeast	0	.9	1.7	3.5	6.2	7.2	7.3	7.6	8.8	9.4
South Central	0	2.4	5.1	8.7	12.2	9.6	10.7	11.0	11.7	12.5
Rocky Mountains	.2	.9	1.2	1.4	1.3	1.3	1.3	1.3	1.3	1.5
Pacific Northwest[b]										
West[c]	8.0	8.7	8.8	8.6	3.8	1.7	.9	.8	.8	.8
East[c]	.1	.6	.9	.9	1.0	1.1	1.1	1.1	1.1	1.1
Pacific Southwest[d]	1.2	.8	.6	.1	0	0	0	0	0	0
United States	9.5	14.3	18.5	25.6	28.5	27.6	29.9	31.5	34.9	38.7

Note: Data may not add to totals because of rounding.
[a] The Great Plains are included in the North-Central region.
[b] Excludes Alaska.
[c] Pacific Northwest West (western Oregon and western Washington) is also called the Douglas-fir subregion, and Pacific Northwest East (eastern Oregon and eastern Washington) is also called the ponderosa pine subregion.
[d] Excludes Hawaii.

Table 48—Nonstructural panel consumption, imports, exports, and production in the United States by type, 1962–97, with projections to 2050

	Consumption					Imports				
Year	Total	Hardwood plywood	Insulating board	Hard-board	Particle-board[a]	Total	Hardwood plywood	Insulating board	Hard-board	Particle-board[a]
	Billion square feet (3/8-inch basis)									
1962	8.0	2.4	3.8	0.9	0.8	1.1	0.9	([b])	0.1	([b])
1970	13.5	3.8	4.3	1.7	3.7	2.3	2.0	.1	.2	([b])
1976	17.0	3.4	4.5	2.3	6.9	2.7	2.4	.1	.2	0.1
1986	21.2	4.5	3.2	2.1	11.4	6.7	3.2	.5	.3	2.8
1990	17.6	3.0	3.3	1.7	9.5	3.0	1.6	.4	.2	.7
1997	21.7	3.6	3.3	1.5	13.4	4.8	2.0	.4	.4	1.9
2010	25.8	3.5	3.5	2.1	16.7	5.8	1.7	.4	.6	3.1
2020	26.8	3.2	3.3	2.2	18.1	6.2	1.7	.4	.6	3.5
2030	27.8	3.0	3.0	2.3	19.6	6.6	1.7	.5	.7	3.8
2040	29.4	2.7	2.7	2.4	21.6	7.1	1.7	.5	.7	4.2
2050	30.9	2.4	2.4	2.5	23.6	7.5	1.7	.5	.7	4.5

	Exports					Production				
Year	Total	Hardwood plywood	Insulating board	Hard-board	Particle-board[a]	Total	Hardwood plywood	Insulating board	Hard-board	Particle-board[a]
	Billion square feet (3/8-inch basis)									
1962	([b])	([b])	([b])	([b])	([b])	7.0	1.5	3.8	0.8	0.8
1970	0.2	0.1	0.1	([b])	([b])	11.2	1.8	4.3	1.5	3.7
1976	.4	.1	.1	0.1	0.2	14.8	1.1	4.5	2.3	6.9
1986	.5	.1	.2	.1	.2	15.0	1.4	2.9	1.9	8.8
1990	1.3	.2	.2	.2	.7	15.9	1.5	3.2	1.7	9.5
1997	1.3	.3	.2	.4	.4	18.2	1.8	3.1	1.5	11.8
2010	1.7	.3	.3	.3	.8	21.7	2.1	3.4	1.8	14.4
2020	1.7	.3	.3	.3	.8	22.3	1.9	3.1	1.9	15.5
2030	1.8	.3	.3	.3	.8	22.9	1.6	2.8	1.9	16.6
2040	1.8	.4	.3	.3	.9	24.2	1.4	2.5	2.0	18.3
2050	1.9	.4	.3	.3	.9	25.3	1.1	2.2	2.1	20.0

Note: Data may not add to total because of rounding.
[a] Includes medium density fiberboard.
[b] Less than 50 million square feet.
Source: Historical: McKeever 2002 from Ulrich 1989 and Howard 2001.

Table 49—Private timberlands area by seral stages

Species and area	Seral stage: Seedlings[a]	Poles-saplings[b]	Young[c]	Mature[d]	Old mature[e]	Total
	Thousand acres					
Hardwood:						
North—						
2000	11,095	29,946	36,476	28,759	616	106,891
2010	8,868	27,489	41,334	29,189	1,261	108,140
2020	7,358	27,715	32,877	37,908	1,587	107,445
2030	7,040	28,049	29,471	38,916	2,856	106,333
2040	6,489	23,601	27,184	43,880	3,574	104,728
2050	6,562	21,132	27,378	42,124	6,171	103,367
South—						
2000	6,061	18,915	42,498	19,180	8,867	95,521
2010	4,944	19,423	35,764	18,221	12,026	90,379
2020	5,622	15,236	39,558	13,302	13,255	86,973
2030	6,298	18,201	38,811	8,461	12,955	84,726
2040	6,329	21,238	39,377	6,726	10,354	84,025
2050	6,117	23,031	40,795	6,030	8,010	83,982
West—						
2000	461	1,571	1,837	3,308	81	7,259
2010	633	1,409	1,515	3,437	72	7,067
2020	562	1,527	1,095	3,666	117	6,966
2030	451	1,673	898	3,705	187	6,915
2040	474	1,680	795	3,617	327	6,893
2050	477	1,523	942	3,466	490	6,900
Softwood:						
North—						
2000	2,859	5,394	8,048	6,977	230	23,508
2010	3,525	2,692	9,238	6,604	311	22,371
2020	2,643	2,917	6,840	8,620	353	21,373
2030	2,099	3,566	5,593	8,394	548	20,200
2040	1,691	2,673	4,550	9,486	653	19,052
2050	1,750	2,118	4,118	9,133	1,102	18,222
South—						
2000	12,102	25,294	31,641	14,548	901	84,487
2010	11,853	25,840	38,882	11,693	793	89,061
2020	10,602	23,147	45,067	12,045	967	91,828
2030	11,209	21,770	43,567	15,827	1,322	93,695
2040	11,325	22,179	39,450	18,928	1,818	93,701
2050	11,606	22,638	39,152	17,372	2,275	93,043

Table 49—Private timberlands area by seral stages (continued)

Species and area	Seral stage: Seedlings[a]	Poles-saplings[b]	Young[c]	Mature[d]	Old mature[e]	Total
	Thousand acres					
West—						
2000	6,407	9,299	10,689	12,149	2,581	41,124
2010	4,568	13,983	7,528	12,563	2,352	40,994
2020	3,478	16,050	6,493	11,386	3,450	40,856
2030	3,369	14,638	8,114	11,028	3,447	40,596
2040	3,266	11,579	12,074	8,748	4,893	40,559
2050	3,640	10,238	13,888	6,850	5,806	40,422

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

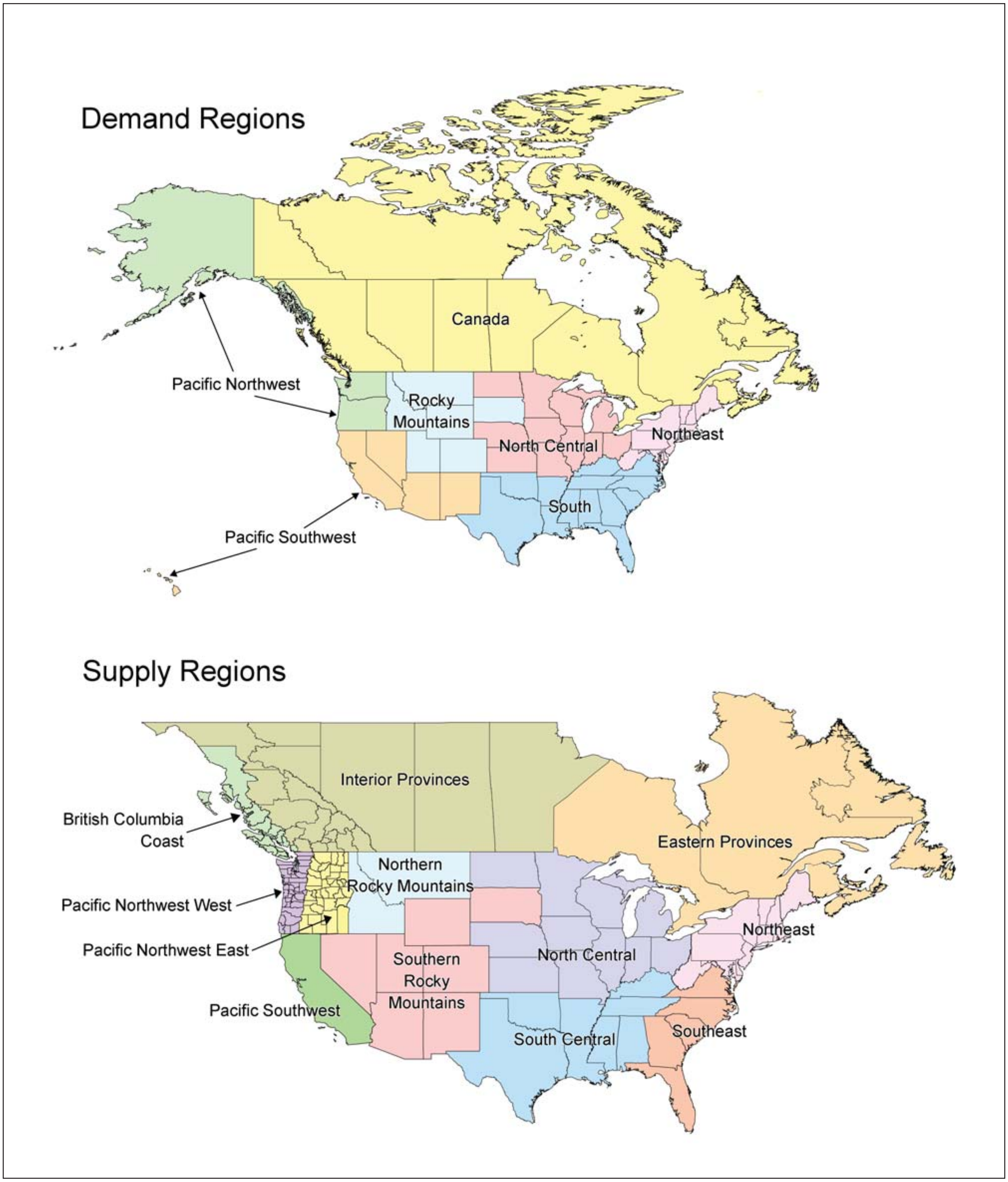
Table 50—National forest timberlands area by seral stages

Species and area	Seral stage: Seedlings[a]	Poles-saplings[b]	Young[c]	Mature[d]	Old mature[e]	Total
	Thousand acres					
Softwood:						
North—						
2000	400	599	1,147	613	100	2,859
2010	261	571	1,151	778	98	2,859
2020	220	400	1,066	1,062	111	2,859
2030	197	263	889	1,372	139	2,859
2040	180	221	751	1,511	197	2,859
2050	167	199	558	1,691	245	2,859
South—						
2000	382	716	1,787	2,726	301	5,912
2010	126	511	1,602	3,149	525	5,912
2020	142	268	1,516	3,061	925	5,912
2030	134	286	1,147	2,949	1,396	5,912
2040	118	259	961	2,767	1,807	5,912
2050	116	234	952	2,461	2,149	5,912
West—						
2000	4,121	4,079	13,669	29,356	15,939	67,164
2010	428	7,148	9,598	30,792	19,198	67,164
2020	434	6,157	7,680	30,155	22,737	67,164
2030	515	5,063	6,917	26,965	27,704	67,164
2040	474	1,456	9,645	24,516	31,072	67,164
2050	508	1,501	9,080	20,343	35,732	67,164
Hardwood:						
North—						
2000	486	1,320	2,819	2,312	192	7,129
2010	224	1,452	1,918	3,315	221	7,129
2020	221	1,203	1,560	3,862	285	7,129
2030	197	938	1,367	4,259	369	7,129
2040	187	643	1,512	4,169	618	7,129
2050	173	609	1,273	4,236	837	7,129
South—						
2000	205	326	1,843	1,457	1,308	5,139
2010		333	1,219	1,680	1,907	5,139
2020			883	1,491	2,765	5,139
2030			641	910	3,587	5,139
2040			426	457	4,256	5,139
2050			205	437	4,498	5,139

Table 50—National forest timberlands area by seral stages (continued)

Species and area	Seral stage					Total
	Seedlings[a]	Poles-saplings[b]	Young[c]	Mature[d]	Old mature[e]	
			Thousand acres			
West—						
2000	362	414	432	2,857	386	4,451
2010		657	281	3,053	459	4,451
2020		515	261	3,081	593	4,451
2030		362	296	3,012	780	4,451
2040			516	2,612	1,323	4,451
2050			362	2,381	1,707	4,451

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



Demand Regions
Canada
Pacific Northwest
Rocky
Mountains
North Central
Northeast
South
Pacific Southwest
Supply Regions
Interior Provinces
British Columbia
Coast
Eastern Provinces
Northern
Rocky Mountains
Pacific Northwest West
Pacific Northwest East
Northeast
North Central
Southern
Rocky
Mountains
Pacific Southwest
South Central
Southeast