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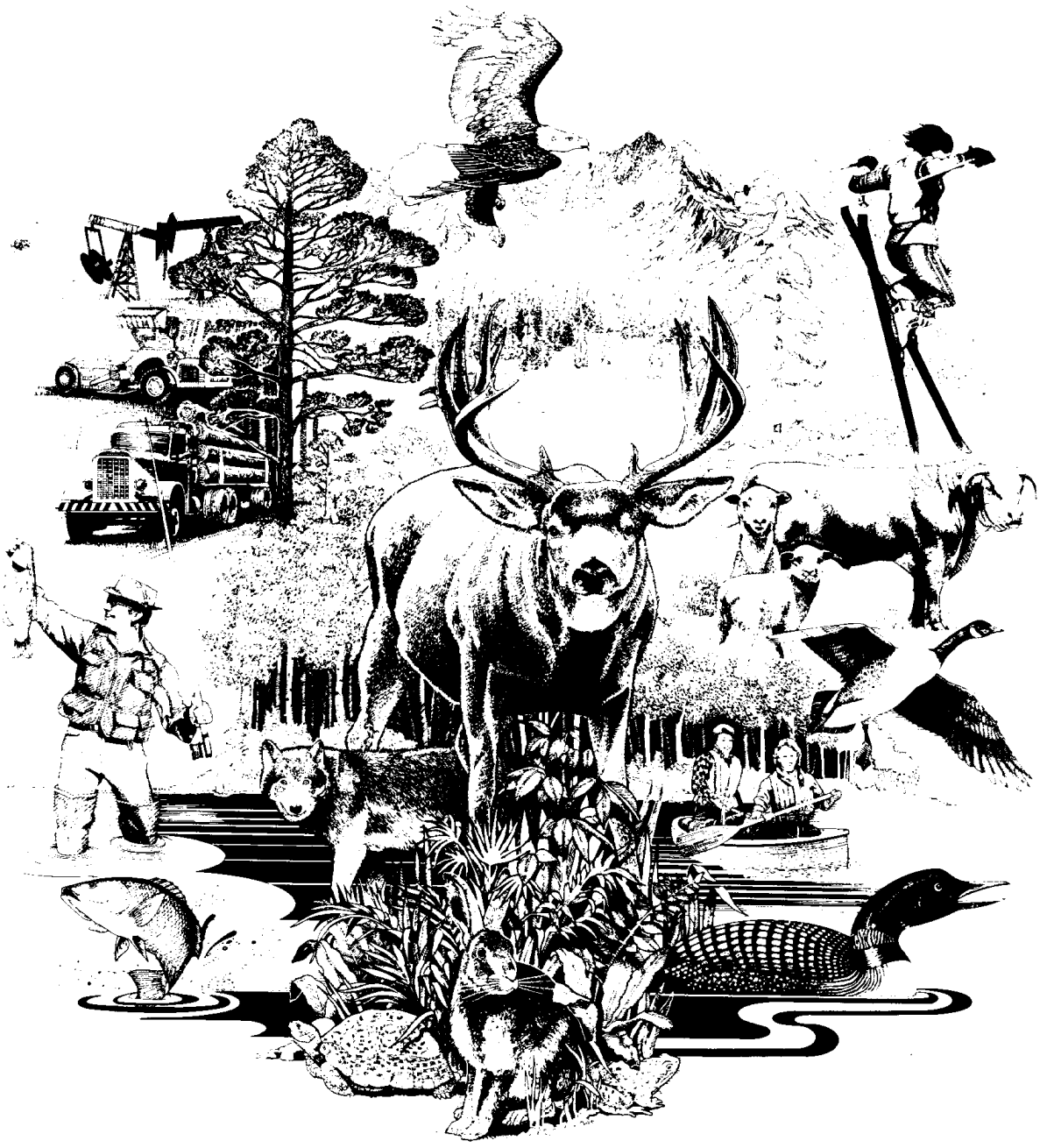
**General Technical
Report RM-199**

An Analysis of the Timber Situation in the United States: 1989–2040

A Technical Document Supporting the 1989 USDA Forest Service RPA Assessment



Preface

The Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA), P.L. 93-378, 88 Stat. 475, as amended, directed the Secretary of Agriculture to prepare a Renewable Resources Assessment by December 31, 1975, with an update in 1979 and each 10th year thereafter. This Asessment is to include "an analysis of present and anticipated uses, demand for, and supply of the renewable resources of forest, range, and other associated lands with consideration of the international resource situation, and an emphasis of pertinent supply, demand and price relationship trends" (Sec. 3.(a)).

The 1989 RPA Assessment is the third prepared in response to the RPA legislation. It is composed of 12 documents, including this one. The summary Assessment document presents an overview of analyses of the present situation and the outlook for the land base, outdoor recreation and wilderness, wildlife and fish, forest-range grazing, minerals, timber, and water. Complete analyses for each of these resources are contained in seven supporting technical documents. There are also technical documents presenting information on interactions among the various resources, the basic assumptions for the Assessment, a description of Forest Service programs, and the evolving use and management of the Nation's forests, grasslands, croplands, and related resources.

The Forest Service has been carrying out resource analyses in the United States for over a century. Congressional interest was first expressed in the Appropriations Act of August 15, 1876, which provided $2,000 for the employment of an expert to study and report on forest conditions. Between that time and 1974, Forest Service analysts prepared a number of assessments of the timber resource situation intermittently in response to emerging issues and perceived needs for better resource information. The 1974 RPA legislation established a periodic reporting requirement and broadened the resource coverage from timber to all renewable resources from forest and rangelands.

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An Analysis of the Timber Situation in the United States: 1989–2040

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The authors of Chapter 1, **Overview**, were David R. Darr and Richard W. Haynes.

The principal authors of Chapter 2, **Recent Trends in the Consumption of Timber Products**, were Robert B. Phelps and David B. McKeever. The author of the section on New Nonresidential Construction was Henry Spelter. Duane Finkel authored the section on Silvichemicals. Irene Durbak authored the sections on Pulpwood Consumption and Railroad Construction. The author of the section on Fuelwood Consumption and Production was Kenneth Skog.

Chapter 3, **Domestic Timber Resources**, was authored by Daniel D. Oswald. The information on Forest Statistics was compiled by Karen Waddell and Daniel D. Oswald. They were assisted by the following members of the Forest Inventory and Analysis Research Work Units at Forest Experiment Stations: Theodore Setzer, Vernon J. LaBau, Gary Carroll, Bruce Hiserote, Thomas Farrenkopf, Sharon Woudenberg, Robert Nevel, David Dickson, Thomas Frieswyk, James Blyth, William B. Smith, John Tansey, Larry Royer, Robert Cathey, Carl Bylin, William McWilliams, and Dennis May. The following provided the same coordination and data submission assistance from Timber Management Staffs at the Regional Offices of the Forest Service: James Laux, Moxon Hart, Daniel Greene, Mel Mehl, Pat D. Jackson, Henry Cheatham, Allen Toby, Ralph Warbington, Carl Bronson, John Teply, Marianne Sheets, Karl Stoneking, Ray Ellis, Richard Hesse, and George Rogers.

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Donald F. Flora and David Brooks were the authors of Chapter 5, **International Trade in Forest Products**.

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The principal authors of Chapter 10, **Opportunities to Change Timber Demand through Altered Timber Utilization**, were Kenneth Skog—Recent Trends in Improving Wood Utilization, Softwood and Composite Lumber Processing, and Impacts of Currrent Research; Dennis Bradley—Timber Harvesting; Henry Spelter—Structural Panel Processing, and Timber Products Use in Construction; Irene Durbak, Peter Ince, and William Lange—Pulp and Paper Processing; Philip Araman—Hardwood Lumber Processing; David B. McKeever—Timber Products Use in Manufacturing and Shipping; John Zerbe—Wood Energy. Other contributors were Michael Thompson, Donald Sirois, Bryce Stokes, Penn Peters, Michael Gonsior, Charles Mann, and Robert McGaughey.

Appendix A, **A Glossary of Forest Inventory Terms Used in the Assessment**, was prepared by Douglas Powell.

Appendix B, **Conversion Factors for Forestry and the Timber Products Industry**, was prepared by Kristine C. Jackson.

Appendix C, **Previous Assessments Bibliography**, was prepared by Kristine C. Jackson.

The planning and general direction of the study and much of the final drafting were provided by Richard W. Haynes, assisted by Judy L. Mikowski.

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An Analysis of the Timber Situation in the United States: 1989–2040

Richard W. Haynes, Coordinator

CHAPTER 1. OVERVIEW

The Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974 as amended by the National Forest Management Act of 1976 directs the Secretary of Agriculture to prepare a Renewable Resource Assessment. The purpose of this Assessment is to analyze the timber resource situation in order 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 that may be judged desirable to change and it identifies developing opportunities that may stimulate both private and public investments. The study is primarily concerned with prospective trends in demands and supplies of timber and the determinants of these trends, the implications of these trends, the land and timber resource base, and the opportunities to manage and use this resource base to meet private and public sector goals.

The map shown on the back cover shows the regional detail used in this Assessment. Much of the information presented in this Assessment will be for the 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, Great Plains, Rockies, Pacific Southwest, Douglas-fir or Pacific Northwest-West, and Pine or Pacific Northwest-East subregions). The Assessment regions correspond to U.S. Forest Service Regions in the East and aggregations of U.S. Forest Regions in the West. All dollar values are given in constant 1982 dollars, unless otherwise noted.

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

TRENDS IN PRODUCT CONSUMPTION

Trends in consumption of timber products reflect the interactions of variables that determine demands and supplies. Increases in U.S. population, income, and economic activity have been strong forces in the growth of demand for timber products. The availability of supplies of roundwood and timber products also influenced the amount of timber products consumed. For example, the development of the softwood plywood industry in the South had a dramatic effect on the availability of wood for use in home construction. Increased imports of softwood lumber from Canada in the 1970s and 1980s have retarded the rates of price increases of softwood lumber, leading to increased consumption. Between 1950 and 1988, these trends in demand and supply determinants led to a nearly 50% increase in softwood lumber consumption. The volume of paper and board consumption nearly tripled, and for softwood plywood, consumption increased more than 7 times.

In total, the consumption of industrial roundwood rose from about 10 billion cubic feet in 1950 to nearly 17 billion cubic feet in 1988. Industrial roundwood does not include fuelwood. The oil price shocks of the 1970s caused a resurgence in the use of wood for fuel after decades of decline. The softening in the real price of petroleum-based energy in the 1980s, however, has led to reduced consumption of fuelwood. While the net effect was an increase in fuelwood consumption, much of this wood originates on land other than timberland and thus its effect on the consumption of industrial roundwood is lessened.

Future consumption of timber products is assumed to be the end result of interactions of determinants of demands and supplies, as it has been in the past. The projections of increased population and economic activity on the demand side and management of the timber resource on the supply side lead to a continuation in the growth of consumption of most timber products. Consumption of lumber, structural panels, pulp, and fuelwood are expected to grow through the coming decades as follows:

Product	1986	2040
Lumber (billion board feet)	56.8	69.4
Structural panels (billion square feet 3/8-inch basis)	24.9	39.8
Paper and board (million tons)	81.7	173.0
Fuelwood (roundwood, billion cubic feet)	3.1	5.4

In the latter part of the projection period, consumption of fuelwood is projected to decline somewhat because the cost of petroleum-based energy is assumed to level off after rising through 2020. These projections have in them explicit assumptions about technology. For example, softwood lumber recovery is assumed to increase 19% in the South by the end of the projection period.

When all products are converted to roundwood equivalent and added together, the results show that consumption rises from 20.5 billion cubic feet in 1986 to 28.6 billion cubic feet in 2040. For softwoods, the increase is from 14.3 billion cubic feet in 1986 to 17.5 billion cubic feet in 2040 and for hardwoods, from 6.2

billion cubic feet to 11.1 billion cubic feet. The faster rate of growth in consumption of hardwoods largely reflects increased use of hardwood roundwood for pulpwood and OSB/waferboard.

Much of the projected increase is in consumption of pulp products. Consequently, pulpwood accounts for about 38% of roundwood consumption in 2040 compared with 28% in 1986.

TRADE

Part of the projected increases in consumption will be based on imports. Between 1950 and 1987, the roundwood equivalent of the imports of timber products, mainly softwood lumber, wood pulp, newsprint, and hardwood plywood and veneer—increased from 1.5 to 1.9 billion cubic feet. Much of the increase was based on development of the Canadian softwood resource, especially interior British Columbia. Increases in softwood lumber imports from Canada in the 1980s led to a trade dispute between the two countries that was settled by a Memorandum of Understanding on softwood lumber trade. This trade was also at issue earlier in this century. For the purposes of projections, however, it is assumed that trade between the two countries will be based on the inherent competitiveness of the forest products industries in the two countries, rather than trade constraints.

In the absence of a national assessment of the timber supply/demand outlook in Canada, there has developed a difference of opinion about the potential for increased output of forest products in that country. One view is that the industry has exceeded the sustainable harvest level in some parts of the country and that for the Nation as a whole, the industry is near the sustainable harvest level. An opposing view is that Canada has large acreages of low quality, currently economically inaccessible timber that will come on to the market as timber prices rise. The exact volume of this timber is unknown but may be enough to increase the allowable cut by tens of millions of cubic meters. Also, there is potential for extending timber supplies through application of technology in processing.

Deforestation, global climate change and other issues have come to be associated with trade in tropical hardwood timber products. In addition, hardwood log export restrictions in Southeast Asia have shifted the origin of most U.S. imports of tropical hardwood veneer and plywood from South Korea and the Philippines to Indonesia. Tropical hardwood products will continue to be available on world markets in the foreseeable future, but the volumes, costs, and origins of these products are increasingly uncertain as projections go beyond the turn of the century.

About the turn of the century, New Zealand and Chile have the potential to be major sources of softwood fiber on world markets with Pacific Rim countries being the likely destination of any increased exports. In addition, Brazil and other countries have the potential to expand pulp shipments in world markets based on plantation forests. Depending on currency exchange rates, other countries such as Sweden can be competitive in the U.S. market for paper.

There is potential for expanded growth in world trade in timber products. For the purposes of this study, however, it is assumed that the United States will continue to rely on Canada for softwood product imports and Southeast Asia for hardwood product imports. In view of the uncertainties about future growth in supplies from these sources, imports are assumed to stay near current levels of about 4 billion cubic feet, roundwood equivalent.

Exports of timber products, chiefly pulpwood-based products and softwood logs and lumber, increased from 140 million cubic feet in 1950 to 2,655 million cubic feet in 1987. Since 1985, the U.S. dollar has been weak as compared with the Japanese yen and other currencies. This, in combination with export promotion programs of U.S. industry and the Foreign Agricultural Service have led to expanded exports of solid-wood products in the late 1980s. It is uncertain as to whether this momentum can be maintained if the U.S. dollar rises in relation to other currencies. In addition, the potential effects of New Zealand, Chile, and Brazil on world markets is uncertain. It is assumed that total U.S. exports measured in roundwood equivalent will increase from about 2 billion cubic feet currently to 2.5 billion cubic feet in 2040, and some change in product mix is assumed. For example, exports of softwood logs from Washington and Oregon are assumed to decline while exports of softwood lumber are assumed to increase. This reflects an expected decline in availability of high-quality, old-growth timber and further success of trade promotion efforts.

Current GATT negotiations, further integration of the European Economic Community in 1992, on-going negotiations with the Japanese, and the Free Trade Agreement with Canada could all have significant effects on U.S. trade in timber products in the coming decade and beyond. Therefore, the pattern of U.S. imports and exports in timber products will be a major factor to be analyzed in the next update of this series of studies.

Given the above assumptions, annual net imports will decline from 2.5 to 1.5 billion cubic feet by 2040. Thus, most of the domestic U.S. consumption will continue to be based on the domestic resource.

CONSUMPTION FROM DOMESTIC FORESTS

After allowances for improvements in utilization, technology, and the international trade outlook, projected consumption of timber from domestic forests increases from 18 billion cubic feet in 1986 to 27.1 billion cubic feet in 2040. For softwoods, the increase is from 11.7 billion cubic feet to 15.8 billion cubic feet and for hardwoods, from 6.3 to 11.3 billion cubic feet.

The U.S. Timber Resource

The United States has a very large domestic timber resource. About 731 million acres—32% of the country's

area—is forest land. Nearly two-thirds of this, or 483 million acres, is classified as timberland—defined as land capable of producing at least 20 cubic feet of industrial wood per acre per year and not reserved for uses that are not compatible with timber production.

Farmer and other private ownerships—a diverse group that includes people from a cross section of the population and firms other than those in the forest industries—contain 276 million acres, some 57% of the timberland. Another 71 million acres, 15% of the total, is owned by forest industries. The remaining area, some 136 million acres, or 28% of the total, is in public ownership. The largest part of this, 85 million acres, is in national forests.

Softwoods predominate in the Nation's timber inventory. In 1987, there was a total of 451 billion cubic feet of softwood growing stock including 2,032 billion board feet of sawtimber. The largest portion of the softwood timber inventory in 1987 was in national forests, including some 41% of all softwood growing stock and 47% of the softwood sawtimber. Most of the timber was in old-growth stands in the western United States. Some 30% of the softwood growing stock and 25% of the sawtimber was in farmer and other private ownerships. Most of this volume was in the East. Another 16% of the softwood growing stock and 15% of the softwood sawtimber volume was in forest industry ownership. Over half of this was in the West.

Hardwood growing stock inventory in 1977 totaled 305 billion cubic feet. About 70% of these inventories were on farmer and other private ownerships and 11% on forest industry ownerships. The bulk of the hardwood timber in these ownerships was in the East and about equally divided between the North and South.

Trends in Inventories, Net Annual Growth, and Harvests

By most measures, the domestic timber situation has been improving. For example, between 1952 and 1987, softwood growing stock inventories increased 5% and hardwoods, 69%. Softwood sawtimber inventories declined 2.8% and hardwood inventories increased 85%. The increase in inventories has been mainly on the young stands in the North, South, and western Washington and Oregon on the farmer and other private ownerships. Softwood growing stock inventories on national forests in the West declined between 1952 and 1977 because of the harvest of old-growth stands with high inventories per acre. Since 1977, large areas of timberland have been taken out of timber production and this is reflected in the drop of 25% in national forest inventories between 1977 and 1987 in Washington and Oregon. Softwood inventories on forest industry ownerships in Washington and California increased between 1977 and 1987, reflecting the growth of young timber on harvested acres. Inventories continued to decline in Oregon. Timber inventories in the Rocky Mountain region, where harvests are at a relatively low level, have changed little since 1952, with most of the volume in Idaho and Montana.

The increase in inventories reflects net annual timber growth/removal balances. Since 1952, net annual growth of softwoods in the eastern sections of the United States has been higher than removals which are defined as harvest of roundwood products plus logging residues and loss of timber inventory from changes in land use and clearing. In 1986, net annual growth of eastern softwood growing stock exceeded removals by 670 million cubic feet, or 10%. Most of the excess of net annual growth over removals was on the farmer and other private ownerships.

For the western United States, removals of softwood growing stock in 1986 exceeded net annual growth by 836 million cubic feet, or 17%. Most of the excess of removals over growth was on the forest industry and national forest ownerships in the Pacific Coast section. In the Rocky Mountain region, net annual growth was over two times removals in 1986.

Net annual growth of eastern hardwoods in 1986 substantially exceeded removals, particularly in the North. For the entire East, net annual growth of hardwood growing stock was 8.8 billion cubic feet, some 78% above removals. The greatest part of the surplus was in farmer and other private ownerships, although growth exceeded harvest on all ownerships.

Outlook for Roundwood Consumption by Region

The current growth/removal balances show that the hardwood forests and eastern softwood forests can now support additional timber harvests. These balances will, of course, change as growth and removals change over time. Given the demand and supply assumptions in this study, it is apparent that timber harvests will increase substantially during the coming decades.

There are important differences in the outlook among the major softwood timber producing regions. The projected softwood growing stock removals in the contiguous states of the Pacific Coast region decline from 4.1 billion cubic feet in 1986 to 3.6 billion board feet in 2000 and then increase to 3.8 billion cubic feet by 2040. The major cause of the decline in the Pacific Coast region is harvest of the remaining old-growth timber on forest industry lands. The old-growth inventory in this ownership class is being liquidated and harvests from second-growth stands cannot offset the decline in supplies from old-growth stands for several decades. The timber supply outlook on public lands in the West is uncertain; many issues that are currently being debated could have a downward influence on timber supplies from these lands.

The supply/demand outlook in the South is strongly influenced by projected increase in the area of pine plantations in this region of the country. Until these plantations begin to reach maturity, the growth/removal balance is near 1.0 and there are periods when the softwood inventory is drawn down to support existing harvest. Even with the plantations, removals exceed net annual growth in 2040. There are also increases in consumption in the North and Rocky Mountains, but on a much smaller scale.

Hardwood roundwood consumption is projected to increase significantly in both the North and South. By 2040, consumption in the North is almost two-thirds higher than in 1986. For the South, consumption in 2040 is 73% larger than in 1986. Hardwood inventories are drawn down significantly in the South, reflecting, in part, conversion of hardwood types to pine plantations.

OUTLOOK FOR PRICES

There are two types of prices that characterize forestry markets. First, there are roundwood prices in the various regional stumpage markets and second there are various product prices set largely in national markets. In addition to both stumpage and product markets there are differences in the short-term and long-term outlook for prices. There differences vary between the two markets.

Roundwood Prices

The projected increase in pine plantations in the South have a dramatic effect on the outlook for softwood stumpage prices. In both the South and Pacific Northwest, stumpage prices increase rapidly through 2020. When the pine plantations in the South come into production, these prices level off and actually decline by 2040. This is in contrast to past assessments where prices were projected to increase continually in the future. Even with the additional pine plantations, however, stumpage prices in the South and Pacific Northwest in 2040 are more than double the price in 1986. Annual rates of increase for the South for the period, 1986–2020, are 2.5% and for the period, 1986–2040, 1.5%. For the Pacific Northwest, the rates of increase are 2.8% through 2020 and 1.7% through 2040.

In general, the projections for hardwood—both roundwood and sawtimber—show a more favorable supply/demand outlook than is the case for softwoods. Advances in pulping technology, however, are blurring the distinction between hardwood and softwood fibers for some paper and paperboard products. There are beginning to appear local situations where softwood and hardwood pulpwood are the same price. Hardwood sawtimber prices vary between the highest quality with the export and other high-value end uses as outlets and lesser quality that may have the pallet industry or firewood markets as outlets. The upper end of the hardwood sawtimber market has become a search for individual trees and this will likely continue. There are huge volumes of hardwoods advancing in age in the North, however, and these volumes may affect the supply situation after the next several decades.

Current concerns over tropical deforestation may lead to increased demands for temperate hardwoods. If this occurs, there will be increased pressure on the price of high-quality hardwoods, but it may also increase foreign interest in application of technologies to make use of lesser quality sawtimber.

Product Prices

Because of market interactions, such as imports of pulp, newsprint, and softwood lumber from Canada, the prices of end products are expected to increase at a lesser rate than for roundwood. For example, between 1986 and 2040, softwood lumber and plywood prices increase at annual rates of 0.6% and 0.3%, respectively. The rate of increase through the projection period is more uniform than that for stumpage prices.

STUDY IMPLICATIONS

(1) The U.S. softwood sawtimber supply situation will be unprecedented through 2020.

Throughout its history, the United States has had available a reserve of undeveloped softwood sawtimber. The timber resource of first the Northeast, then the South, the Lake States, the U.S. West Coast, interior British Columbia, and then the South again all played important roles in the development of the Nation. For the next two decades, until the pine plantations in the South reach maturity, the United States will not have a reserve of softwood sawtimber available for harvest. There will be a period of two to three decades when the price of softwood sawtimber will increase significantly. This run-up in stumpage prices has many and far-reaching implications. It will:

- Offer opportunities for application of technologies to further develop the northern hardwood resource;
- Stimulate development of innovative ways to conserve on softwood sawtimber such as laminated beams and wood-saving engineering in construction designs;
- Stimulate substitution of glass, steel, and other construction materials for wood;
- Stimulate production of timber products from currently economically inaccessible timber stands in Canada and thereby lead to increased imports;
- Decrease the competitive advantage of U.S. timber products in world markets and thereby decrease U.S. exports;
- Provide further market incentives for tree planting on private lands;
- Force reconsideration of many issues related to management of timber on public lands, such as below-cost timber programs.

During the next two to three decades, much of the softwood roundwood used in the manufacture of lumber will come from trees that are young by historical standards—as young as 45 years in the Pacific Northwest and 25 years in the South. Technical issues such as the strength properties of juvenile wood may gain higher visibility as lumber from young trees makes up a higher proportion of the total lumber used in the United States.

In the short term there are few options for alleviating pressures on softwood sawtimber stumpage prices. Research on and application of improved utilization and

use of abundant hardwoods appear to be promising responses to the declining availability of large-sized softwood sawtimber. The decade of the 1980s saw application of many technologies that are saving of softwood—OSB/waferboard, for example, and laminated beams. The use of manufactured components in housing can cut down on wood waste as compared with on-site assembly. It is reasonable to expect further application of softwood-saving technologies and allowances have been made for them in projections. Other potential responses to the short-term outlook such as increasing imports or decreasing exports would affect the situation, but do not appear viable in the current trade environment.

As discussed in the later section on assumptions used in the study, increased recycling may significantly affect the short-term supply/demand outlook.

(2) The Nation's forest industries will continue to be concentrated in the East.

In the mid-1980s, some 45% of the U.S. employment in primary and secondary wood processing was in the North and 35% in the South. In 2040, these two Eastern regions will continue to have about 80% of the total industry employment. New technologies being applied in primary processing such as in the softwood lumber segment of the industry have as a side effect lasting elimination of employment in the industry as capital is substituted for labor. In 2040, employment in the lumber and wood products portion of the industry will only be 72% of the employment in 1985, despite a 44% increase in lumber production and a 60% increase in production of structural panels.

(3) There are opportunities to increase timber supplies.

Available information shows that the potential exists for intensifying management and earning an economic return on some 66 million acres of timberland in the other private ownership category. With treatment of these acres, net annual timber growth could be increased by 3.5 billion cubic feet. Almost all of increase in growth would be softwood. About two-thirds of these opportunities involve some form of regeneration activity. Approximately three-fourths of the opportunities are in the South and one-fifth in the North.

There are also large acreages termed marginal crop and pastureland that may be suitable for tree planting. For example, there are 22 million acres in the South with this designation that would yield greater returns as pine plantations than in crop or pasture use.

The Assessment projection assumes that continuation of trends will lead to the implementation of some of these economic opportunities. For example, some 20% of opportunities on other private timberland in the South are assumed to be treated by 2040.

As the Nation enters the decade of the 1990s, concerns for the world environment have high visibility and are expressed in differing ways. For example, the potential effects of tree planting in aiding the environment are so appealing that the economics of tree planting are often second stage to the potential benefits to the global environment such as urban shading and carbon sequestration. This view is unprecedented in modern times. It may well have a major influence on the Nation's future timber supply/demand outlook, but the supply-enhancing aspect of this view may be a byproduct of other goals of tree planting.

Tree-planting initiatives such as the Conservation Reserve Program and America the Beautiful should increase the area of timberland in the short term. The long-term influence of these initiatives is uncertain at this time and their potential influence on long-term trends will be reviewed in the next update of the supply/demand situation and in subsequent Assessments.

(4) There are opportunities to extend timber supplies through improved utilization.

The Nation's timber industries have come far in the utilization of the timber resource in the past 50 years. For example, in the early 1950s, logging residue amounted to 13% of growing stock removals and in the late 1980s, it was 9.6%. There have been major advances in the manufacture of softwood plywood, fiber-based structural panels, and pulping technologies that have had major influences on the current supply/demand situation. Opportunities for further improvement of these technologies are considered in the study.

ASSUMPTIONS USED IN THE STUDY

All projections are the consequence of assumptions. In this study, these include assumptions about the basic determinants of timber demands such as growth in population, economic activity, and income; technological and institutional changes; energy costs; capital availability; prices of stumpage and timber products; and public and private investments in forest management, utilization, and research (USDA FS 1989a).

In making assumptions about these basic determinants, it is recognized that the long-run course of events may be different from what is assumed. However, expectations about the future of these determinants are often strongly influenced by past trends. These trends reflect the interactions of massive economic, social, and political forces which are not easily or quickly changed. Barring major catastrophes such as nuclear war, such trends are likely to continue over a considerable time. Thus, it is reasonably certain that the basic assumptions provide a sound basis for preparing an analysis for use in developing and guiding public and private responses to the projected timber resource situation. The following important assumptions were used to develop this Assessment.

Population

The population of the United States has grown by about 118 million people in the last five decades reaching 249 million in 1989. Projections of the U.S. Department of Commerce, Bureau of the Census, indicate that

population is likely to continue to show substantial growth during the next 50 years. The median population projection with a high immigration assumption shows population rising by another 84 million to 333 million in 2040. In the later decades of the projection period, much of the growth in population is attributable to immigration.

Economic Activity

Economic activity as measured by the gross national product in constant 1982 dollars, increased more than 4 times in the last 5 decades, to $4 trillion. Projections prepared by Wharton Econometrics Associates show the gross national product continuing to rise and reaching $15.6 trillion in 2040—almost 4 times that of 1988.

Disposable personal income, i.e., the income available for spending by the Nation's population, is projected to grow from about $2.9 trillion in 1989 to $9.6 trillion ($1982) in 2040. Associated per capita disposable income rises to $28,790 in 2040, some 2.4 times the 1989 average. This growth means that the Nation is faced not only with the task of meeting the resource demands of an additional 84 million people, but the demands of 333 million people with much greater purchasing power than today's population.

Timber Growth

Assumptions about future growth of the timber inventory are key components of the analysis of timber supply. The basis for assumptions about growth on private lands is continuation of the growth indicated in the latest reinventory of permanent plots on these lands, as modified by management intensity assumptions. Growth for national forests and other public lands is the projected growth as reported by the agencies.

Management Intensity for Private Timberlands

Growth is determined, in part, by assumptions about management intensity. Advances in research have enabled a growing sophistication in the way that these assumptions are used in conjunction with models of forest growth. A key assumption of the study is that by the turn of the century, all of forest industry lands in the South and western Washington and Oregon will be managed intensively and that there will be a growing acreage of softwood plantations on nonindustrial private lands in the South. These pine plantations begin to affect the supply/demand outlook in significant ways about the decade of 2020. After 2020, the pine plantations begin to reach merchantable size and affect domestic prices, imports, and other indicators of the supply/demand situation.

The assumptions about future management intensity lead to higher timber supplies as compared with similar assumptions in previous RPA Assessments. The assumptions are so critical to the outlook that they will be reviewed in depth for an update of the supply/demand situation planned for 1993.

Timberland Area

Assumptions about future area of timberland also have an obvious effect on the timber supply/demand outlook. Trends for the past 40 years indicate a decline in timberland area for the Nation as a whole. This trend is expected to continue in the future and by 2040, there is projected to be a net loss of 21 million acres of timberland. There are some gains in timberland area as some land reverts from agriculture to timberland in the North. Urbanization and shifts from timberland to agricultural areas are expected to more than compensate for these gains, however.

Future Timber Harvest on National Forests

The National Forest Management Act of 1976 set in motion an unprecedented planning effort on the Nation's national forests that is near completion for the first round of planning. For the purposes of this study, it is assumed that harvests on national forests will be the volume shown in plans in effect or in draft stage as of 1987. In total, this assumption means that harvest on national forests will increase from 2.3 billion cubic feet in 1986 to 2.7 billion cubic feet in 2040.

There are a number of issues whose resolution may have a downward influence on national forest harvest levels. For example, the Threatened and Endangered Species Act of 1973 contains provisions for protection of habitat for species listed as threatened or endangered. The Forest Service has habitat management responsibility for approximately 31% of the Nation's threatened and endangered plant and animal species. The number of species listed is growing with implications for timber harvest in areas that contain the species' habitat. In general, the effect has been to reduce rather than to increase timber harvest where timber harvest has been affected. Nonetheless, the sum of forest plans is considered to be a reasonable estimate of future harvest levels. As plans are revised, any changes in future expectations will be considered in future Assessments of the timber supply/demand situation.

Changes in Processing Technology

The decade of the 1980s has been one of rapid changes in the application of technology in the U.S. timber industries and their utilization of timber resources. For example, OSB/waferboard has been accepted in the marketplace and advances in processing technology have increased the proportion of roundwood recovered as solid products. Also, application of technology has enabled the pulp industry to increase the proportion of hardwoods in the pulp mix. Explicit assumptions are

made in this study about technology in the manufacture of both solid and fiber-based wood products. In general, the effect of technology is to extend timber supplies—satisfying the same demand with less wood and to use the fiber available as in the use of hardwoods in pulp manufacture. The cumulative effects of 50 years of technology development and application has significantly affected the U.S. timber industries and similar effects are expected in the future.

POTENTIAL SOURCES OF STRUCTURAL CHANGE IN THE OUTLOOK

Sources of change in the supply/demand situation are generally gradual and can take years or decades to shift long-term trends. For example, the pine plantations in the South in the Assessment projection are a source of structural change, but they take decades to reach maturity. Two potential sources of fairly rapid change in the U.S. timber industries are global change and recycling of paper and paperboard.

Global Change

Global change has developed into a phrase that signifies all the disruptions that may attend significant increases in global warming—not only changes in the growth and distribution of trees, but the massive socioeconomic dislocations that may be caused by global warming. The potential for global warming to occur and its aftermath are currently the subject of debate. If it occurs, there is potential for shifting of the supply/demand outlook with as yet undetermined implications. For the purposes of this study, it is assumed that changes in the global climate will not affect the overall supply/demand outlook.

Recycling

The study assumes that recycling of paper in the United States will increase from about 25% of consumption to 31% in 2040. An alternative future was analyzed that assumed 39% by 2040. The high recycling future has dramatic effects on the supply/demand outlook by lowering stumpage prices and the demand for wood in pulp manufacture. At the time of the writing of this summary chapter, the U.S. pulp and paper industry has announced as a goal 40% paper recovery and reuse by 1995. There are technical and market problems that must be overcome to achieve this goal. If achieved, it would have major influences on forestry in the United States and Canada. The 40% goal is established with the expectation of using existing technologies. New technologies developed through research may make a 50% goal achievable.

Summary

In summary, this study projects rising demands for timber products, as have previous assessments. The study, however, has identified three potential sources of structural change in the supply situation that could shift the outlook.

- Continuation of establishment of pine plantations in the South will affect the outlook and this is reflected in the Assessment projection. If these plantations are not established, the Nation faces prolonged increases in prices of timber products.
- Concerns over the global environment have stimulated interest in planting trees as a way to sequester carbon. Large tree planting programs in addition to the plantations in the Assessment projection could further affect the supply outlook after 2020. If global warming occurs, it could either increase tree growth or reduce it, depending on rainfall and other characteristics of the environment at that time.
- Increased recycling of paper and paperboard could shift the outlook during the next decade.

These sources of structural change are not reflected in historical data except for the establishment of pine plantations in the South. Global change and recycling of paper and paperboard are developing issues. They should be monitored closely for their potential effects on the outlook.

CHAPTER 2. RECENT TRENDS IN THE CONSUMPTION OF TIMBER PRODUCTS

This chapter presents estimates of timber products consumption in the United States over the past three and a half decades, and relates changes in consumption to economic, social, and institutional factors during the period. In this analysis, the following timber products are considered: (a) lumber; (b) structural panels—softwood plywood, oriented strand board, waferboard, and similar wood panel products used primarily for structural applications; (c) nonstructural panels—hardwood plywood, insulating board, hardboard, particleboard, medium-density fiberboard, and similar wood panel products used primarily for nonstructural applications; (d) pulpwood; (e) silvichemicals; (f) fuelwood; and (g) other miscellaneous industrial roundwood products such as poles and piling, posts, and mine timbers. Consumption of lumber is discussed in terms of the major markets for structural and nonstructural panels, i.e., new housing, residential upkeep and improvements, new nonresidential and railroad construction, manufacturing, packaging and shipping, and other uses. The pulpwood section contains a discussion of trends in the consumption and production of woodpulp, and of paper and board by type. A final section summarizes trends in consumption of the major roundwood products—saw logs, veneer logs, pulpwood, miscellaneous products, and fuelwood—by softwoods and hardwoods.

Total U.S. consumption of timber products has increased markedly over the past 35 years, rising from about 12 billion cubic feet in the early 1950s to almost 20 billion in 1986. Although total use has grown through most of the period, there have been short-term fluctuations and divergent trends in the relative importance of the various products and in the species mix of timber consumed. These fluctuations and trends are the result of changing market levels and changing product use within these markets.

TIMBER PRODUCTS CONSUMPTION IN NEW HOUSING

New housing has long been the largest single U.S. market for timber products. In 1986, more than a third of the lumber and structural panel products, and over a fourth of the nonstructural panel products were used for the construction of new housing units.

New Housing Unit Production

The volumes of timber products consumed in new residential construction are dependent on the numbers and types of housing units built, and the amounts and types of wood products used in each.

The average number of new housing units—conventional units and mobile homes—produced in the United States has been somewhat higher in the 1970s and 1980s than during the 1950s and 1960s (table 1). Despite this long-term trend, changes in such demand determinants as interest rates, household formations, vacancy and replacement rates, and conversion of existing structures to alternative uses, have caused annual production to vary substantially from the decade averages (fig. 1). For example, in 1972 total housing production reached nearly 3.0 million units, dropped to 1.4 million in 1975, and subsequently increased to more than 2.3 million in 1978. Total output again declined to a low of 1.3 million in 1982, recovered to more than 2.0 million in 1983 through 1986, and dropped to just under 1.9 million units in 1987.

Table 1.—Average annual production of new housing units in the United States, by type of unit, specified periods 1950–87.

Period	Total demand	Conventional units			Mobile homes
		Total	Single family	Multi-family	
	Thousand units				
1950–54	1,692	1,619	1,434	185	73
1955–59	1,569	1,455	1,260	194	115
1960–64	1,601	1,470	996	474	131
1965–69	1,695	1,415	860	554	281
1970–74	2,342	1,868	1,060	808	474
1975	1,384	1,171	896	275	213
1976	1,793	1,547	1,166	381	246
1977	2,279	2,002	1,452	550	277
1978	2,312	2,036	1,433	603	276
1979	2,037	1,760	1,194	566	277
1980	1,535	1,313	852	461	222
1981	1,341	1,100	705	395	241
1982	1,312	1,072	663	409	240
1983	2,008	1,712	1,068	644	296
1984	2,052	1,756	1,084	672	296
1985	2,029	1,745	1,072	673	284
1986	2,051	1,807	1,179	628	244
1987	1,853	1,620	1,146	474	233

Note: Data may not add to totals because of rounding.
Sources: 1950–58: USDC BC 1966b, 1959–87: USDC BC 1987c.

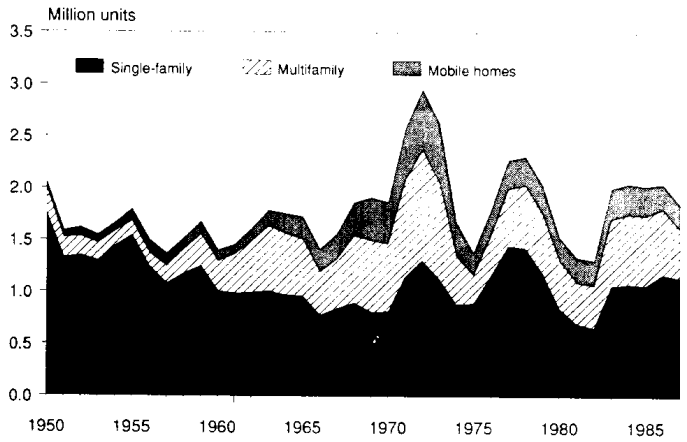

Figure 1.—New housing unit production, by type of unit, 1950–1987.

In addition to the total numbers of units produced, their type (single-family, multifamily, mobile home) also has been an important factor in determining the volumes of timber products used in new housing because of the large differences in the average amounts of timber products used in each.

Single-family houses are typically occupied by households whose heads are in the middle-age classes, while occupancy of units in multifamily buildings and mobile homes is highest among households headed by younger and older persons (USDA FS 1982). Since 1950, about 60% of all housing units produced (including mobile homes) have been of the single-family type (fig. 1). However, as a result of shifts in the age distribution of the population, and the associated changes in household types and income, there has been wide variation in their relative importance. For example, the proportion of single-family housing units—about 85% in the mid-1950s—dropped to less than 45% in the early 1970s. By 1976, however, single-family homes accounted for nearly two-thirds of all housing production. Subsequently, the proportion dropped to slightly more than 50% in 1982, before climbing to 57% in 1986, and 62% in 1987.

Through most of the 1950s, multifamily units accounted for nearly all of the remaining output. However, in the late 1950s the mobile home emerged as a significant source of new housing. Its share of the housing market grew to over 21% in 1973, before declining, with some fluctuation, to about 12% in 1986 and 13% in 1987.

Timber Products Use Per Housing Unit

In 1986, single-family houses used an average of about 12,975 board feet of lumber; 6,770 square feet, 3/8-inch basis, of structural panel products; and 2,755 square feet, 3/8-inch basis, of nonstructural panel products (table 2).

Table 2.—Timber products used per housing unit in the United States, by product and type of unit, specified years 1962–86.

Product and type of unit	1962	1970	1976	1986
Lumber		*Board feet*		
Single family	11,385	11,130	12,375	12,975
Multifamily	5,325	5,375	5,030	4,720
Mobile homes	1,525	1,905	2,655	4,340
Structural panels[1]		*Square feet (3/8-inch basis)*		
Single family	2,960	4,580	5,560	6,770
Multifamily	1,810	2,150	2,575	2,505
Mobile homes	855	1,135	1,225	1,610
Nonstructural panels[2]		*Square feet (3/8-inch basis)*		
Single family	1,805	2,535	2,855	2,755
Multifamily	1,205	1,175	920	850
Mobile homes	1,240	2,125	3,765	3,805

[1]*Softwood plywood, waferboard, oriented strand board, and composite board.*

[2]*Hardwood plywood, hardboard, insulating board, particleboard, and medium-density fiberboard.*

Note: Volumes include allowances for onsite and manufacturing waste.

Multifamily units averaged less than half as much lumber and structural panels, and a third as much nonstructural panels as single family units. Mobile homes used lesser amounts of lumber and plywood than multifamily units, but somewhat greater amounts of nonstructural panels than other types of units.

As shown in table 2 and figure 2, the types and amounts of timber products used per housing unit have changed over the past 25 years. In general, structural and nonstructural panel products use have increased significantly, while lumber use has grown much more slowly. These trends have resulted from changes in such factors

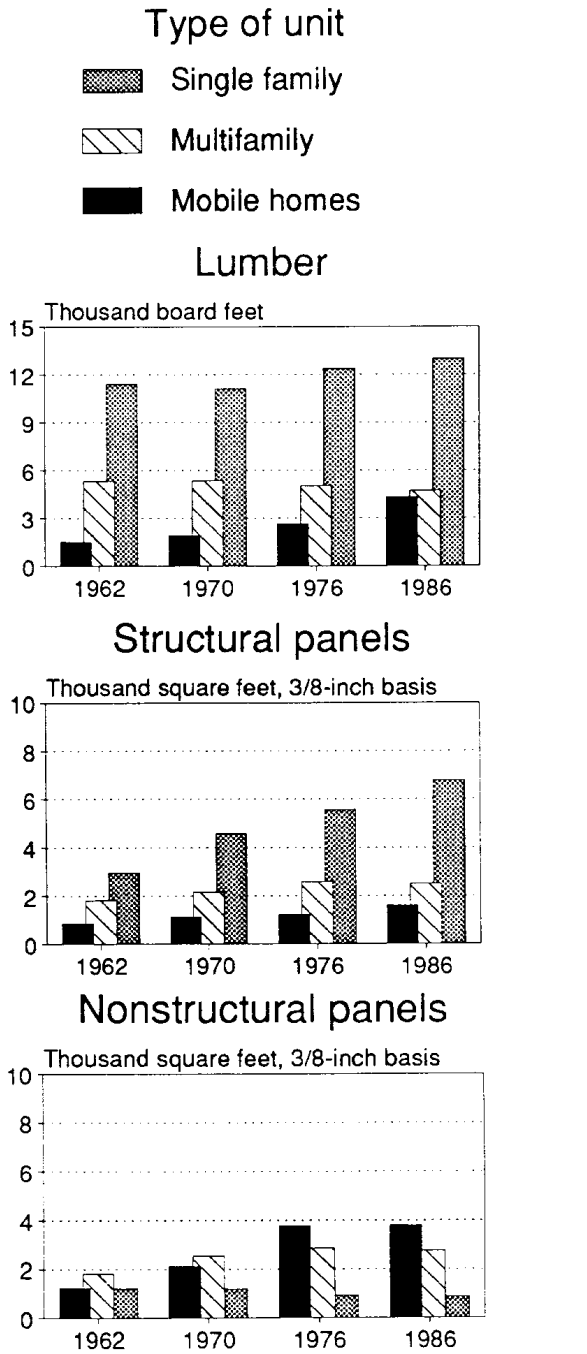

Figure 2.—Timber products use per unit in new residential construction.

as unit size, structural and architectural characteristics, and materials substitution.

Trends in Unit Size

The average size of new single-family housing units grew fairly steadily between the early 1950s and the 1970s, rising from less than 1,100 square feet of floor area in 1950–53 to 1,700 square feet in 1976, and 1,760 square feet in 1979 (Phelps 1988) (fig. 3). This growth, in part a reflection of rising real household income during the period, contributed to the increases in the use of structural and some nonstructural panel products per single-family unit, and partially offset a downward trend in lumber use per square foot of floor area (USDA FS 1982). Average single-family house size fell to 1,710 square feet in 1982 as housing production dropped to the lowest level since 1945, but subsequent increases in the 1980s raised the average to 1,825 square feet in 1986 and to 1,905 square feet in 1987 (USDC BC 1988a).

The size of units in multifamily structures also increased into the early 1970s, but has been somewhat lower since that time. For example, the average size of new multifamily units in 1986 was 911 square feet, 15% above the average in the early 1950s, but down 20% from the mid 1970s (Phelps 1988, USDC BC 1988a).

Mobile homes have shown the most dramatic increase in size in recent years. In the early 1960s, most were single units, 10 feet or less in width and typically 29 to 45 feet in length. By 1970, most units were 12 or more feet wide, and 50 or more feet long. In addition, a growing number were double-wide or expandable models. In 1976, nearly half were 14 feet wide, while double-wide mobile homes accounted for about a fourth of total shipments. This trend continued over the next 10 years, and by 1987 more than 37% of all mobile homes placed at building sites were double-wide units. As a result of these changes, average unit size has increased from about 620 square feet in the early 1960s, to 966 square feet in 1976, 1,110 square feet in 1986 and 1,140 square feet in 1987 (Phelps 1988, USDC BC 1988a).

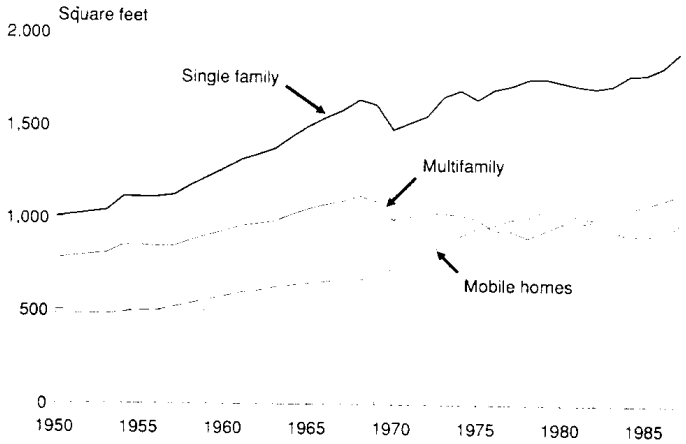

Figure 3.—New housing unit average floor area, by type of unit, 1950–1987.

Trends in Use Per Square Foot of Floor Area

In addition to changes in unit size, the amounts of timber products used per housing unit have been strongly affected by trends in the average use per square foot of floor area. As shown in the tabulation below, estimated lumber use per square foot of floor area in single-family units dropped from 8.5 board feet in 1962 to about 7.3 board feet in 1976, and to 7.1 board feet in 1986. Lumber use per square foot in multifamily units has shown the same general downward trend. On the other hand, structural panel use per square foot of floor area increased in both single-family and multifamily units. Over the past 35 years, mobile homes have been constructed increasingly like conventional single-family units. As a result, use of nearly all types of timber products per square foot of floor area has increased.

Floor area, and average timber products used per square foot of floor area in single-family houses

Year	Floor area	Lumber	Structural panels	Nonstructural panels
	Square feet	*Board feet*	*Square feet (3/8-inch basis)*	*Square feet (3/8-inch basis)*
1962	1,346	8.46	2.20	1.34
1970	1,482	7.51	3.09	1.71
1976	1,700	7.28	3.27	1.68
1986	1,825	7.11	3.71	1.51

These trends in timber products use per square foot of floor area have resulted, in part, from changes in the structural and architectural characteristics of the units built, and in materials substitution in the construction process. A discussion of each of these factors follows.

Structural and Architectural Characteristics

Shifts in structural and architectural characteristics of new units built since the early 1950s have had marked effects on timber products used per square foot of floor area. For example, growth in use per square foot has resulted from the rising proportion of new, single-family houses built with garages. About 50% of all houses built in 1950 had garages, compared to 79% in 1987—over four-fifths of which could accommodate two or more cars (USDC BC 1988a).

Increases in wood products use per square foot of floor area have also come from growth in the percentage of new single-family units using wood products as the principal exterior siding material, particularly during the 1970s and early 1980s. In 1986, 43% of new single-family houses used wood or wood products as the principal exterior wall material, up from 37% in 1976 (USDC BC 1977, 1988a). In addition, an increasing number of new houses are being built with wooden decks. This latter trend has been accelerating since the early 1980s.

One of the most important factors tending to reduce timber products use per square foot of floor area has been the substantial increase in the proportion of single-family

units built on concrete slab foundations, a type of construction that markedly lowers average wood products use because of the elimination of the wood-joist floor system. Between 1956 and 1970, the proportion of single-family houses constructed with concrete slab floor systems rose from 16 to 36%, with a further climb to 45% in 1986 (USDL 1958, USDC BC 1988a).

Another change affecting timber products use has been the steady growth in the percentage of two-story houses built. In 1956, less than 10% of new, single-family houses had two stories; by 1986, 44% had two stories (USDL 1958, USDC BC 1988a). This type of construction reduces the roof area required to cover a given floor area, thereby lowering total wood products use and construction costs per square foot of floor area. In addition, two-story construction allows enlarging house size without increasing the size of the building lot.

Rising land costs have apparently resulted in somewhat smaller lot sizes, and in increased construction of attached single-family units such as townhouses and cluster homes. Such units are characterized by having at least one common wall—frequently of masonry construction—which consequently lowers the volumes of exterior wall framing, sheathing, and siding used.

Recent increases in the use of prefabricated housing components and modular housing units has tended to lower average use of some wood products, particularly lumber, through reduction of waste and improved design. Wood roof trusses are perhaps the most widely used, factory-prefabricated structural component in single-family houses. However, floor trusses, prefabricated beams and lintels, exterior and interior wall panels, and roof and floor panels are used in onsite construction of both single and multifamily housing units. Other building components, such as doors, windows, and cabinets, are almost universally factory-fabricated for onsite installation.

In conventional onsite construction, more efficient use of wood, such as wider spacing of studs and other structural members, has tended to bring about somewhat lower use of timber products per unit. Other savings in materials have resulted from changes in design, and more realistic specifications for wood building components based on stress testing and other performance criteria.

Materials Substitution

The volumes of specific timber products used per square foot of floor area in new housing have been greatly affected by the substitution of alternate materials—both wood and nonwood—in the construction process. For example, the rising trend in use of structural and nonstructural panel products per housing unit in the 1950s, 1960s, and 1970s largely reflected substitution of these materials for lumber in such components as sheathing and subflooring. Through the early 1970s, structural plywood use showed the largest growth. Between 1959 and 1968, the proportion of new single-family houses constructed with plywood roof sheathing rose from 50 to more than 90% (Phelps 1970). However, the 1970s was the period of maximum plywood penetration of roof sheathing markets; since then, newer structural panel products such as waferboard and oriented strand board have had increasingly widespread acceptance (Anderson 1987a).

Nonwood materials, such as aluminum, steel, plastics and masonry products also compete with wood in many residential uses. Wood products have been displaced in a number of applications by metal siding, by plastic and aluminum siding and trim, and by nonwood flooring materials. For example, substitution of carpeting for oak flooring, either on a concrete slab floor or over particleboard underlayment, was an important factor in the decline of wood use—particularly hardwood lumber use—in the late 1960s and early 1970s.

Aluminum and steel have been used as alternative framing materials in light frame construction. With the price relationships existing in the early 1970s, aluminum framed exterior walls were less expensive than those framed with lumber. Since that time, aluminum prices have increased sharply. Steel framing has been used in construction of apartment buildings; but, in general, its use has been limited in single-family houses, even though at times in the 1980s the inplace cost for steel was less than for wood in some applications (USDA FS 1982).

Total Timber Products Use in New Housing

Total consumption of lumber in new housing amounted to an estimated 19.3 billion board feet in 1986 (table 3, fig. 4). Although this was less than in some prior years, it was about 75% above use in 1982 when total number of housing units produced dropped sharply, and use per unit was down because of a temporary decline in average unit size.

Consumption of structural panels in new housing in 1986 was nearly 10 billion square feet, 3/8-inch basis, about 28% above total use in 1976, and somewhat above

Table 3.—Timber products used in new housing in the United States, by product, specified years 1962–86.

Year	Lumber	Structural panels[1] (3/8-inch basis)	Nonstructural panels[2] (3/8-inch basis)
	Million board feet	*Million square feet*	*Million square feet*
1962	14,160	3,950	2,540
1970	13,350	5,590	3,680
1976	17,000	7,760	4,610
1986	19,320	9,950	4,710

[1]*Softwood plywood, waferboard, oriented strand board, and composite board.*

[2]*Hardwood plywood, hardboard, insulating board, particleboard, and medium-density fiberboard.*

Note: Volumes include allowances for onsite and manufacturing waste.

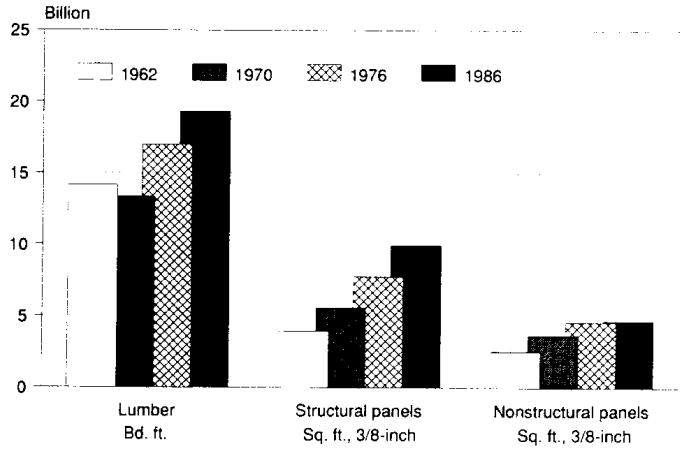

Figure 4.—Total timber products use in new housing, 1962, 1970, 1976, 1986.

consumption in most prior years. Almost 13% of total structural panel consumption in 1986 was waferboard, oriented strand board, and similar products, up sharply from about 2% in 1976. Much of this growth was at the expense of softwood plywood, as described earlier.

Nonstructural panel consumption in new housing in 1986 totaled 4.7 billion square feet, 3/8-inch basis. This was about 2% above total use in 1976, but much above consumption in the 1950s and 1960s. Among the various nonstructural panel products used in new housing, particleboard and hardboard have trended upwards in recent years; insulating board and hardwood plywood have trended down.

TIMBER PRODUCTS CONSUMPTION IN UPKEEP AND IMPROVEMENTS

In addition to use in the construction of new residential units, substantial volumes of timber products are used each year for the upkeep and improvement of units in the existing housing inventory. In 1986, about 18% of the lumber, 24% of the structural panel products, and 17% of the nonstructural panel products consumed, were used for such purposes. This market has become much more important in recent years as the Nation's housing stock has grown larger, its average age has increased, and homeowner incomes have risen (Council of Economic Advisors 1988).

Residential Upkeep and Improvement Expenditures

Expenditures for residential upkeep and improvements have more than doubled in the last 25 years, rising from $37.8 billion (1982 dollars) in 1962 to $82.2 billion in 1986 (table 4, fig. 5). Most of the increase during this period took place between 1980 and 1986 as total expenditures rose by more than 60%.

Timber Products Use Per $1,000 of Expenditure

In contrast to trends in use per square foot of floor area in new housing, lumber use per $1,000 of expenditure

Table 4.—Expenditures and timber products used per thousand dollars of expenditure in residential upkeep and improvements in the United States, specified years 1962–86.

		Use per thousand dollars of expenditures[1]		
	Total expenditures	Lumber	Structural panels[2] (3/8-inch basis)	Nonstructural panels[3] (3/8-inch basis)
	Million 1982 dollars	*Board feet*	*Square feet*	*Square feet*
1962	37,830	115	44	37
1970	42,170	118	55	39
1976	52,320	120	62	42
1986	82,240	121	75	38

[1]*Includes allowance for onsite and manufacturing waste.*
[2]*Includes softwood plywood, waferboard, oriented strand board, and composite board.*
[3]*Includes hardwood plywood, hardboard, insulating board, particleboard, and medium-density fiberboard.*
Sources: Expenditures: USDC BC 1987f.

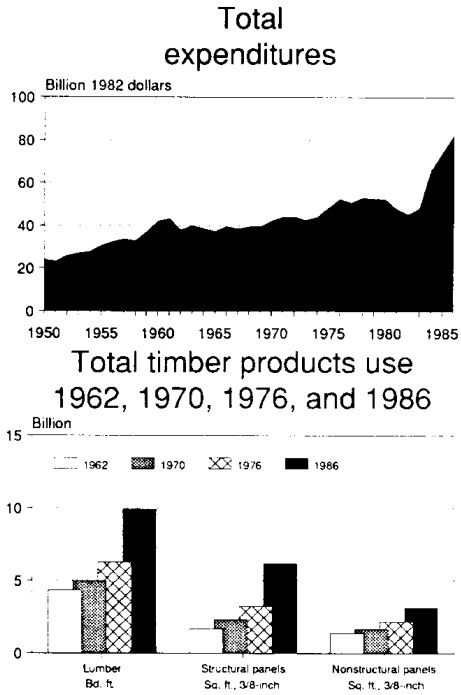

Figure 5.—Residential upkeep and improvements.

for upkeep and improvements has increased over the past 25 years, rising from about 115 board feet in 1962 to 121 board feet in 1986 (table 4). Structural panel products use per $1,000 also has grown; however, nonstructural panels consumption, while increasing until 1976, has subsequently declined to about the same level of use as in the early 1960s.

Total Use in Residential Upkeep and Improvements

Residential upkeep and improvements consumed a total of 9.9 billion board feet of lumber in 1986, up nearly

59% from use in 1976, and well over twice the volume used in the early 1960s (table 5, fig. 5). Structural and nonstructural panels consumed for residential upkeep and improvements—6.2 and 3.2 billion square feet, 3/8-inch basis, respectively—have also increased over the past 25 years, with structural panels use rising more than three-fold since 1962. Nonstructural panels consumption more than doubled in the same period.

TIMBER PRODUCTS CONSUMPTION IN NEW NONRESIDENTIAL AND RAILROAD CONSTRUCTION

New nonresidential construction accounted for about 7% of the lumber, 10% of the structural panels, and 8% of the nonstructural panels consumed in the United States in 1986. An estimated additional 2% of the lumber, and much smaller amounts of the structural panel products were used for railroad ties and rail car repair.

New Nonresidential Construction

For purposes of this analysis, new nonresidential construction has been divided into two major classes: (1) nonresidential buildings—including, for example, stores, restaurants, warehouses, hotels and motels, and office, industrial, educational, religious, hospital, institutional, and nonresidential farm buildings; and (2) all other types, such as highways and streets, water and sewer systems, dams, military and conservation and development projects, railroad construction except track, and similar types of nonbuilding construction.

The total amounts of the various timber products used in the new nonresidential sector each year are dependent on the numbers, types, and sizes of buildings and other structures produced, and the amounts and types of wood materials used in building them. Because of its diverse nature, the volume of nonresidential construction is usually expressed as expenditures in the form of value of construction put in place.

Table 5.—Timber products used in residential upkeep and improvements in the United States, by product, specified years 1962–86.[1]

Year	Lumber	Structural panels[2] (3/8-inch basis)	Nonstructural panels[3] (3/8-inch basis)
	Million board feet	*Million square feet*	*Million square feet*
1962	4,330	1,670	1,400
1970	4,975	2,320	1,655
1976	6,255	3,245	2,190
1986	9,935	6,170	3,160

[1]*Includes allowance for onsite and manufacturing waste.*
[2]*Includes softwood plywood, waferboard, oriented strandboard, and composite board.*
[3]*Includes hardwood plywood, hardboard, insulating board, particleboard, and medium-density fiberboard.*

New Nonresidential Construction Expenditures

Total expenditures for new nonresidential construction (1982 dollars) were $175.4 billion in 1986, about 14.6% higher than in 1976, and more than twice the expenditures in 1950 (table 6, fig. 6). Though fluctuating somewhat in response to changing economic conditions, total expenditures increased fairly rapidly through the late 1960s. Expenditures were up for nearly all types of building and nonbuilding construction during this period. Beginning in 1968, expenditures for most types generally trended down, or showed little growth over the next decade. After reaching a low of $146.1 billion in 1977, total expenditures increased, dropped again in 1983, and subsequently rose to $177.4 billion in 1985, the highest level on record. Total expenditures in 1987 were $176.3 billion. In general, expenditures for buildings and the other types of construction followed the same trends.

Table 6.—Expenditures for new nonresidential construction in the United States, by type, specified years 1950–87.

Year	All classes		Buildings[1]		Other types[2]	
	Expenditures	Annual rate of change	Expenditures	Annual rate of change	Expenditures	Annual rate of change
	Billion 1982 dollars	*Percent*	*Billion 1982 dollars*	*Percent*	*Billion 1982 dollars*	*Percent*
1950	79.0	. . .	42.0	. . .	37.0	. . .
1955	108.3	6.5	59.8	7.3	48.5	5.5
1960	125.0	2.9	66.8	2.2	58.2	3.7
1965	166.7	5.9	93.2	6.9	73.4	4.7
1970	172.2	.6	91.0	- .5	81.1	1.0
1973	176.2	.8	94.6	1.3	81.6	-1.8
1975	155.7	-6.0	81.5	-7.2	74.2	-4.6
1976	153.1	-1.7	74.8	-8.2	78.3	5.4
1977	146.1	-4.6	72.7	-2.9	73.4	-6.2
1978	159.5	9.2	81.0	11.5	78.5	7.0
1979	166.0	4.1	88.2	8.9	77.8	-1.0
1980	165.9	1.3	89.3	1.9	76.6	.6
1981	164.1	-1.1	89.4	.2	74.7	-2.4
1982	160.3	-2.3	88.3	-1.2	72.0	-3.7
1983	150.4	-6.2	81.4	-7.9	69.0	-4.1
1984	162.8	8.3	92.7	13.9	70.2	1.7
1985	177.4	9.0	104.2	12.5	73.2	4.3
1986	175.4	- .1	100.9	-3.2	74.6	1.9
1987	176.3	.5	99.9	- .1	76.5	2.5

[1]*Includes private and public industrial buildings; private office and other commercial buildings; hotels and motels; churches and other religious buildings; public and private educational buildings; public and private hospital and other institutional buildings; animal hospitals and shelters; farm buildings (except residences); amusement and recreational buildings; bus, airline, and other passenger terminals; police and fire stations; civic centers; court houses; space facilities; postal facilities; and other private and public buildings.*
[2]*Includes telephone and telegraph systems; gas, electric light and power facilities; water and sewer systems; petroleum pipelines; railroads (except track construction); highways and streets; military facilities; conservation and development projects; and all other public and private nonbuilding construction.*
Source: USDC BC 1987j.

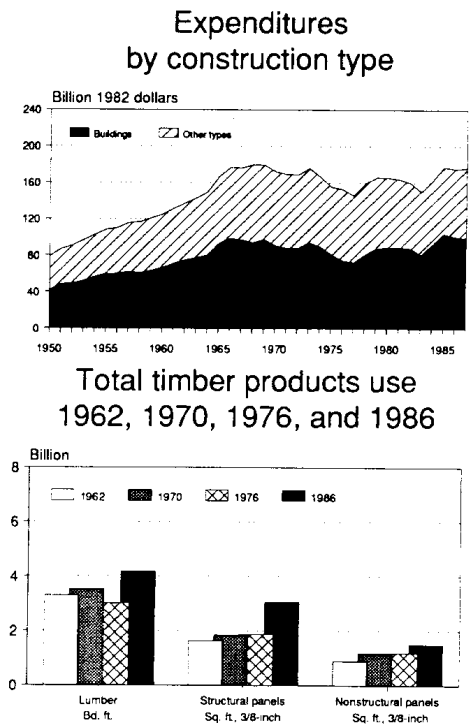

Figure 6.—Nonresidential construction.

Timber Products Use per $1,000 of Expenditure

Except for lumber, the fluctuations in total consumption of the various timber products in new nonresidential construction since the early 1960s were largely due to the variability in expenditures. Lumber use per $1,000 of construction expenditures declined in the mid 1970s, but is estimated to have subsequently increased in the 1980s (table 7). Structural and nonstructural panel use per $1,000 generally increased over the entire period.

Table 7.—Timber products used in new nonresidential construction in the United States, by product, specified years 1962–86.

Year	Lumber		Structural panels[1] (3/8-inch basis)		Nonstructural panels[2] (3/8-inch basis)	
	Total use	Use per $1,000 of expenditure[3]	Total use	Use per $1,000 of expenditure[3]	Total use	Use per $1,000 of expenditure[3]
	Million board feet	*Board feet*	*Million square feet*	*Square feet*	*Million square feet*	*Square feet*
1962	3,300	24.0	1,630	11.9	890	6.5
1970	3,530	20.5	1,840	10.7	1,190	6.9
1973	3,695	21.0	2,149	12.2	1,304	7.4
1976	3,000	19.6	1,870	12.2	1,190	7.8
1982	3,767	23.5	2,567	16.0	1,370	8.5
1986	4,180	23.8	3,060	17.4	1,510	8.6

[1]*Includes softwood plywood, waferboard, oriented strand board, and composite board.*

[2]*Includes hardwood plywood, hardboard, insulating board, particleboard, and medium-density fiberboard.*

[3]*1982 dollars. Use per $1,000 of construction expenditures computed by Forest Service. (See table 6 for construction expenditures.)*

Such trends in timber products use per $1,000 of expenditures are the result of many complex technological and institutional forces. Much of the decline in lumber use per $1,000 resulted from such things as increasing use of softwood plywood and metal for concrete forming; substitution of metal for wood in studs, joists, and decking; rising use of precast and prestressed concrete beams and other structural members in lieu of onsite forming; and other construction innovations such as slipform and tiltwall construction (USDA FS 1982). In addition, the metal buildings industry, which produced increasing numbers of pre-engineered warehouses and similar industrial buildings during the 1950s and 1960s, began to make inroads into other nonresidential markets with sophisticated designs for medium-sized, low-rise offices, motels, and shopping centers. Restrictive codes and other building regulations have also been important in limiting wood use in some types of buildings and in some locations (Spelter et al. 1987).

Countering these trends has been increased use of large wooden structural framing members such as beams, trusses and arches in some building types; improvement in the durability of many timber products; and rising use of wood siding on some types of small buildings (USDA FS 1982).

In general, wood construction is most cost effective in smaller nonresidential buildings, and its use is widespread in those types of structures. For example, in 1982, 48% of the one-story and 61% of the two-story buildings with floor areas less than 5,000 square feet had wood frames (Spelter et al. 1987). Moreover, wood structural panels are generally used with wood framing systems. These factors, in conjunction with the increasing share of buildings erected in suburban areas, where buildings tend to be low-rise and somewhat smaller than in cities, have also contributed to the increasing use of timber products per $1,000 of expenditure since the mid-1970s.

Total Timber Products Use in New Nonresidential Construction

Although total use of lumber and panel products for new nonresidential construction has fluctuated in the past, the overall trend during the past 25 years has generally been rising (table 7, fig. 6). For example, estimated consumption of lumber rose from 3.3 billion in 1962 to 3.7 billion board feet in 1973, and then declined to 3.0 billion in 1976. Over the next 10 years total use increased, reaching nearly 4.2 billion board feet in 1986—about 27% above the 1962 volume. Structural and nonstructural panels consumption showed the same general trends between 1962 and 1986, but the percentage increases—88% and 70%, respectively—were much larger.

Most of the timber products used in the nonresidential sector are used in building construction. For example, about 80% of the lumber and structural panels and more than 90% of the nonstructural panels consumed in new nonresidential construction in 1986 are estimated

Wood is being increasingly used in large nonresidential structures such as the Tacoma Dome.

to have been used in the construction of buildings. In the mid-1970s, most of the lumber and nonstructural panel products used for buildings was retained in the structure as rafters, joists, beams, wall paneling and millwork, whereas the most important use for structural panels was as concrete forming or security fencing and other facilitating purposes (Reid 1977). These general trends continued into the early 1980s (Spelter 1985c, Spelter and Anderson 1985, Spelter et al. 1987).

Railroad Construction

In 1986, about 1.1 billion board feet of lumber and 25 million square feet, 3/8-inch basis, of structural panels were used by the railroad industry for the construction of new track, and for the maintenance of existing track and rolling stock.[2] Of all lumber consumed in 1986 by the railroad industry, about four-fifths (881 million board feet) was used for the 20.4 million crossties and 1.0 million switch and bridge ties installed during the year (table 8, fig. 7). The remaining lumber, and all of the structural panels are estimated to have been used for repair and refurbishing railroad cars in industry-owned facilities. Slightly more than 90% of the lumber used for ties was hardwoods, principally oak. A somewhat smaller percentage of the lumber used for car repairs is estimated to have been hardwoods.

The number of railroad ties (crossties plus bridge and switch ties) installed each year, and the resulting volumes of lumber consumed, nearly doubled between the early 1960s and the mid-1970s. Since peaking at 29.9 million ties in 1976, however, installations have fluctuated but gradually moved lower. Although year-to-year variations are largely due to short-term economic fac-

Table 8.—Wood railroad tie installations[1] and lumber consumption in the United States, specified years 1950–86.

Period	Total volume	Crossties		Switch and bridge ties	
		Number	Volume	Number	Volume
	Million board feet	*Thousands*	*Million board feet*	*Thousands*	*Million board feet*
1950–59[2]	1,262	29,523	1,151	1,762	111
1960–69[2]	771	17,872	705	1,048	66
1970–74[2]	964	22,487	899	1,029	65
1975	938	21,850	874	1,016	64
1976	1,220	28,748	1,150	1,111	70
1977	1,204	28,265	1,131	1,160	73
1978	1,196	28,079	1,123	1,160	73
1979	1,162	27,057	1,100	978	62
1980	1,115	26,247	1,050	1,028	65
1981	1,122	26,719	1,069	840	53
1982	881	20,811	832	777	49
1983	871	20,553	822	779	49
1984	1,056	24,863	995	981	62
1985	1,003	23,434	937	1,035	65
1986	881	20,412	816	1,037	65

[1]*Includes ties used for replacement and for new track.*

[2]*Data shown are annual averages for the period.*

Note: Data on tie installations by class I railroads have been adjusted to include installations by all railroads. Data may not add to totals because of rounding.

Sources: Crossties, and switch and bridge ties: 1950–77—USDA FS 1982; 1978–86—Association of American Railroads 1970, 1984, 1987.

[2]*Substantial volumes of timber products are also used in the construction and maintenance of nonresidential structures used by railroads and in the manufacture of freight cars. Past consumption of timber products in these uses are included in other sections of this chapter dealing with nonresidential construction and manufacturing.*

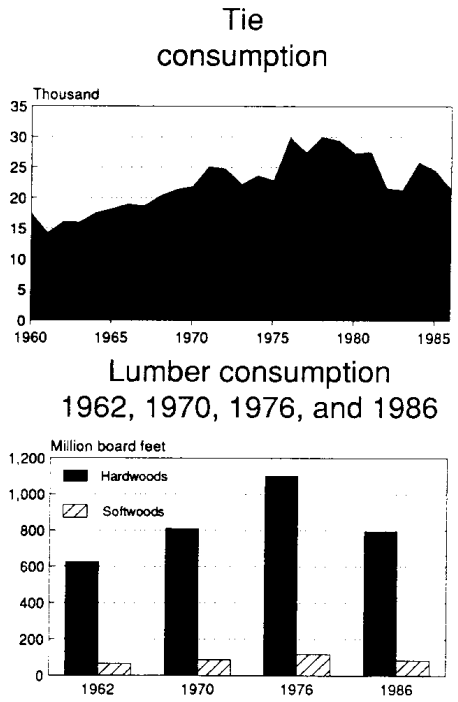

Figure 7.—Railroad ties.

tors, longer-run trends have resulted from fundamental changes in the railroad industry and its operations. For example, based on data available for Class I railroads from the Association of American Railroads (1984, 1987), the miles of track operated by all U.S. railroads dropped by at least 18% over the last two decades, the outgrowth of restructuring and streamlining systems and operations. Despite this decline, annual tie installations have been somewhat higher in the 1980s than in the 1960s. The principal reason for this has been the necessity to upgrade the remaining system to accommodate increasing track loads. Data show that average car load has increased almost 40% since the mid-1960s. Because of these trends, the average number of crossties installed annually per mile of track has about doubled (Association of American Railroads 1972, 1987).

Over the last two decades, nearly all of the crossties installed have been wood. Although a few railroads have been installing a larger percentage of concrete ties on their high-speed passenger lines, they amounted to only a very small percentage of all crossties installed in 1986 (Buekett et al. 1987).

TIMBER PRODUCTS CONSUMPTION IN MANUFACTURING

U.S. manufacturing industries, including those producing pallets and containers, rank second only to new residential construction in the use of solid-wood products. In 1986, about 8% of the lumber and more than 20% of the wood panel products consumed were used for the production of a wide variety of products made for sale, and in the production process for jigs, models, patterns, flasks and other facilitating purposes.

For this analysis, these manufactured goods have been divided into three groups: (1) household furniture, (2) commercial and institutional furniture, and (3) other products.[3] Although this latter group accounts for a moderately large part of total manufacturing timber products consumption, use for individual manufactured products is relatively small; thus, they have been combined.

In addition to the estimates presented in this section, substantial amounts of timber products are used to produce pallets, containers, prefabricated wooden buildings, structural wood members, mobile homes, millwork, and flooring. Information on timber products consumed in the production of these items is included in those sections of this chapter dealing with packaging and shipping and residential and nonresidential construction.

Recent trends in wood products use for manufacturing reflect both differential growth in the production and shipments of the various manufactured products, and technological changes which have affected the kinds and amounts of materials used in their production.

Shipments of Manufactured Products

Total shipments of the manufactured products included in this section amounted to $2,286 billion in 1986 (measured in 1982 dollars), a record volume, and about 3 times larger than in 1948 (table 9, fig. 8). In general, the manufacture and shipment of these products follow trends in the economy. Thus, growth in shipments was fairly steady at an annual rate of 3.8% during the 1950s through early 1970s period. However, the economic recessions in the mid-1970s, and particularly in the early 1980s resulted in sharp reductions. After 1982, shipments steadily increased in line with the gross national product. Per capita shipments, which rose from $4,982 in 1948 to $9,463 in 1986, have followed similar directions (McKeever and Jackson 1990: table A-1).

Household furniture shipments—$15.9 billion in 1986—have closely followed trends in total manufacturing, rising through the early 1970s, declining during the economic downturns, and increasing between 1982 and 1986. Nevertheless, shipments in 1986 were still below those for some years in the early and late 1970s. Shipments of commercial and institutional furniture and of other products have also increased fairly rapidly since 1982 reaching $15.5 billion and $2,255 billion, respectively, in 1986.

Timber Products Use Per Dollar of Shipments

There have been divergent trends in the use of lumber, structural, and nonstructural panels per dollar of

[3]*Includes sporting goods, musical instruments, boat building and repair, toys and games, luggage and trunks, handles, wood pencils, mortician's goods, shoe and boot findings, wooden matches, commercial refrigeration, signs and displays, patterns and jigs, truck bodies and trailers, general machinery, agricultural implements, electrical equipment, and textile machinery supplies.*

Table 9.—Value of manufacturing shipments in the United States, by commodity group, specified years 1948–86.

Year	All products		Household furniture		Commercial and institutional furniture		Other products[1]	
	Value	Annual rate of change	Value	Annual rate of change	Value	Annual rate of change	Value	Annual rate of change
	Billion 1982 dollars	*Percent*	*Billion 1982 dollars*	*Percent*	*Billion 1982 dollars*	*Percent*	*Billion 1982 dollars*	*Percent*
1948	733.3	NA	7.3	NA	1.8	NA	724.2	NA
1950	798.4	4.3	8.3	6.6	2.3	13.0	787.8	4.3
1955	1,057.3	5.8	10.6	5.0	3.3	7.5	1,043.5	5.8
1960	1,140.8	1.5	11.0	.7	5.0	8.7	1,124.7	1.5
1965	1,492.5	5.5	14.6	5.8	6.8	6.3	1,471.2	5.5
1970	1,682.7	2.4	16.1	2.0	8.5	4.6	1,658.1	2.4
1975	1,735.0	.6	13.1	-4.0	8.2	- .7	1,713.8	.7
1976	1,898.0	9.4	14.8	13.0	8.5	3.7	1,874.8	9.4
1977	2,032.0	7.1	16.0	8.1	10.2	20.0	2,005.9	7.0
1978	2,119.9	4.3	17.0	6.3	10.9	6.9	2,091.9	4.3
1979	2,138.9	.9	15.8	- 7.1	10.9	.0	2,112.1	1.0
1980	2,016.3	-5.7	14.3	-9.5	10.6	-2.8	1,991.4	-5.7
1981	2,016.1	.0	13.9	-2.8	10.4	-1.9	1,991.7	.0
1982	1,865.4	-7.5	12.8	-7.9	11.4	9.6	1,841.3	-7.6
1983	1,969.0	5.6	14.0	9.4	12.2	7.0	1,942.8	5.5
1984	2,141.6	8.8	15.0	7.1	13.9	13.9	2,112.6	8.7
1985	2,217.4	3.5	15.4	2.7	15.0	7.9	2,187.0	3.5
1986	2,286.1	3.1	15.9	3.2	15.5	3.3	2,254.8	3.1

[1]*Includes all other manufactured products except pallets, prefabricated wooden buildings and structural members, containers, mobile homes, millwork, flooring, and other similar goods reported in the construction and shipping sections of this chapter.*

Note: Value of shipments in 1982 dollars derived by dividing the value of shipments in current dollars by the producer price index for all commodities (1982 = 100). Data may not add to totals due to rounding.

Sources: Council of Economic Advisors 1988; USDC BC 1966a, 1971, 1976b, 1985, 1987a.

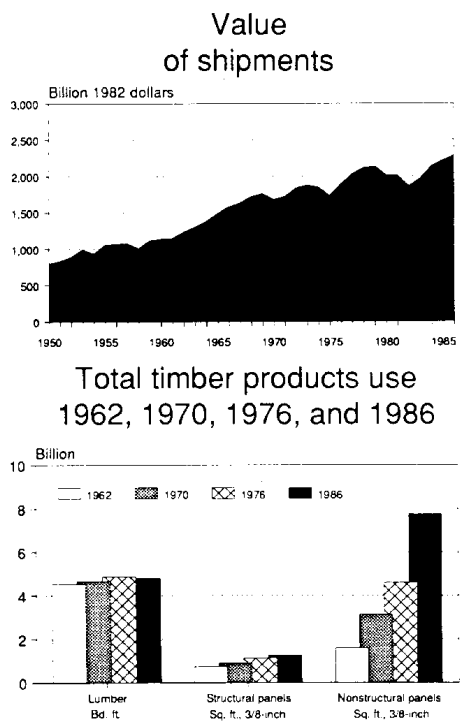

Figure 8.—Manufacturing.

shipments of manufactured products over the past three and a half decades (table 10 and McKeever and Jackson 1990: table A-2). For example, lumber consumption per dollar of shipments has dropped for each of the manufactured products groups, while structural panel use has fluctuated but shown no long-run trend, and nonstructural panels consumption has increased fairly steadily.

These trends reflect numerous technical and institutional shifts both within the manufacturing industries and their major markets. For example, part of the decline in the use of lumber and the relatively level trends in the use of structural panels per dollar of shipments reflects inroads of alternative materials. Plastics became a particularly important substitute for wood in furniture manufacture in the late 1960s and early 1970s, especially for highly ornate, detailed furniture parts and styles (Clark 1971). Lower costs, greater freedom in design, superior dimensional stability, and resistance to damage were among the principal factors contributing to its increased use during that period. Although numerous plastic components and parts continue to be used in the household furniture industry, overall consumption has apparently dropped since 1972 (USDC BC 1985). In addition to such technical factors as wood's ease of refinishing and repair, greater fracture resistance, and higher load bearing strength, the deep-seated preference for

Table 10.—Timber products used in manufacturing in the United States, by product, specified years 1948–86.

Year	Lumber		Structural panels (3/8-inch basis)		Nonstructural panels (3/8-inch basis)	
	Total	Per dollar of shipments[1]	Total	Per dollar of shipments[1]	Total	Per dollar of shipments[1]
	Million board feet	*Board feet*	*Million square feet*	*Square feet*	*Million square feet*	*Square feet*
1948	3,924	0.00535	363	0.00050	763[2]	0.00104
1960	3,865	.00339	910	.00080	1,378	.00121
1965	4,609	.00309	811	.00054	2,083	.00140
1970	4,670	.00278	902	.00054	3,128	.00186
1976	4,864	.00256	1,132	.00060	4,583	.00241
1986	4,803	.00210	1,257	.00055	7,750	.00339

[1]*Use per dollar (1982 dollars) of shipments, 1948–86, computed by Forest Service. (See table 9 for values of shipments.)*

[2]*Includes hardwood plywood only.*

Note: Timber products use by manufacturing group is shown in McKeever Jackson 1990, table A–2. Data may not add to totals because of rounding.

Sources: Merrick 1951, Gill 1965, Gill and Phelps 1969, McKeever and Martens 1983.

wood furniture by some consumers, and the return to more traditional furniture styles may have been contributing factors in plastic's decline.

For some other manufactured products—such as commercial and institutional furniture, boats, and toys—materials such as fiberglass, reinforced plastics, and metals have replaced lumber and wood panel products and continue to be used because of their lower costs or preferred performance characteristics.

Nonstructural panels have also partially displaced lumber and structural panels in some manufactured products. This substitution has been particularly rapid over the past 35 years in the manufacture of household furniture. For example, particleboard instead of lumber is now used extensively for panel corestock and hardboard has replaced plywood for such components as drawer bottoms and backs in cabinets. In addition, the superior edge-working characteristics of medium-density fiberboard has been a major factor in its substitution for lumber, plywood, and particleboard. Unlike most plywood and particleboard, its smoothness after machining permits the printing of a wood grain or other pattern directly on the surface, thus eliminating the need for a veneer or paper overlay.

Part of the decline in the use of lumber, and the relatively stable use of structural panels, per dollar of shipments also reflects a general reduction in use of all raw materials per dollar of product value. This has resulted from increases in the degree of processing of materials and rising relative costs of labor and capital per unit of production (USDC BC 1985).

Total Timber Products Use in Manufacturing

Trends in the volumes of lumber and panel products consumed in the manufacture of the products included in this section have varied greatly in recent decades as a result of the changing production and shipments, and use per dollar values discussed earlier. Total lumber consumption—4.8 billion board feet in 1986—varied, but showed little overall growth after 1965, as rising shipments were nearly offset by declining use per dollar (Gill 1965, Gill and Phelps 1969, USDA FS 1982, McKeever and Martens 1983) (tables 10, 11, McKeever and Jackson 1990: A-2, and fig. 8). Structural panel consumption, which had increased fairly rapidly during the 1950s, also slowed somewhat between 1965 and 1986, rising to 1.3 billion square feet, 3/8-inch basis. Consumption of nonstructural panels, on the other hand, has been increasing steadily since the early 1950s. As was discussed earlier in this section, much of the increase in the last two decades has come because of their substitution for lumber and structural panels. Total nonstructural panels consumption in manufacturing in 1986 was about 7.8 billion square feet, 3/8-inch basis, more than 10 times that used in 1948 and almost 4 times more than was consumed in 1965.

Until the early 1970s the household furniture manufacturing industry group consumed the largest volumes of lumber and nonstructural panel products. However, over the next 15 years, there was very rapid growth for those industries in the "other products" group, and declines and erratic and slower increases for household furniture. As a consequence, in 1986 the "other products" group was the largest consumer of lumber—2.7 billion board feet—and of nonstructural panel products—3.3 billion square feet, 3/8-inch basis (table 11). The "other products" group also consumed the largest volume of structural panel products in 1986, 840 million square feet, 3/8-inch basis, as has been the case for more than 25 years.

Although the "other products" group became the largest consumer of lumber and nonstructural panel

Table 11.—Timber products used in manufacturing in the United States, by product and commodity group, specified years 1948–86.

Year and commodity group	Lumber	Structural panels (3/8-inch basis)	Nonstructural panels (3/8-inch basis)
	Million board feet	*Million square feet*	*Million square feet*
1948			
Household furniture	1,970	195	397[1]
Commercial and institutional furniture	321	90	184[1]
Other products[2]	1,633	78	182[1]
Total	3,924	363	763[1]
1960			
Household furniture	2,116	351	719
Commercial and institutional furniture	289	137	322
Other products[2]	1,460	422	337
Total	3,865	910	1,378
1965			
Household furniture	2,987	300	1,289
Commercial and institutional furniture	280	87	427
Other products[2]	1,342	424	367
Total	4,609	811	2,083
1970			
Household furniture	2,961	327	1,912
Commercial and institutional furniture	271	114	736
Other products[2]	1,438	461	480
Total	4,670	902	3,128
1976			
Household furniture	2,317	204	1,390
Commercial and institutional furniture	285	218	993
Other products[2]	2,262	710	2,200
Total	4,864	1,132	4,583
1986			
Household furniture	1,773	154	2,150
Commercial and institutional furniture	310	263	2,300
Other products[2]	2,720	840	3,300
Total	4,803	1,257	7,750

[1]*Includes hardwood plywood only.*

[2]*Includes all other manufactured products except pallets, prefabricated wooden buildings and structural members, containers, mobile homes, millwork, flooring, and other similar goods reported in the construction and shipping sections of this chapter.*

Source: See source note table 10.

products in 1986, the manufacturers of household furniture are still the largest users among those industries manufacturing generally similar products. In addition, they also remain the most important consumers of the high quality and preferred species of domestic and imported lumber.

TIMBER PRODUCTS CONSUMPTION IN PACKAGING AND SHIPPING

In 1986, some 6.8 billion board feet of lumber; 373 million square feet, 3/8-inch basis, of structural panels; and 243 million square feet, 3/8-inch basis, of nonstructural panels were used in shipping (table 12). These materials—about 14% of the lumber, 2% of the structural panels, and 1% of the nonstructural panels consumed in 1986—were used for the manufacture of pallets, boxes, crates, hampers, baskets, and other wooden containers; and for dunnage, blocking, and bracing required for the transportation, handling, and storage of industrial, agricultural, and military products.[4]

There were increases in consumption of all of the major product groups between 1976 and 1986. Lumber consumption rose about 15%, structural panels 44%, and nonstructural panels 24%. For lumber this was a continuation of the increases in use that has been evident since 1960. However, for structural and nonstructural panels, the rise was a reversal of the declining trends over the past 25 years.

[4]*In addition to lumber and panel products, large volumes of paper and board are used for packaging and shipping. Trends in the consumption of those products are discussed in the pulpwood section of this chapter.*

Table 12.—Timber products used in shipping in the United States, by product and end use, specified years 1948–86.

Year and end use	Lumber	Structural panels (3/8-inch basis)	Nonstructural panels (3/8-inch basis)
	Million board feet	*Million square feet*	*Million square feet*
1948			
Wooden containers	3,997	313	([1,2])
Pallets	220	1	([1,2])
Dunnage, blocking, and bracing	740	([2])	([1,2])
Total	4,957	314	([1,2])
1960			
Wooden containers	1,866	304	821
Pallets	1,550	16	3
Dunnage, blocking, and bracing	800	([2])	1
Total	4,216	320	825
1965			
Wooden containers	1,829	203	393
Pallets	2,200	62	18
Dunnage, blocking, and bracing	856	4	8
Total	4,885	269	419
1970			
Wooden containers	1,754	174	262
Pallets	3,150	105	44
Dunnage, blocking, and bracing	820	6	8
Total	5,724	285	314
1976			
Wooden containers	822	97	113
Pallets	4,900	157	78
Dunnage, blocking, and bracing	195	5	5
Total	5,917	259	196
1986			
Wooden containers	275	47	53
Pallets	6,341	321	187
Dunnage, blocking, and bracing	170	5	3
Total	6,786	373	243

[1] *Includes hardwood plywood only.*
[2] *Less than 500,000 units.*
Sources: Wooden containers, and dunnage, blocking and bracing: See source note table 10; Pallets: See source note table 10, McCurdy et al. 1988, McKeever et al. 1986.

Timber Products Consumption in Pallets

The increases in shipping use of lumber since the early 1960s and of structural and nonstructural panels since 1976 have been entirely attributable to the steadily rising number of pallets produced (fig. 9). In 1960, some 62 million pallets were produced (National Wooden Pallet and Container Association 1987), consuming an estimated 1.6 billion board feet of lumber, 16 million square feet of structural panels, and 3 million square feet of nonstructural panels (table 13). Since then, pallet output, and the timber products used to produce them, has increased rapidly. Between 1960 and 1976, pallet production and lumber consumption more than tripled. Because of increasing use per pallet, structural and nonstructural panel consumption rose much faster. In the next 10 years, 1976–86, pallet production nearly doubled to 373 million units; however, lumber consumption only rose 29% to 6.3 billion board feet because of declines in use per pallet. Total consumption and use per pallet of structural and nonstructural panels continued to increase rapidly during this period.

The decline in lumber use per pallet from 25 to 17 board feet since 1976 is the result of many factors. Use of a relatively larger proportion of expendable pallets (which generally use less wood per pallet than other types), substitution of other wood and of nonwood materials, and increased efficiency in pallet design emanating from increased raw material costs and competition from other shipping media have been contributing factors (USDA FS 1982, McCurdy et al. 1988, McKeever et al. 1986).

The rapid increase in pallet production since the early 1960s has, in part, been due to the introduction of new methods of materials handling and to the construction of new facilities geared to pallet use. At the same time,

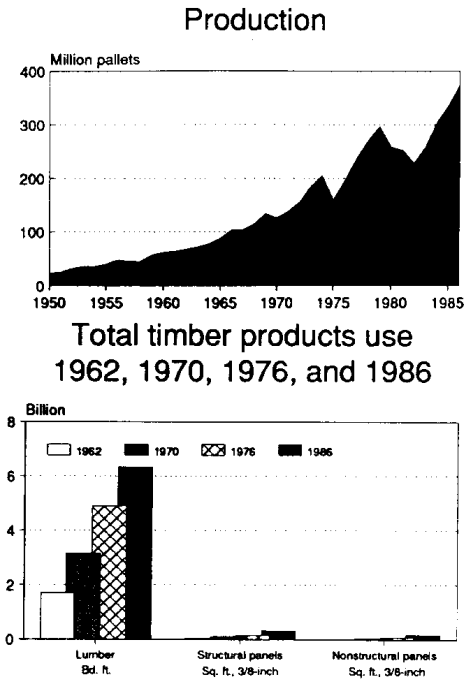

Figure 9.—Wooden pallets.

growth in industrial and agricultural production has led to increased demand in those sectors of the economy where pallet systems were already established.

Timber Products Consumption in Wooden Containers

The use of wooden containers (nailed boxes and crates, wirebound boxes and crates, and veneer and plywood containers) in the United States for agriculture, manufacturing and other uses, has been declining. Since 1970, the value of shipments for wooden containers in constant 1982 dollars has dropped from $1.2 billion to $0.6 billion in 1986 (table 14). This decline followed a small increase during the 1960s, and reflects the continued displacement of wooden containers by fiber and plastic containers, by metal, plastic, and fiber barrels and pails, and by multiwall fiber and plastic bags, that has been going on for the past 30 years.

Several factors contributed to these changes, including lower costs of substitute containers and their superior adaptability to automated packaging and shipping operations. In addition, lower shipping weights have become more important in recent years as freight costs have increased. In packaging some items, however, such as large bulky products, delicate instruments, glass, ceramics, and certain fruits and vegetables, these advantages continue to be outweighed by the need for special protection; wooden containers are still used.

The use of lumber and panel products per dollar of shipments of wooden containers has shown a consistent downward trend since the early 1960s (table 14), reflecting increasing use of nonwood materials such as plastics and paperboard in conjunction with wood, changes in the types of containers produced, and use of more efficient container manufacturing processes.

As a result of the declines in production and shipments and the decreasing wood use per unit discussed above, total timber products use for wooden containers has fallen dramatically. In 1986 just 275 million board feet of lumber; 47 million square feet, 3/8-inch basis, of structural panels; and 53 million square feet, 3/8-inch basis, of nonstructural panels were used. These volumes were far under 1960 consumption, and are probably all-time lows in this century.

Timber Products Consumption in Dunnage

The volume of lumber used for dunnage, blocking, and bracing in railroad cars, trucks, and ships remained fairly stable through the 1950s and 1960s, but experienced rapid declines in the late 1970s and early 1980s. Lumber consumed for dunnage in 1986 is estimated to be just 170 million board feet, only one-fifth as much as the 820 million board feet used in 1970 (table 15).

Table 13.—Timber products used in the manufacture of pallets in the United States, by product, specified years 1960–86.

Year	Pallet production	Lumber		Structural panels (3/8-inch basis)		Nonstructural panels (3/8-inch basis)	
		Use per pallet	Total	Use per pallet	Total	Use per pallet	Total
	Millions	*Board feet*	*Million board feet*	*Square feet*	*Million square feet*	*Square feet*	*Million square feet*
1960	62	25	1,550	0.25	16	0.05	3
1965	88	25	2,200	.70	62	.21	18
1970	126	25	3,150	.83	105	.35	44
1976	196	25	4,900	.80	157	.40	78
1986	373	17[1]	6,341	.86	321	.50	187

[1]*Based on lumber use per pallet data in McKeever et al. 1986.*

Sources: Pallet production: National Wooden Pallet and Container Association 1987, see source note table 10.

Table 14.—Value of shipments and timber products used in the manufacture of wooden containers in the United States, by product, specified years 1960–86.

Year	Value of wooden container shipments	Lumber		Structural panels (3/8-inch basis)		Nonstructural panels (3/8-inch basis)	
		Use per dollar of shipments[1]	Total	Use per dollar of shipments[1]	Total	Use per dollar of shipments[1]	Total
	Million 1982 dollars	*Board feet*	*Million board feet*	*Square feet*	*Million square feet*	*Square feet*	*Million square feet*
1960	1,074	1.737	1,866	0.283	304	0.764	821
1965	1,152	1.588	1,829	.176	203	.341	393
1970	1,184	1.481	1,754	.147	174	.221	262
1976	802	1.025	822	.121	97	.141	113
1986	643	0.428	275	.073	47	.082	53

[1]*Use per dollar (1982 dollars) of shipments, 1948–86, computed by Forest Service.*

Note: Value of shipments in 1982 dollars derived by dividing the value of shipments in current dollars by the producer price index for all commodities (1982 = 100).

Sources: Value of wooden container shipments: USDC BC 1966a, 1971, 1976b, 1985, 1987a; timber products use: see source note table 10.

Table 15.—Timber products used in dunnage, blocking, and bracing in the United States, by product, specified years 1948–86.

Year	Lumber	Structural panels (3/8-inch basis)	Nonstructural panels (3/8-inch basis)
	Million board feet	*Million square feet*	*Million square feet*
1948	740	([1])	([1,2])
1960	800	([1])	1
1965	856	4	8
1970	820	6	8
1976	195	5	5
1986	170	5	3

[1]*Includes hardwood plywood only.*

[2]*Less than 500,000.*

Source: See source note, table 10.

Table 16.—Timber products used for other purposes[1] in the United States, by product, specified years 1962–86.

Year	Lumber	Structural panels (3/8-inch basis)	Nonstructural panels (3/8-inch basis)
	Million board feet	*Million square feet*	*Million square feet*
1962	7,298	1,299	1,354
1970	6,444	3,264	3,228
1976	6,143	3,663	4,116
1986	11,053	5,119	864

[1]*Includes upkeep and improvement of nonresidential buildings and structures; made-on-the-job items such as advertising and display structures; and a wide variety of products and uses.*

This rapid decline reflects growth in containerized and bulk shipments of manufactured and agriculture goods, and increased use of palletized transportation systems.

Small and relatively stable volumes of structural panels have also been used for dunnage, blocking, and bracing over the past 25 years. Nonstructural panels use has declined.

TIMBER PRODUCTS CONSUMPTION IN OTHER USES

In addition to the major end uses discussed above, an estimated 11.1 billion board feet of lumber; 5.1 billion square feet, 3/8-inch basis, of structural panels; and 0.9 billion square feet, 3/8-inch basis, of nonstructural panels were used in 1986 for other purposes (table 16). These included upkeep and improvement of nonresidential structures; roof supports and other construction in mines; made-at-home or do-it-yourself projects such as furniture, boats, and picnic tables; and made-on-the-job products such as advertising and display structures.

There are no historical data on the consumption of timber products in these various uses. Accordingly, use for these purposes in 1962, 1970, 1976, and 1986 was estimated by subtracting volumes of timber products consumed in the specific end uses discussed above from the estimated total consumption of each product. These residuals probably include some lumber and panel products which properly belong in the construction, manufacturing, or shipping sectors. The "other uses" categories also include any statistical discrepancies associated with the estimates of production, imports, and exports, used in estimating total consumption.

RECENT TRENDS IN LUMBER, STRUCTURAL, AND NONSTRUCTURAL PANELS CONSUMPTION, TRADE, AND PRODUCTION

Lumber

Consumption

Lumber consumption in all uses in 1986 was 57.2 billion board feet (tables 17, 18, McKeever and Jackson 1990: A-3, and fig. 10). This was well above total use in any year in the past three and one-half decades and exceeded the levels in the early 1900s, when lumber was the most important raw material used in the United States for construction, manufactured products, and shipping.

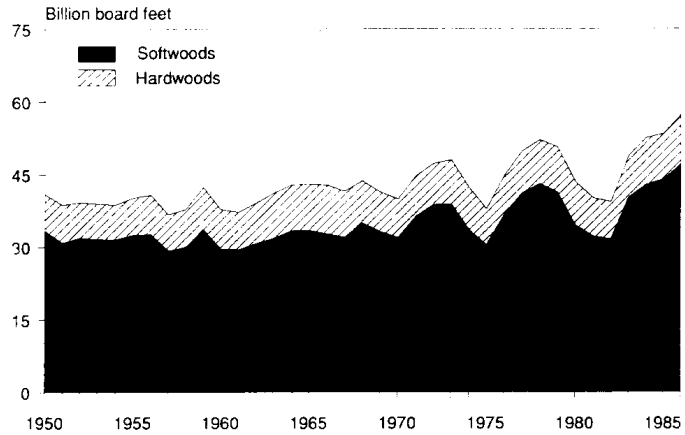

Figure 10.—Lumber consumption, by species group, 1950–1986.

Table 17.—Lumber consumption in the United States, by per capita use, softwoods and hardwoods, and end use, specified years 1962–86.

Year	Total	Per capita	Species group		End use					
			Soft-woods	Hard-woods	New housing	Residential upkeep and improvements	New non-residential construction[1]	Manufac-facturing	Shipping	All other[2]
	Million board feet	*Board feet*	*Million board feet*							
1962	39,078	210	30,773	8,501	14,160	4,330	4,200	4,540	4,550	7,298
1970	39,869	194	31,959	7,910	13,350	4,980	4,700	4,670	5,725	6,444
1976	44,653	205	36,627	8,026	17,000	6,260	4,470	4,865	5,915	6,143
1986	57,203	237	47,094	10,109	19,320	9,930	5,310	4,805	6,785	11,053

[1]*In addition to new construction, includes railroad ties laid as replacements in existing track and lumber used by railroads for railcar repair.*
[2]*Includes upkeep and improvement of nonresidential buildings and structures; made-at-home projects, such as furniture, boats, and picnic tables; made-on-the-job items such as advertising and display structures; and a wide variety of miscellaneous products and uses.*
Note: Product use by market has been rounded to the nearest 5 million board feet. Data may not add to totals because of rounding.

Table 18.—Lumber consumption, imports, exports, and production in the United States, specified years 1950–86.

Year	Consumption			Imports			Exports			Production		
	Total	Softwood lumber	Hardwood lumber	Total	Softwood lumber[1]	Hardwood lumber	Total	Softwood lumber[1]	Hardwood lumber	Total	Softwood lumber	Hardwood lumber
	Billion board feet											
1950	40.9	33.4	7.5	3.4	3.1	0.3	0.5	0.4	0.1	38.0	30.6	7.4
1955	40.1	32.5	7.6	3.6	3.3	.3	.8	.7	.2	37.4	29.8	7.6
1960	37.7	29.6	8.1	3.9	3.6	.3	.9	.7	.2	34.7	26.7	8.0
1965	43.0	33.4	9.6	5.2	4.9	.3	.9	.8	.1	38.7	29.3	9.4
1970	39.9	32.0	7.9	6.1	5.8	.3	1.2	1.1	.1	35.0	27.3	7.7
1975	37.8	30.5	7.3	6.0	5.7	.3	1.6	1.4	.2	33.5	26.1	7.3
1976	44.7	36.6	8.0	8.2	8.0	.3	1.8	1.6	.2	38.3	30.3	8.0
1977	49.7	41.1	8.6	10.7	10.4	.3	1.7	1.4	.2	40.7	32.2	8.5
1978	52.1	43.1	9.0	12.2	11.9	.4	1.6	1.4	.3	41.5	32.6	9.0
1979	50.6	41.3	9.3	11.5	11.2	.4	2.1	1.8	.4	41.2	31.9	9.3
1980	43.4	34.5	8.9	9.9	9.6	.3	2.5	2.0	.5	36.1	27.0	9.1
1981	40.1	32.3	7.8	9.5	9.2	.3	2.4	1.9	.5	33.0	25.0	8.0
1982	39.3	31.6	7.7	9.4	9.1	.2	2.0	1.6	.4	32.0	24.1	7.9
1983	48.8	40.2	8.6	12.3	12.0	.3	2.3	1.8	.5	38.8	30.0	8.8
1984	52.5	42.9	9.6	13.6	13.3	.3	2.2	1.6	.5	41.0	31.2	9.8
1985	53.4	44.0	9.4	15.0	14.6	.4	1.9	1.5	.4	40.3	30.9	9.5
1986	57.2	47.1	10.1	14.6	14.3	.3	2.4	1.9	.5	45.0	34.7	10.3

[1]*Includes small volumes of mixed species not classified as softwoods or hardwood.*
Note: Data may not add to totals because of rounding.
Sources: Production: USDC BC 1987d. Trade: USDC BC 1987h, 1987i.

Per capita consumption in 1986 was 237 board feet, somewhat above per capita use in the 1960s and 1970s, but below the average for most years prior to that time. Moreover, this was far below the early 1900s, when per capita use reached a high of more than 500 board feet.

More than half of the lumber consumed in 1986 was used for housing—34% for construction of new units and 17% for the upkeep and improvement of existing units. Shipping accounted for another 12%, new nonresidential construction and railroads 9%, manufacturing 8%, and the remaining 19% was consumed in other uses.

In 1986, softwood species composed about 82% of total lumber consumption. This was very nearly the same as in 1976, but somewhat above the proportions in 1970 and 1962. Changes of this sort are largely due to differential strength of the various markets, and the wide variation in species consumption between them. As shown in the tabulation below, about 96% of the lumber used in new housing in 1986 is estimated to have been softwood species. In contrast, only 30% of the lumber used in shipping was softwood. The rise in the percentage of softwood used in housing between the early 1960s and the 1980s was largely due to the decline in hardwood flooring use; whereas the decline in shipping was the result of the growth of pallets which are mostly manufactured from hardwoods.

Exports and Imports

In addition to domestic consumption, there has been a rising demand for U.S. lumber in foreign markets over the past 35 years (table 18 and McKeever and Jackson 1990: A-3). Total exports, which had reached 2.5 billion board feet in 1980, fluctuated downward in the early 1980s in response to economic conditions in the major importing countries and the strong dollar in relation to most of the world's currencies (see Chapter 5 for more detail), but subsequently returned to 2.4 billion in 1986. This amounted to about 5% of total U.S. lumber production.

More than three-fourths of total exports in 1986 were softwood species. The most important softwood lumber export markets were Japan—which accounted for about 43% of total softwood shipments, Canada with imports of 19%, and the European Economic Community (EEC) countries who collectively purchased 16%. Canada—with 31% in 1986—was the most important export market for hardwoods, followed by the EEC with imports of 27%. Other purchasers of U.S. hardwood lumber include Japan, several countries in South and Central America, and more recently Taiwan and South Korea.

Between 1950 and 1985, U.S. imports of lumber rose from 3.4 billion to 15.0 billion board feet—an increase that accounted for nearly two-thirds of the total expansion in timber products imports during this period. Although imports dropped slightly to 14.6 billion board feet in 1986, this was second only to the 1985 record volume.

Nearly all of the increase in total lumber imports since the early 1950s has been composed of softwoods from Canada, chiefly from British Columbia. Moreover, there was particularly rapid growth after the mid-1970s, and by 1985, Canadian shipments amounted to more than a third of total U.S. softwood lumber consumption. The percentage (and the volume) of softwoods from Canada dropped somewhat in 1986. Hardwood imports from the tropical regions of the world and from Canada, have fluctuated between 0.2 and 0.4 billion board feet since 1950, but have shown no overall trend.

Production

Although there has been a great deal of fluctuation in response to changing demands in domestic and export markets, U.S. production of both softwoods and hardwoods has been somewhat higher in the late 1970s and 1980s than in 1950–69 and most prior years. In 1986, U.S. mills produced 45.0 billion board feet of lumber—the largest volume in more than seven decades and only slightly under the record 46 billion produced in 1906 and 1907 (Steer 1948). Softwood production—34.7 billion board feet—was at near record levels, surpassed only by output in 1906 and 1907. Production of hardwood species is estimated at 10.3 billion board feet. This was smaller than in most years between 1904 and 1912; however, it was the largest volume produced since that time.

Structural Panels

Consumption

Structural panel consumption totaled 25.9 billion square feet, 3/8-inch basis, in 1986 (tables 19, 20, McKeever and Jackson 1990: A-4, and fig. 11). This was a record volume, almost 9% above 1985, and more than 10 times total use in 1950. Per capita consumption has also shown a sharp upward trend during this period,

Estimates of softwood species as a percent of total lumber consumption

Year	All end uses	New housing	Residential upkeep and improvements	New nonresidential construction*	Manufacturing	Shipping	Other
1962	79	93	97	74	52	40	84
1986	82	96	97	74	47	30	97

*Includes railroad construction.

Table 19.—Structural panel consumption in the United States, by per capita use, panel type, and end use, specified years 1962–86.

Year	Total	Per capita	Panel type		End use					
			Softwood plywood	OSB/ waferboard	New housing	Residential upkeep and improvements	New nonresidential construction[1]	Manufacturing	Shipping	All other[2]
	Million square feet (3/8-inch basis)	*Square feet (3/8-inch basis)*	*Million square feet (3/8-inch basis)*							
1962	9,509	51	9,509	[3]	3,950	1,670	1,650	730	210	1,299
1970	14,229	69	14,229	[3]	5,590	2,320	1,870	900	285	3,264
1976	17,963	82	17,736	227	7,760	3,240	1,910	1,130	260	3,663
1986	25,949	107	21,665	4,284	9,950	6,170	3,080	1,255	375	5,119

[1]*In addition to new construction, includes structural panels used by railroads for railcar repair.*
[2]*Includes upkeep and improvement of nonresidential buildings and structures; made-at-home projects, such as furniture, boats, and picnic tables; made-on-the-job items such as advertising and display structures; and a wide variety of miscellaneous products and uses.*
[3]*Less than 500,000 square feet.*
Note: Estimates for manufacturing and shipping contain softwood veneer consumed in other than plywood production. Product use by market has been rounded to the nearest 5 million square feet. Data may not add to totals because of rounding.

Table 20.—Structural panel consumption, imports, exports, and production in the United States, specified years 1950–86.

Year	Consumption			Imports			Exports			Production		
	Total	Softwood plywood	OSB/ waferboard	Total	Softwood plywood	OSB/ waferboard	Total	Softwood plywood	OSB/ waferboard	Total	Softwood plywood[1]	OSB/ waferboard
	Billion square feet (3/8-inch basis)											
1950	2.6	2.6	(2)	(2)	(2)	(2)	(2)	(2)	(2)	2.6	2.6	(2)
1955	5.1	5.1	(2)	(2)	(2)	(2)	(2)	(2)	(2)	5.1	5.1	(2)
1960	7.8	7.8	(2)	(2)	(2)	(2)	(2)	(2)	(2)	7.8	7.8	(2)
1965	12.4	12.4	(2)	(2)	(2)	(2)	(2)	(2)	(2)	12.4	12.4	(2)
1970	14.2	14.2	(2)	(2)	(2)	(2)	0.1	0.1	(2)	14.3	14.3	(2)
1975	15.5	15.3	0.2	0.1	(2)	0.1	.8	.8	(2)	16.1	16.1	0.1
1976	18.0	17.7	.2	.2	(2)	.1	.7	.7	(2)	18.5	18.4	.1
1977	19.4	19.1	.3	.2	(2)	.2	.3	.3	(2)	19.5	19.4	.1
1978	20.1	19.7	.4	.3	0.1	.2	.3	.3	(2)	20.1	20.0	.2
1979	19.7	19.3	.4	.3	(2)	.3	.4	.4	(2)	19.8	19.7	.2
1980	16.4	15.9	.5	.3	(2)	.3	.4	.4	(2)	16.5	16.3	.2
1981	16.7	16.0	.7	.3	(2)	.3	.7	.7	(2)	17.0	16.7	.3
1982	16.2	15.4	.9	.3	(2)	.3	.5	.5	(2)	16.4	15.8	.6
1983	20.7	19.0	1.7	.5	(2)	.4	.6	.6	(2)	20.8	19.5	1.3
1984	22.4	19.6	2.8	.8	.1	.7	.4	.4	(2)	22.0	19.9	2.1
1985	23.8	20.0	3.8	.9	.1	.8	.3	.3	(2)	23.2	20.3	3.0
1986	25.9	21.7	4.3	.9	.1	.8	.6	.6	(2)	25.6	22.1	3.5

[1]*Includes production from both domestic and imported species.*
[2]*Less than 50 million square feet.*
Note: Data may not add to totals because of rounding.
Sources: Production: Anderson 1987b, USDC BC 1987g. Trade: USDC BC 1987h, 1987i.

rising from about 18 square feet in 1950 to 107 square feet in 1986.

More than three-fourths of all the structural panels consumed in 1986 went into construction. Of the total, major construction uses included about 38% for new residential construction, 24% for residential upkeep and improvements, and 12% for new nonresidential construction. In addition, the "all other" category includes an unknown amount that was used for other construction purposes such as nonresidential upkeep and improvements. Manufacturing uses accounted for almost 5% of the total, and shipping accounted for the remainder of the identifiable uses.

Softwood plywood, chiefly manufactured from Douglas-fir and southern pine, amounted to 21.7 billion square feet or about 83% of total structural panels con-

sumption in 1986. The remaining 4.3 billion square feet was oriented strand board (OSB) and waferboard. Record volumes of both softwood plywood and OSB/waferboard were consumed in 1986, and growth for both has been particularly rapid since construction began to pick up after the 1980–82 economic slump. Softwood plywood consumption has increased ten-fold since the early 1950s, and by about 42% since the mid-1970s. OSB/waferboard, which was not in wide use in the United States prior to the mid-1970s, has grown much more rapidly over the past 10 years. These trends are expected, since, as was discussed earlier, much of the penetration of construction markets by OSB/waferboard has come at the expense of softwood plywood.

Exports and Imports

Structural panel exports, estimated to be nearly all softwood plywood, totaled 0.6 billion square feet, 3/8-inch basis, in 1986. Exports grew fairly slowly through the mid 1970s; however, since reaching 0.8 billion square feet in 1975, shipments have fluctuated between 0.3 and 0.6 billion square feet. About 2% of total domestic production of structural panels is currently exported. Principal foreign markets include the EEC countries, Canada, and several South and Central American nations.

Imports of structural panels in 1986 amounted to 0.9 billion square feet, 3/8-inch basis. More than 85% of the total (0.8 billion) was OSB/waferboard. Structural panel imports prior to the mid-1970s were nearly all softwood plywood and were relatively insignificant. Although softwood plywood imports have shown some growth since that time, most of the increase has been for OSB/waferboard from Canada. In 1986, about 18% of the OSB/waferboard consumed in the United States was supplied by imports, down from almost 94% in the mid-1970s. Less than 1% of softwood plywood consumption is imported.

Production

Domestic structural panel production in 1986 reached 25.6 billion square feet, 3/8-inch basis, almost 10 times the level of output in the early 1950s. As was true for consumption, this was a record production volume for both softwood plywood and OSB/waferboard.

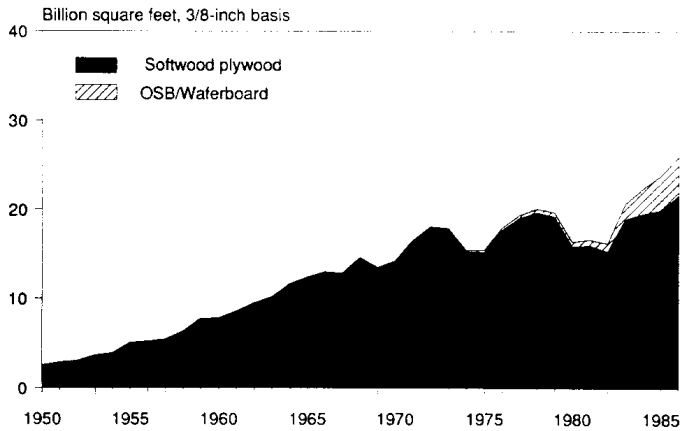

Figure 11.—Structural panels consumption, by type, 1950–1986.

In 1986, 48% of structural panel production was in the South, 38.8% in the Pacific Coast states of Washington, Oregon, and California, 8.9% in the North, and the remainder in the Rocky Mountain Region (Anderson 1987b). Although the South currently leads, there have been dramatic shifts in the regional production of structural panels over the last three and one-half decades (Adams et al. 1988). In the early 1950s, 100% of structural panel production—all softwood plywood at the time—was located in the Pacific Coast states. By the mid-1950s, a significant volume of softwood plywood also was being produced in the Rocky Mountain Region. However, beginning in 1964 with the first southern pine plywood production, regional output began to shift to the South. Currently, more than half of the softwood plywood produced each year comes from southern mills. U.S. OSB/waferboard production began in the North in 1973. Production came on line in the three other major regions in the 1980s; however, the North still accounted for over 75% of total OSB/waferboard output in 1986.

Nonstructural Panels

Consumption

Total consumption of nonstructural panels—hardwood plywood, insulating board, hardboard, and particleboard (including medium-density fiberboard)—amounted to 18.2 billion square feet, 3/8-inch basis, in 1986 (tables 21, 22, McKeever and Jackson 1990: A-5, and fig. 12). This was nearly 4 times larger than in the early 1950s, but somewhat less than in 1972–73 and 1977–79 when consumption of all four products was near record levels. Per capita consumption, 75 square feet in 1986, has followed the same general trends over the past 35 years.

Although consumption of each of the nonstructural panel products was larger in 1986 than in the early 1950s, use of only one, particleboard, has shown a generally upward trend over the entire period. Consumption of particleboard reached a record 9.8 billion square feet in 1986 and accounted for over half of the total use of all nonstructural panels. For each of the other three, output in 1986 was somewhat below the levels reached in the 1970s, reflecting product substitution and changing markets discussed earlier in this chapter. For example, hardwood plywood consumption—2.7 billion square feet in 1986—was only about half as much as in 1972, when use reached a high of 5.2 billion square feet. Similarly, consumption of insulating board fell from 5.3 billion square feet in 1973 to 3.8 billion in 1986; and hardboard use dropped from 2.7 billion square feet in 1978 and 1979 to 2.0 billion in 1986.

Manufacturing was the most important end use for nonstructural panels in 1986, accounting for over 42% of the total. This was more than double the 20% of total use in manufacturing in 1962 and was the result of the

Table 21.—Nonstructural panel consumption in the United States, by per capita use, panel type, and end use, specified years 1962–86.

Year	Total	Per capita	Panel type				End use					
			Hardwood plywood	Insulating board	Hardboard	Particleboard[1]	New housing	Residential upkeep and improvements	New nonresidential construction	Manufacturing	Shipping	All other[2]
	Million square feet (3/8-inch basis)	*Square feet (3/8-inch basis)*	*Million square feet (3/8-inch basis)*									
1962	7,994	43	2,404	3,844	930	816	2,540	1,400	895	1,580	225	1,354
1970	13,198	64	3,784	4,328	1,572	3,514	3,680	1,660	1,185	3,130	315	3,228
1976	16,891	77	3,360	4,500	2,105	6,926	4,610	2,190	1,195	4,585	195	4,116
1986	18,239	75	2,650	3,815	1,952	9,822	4,710	3,160	1,510	7,750	245	864

[1]*Includes medium-density fiberboard.*

[2]*Includes upkeep and improvement of nonresidential buildings and structures; made-at-home projects, such as furniture, boats, and picnic tables; made-on-the-job items such as advertising and display structures; and a wide variety of miscellaneous products and uses.*

Note: Estimates for manufacturing and shipping contain hardwood veneer consumed in other than plywood production. Product use by market has been rounded to the nearest 5 million square feet. Data may not add to totals because of rounding.

Table 22.—Nonstructural panel consumption, imports, exports, and production in the United States, specified years 1950–86.

Year	Consumption					Imports				
	Total	Hardwood plywood	Insulating board	Hardboard	Particleboard[1]	Total	Hardwood plywood	Insulating board	Hardboard	Particleboard[1]
	Billion square feet (3/8-inch basis)									
1950	NA	NA	3.0	0.3	(2)	(2)	(2)	(2)	(2)	(2)
1955	6.5	1.8	4.0	.5	0.1	0.6	0.4	0.1	(2)	(2)
1960	6.5	1.8	3.8	.7	.5	.9	.7	.1	0.1	(2)
1965	10.4	3.1	4.5	1.2	1.6	1.3	1.0	.1	.2	(2)
1970	13.2	3.8	4.3	1.6	3.5	2.3	2.0	.1	.2	(2)
1975	13.9	2.9	3.9	1.7	5.4	2.1	1.9	(2)	.1	(2)
1976	16.9	3.4	4.5	2.1	6.9	2.7	2.4	.1	.2	.1
1977	18.6	3.4	4.6	2.3	8.3	2.9	2.3	.1	.2	.3
1978	20.1	3.6	4.6	2.7	9.1	3.4	2.5	.2	.3	.4
1979	18.8	3.2	4.5	2.7	8.4	3.0	2.1	.2	.3	.4
1980	15.5	2.2	3.8	2.1	7.4	2.0	1.2	.1	.2	.5
1981	14.4	2.4	2.8	2.0	7.2	2.3	1.5	.1	.2	.5
1982	12.6	2.0	2.5	1.9	6.2	1.9	1.1	.2	.2	.5
1983	15.8	2.6	3.2	2.1	7.9	2.8	1.6	.3	.2	.7
1984	17.0	2.4	3.7	2.0	8.9	3.2	1.5	.4	.3	1.1
1985	17.6	2.5	3.9	2.0	9.2	3.7	1.7	.5	.3	1.2
1986	18.2	2.7	3.8	2.0	9.8	3.8	1.9	.5	.3	1.1
	Exports					Production				
1950	0.1	(2)	0.1	(2)	(2)	NA	NA	3.1	0.3	(2)
1955	.1	(2)	.1	(2)	(2)	6.0	1.4	4.0	.5	0.1
1960	.1	(2)	(2)	(2)	(2)	6.1	1.1	3.8	.6	.5
1965	.1	(2)	.1	(2)	(2)	9.1	2.0	4.5	1.0	1.6
1970	.2	0.1	.1	(2)	(2)	11.0	1.8	4.3	1.4	3.5
1975	.4	.1	.1	0.1	0.2	12.2	1.1	3.9	1.7	5.5
1976	.4	.1	.1	.1	.2	14.6	1.1	4.5	2.0	7.0
1977	.4	.1	.1	.1	.1	16.1	1.2	4.6	2.2	8.1
1978	.3	(2)	.1	(2)	.1	17.0	1.2	4.6	2.5	8.8
1979	.3	(2)	.1	(2)	.2	16.1	1.2	4.4	2.4	8.1
1980	.4	(2)	.1	(2)	.2	13.8	1.0	3.7	2.0	7.1
1981	.5	(2)	.1	.1	.2	12.6	1.0	2.8	1.9	6.9
1982	.3	(2)	.1	(2)	.1	11.0	.9	2.4	1.8	5.9
1983	.4	(2)	.1	.1	.2	13.3	1.0	3.0	2.0	7.4
1984	.4	(2)	.1	.1	.2	13.5	.9	3.4	1.2	8.0
1985	.4	(2)	.1	.1	.2	14.3	.8	3.5	1.8	8.2
1986	.6	.1	.2	.1	.3	15.0	.8	3.5	1.7	9.0

[1]*Includes medium-density fiberboard.*

[2]*Less than 50 million square feet.*

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

Sources: Hardwood plywood production: USDC BC 1987b; insulating board and hardboard: USDC BC 1987e; particleboard production: USDC BC 1977b; National Particleboard Association 1987; trade: USDC BC 1987d, 1987h.

large and increasing amounts of particleboard and medium-density fiberboard used primarily in furniture production. Most of the remainder in 1986 was used in construction: 26% in new residential construction, 17% in residential upkeep and improvements, and 8% in nonresidential construction.

Exports and Imports

Exports of nonstructural panels totaled 0.6 billion square feet, 3/8-inch basis, in 1986, up from 0.1 billion square feet in 1950, and the peak in a very gradually rising trend over the past three and one-half decades. Total nonstructural panel imports have fluctuated; however, the overall trend has also risen, as increases in particleboard and insulating board offset declines in hardwood plywood.

Production

Production of nonstructural panels totaled 15.0 billion square feet, 3/8-inch basis, in 1986, about 3.2 times output in the early 1950s, but down somewhat from the mid-1970s. Although production of all four products generally rose through the late 1960s and early 1970s, subsequent declines in the output of insulating board, hardboard, and particularly hardwood plywood, more than offset continuing increases in particleboard production. As a result, total production of nonstructural panels in 1986 was nearly 12% below the high reached in 1978.

PULPWOOD CONSUMPTION

More than a fourth of the roundwood timber products and large volumes of byproducts from other primary wood products manufacturing processes are consumed annually in the United States for the manufacture of woodpulp. Most of the woodpulp produced in U.S. mills is used in the production of paper and board products that are consumed in the United States. Thus, the discussion of pulpwood demands in this section begins with trends in paper and board consumption.

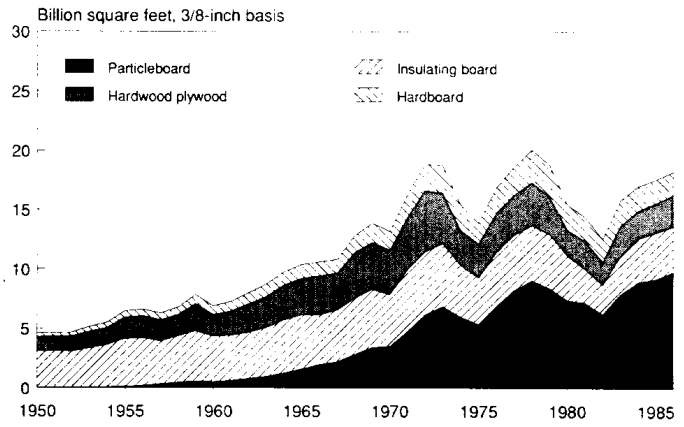

Figure 12.—Nonstructural panels consumption, by type, 1950–1986.

An extremely wide range of paper and board products are consumed in the United States for a variety of purposes, embracing communication, sanitary, packaging and wrapping, construction and industrial uses. In this analysis this large number of products is classified into three major groups: paper, including printing and writing paper, newsprint, packaging and special industrial paper, tissue paper, and construction paper; paperboard, including unbleached kraft paperboard, solid bleached paperboard, semichemical paperboard, recycled paperboard, and wet machine board; and building board, which includes insulating board and hardboard.

Paper and Board Consumption, Trade, and Production

Consumption

Total U.S. paper and board consumption increased to an all time high of 81.7 million tons in 1986 (table 23, McKeever and Jackson 1990: A-6, and fig. 13). The economic recessions in the mid 1970s and the early 1980s severely impacted paper and board consumption. However, with the exception of these two periods, paper and board consumption has increased fairly steadily since 1950, and nearly tripled over the 36 year span. Per capita paper and board consumption followed the same general trends, reaching a record 677 pounds in 1986, about 77% more than average consumption in 1950 and 15% more than in 1976.

Many factors have contributed to the increases in total and per capita consumption of paper and board over the past three and one-half decades. Although increases in population, economic activity, and per capita disposable income have been the major driving forces, the substitution of paper and board for nonpaper products and the development of new products and markets has also been important. Examples of the former include the substitution of paper and paperboard for lumber and plywood in packaging and shipping containers; and of the latter, the development of special paper products for the fast food, convenience food, and computer and copier industries. Consumption likely would have risen more rapidly

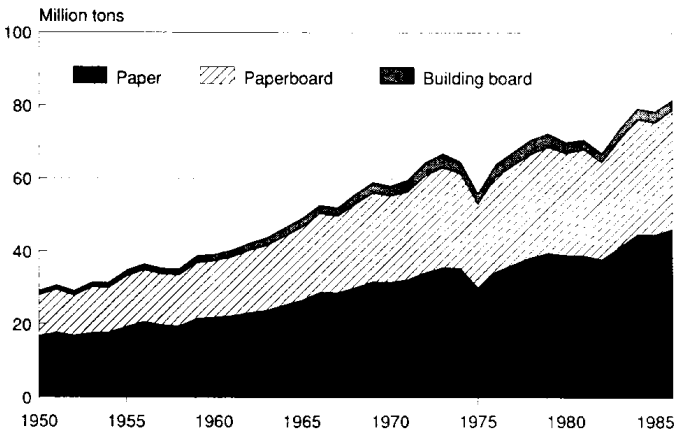

Figure 13.—Paper and board consumption, by type, 1950–1986.

Table 23.—Paper and board consumption, exports, imports, and production in the United States, specified years 1950–86.

Year	Consumption[1]		Exports	Imports	Production
	Total	Per capita[2]			
	Thousand tons	*Pounds*		*Thousand tons*	
1950	29,076	381.9	298	4,999	24,375
1955	34,804	419.5	736	5,382	30,178
1960	39,217	434.1	902	5,674	34,444
1965	49,219	506.6	1,641	6,769	44,091
1970	58,058	566.3	2,698	7,237	53,517
1975	55,955	518.2	2,876	6,309	52,522
1976	63,951	586.6	3,196	7,249	59,897
1977	67,329	611.4	2,953	7,560	62,723
1978	70,732	635.6	2,922	9,318	64,333
1979	72,476	644.1	3,142	9,290	66,329
1980	70,081	615.3	4,611	8,858	65,834
1981	70,779	615.2	4,095	8,434	66,440
1982	67,052	576.8	3,717	8,070	62,699
1983	73,829	628.9	4,045	9,073	68,801
1984	79,343	669.6	3,883	11,127	72,099
1985	78,529	656.3	3,646	11,521	70,654
1986	81,720	676.5	4,222	11,838	74,104

[1]*Includes hardboard.*
[2]*Per capita consumption computed by Forest Service.*
Note: Data may not add to totals because of rounding.
Source: Ulrich 1989.

had not paper and board met strong competition from, for example, plastics in grocery bags and in packaging of food and other materials. The increased use of electronic media for data communications and financial transactions has also acted to slow the increases in recent years.

Paper.—U.S. consumption of paper has increased relatively rapidly over the past 36 years, rising from 16.8 million tons in 1950 to a record 46.3 million tons in 1986 (table 24, fig. 13). Per capita paper consumption also grew, expanding from 221 to 384 pounds. With the exception of the economic recession years, total and per capita paper consumption have increased steadily. Since 1950, total consumption has increased at an average annual rate of 2.8%. The growth rate during the 1980s has remained fairly consistent with this long-term average.

More printing and writing paper is consumed in the United States than any other grade of paper, paperboard, or building board. In 1986, almost 22 million tons—nearly half of all paper and more than a quarter of total paper and board was used for printing and writing (McKeever and Jackson 1990: table A-7). Printing and writing has been the fastest growing paper grade during the past decade, largely due to strong demand for office papers and advertising material.

Newsprint is the paper grade used in second largest amounts—14 million tons in 1986. This was about 29% of all paper consumed during the year. U.S. consumption of newsprint increased by just over 75% between 1960 and 1986; however, production rose by more than 200%. As a result, imports currently supply about 62% of total newsprint consumption compared to about 74% 25 years ago.

Tissue papers, and packaging and special industrial papers each accounted for 11% of total paper consumption in 1986. Packaging paper consumption, in contrast to other paper grades, has declined markedly since 1979, largely due to the penetration of plastic products. Construction paper consumption is small compared to other paper grades, and accounted for just 1% of total paper consumption in 1986.

Paperboard.—Paperboard consumption in the United States nearly tripled between 1950 and 1986, increasing from 11.0 million to 32.6 million tons (table 25, fig. 13). Per capita consumption increased from 145 to 270 pounds. With the exception of the economic recession years, total paperboard consumption has increased fairly steadily since 1950 rising at an annual rate of 3.0%, just slightly higher than the 2.8% rate for paper. Since 1976, however, growth in paperboard consumption has dropped to a rate of about 2.1%, while paper consumption, as mentioned earlier, maintained its long-term average rates of growth. One possible explanation for this recent trend is a shift in the economy from manufacturing to services. Many paper products are used largely in the service sectors, while most paperboard grades are associated with manufacturing.

Consumption of unbleached kraft paperboard, used mostly as linerboard facing material for corrugated boxes, totaled 15.6 million tons in 1986, nearly 48% of total paperboard use (McKeever and Jackson 1990: table A-8). Growth in unbleached kraft paperboard consumption be-

Table 24.—Paper consumption, exports, imports, and production in the United States, specified years 1950–86.

Year	Consumption		Exports	Imports	Production
	Total	Per capita[1]			
	Thousand tons	*Pounds*		*Thousand tons*	
1950	16,802	220.7	175	4,913	12,064
1955	19,341	233.1	414	5,273	14,503
1960	21,983	243.3	361	5,534	16,809
1965	26,769	275.5	500	6,508	20,761
1970	31,699	309.2	548	7,027	25,219
1975	30,137	279.1	975	6,190	24,922
1976	34,466	316.2	958	7,041	28,383
1977	36,490	331.4	732	7,274	29,948
1978	38,452	345.5	580	8,863	30,168
1979	39,703	352.8	635	8,890	31,448
1980	39,142	343.7	939	8,549	31,532
1981	39,034	339.2	1,031	8,072	31,994
1982	37,942	326.2	860	7,752	31,050
1983	41,364	352.3	794	8,583	33,576
1984	44,831	378.3	837	10,503	35,166
1985	44,842	374.8	801	10,927	34,716
1986	46,328	383.5	910	11,128	36,110

[1]*Per capita consumption computed by Forest Service.*
Note: Data may not add to totals because of rounding.
Source: Ulrich 1989.

Table 25.—Paperboard consumption, exports, imports, and production in the United States, specified years 1950–86.

Year	Consumption		Exports	Imports	Production
	Total	Per capita[1]			
	Thousand tons	*Pounds*		*Thousand tons*	
1950	11,047	145.1	98	55	11,090
1955	13,796	166.3	295	45	14,045
1960	15,365	170.1	521	35	15,851
1965	19,885	204.7	1,112	18	20,979
1970	23,530	229.5	2,105	19	25,616
1975	22,765	210.8	1,814	12	24,567
1976	25,850	237.1	2,140	20	27,970
1977	27,039	245.5	2,128	32	29,135
1978	28,137	252.8	2,289	102	30,324
1979	28,942	257.2	2,454	85	31,312
1980	27,764	243.8	3,617	100	31,281
1981	28,918	251.4	2,957	132	31,742
1982	26,508	228.0	2,782	117	29,173
1983	29,301	249.6	3,155	171	32,285
1984	31,443	265.3	2,944	245	34,142
1985	30,493	254.9	2,746	187	33,052
1986	32,592	269.8	3,201	285	35,509

[1]*Per capita consumption computed by Forest Service.*
Note: Data may not add to totals because of rounding.
Source: Ulrich 1989.

tween 1960 and 1986 was dramatic. Total consumption more than tripled, and average growth exceeded 4.5% per year. Although somewhat slower in recent years, growth in unbleached paperboard consumption remains well above that for any other paper or board grade. Over the past several decades, the United States has shifted to corrugated containers as the principal types used by its manufacturing industries.

Recycled paperboard is second in total consumption to unbleached kraft among the paperboard grades. In 1986, 7.8 million tons were consumed, half as much as unbleached kraft. Recycled paperboard has a variety of uses, including corrugating medium, folding cartons, and gypsum wallboard facings. Consumption has been fairly constant throughout the years, fluctuating between about 6 and 8 million tons. Use of recycled paperboard, and recycled grades of paper and board, likely could increase in the future as disposal costs and environmental concerns increase.

Semichemical paperboard, used primarily as a corrugating medium, accounts for about 17% of total paperboard consumption; solid bleached paperboard, used for folding cartons and other food and drug packaging for 11%; and wet machine board, which is used for such products as counter board, shoe board, and luggage, less than 1% of total paperboard consumption.

Building board.—Building board consumption rose steadily between 1950 and the early 1970s, declined during the mid-1970s recession, and then peaked at 4.1 million tons in 1978 (table 26, fig. 13). Following the construction downturn in the early 1980s, consumption increased slightly to 2.8 million tons in 1986.

Hardboard is the larger of the two building board grades, accounting for about two-thirds of total consumption in 1986. Hardboard consumption generally increased through the 1960s and 1970s, rising to nearly 2.7 million tons in 1978 (McKeever and Jackson 1990: table A-9). Consumption then dropped by about 20% in 1980, and has since remained constant.

Consumption of insulating board, which includes wallboard, exterior sheathing, and acoustical tiles, reached its highest levels in the early 1970s. Thereafter, use dropped and the declines in housing construction in the early 1980s, coupled with the increased use of foamed plastic exterior sheathing, reduced insulating board use to 0.8 million tons by 1982. Consumption increased somewhat in 1983–86 to about 1.0 million tons.

Imports and Exports

The United States has long imported larger volumes of paper and board than it has exported. In 1986, imports amounted to 11.8 million tons, 2.8 times the 4.2 million tons exported (table 23). Although the volume of imports has grown, U.S. dependency on imports has declined over the years. Currently, the U.S. imports a smaller proportion—14% in 1986—of its paper and board consumption than in 1950—17%. About 5% of total production was exported in 1986 in contrast to about 1% in 1950.

The United States is a net importer of paper, principally newsprint and, more recently, printing and writing paper. In 1986, an estimated 11.8 million tons of paper were imported, compared to just over 0.9 million tons exported (table 24). Most of the paper imported each year comes from Canada.

Unlike the situation for paper, the U.S. exports more paperboard than it imports. Exports of paperboard totaled more than 3.2 million tons in 1986 (table 25). Unbleached kraft paperboard, which accounts for about

Table 26.—Building board[1] consumption, exports, imports, and production in the United States, specified years 1950–86.

Year	Consumption		Exports	Imports	Production
	Total	Per capita[2]			
	Thousand tons	*Pounds*	*Thousand tons*		
1950	1,227	16.1	25	31	1,221
1955	1,667	20.1	27	64	1,630
1960	1,869	20.7	20	105	1,784
1965	2,565	26.4	29	243	2,351
1970	2,829	27.6	45	191	2,682
1975	3,053	28.3	87	107	3,033
1976	3,635	33.3	98	188	3,544
1977	3,800	34.5	93	254	3,640
1978	4,143	37.2	53	353	3,841
1979	3,831	34.0	53	315	3,569
1980	3,176	27.9	55	210	3,021
1981	2,828	24.6	107	230	2,704
1982	2,602	22.4	75	201	2,476
1983	3,164	27.0	95	319	2,940
1984	3,069	25.9	101	379	2,791
1985	3,194	26.7	99	407	2,886
1986	2,799	23.2	111	426	2,485

[1]*Hardboard and insulating board.*
[2]*Per capita consumption computed by Forest Service.*
Note: Data may not add to totals because of rounding.
Source: Ulrich 1989.

two-thirds of the total, and solid bleached board are the two grades exported in greatest amounts (McKeever and Jackson 1990: table A-8). In recent years, paperboard imports have begun to increase; however, they were still less than 10% as large as exports in 1986, reaching about 0.3 million tons.

The United States is a net importer of building board products with imports exceeding exports by 0.3 million tons in 1986 (table 26). Net imports account for less than 10% of total U.S. building board consumption.

Production

Total paper and board production reached an all-time high of 74.1 million tons in 1986 (table 23). With the exception of the recessions in the mid-1970s and early 1980s, paper and board production have increased steadily, rising more than three-fold over the 36 year period since 1950.

Production of both paper and paperboard were at record levels in 1986 at 36.1 and 35.5 million tons, respectively (tables 24 and 25); however, building board production totaled just 2.5 million tons in 1986, down from peak production in the early 1970s (table 26).

Woodpulp Consumption, Trade, and Production

Consumption

The 74.1 million tons of paper and board produced in 1986 required 75.9 million tons of fiber to produce, including 60.0 million tons of woodpulp, 15.5 million tons of wastepaper, and 0.4 million tons of other fibers such as cotton linter, kenaf, bagasse, fiber glass, rag, etc. (table 27, fig. 14). The trends in consumption of all fibrous material has closely paralleled trends in paper and board production, increasing almost 3 times between 1950 and 1986.

In 1950, about 64% of all fiber consumed was woodpulp; 31% recycled wastepaper, and nearly 6% other fibers. During the 1950s and 1960s, trends began to shift toward increased use of woodpulp, with consequent reductions in wastepaper and other fiber use. During the 1970s, woodpulp reached about 79% of total consumption, and with some slight fluctuation has remained at about that level. Wastepaper consumption fell to about 19% before increasing to about 20% in the 1980s, while other fiber dropped to less than 1%. These proportions could change in the future as increased amounts of wastepaper are made available through mandatory municipal recycling programs, and new technologies to more effectively sort, clean, and transport waste paper. Nonwood fiber is now used primarily for high-quality writing paper, and for specialty industrial and packaging papers.

Wastepaper use varies considerably by grade of paper and board. Among the paper grades, tissue and newsprint use the greatest amount of recycled fiber, and have exhibited the largest increases in recycled fiber use over the past two decades. Recycled paperboard, and some construction board grades also use large amounts of recycled fiber.

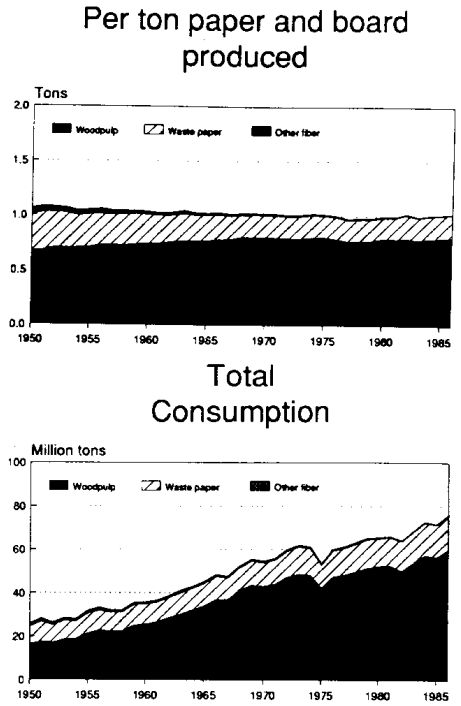

Figure 14.—Fiber consumed in paper and board, by type, 1950–1986.

A dramatic development during the past decade has been the large increase in exports of wastepaper. Exports rose from 0.4 million tons in 1970 to 3.7 million tons in 1986 (American Paper Institute 1987a). Much of this increase is attributable to a more rapid adoption of technologies in Europe and Japan which allow greater use of recycled fiber. Wastepaper utilization rates in excess of 50% in Japan partially reflect the adoption of these technologies.

Total apparent consumption of woodpulp in the manufacture of both paper and board and nonpaper products in the United States in 1986 totaled 60.7 million tons (table 28).[5] This was a record volume, some 25% above consumption in 1976, and nearly 3.6 times more than in 1950 (McKeever Jackson 1990: table A-11).

Woodpulp use per ton of paper and board.—Fiber consumption per ton of paper and board produced declined very slowly through the 1950 to mid-1970s period. Since then, use has remained fairly constant, averaging about 1.02 tons (table 27, fig. 14).

While total fiber use per ton of paper and board produced has varied little in recent years, the mix of fiber types has changed markedly. During the 1950s and 1960s, woodpulp use per ton of paper and board produced increased from 0.68 tons to 0.81 tons (McKeever

[5]*The woodpulp consumption data shown in tables 27 and 28 differ because those in table 28 are "apparent consumption" (production plus imports minus exports) for paper and board and for nonpaper products such as rayon, cellulose acetate, plastics, and molded pulp products, while those shown in table 27 are "actual consumption" (contain allowances for inventory changes) only in paper and board production. In the early 1980s, about 800 million tons of woodpulp were used for nonpaper products. More current data are not available.*

Table 27.—Paper and board production, and fibrous material used, total and per ton of product in the United States, specified years 1950–86.

Year	Paper and board production	Fiber consumption in paper and board production				Fiber consumption per ton of paper and board produced			
		Total	Wood-pulp	Waste paper	Other	Total	Wood-pulp	Waste paper	Other
		Thousand tons				*Tons*			
1950	24,375	25,904	16,509	7,956	1,439	1.062	0.677	0.326	0.059
1955	30,178	31,835	21,454	9,041	1,340	1.056	.711	.300	.045
1960	34,444	35,703	25,700	9,032	971	1.036	.746	.262	.028
1965	44,091	45,116	34,006	10,231	879	1.023	.771	.232	.020
1970	53,516	54,614	43,192	10,594	828	1.021	.807	.198	.015
1975	52,521	53,422	42,431	10,367	625	1.017	.808	.197	.012
1976	59,898	60,156	47,541	11,874	742	1.004	.794	.198	.012
1977	62,722	61,406	48,477	12,103	826	.979	.773	.193	.013
1978	64,333	63,273	49,834	12,586	854	.984	.775	.196	.013
1979	66,329	65,316	51,577	13,012	727	.985	.778	.196	.011
1980	65,834	65,633	52,448	12,583	602	.997	.797	.191	.009
1981	66,440	66,161	52,779	12,872	510	.996	.794	.194	.008
1982	62,699	64,145	50,187	13,563	396	1.023	.800	.216	.006
1983	68,801	68,554	53,970	14,170	413	.996	.784	.206	.006
1984	72,099	72,848	57,466	14,944	438	1.010	.797	.207	.006
1985	70,654	71,757	56,639	14,818	301	1.016	.802	.210	.004
1986	74,104	75,940	60,049	15,491	400	1.025	.810	.209	.005

Note: Data may not add to totals because of rounding.
Source: Ulrich 1989.

Table 28.—Woodpulp consumption, exports, imports and production in the United States, specified years 1950–86.

Year	Consumption		Exports	Imports	Production
	Total	Per capita[1]			
	Thousand tons	*Pounds*		*Thousand tons*	
1950	17,138	225	96	2,385	14,849
1955	22,323	269	631	2,214	20,740
1960	26,563	294	1,142	2,389	25,316
1965	35,721	368	1,402	3,130	33,993
1970	43,969	429	3,095	3,518	43,546
1975	43,380	402	2,782	3,078	43,084
1976	48,930	449	2,518	3,727	47,721
1977	50,363	457	2,640	3,871	49,132
1978	51,443	462	2,599	4,023	50,020
1979	52,559	467	2,935	4,318	51,177
1980	53,204	467	3,806	4,051	52,958
1981	53,199	462	3,678	4,087	52,790
1982	51,247	441	3,395	3,656	50,986
1983	54,505	464	3,644	4,093	54,055
1984	58,644	495	3,594	4,490	57,747
1985	58,364	488	3,796	4,466	57,693
1986	60,697	503	4,459	4,594	60,562

[1]*Per capita consumption computed by Forest Service.*
Note: Data may not add to totals because of rounding.
Source: Ulrich 1989.

and Jackson 1990: table A-10), but then leveled off at about 0.80 tons. As woodpulp use per ton was increasing, recycled wood fiber use was declining to a low of 0.191 tons per ton of paper and board in 1980. There has been a slight increase since that time.

Imports and Exports

Woodpulp imports totaled 4.6 million tons in 1986, exports, 4.5 million tons (table 28). Exports of woodpulp have increased much more rapidly than imports over the past three and one-half decades. As a result, the United States currently imports about 8% of its woodpulp consumption compared with 14% in 1950. Conversely, U.S. exports of woodpulp amounted to 7% of production in 1986 compared to less than 1% in 1950.

Production

Since 1950, woodpulp production has more than quadrupled. In 1986, U.S. pulpmills produced 60.6 million tons of woodpulp (table 28). Nearly 75% of all woodpulp produced was sulfate (kraft) pulp. Sulfate pulp is used to produce various printing and writing papers, packaging papers, and linerboard. During the past 26 years, sulfate production increased steadily, primarily at the expense of sulfite, soda, and other chemical pulp types. In 1986, sulfite accounted for just 3% of total production, compared to an estimated 12% in 1960.

In recent years, a gradual substitution of mechanical pulps for sulfite and other chemical pulps, especially in the production of newsprint and printing and writing papers, has occurred. Mechanical pulpmills require much lower capital investment per ton of product output than chemical pulpmills, and can be built economically with smaller capacity because of smaller economies of scale. In 1986, mechanical woodpulps made up 9% of total production.

Most woodpulp is produced in mills integrated with a paper and/or board mill. However, in 1986, about 7.6 million tons of market pulp (usually from nonintegrated facilities) were produced. Of this total—about 12% of all woodpulp production—3.1 million were sold to domestic paper and board producers and 4.5 million were exported (American Paper Institute 1987a). Woodpulp exports are mostly bleached sulfate.

Pulpwood Consumption, Trade, and Production

Consumption

Trends in pulpwood consumption in the United States closely follow trends in woodpulp production. In 1986, 92.1 million cords of pulpwood were consumed in U.S. mills (table 29, fig. 15).[6] This includes roundwood pulpwood, chips from logging and mill residues, and whole-

[6]*The pulpwood consumption data shown in tables 29 and 30 differ because those shown in table 29 are "apparent consumption" (production plus imports minus exports), while those in table 30 are "actual consumption" (contain allowances for inventory changes).*

Table 29,—Pulpwood consumption, exports, imports, and production, specified years 1950–86.

Year	Consumption	Exports	Imports	Production				
				Total	Roundwood			
					Total	Softwoods	Hardwoods	Chips[1]
				Thousand cords				
1950	22,100	25	1,410	20,715	19,465	16,680	2,785	1,250
1955	32,655	60	1,765	30,950	28,600	23,365	5,235	2,350
1960	41,170	160	1,320	40,010	33,465	25,450	8,015	6,545
1965	53,470	155	1,305	52,320	40,290	29,250	11,040	12,030
1970	69,620	1,965	1,120	70,460	50,220	36,660	13,560	20,240
1975	67,165	2,645	765	69,040	44,280	31,660	12,610	24,760
1976	75,255	3,270	1,115	77,410	47,650	32,970	14,680	29,760
1977	77,745	3,370	1,350	79,760	45,800	31,100	14,700	33,970
1978	78,700	3,055	1,675	80,080	47,130	30,900	16,230	32,950
1979	83,815	3,790	1,405	86,200	51,550	34,810	16,740	34,650
1980	86,490	3,700	1,590	88,600	54,940	37,810	17,120	33,660
1981	83,780	2,955	1,490	85,250	51,800	35,160	16,640	33,450
1982	80,780	2,355	1,405	81,730	50,010	33,350	16,660	31,720
1983	87,195	2,040	1,715	87,520	52,410	32,970	19,440	35,110
1984	91,450	1,920	1,825	91,540	54,750	34,740	20,010	36,790
1985	86,120	1,870	650	87,340	52,360	33,050	19,310	34,980
1986	92,060	1,945	630	93,380	57,130	35,290	21,840	36,250

[1]*Roundwood equivalent. Includes whole tree chips, and chips provided from primary processing plant byproducts, such as slabs, edgings, and veneer cores, and chips from logging residues.*

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

Source: Ulrich 1989.

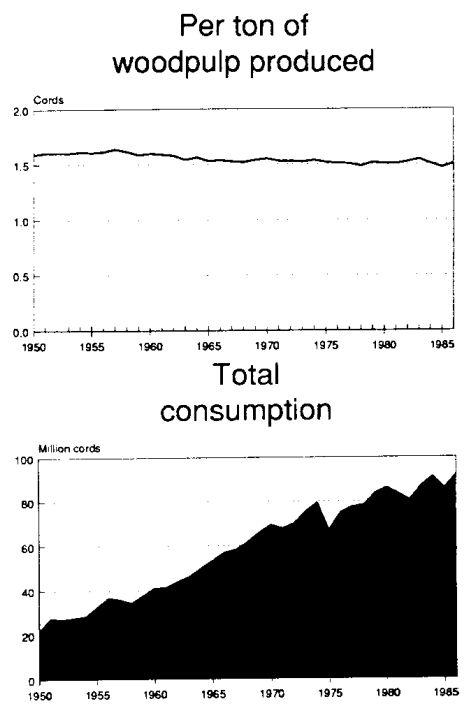

Figure 15.—Pulpwood consumption, 1950–1986.

tree chips. Except for the recession years of the 1970s and 1980s, pulpwood consumption increased fairly steadily between 1950 and 1986, rising more than 4 times (McKeever and Jackson 1990: table A-12).

Softwoods have long been the preferred species group for many pulp and paper products. Their relatively long, more flexible fibers result in higher interfiber bonding resulting in paper and board products with superior strength properties compared to those produced from hardwoods (USDA FS 1982). In recent years, however, the use of hardwoods has increased dramatically. In 1950, less than 15% of the pulpwood consumed in U.S. mills was hardwood; but by 1986 hardwoods composed more than 31%. This increase, in part, is due to relatively lower-cost hardwoods in some areas; improvements in pulping and papermaking technology; and the realization that, where strength is not a critical factor, the shorter hardwood fibers can improve the quality of some grades of paper and paperboard. For example, semichemical paperboard, used for corrugating medium, and tissue paper use larger proportions of hardwood fibers than packaging and special industrial papers and unbleached kraft linerboard. Printing and writing papers have been using increasing amounts of hardwood fiber in recent years to improve printability, smoothness, and opacity (Ince 1986). Adoption of the press-drying process, which permits the use of the shorter hardwood fibers in a broad range of products, could further increase hardwood pulpwood consumption in the future (Setterholm and Ince 1980, Ince 1981).

Pulpwood use per ton of woodpulp produced.— Pulpwood consumption per ton of woodpulp produced has been slowly declining, with some fluctuation, since the early 1950s (table 30, McKeever and Jackson 1990: A-13, and fig. 15). In 1986, about 1.5 cords per ton were required, down from 1.6 cords in 1950. One reason for the decline has been a shift from the sulfite and soda pulping processes to higher yielding sulfate, semichemical, and, more recently, high-yield mechanical processes. Other reasons include increased use of higher yielding hardwoods and better fiber recovery. Offsetting these technological shifts, to some extent, has been an increase in the production of semi-bleached and bleached grades of pulp which require more fiber to produce than unbleached grades.

Table 30.—Pulpwood consumed in the manufacture of woodpulp in the United States, specified years 1950–86.

Year	Consumption		Woodpulp production
	Total	Per ton of woodpulp	
	Thousand cords	*Cords/ton*	*Thousand tons*
1950	23,627	1.591	14,849
1955	33,356	1.608	20,740
1960	40,485	1.599	25,316
1965	51,970	1.529	33,993
1970	67,562	1.552	43,546
1975	65,421	1.518	43,084
1976	72,011	1.509	47,721
1977	73,935	1.505	49,132
1978	74,170	1.483	50,020
1979	77,595	1.516	51,177
1980	79,703	1.505	52,958
1981	79,350	1.503	52,790
1982	77,573	1.521	50,986
1983	83,493	1.545	54,055
1984	86,948	1.506	57,747
1985	84,840	1.471	57,693
1986	90,083	1.500	60,562

Source: Ulrich 1989.

Imports and Exports

Prior to the late 1960s, the United States was a net importer of pulpwood. Since then, exports—largely composed of chip shipments to Japan from the West Coast and more recently to Scandinavia from the South—have exceeded imports. Imports and exports of pulpwood are small compared to domestic production and consumption. Just 1.9 million cords of pulpwood were exported in 1986, compared to 0.6 million cords imported. Most imports came from Canada (American Paper Institute 1987a).

Production

Domestic production of pulpwood in the United States has increased rapidly over the past three and one-half decades, rising from 20.7 million cords in 1950 to 93.4 million in 1986 (fig. 16). The pulpwood produced in the United States comes from three principal sources—

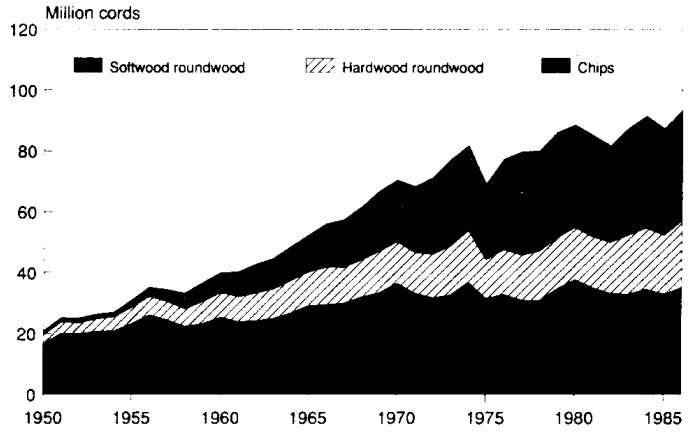

Figure 16.—Pulpwood production, by type, 1950–1986.

roundwood; plant byproducts such as slabs, edgings, veneer cores, sawdust, and other materials; and logging residues and whole-tree chips. Currently available data on chip production do not distinguish between chips from byproducts and from whole-tree and other sources.

Roundwood.—In 1986, pulpwood production from domestic roundwood totaled 57.1 million cords, the high in a trend that has generally been rising since early in the century. About 35.3 million cords were softwood species and 21.8 million hardwoods. Although softwoods predominate, their proportion of the total has been declining over the past 35 years. In 1986, 62% of total roundwood production was softwoods, down from 86% in 1950. As discussed earlier, a combination of technological, cost, and supply factors have been responsible for the increasing proportion of hardwoods consumed in U.S. mills over the past several decades.

Chips.—Production of chips for pulpwood has increased much more rapidly than the consumption of roundwood in recent years, rising from 1.3 million cords in 1950 to 36.3 million in 1986. Over this period, the proportion of pulpwood produced from chips increased from about 6% to almost 39%. Because the volumes of timber products produced from softwood species are far larger than the volumes of those produced from hardwoods, most of the plant byproducts available, and used, are softwoods. Consequently, the proportion of softwood roundwood cut for pulpwood is somewhat smaller than the proportion of softwoods (roundwood and chips) used in domestic mills.

MISCELLANEOUS INDUSTRIAL TIMBER PRODUCTS CONSUMPTION

As shown in table 31, a variety of other industrial roundwood products is consumed in the United States each year in addition to the solid-wood and pulp-based products discussed earlier in this chapter. Total consumption of these products amounted to 473.3 million cubic feet in 1986. This was somewhat above the levels in the 1960s and 1970s, but still below the 1950s and especially the early 1900s when consumption exceeded 2 billion cubic feet per year. About 54% of the total was from softwood species. International trade in these products is relatively small and consumption has been roughly equal to production.

Poles and Piling

Combined use of wood poles for the construction and maintenance of utility lines and other structures and of piling for the construction of docks, bridges, and buildings has been relatively stable over the past 35 years. Total consumption in 1986 was 95.8 million cubic feet, down about 18% from use in 1976, but up about 2% from 1970. Nearly all of the poles and piling consumed in 1986 were manufactured from softwood species and more than 80% of the total came from forests in the South—and principally the South Central Region.

Posts

Use of round and split posts for farm fencing and other purposes such as highway barricades and residential property enclosures has declined sharply over the past three and one-half decades, dropping from 194.1 million cubic feet in 1952 to 40.0 million in 1986. This was a continuation of the trend that has been ongoing since the early 1920s, when consumption exceeded an estimated 1 billion cubic feet. This decline has resulted from a number of factors, including substitution of steel posts, increased use of preservative-treated wood posts thereby lengthening useful post life, and changes in farm size and farming methods that involve less use of fencing.

More than 80% of the posts consumed in 1986 were softwoods—a reversal of the situation in 1952 when hardwoods were most important. The shift away from hardwoods, which are generally more durable than softwoods but less easily cut and shaped, has resulted from increased use of preservative-treated softwood posts. The South accounted for about 47% of the posts produced in 1986; about two-thirds of these came from the South Central Region.

Mine Timbers

Consumption of round and split timbers in mines has also fallen since the early 1950s, dropping from about 81.0 million cubic feet in 1952 to 19.3 million in 1986. In 1986, about 91% of these were hardwoods and all from eastern forests. The most important producing region was the Northeast, which accounted for about 64% of all production in 1986.

Cooperage

Cooperage logs and bolts used for the manufacture of barrels, kegs, pails and tubs made of wood staves has been declining since early in this century as a result of changing consumer buying habits and competition from plastics, wood-based fiber containers, and other pack-

Table 31.—Miscellaneous industrial timber products consumption in the United States, by product and species group, specified years 1952–1986.

Product	1952	1962	1970	1976	1986
			Thousand cubic feet		
Poles and piling					
Softwoods	112,938	116,900	93,114	115,268	95,335
Hardwoods	2,698	3,153	1,095	1,416	415
Total	115,636	120,053	94,209	116,684	95,750
Posts					
Softwoods	68,993	48,803	39,868	35,310	32,453
Hardwoods	125,087	62,118	28,110	10,268	7,595
Total	194,080	110,921	67,978	45,578	40,048
Mine timbers					
Softwoods	18,508	8,062	8,794	5,955	1,815
Hardwoods	62,452	40,312	23,294	17,662	17,528
Total	80,960	48,374	32,088	23,617	19,343
Cooperage					
Softwoods	26,420	3,495	2,136	1,008	50
Hardwoods	46,527	24,961	28,955	13,587	9,739
Total	72,947	28,456	31,091	14,595	9,789
Other products[1]					
Softwoods	99,458	61,457	85,444	80,848	124,744
Hardwoods	135,705	96,142	113,209	96,179	183,583
Total	235,163	157,599	198,653	177,027	308,327
All products					
Softwoods	326,317	238,717	229,356	238,389	254,397
Hardwoods	372,469	226,686	194,663	139,112	218,860
Total	698,786	465,403	424,019	377,501	473,257

[1]*Includes roundwood used in the manufacture of particleboard and OSB/waferboard; charcoal wood; bolts used for shingles, wood turnings, and handles; poles and rails used in fencing; and other miscellaneous items such as hop poles, and wood used for chemicals.*

aging and shipping materials. In 1986, total consumption of cooperage logs and bolts amounted to 9.8 million cubic feet, down from 72.9 million in 1952 and more than 350 million cubic feet in the early 1900s.

More than 99% of the cooperage logs and bolts consumed in 1986 were hardwoods, and most was used for the manufacture of tight cooperage for the bourbon industry. Nearly all of this material—more than 99%—came from eastern U.S. forests. The North Central Region, with about 64% of the total, was the leading producing region.

Other Industrial Timber Products

Consumption of wood for a wide variety of products such as particleboard, oriented strand board, waferboard, charcoal, shingles, wood turnings, and other miscellaneous products amounted to about 308.3 million cubic feet of roundwood in 1986. This was 74% more than in 1976, and the largest volume used for these products in more than 35 years. Although definitive data are not available, most of the increase since 1976 was probably due to the rising use of roundwood for the production of oriented strand board and waferboard.

About 60% of the other industrial timber products were hardwood species, and 75% of the hardwoods were from the North Central Region. Output of softwood species was evenly divided between the East and the West. The Rocky Mountain Region was the largest producer of softwood used for these products.

SILVICHEMICALS CONSUMPTION

Many chemicals and chemical compounds are derived from wood and its byproducts. These chemicals include, but are not limited to, naval stores products such as rosin, turpentine and fatty acids, and byproducts from pulping liquors, such as lignin derivatives, ethyl alcohol, vanillin and acetic acid. In 1982, shipments of all such products were valued at $762 million dollars (USDC BC 1985).

Rosin and turpentine are the two major chemicals derived from wood. Rosin is used for sizing paper to control water absorptivity and in the production of synthetic resins and adhesives. Turpentine, once used mainly as a paint solvent, is now used as a chemical raw material to produce synthetic pine oils, and polyterpene resins used in transparent tape adhesives.

Historically, naval stores were derived from oleoresin (gum) collected from southern pine trees, and extractives from shredded and processed pine stumps. In 1940, all the rosin and 91% of the turpentine came from these

sources (Slatin 1986). However, development of the sulfate (kraft) pulping process, for which naval stores are a byproduct, provided an alternative source. The rapid growth in sulfate pulp production after World War II greatly diminished the use of collected oleoresins and pine stump extractives for naval stores production. By 1985, 82% of all rosin, and 95% of all turpentine came from sulfate pulping, with total rosin production being estimated at 262 thousand short tons, and total turpentine production being estimated at 22.2 million gallons (Naval Stores Review 1987).

Fatty acids are also derived from the sulfate pulping process through distillation of crude tall oil. They are used as intermediate chemicals in the production of resins for inks, adhesives and coatings, and also used in paints, varnishes, soaps and detergents. Production in 1986 was estimated at 215,000 tons, 5,000 tons greater than in 1985 (Naval Stores Review 1987).

Other byproducts of chemical pulping processes (sulfate and sulfite), derived from spent pulping liquors, include various lignin derivatives, ethyl alcohol, acetic acid, and vanillin. Shipments in 1982 were estimated to be 1.1 million tons, and valued at $85.7 million (USDC BC 1985). Lignin derivatives make up the majority of these products, and are used as drilling thinners in oil wells, in adhesives and dispersants, and for water treatment.

FUELWOOD CONSUMPTION

In 1986, the United States produced about 76.6 quads (quadrillion BTU's) of energy. Of this total, an estimated 2.65 quads, or 3.5%, came from wood-derived fuels (table 32). This was up from 2.1% in 1970 and 2.8% in 1980 (USDE 1985c).

Wood used for fuel comes from many sources. In 1986, about 3.1 billion cubic feet (39 million cords)—17% of the estimated 18 billion cubic feet of roundwood timber harvested in the United States—was used for fuelwood (table 33, fig. 17). This was the largest volume harvested for fuelwood since before World War II, and more than 6 times production in 1970. Most of the round fuelwood harvested was consumed by households, with limited amounts used by industry, commercial buildings, and utilities. In addition, it came mainly from sources not traditionally used to produce lumber, panel products, and woodpulp. For example, less than 0.8 billion cubic feet was from the main stem portions of growing stock trees on timberland, while more than 2.3 billion was from other roundwood sources.[7] In total, fuelwood accounted for less than 6% of all growing stock timber harvested in 1986.

Table 32.—Wood and black liquor fuel consumption in the United States, specified years 1977–1986.

Sector	1977	1980	1983	1984	1986
			Quad[1]		
Wood fuel[2]			1.92		
Black liquor	.81	.82	.82	.85	.90
Total			2.74		
Department of Energy total	1.55		2.48		2.65

[1]*One quad equals 10^{15} BTU's.*
[2]*Assumes 17.2 million BTU's per ton of wood.*
Sources: Wood fuel and black liquor: see source note table 33; Department of Energy total: USDE 1985c, USDE 1988.

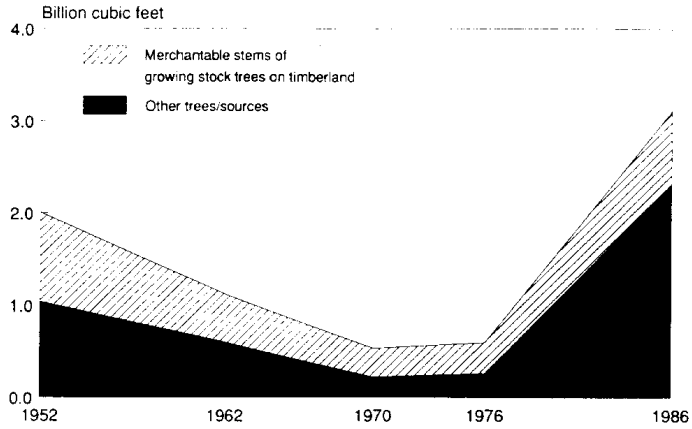

Figure 17.—Roundwood fuelwood harvest, by source, specified years, 1952–1986.

Wood and wood fiber is also consumed for fuel after it has been removed from the forest for other purposes. In 1986, 1.4 billion cubic feet, solid-wood equivalent, of sawdust, slabs, chips, veneer clippings, and similar materials from primary wood products mills were burned (table 33). In addition, 17.8 million dry tons of bark from these sources were used for fuel (Waddell et al. 1989: table 31). The proportion of all primary wood residues and bark that are used for fuel is estimated to have increased from 25% in 1970 (Grantham and Howard 1980) to 41% in 1986. Secondary wood products plants provided a smaller, but unknown, amount of fuel, and pulp and paper mills burned an estimated 79.8 million tons (0.9×10^5 BTU equivalent) of spent liquor for process steam, heat, and electricity (American Paper Institute 1987b). Discarded wood products, such as demolition waste, are also used for fuel; an estimated 7 million households acquired such material for burning in 1980–81 (Skog and Watterson 1986).

Uses of Fuelwood

As noted earlier, roundwood has long been used by households for heating, cooking, and more recently in fireplaces for esthetic purposes. However, increasing amounts are being chipped and burned in nonforest products plants and electric utilities. Data for 1983 shows the distribution of roundwood and residue consumption by major end user (table 34). Households account for 54% while the forest products industry accounts for 42% of the total. Nonwood products plants,

[7]*Other roundwood sources on timberland are rough, rotten, or salvable dead trees, trees of noncommercial species, trees less than 5 inches dbh, and tree limbs and tops. Roundwood also comes from trees on woodlands where growth is less than 20 cubic feet per acre per year, and trees on nonforest lands which includes rural fence rows and all urban trees.*