

# Domestic Market Activity in Solid Wood Products in the United States, 1950-1998

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## Abstract

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Solid wood is important to the construction, manufacturing, and shipping segments of the U.S. economy. Nearly all new houses are built with wood, and wood building products are used in the construction of nonresidential buildings, and in the upkeep and improvement of existing structures. Solid wood is used extensively to produce and transport manufactured products. It also provides a renewable energy source for industrial, commercial, and residential applications. In 1998, 19.6 billion cubic feet, roundwood equivalent, of all timber products were consumed in the United States, down slightly from 1996, but considerably greater than in 1962. About 87 percent of this was for industrial products, and 13 percent for fuelwood. Excluding fuelwood, solid wood timber products accounted for about 67 percent of the industrial roundwood consumed, and pulpwood products about 33 percent. Large amounts of residues are generated in the production of solid wood products, about 10 to 15 percent of total industrial roundwood consumption. Thus, solid wood products and pulpwood products each account for about half of the industrial roundwood consumed. This report examines solid wood timber products consumption in the United States over the past 40 to 45 years, relates changes in consumption to economic, social, and institutional factors during the period, and presents estimates of consumption in major end-use markets. Trends in timber products production, foreign trade, and domestic consumption over the past half century also are examined.

**Keywords:** Production, consumption, timber products consumption, industrial roundwood production, solid wood consumption, wood use, softwood lumber, hardwood lumber, structural panels, softwood plywood, oriented strandboard, OSB, waferboard, nonstructural panels, hardwood plywood, particleboard, medium-density fiberboard, MDF, hardboard, insulation board, engineered wood products, wood I-joists, glue-laminated timbers, glulam, structural composite lumber, laminated veneer lumber, LVL, parallel strand lumber, PSL, oriented strand lumber, OSL, fuelwood, construction, housing, new residential construction, single-family, multifamily, apartments, mobile homes, repair, remodeling, upkeep, improvements, expenditures, nonresidential construction, railroads, manufacturing, furniture, shipping, wooden containers, pallets, fuelwood.

## Highlights Roundwood

- In 1998, 19.6 billion cubic feet, roundwood equivalent, of timber products (solid wood, and pulp and paper) were consumed in the United States, down slightly from 19.7 billion cubic feet in 1996, but considerably greater than in 1962 when 11.6 billion cubic feet were consumed.
- Just over 87 percent (17.1 billion cubic feet) was for industrial products, 13 percent for fuelwood.
- Excluding fuelwood, solid wood products accounted for about two-thirds of the industrial roundwood consumed in 1998; pulp products about one-third. Solid wood residues used for pulpwood, however, make overall wood use nearly equally divided between solid wood, and pulp and paper products.

## Construction

- Construction is the largest overall market for solid wood in the United States. About 65 percent of all lumber, 85 percent of all structural panels, and 37 percent of all nonstructural panels consumed in 1998 was for construction.
- The share of lumber and nonstructural panels used for construction declined since 1986 when they were 72 and 62 percent, respectively. Structural panel market shares remained steady at 85 percent.

## Types of Construction

### **New residential—**

- New residential construction accounted for about 57 percent of all wood products used in construction in 1998, up from 53 percent in 1996.
- Nearly 22.2 billion board feet of lumber, 19.4 billion square feet, 3/8-in basis, of structural panels, and 4.5 billion square feet, 3/8-in basis, of nonstructural panels were consumed for new residential construction in 1998.
- Single-family houses used 82 percent, multifamily houses 8 percent, and mobile homes 10 percent of the wood products used in new residential construction in 1998. This distribution of use was unchanged from 1996.
- In 1998 the average single-family house used about 14,400 board feet of lumber; 12,800 square feet, 3/8-in basis, of structural panels, and 2,500 square feet of nonstructural panels, compared to 14,300 board feet, 8,300 square feet, 3/8-in basis, and 5,100 square feet in 1986.
- Structural panel use per square foot of floor area increased between 1986 and 1998; both lumber and nonstructural panel use per square foot of floor area decreased.

### **Residential upkeep and improvements—**

- Residential upkeep and improvements accounted for 32 percent of all wood products used in construction in 1998, down from 36 percent in 1996.
- More than 14.1 billion board feet of lumber, 7.3 billion square feet, 3/8-in basis, of structural panels, and 2.7 billion square feet, 3/8-in basis, of nonstructural panels were consumed for residential upkeep and improvements in 1998.
- Residential upkeep and improvements became a more important market for wood-based building products over the past 10 to 15 years. Before 1986, the residential upkeep and improvements market for wood products was equivalent to about 45 percent of the new single-family residential construction market. Since then, it has been equivalent to about 80 percent of new single-family residential construction.

### **New nonresidential—**

- Nonresidential construction accounted for about 12 percent of wood used in construction in both 1998 and 1996.
- Nearly 4.6 billion board feet of lumber, 2.9 billion square feet, 3/8-in basis, of structural panels, and 1.3 billion square feet, 3/8-in basis, of nonstructural panels were consumed for new nonresidential construction in 1998.
- Since 1986, total wood use for new nonresidential construction was about 20 percent of that for new residential construction.

### **Manufacturing**

- Manufacturing activities in the United States accounted for about 13 percent of the lumber, 11 percent of the structural panels, and 48 percent of the nonstructural panels consumed in 1998, virtually unchanged from 1996.
- Since 1986, the share of lumber, structural panels, and nonstructural panels used for manufacturing increased 2, 4, and 16 percent, respectively.
- Nearly 8.4 billion board feet of lumber, 3.7 billion square feet, 3/8-in basis, of structural panels, and 10.9 billion square feet, 3/8-in basis, of nonstructural panels were consumed for manufacturing in 1998.

### **Packaging and Shipping**

- Packaging and shipping accounted for about 11 percent of the lumber, and 2 percent or less of the structural and nonstructural panels consumed in 1998.
- Since 1986, the share of lumber used for packaging and shipping dropped 2 percent largely owing to reduced amounts of lumber used per pallet, and the advent of pallet recycling.
- New pallets used 6.6 billion board feet of lumber in 1998, more than 90 percent of all the lumber used for packaging and shipping.
- Recent advances in pallet repair, recovery, and design have resulted in reduced numbers of new pallets being built, and lesser amounts of lumber being used per pallet.
- In 1998, an estimated 250 million pallets were recovered by the pallet industry, 70 million more than in 1996, and 185 million more than in 1992.
- About 3.4 billion board feet of salvaged lumber was used to repair, rebuild, and manufacture recycled pallets in 1998. This is in addition to the 6.6 billion board feet of “new” lumber used to produce new pallets in 1998.

### **Other**

- Uses other than construction, manufacturing, and packaging and shipping accounted for about 11 percent of the lumber, 3 percent of the structural panels, and 15 percent of the nonstructural panels consumed in 1998.

### **Consumption, Trade, and Production**

- Lumber consumption in 1998 was 64.2 billion board feet, 2.9 billion board feet greater than in 1996, 6.8 billion board feet greater than in 1986, and greater than in any year in the past five decades.
- Softwood species accounted for just over 80 percent of all lumber consumed in 1998.
- Structural panel consumption in 1998 was 34.8 billion square feet, 3/8-in basis, 3.2 billion square feet greater than in 1996, 9.1 billion square feet greater than in 1986, and substantially above total use in any year in the past five decades.

- In 1998, for the first time ever, oriented strandboard (OSB) accounted for more than half (51 percent) of all structural panels consumed.
- Nonstructural panel consumption totaled 23.0 billion square feet, 3/8-in basis, in 1998, up 2.0 billion square feet from 1996, and 1.7 billion square feet from 1986. This was a new record high level of consumption.
- About 40 million cubic feet of laminated veneer lumber, 267 million board feet of glue-laminated timbers, and 624 million linear feet of wood I-joists were consumed in the United States in 1998. These were increases of 33, 13, and 40 percent, respectively, over 1996, and were record high levels of consumption for laminated veneer lumber and wood I-joists.

### **Fuelwood**

- In 1998, wood energy consumption in the United States was about 2.4 quadrillion British thermal units, or about 2.5 percent of total U.S. energy consumption.
- Roundwood timber use for fuel has been declining since 1985, both in absolute terms, and as a share of total wood-derived fuel use. In 1986, roundwood use, primarily used by households, was about 37 percent of total wood energy use. In 1997, roundwood provided about 23 percent of total wood energy.
- Household consumption, the largest portion of roundwood used, dropped from 3.9 billion cubic feet in 1984 to 1.6 billion cubic feet in 1997.

### **Other Industrial Timber Products**

- In 1998, 485 million cubic feet of other industrial timber products were consumed in the United States, 15 million cubic feet below consumption in 1996, and 60 million cubic feet below the 1990s average of 545 million cubic feet.

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## Introduction

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

In 1998, 19.6 billion cubic feet, roundwood equivalent,<sup>1</sup> of all timber products were consumed in the United States, down slightly from 19.7 billion cubic feet in 1996, but considerably greater than in 1962 when 11.6 billion cubic feet were consumed (Howard 2001, Ulrich 1989). Included is industrial roundwood used for lumber, plywood and veneer, pulpwood products, other industrial products, imported logs and pulpwood chips, and timber harvested for fuelwood. Of the 19.6 billion cubic feet of timber consumed in 1998, 87 percent (17.1 billion cubic feet) was for industrial products, 13 percent (2.5 billion cubic feet) for fuelwood. In 1996, consumption was 86 and 14 percent for industrial products and fuelwood, respectively. Excluding fuelwood, solid wood timber products accounted for about 67 percent of the industrial roundwood consumed in 1998, and pulpwood products about 33 percent. Fairly large amounts of residues are generated in the production of solid wood products annually. Much of these residues are used in the production of pulp and paper and are equivalent to about 10 to 15 percent of total industrial roundwood consumption. Thus, solid wood products, and pulpwood products each accounted for about half of the industrial roundwood consumed in 1998.

This report presents estimates of solid wood timber products consumption in the United States over the past 40 to 45 years; relates changes in consumption to economic, social, and institutional factors during the period; and presents estimates of consumption in major end-use markets. The solid wood timber products considered here (see table 1) are lumber (softwood and hardwood), structural panels (softwood plywood, oriented strandboard [OSB], which includes small amounts of waferboard, and similar wood panel products used primarily for structural applications), nonstructural panels (hardwood plywood, particleboard, medium-density fiberboard [MDF], hardboard, insulation board, and similar wood panel products used primarily for nonstructural applications), engineered wood products (wood I-joists, glue-laminated (glulam) timbers, and structural composite lumber [SCL] consisting of laminated veneer lumber [LVL], parallel strand lumber [PSL], and oriented strand lumber [OSL]), fuelwood, and other industrial timber products such as cooperage logs, poles and piling, fence posts, hewn ties, round mine timbers, box bolts, excelsior bolts, chemical wood, shingle bolts, and other miscellaneous items. Throughout this report, lumber and glulam timbers are measured in board feet, structural and nonstructural panels in square feet, 3/8-in basis, wood I-joists in linear feet, and SCL, fuelwood and other industrial timber products in cubic feet. Lumber, structural panels, nonstructural panels, and engineered wood products consumption are discussed in terms of their major markets; i.e., new construction, which includes new housing, residential upkeep and improvements, and new nonresidential and railroad construction; manufacturing; packaging and shipping; and other

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<sup>1</sup>Roundwood equivalent is defined as the volume of logs or other round products required to produce given quantities of lumber, plywood, woodpulp, paper, or other similar products (Haynes 1990).

**Table 1—Solid wood timber products**

<b>Timber product</b>	<b>Unit of measure<sup>a</sup></b>
Lumber:	
Softwood	Bd. ft
Hardwood	Bd. ft
Structural panels:	
Softwood plywood	Sq. ft
Oriented strandboard (OSB)	Sq. ft
Waferboard	Sq. ft
Nonstructural panels:	
Hardwood plywood	Sq. ft
Particleboard	Sq. ft
Medium-density fiberboard (MDF)	Sq. ft
Hardboard	Sq. ft
Insulation board	Sq. ft
Engineered wood products:	
Wood I-joists	Lf
Glued-laminated (glulam) timbers	Bd. ft
Structural composite lumber (SCL)	Cf
Laminated veneer lumber (LVL)	Cf
Parallel strand lumber (PSL)	Cf
Oriented strand lumber (OSL)	Cf
Fuelwood	Cf
Other industrial timber products	Cf

<sup>a</sup> Bd. ft = board feet; Sq. ft = square feet, 3/8-in basis; Lf = linear feet; and Cf = cubic feet.

uses. New housing is commonly referred to in terms of square feet of floor area, where residential upkeep and improvements and new nonresidential construction in terms of dollar value. Fuelwood is discussed in terms of fuel type and end user, and other industrial timber products in terms of softwoods and hardwoods.

Estimates of solid wood products consumption in major end-use markets reported here were based, in general, on findings from a limited number of public and private research reports, which were conducted at irregular intervals over the years. Information on wood products use from these reports was related to more readily available, annual time series economic data to generate end-use factors—the amount of a specific wood product used at a specific time in a specific application per unit of the economic variable. Changes in (1) the end-use factors over time, (2) other closely related indicators of consumption in the end-use market, and (3) the economic variables over time were used to estimate wood products consumption for years not specifically studied, and of interest here. For example, comprehensive studies of wood used for residential upkeep and improvements were conducted in 1991 and 1997 (McKeever and Anderson 1993, Wood Products Council 1999a). Information on expenditures in the United States for

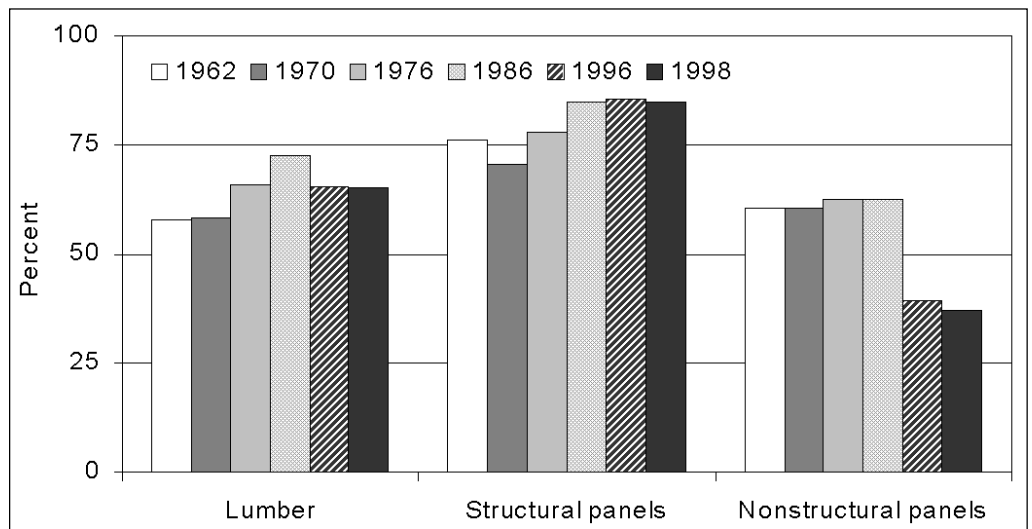


Figure 1—Timber products consumption for construction as a percentage of total timber products consumption, by product, selected years 1962-98.

residential upkeep and improvements are collected annually by the U.S. Department of Commerce, Bureau of the Census (2000e). Wood use estimates from the 1991 and 1997 studies were divided by expenditures in 1991 and 1997, resulting in estimates of the amount of each wood product used per dollar of expenditure. Then, use factors for a year of interest, such as 1998, were estimated based on trends in the reported use factors themselves, and on trends in related indicators of consumption. The related indicators of consumption for residential upkeep and improvements were wood products used for new residential construction.<sup>2</sup> The 1998 estimated use factors were then multiplied by expenditures in 1998, resulting in estimated wood products consumption for residential upkeep and improvements. This basic approach was used to estimate wood products consumption in each major end-use market. The specific end-use research reports, related indicators of consumption, and annual time series economic data used to develop the end-use factors and estimates were specific to each end-use market, and are cited in the text and tables for each end-use market.

## Timber Products Consumption in Construction

Construction is the single largest market for timber products in the United States. The construction of new houses and their upkeep and improvement, new stores, offices, hotels and other nonresidential buildings, highways, dams and other nonresidential nonbuilding structures, and railroad track construction and maintenance required about 65 percent of all the lumber, 85 percent of all the structural panels, and 37 percent of all the nonstructural panels consumed in the United States in 1998 (fig. 1). The use of wood in construction has changed in many ways over the past several decades and continues to change. Changes have included the substitution of nonwood for wood building products, the development and adoption of new wood products to substitute for existing wood and nonwood building products, changes in architectural characteristics

<sup>2</sup> Because many upkeep and improvement projects use the same building products and construction techniques as those used in new residential construction, changes in how wood is used in new residential construction were used to help explain changes in wood use in residential upkeep and improvements.

of buildings and in building codes, that favor one type of building product over another, and changes in the ways structures are built. Because of these and other changes, market shares (consumption for construction as a percentage of total consumption) for lumber and nonstructural panels decreased 8 and 25 percent since 1986. During the same time, structural panel market shares remained steady. Despite these changes, construction remains the principal market for lumber and panel products in the United States.

Three principal construction markets are examined: (1) new residential construction, including single-family and multifamily houses, and mobile homes; (2) upkeep and improvements to the existing housing stock; and (3) new nonresidential construction including buildings, other nonbuilding construction, and railroad track construction and maintenance. Although each uses large amounts of timber products, actual amounts, types, and ways in which these products are used differ greatly. To better understand how wood is used and how its use has changed, each market was evaluated separately in terms of the types and quantities of timber products used in 1998, changes in use over time, factors affecting use, and anticipated future levels of use. Another important construction category is the upkeep and remodeling of nonresidential buildings and structures. Adequate, nationwide information on the magnitude of, and building products used in this construction market is not available. Therefore, separate wood use estimates for nonresidential upkeep and remodeling have not been made but are included in the "other uses" category.

Various timber products are used for construction. Specific products evaluated here are lumber, structural panels, nonstructural panels, and engineered wood products. See table 1 for products included in each category. Over the past 10 years, new and existing engineered wood products have made important inroads into traditional lumber and structural panel markets. Before 1995, engineered wood products consumption in major end-use markets was not specifically identified. Consumption was included with lumber and structural panels, or not included at all. Also, the lumber used to produce glulam timbers, and the lumber and OSB used to produce wood I-joists were included in the lumber and structural panel production data. To make more meaningful comparisons between 1996 and later years to years before 1996, engineered wood products consumption in 1996 and 1998 was converted to equivalent amounts of lumber and structural panels. Linear feet of wood I-joists were converted to their equivalent amounts of lumber and SCL flanges, and OSB webs, and cubic feet of SCL were converted to the equivalent volume of structural panels. Although SCL products are strictly not structural panels, their volumes were included with structural panels because they are closer to structural panels in terms of both their production processes and end uses than to lumber or nonstructural panels. These equivalent volumes, along with board-foot volume of glulam timbers were added to lumber and structural panel consumption estimates. Separate estimates for lumber and structural panel consumption including and excluding these equivalent volumes of engineered wood are reported for new residential construction, residential upkeep and improvements, and new nonresidential construction in 1996 and 1998. Also, all reported volumes for construction include allowances for onsite waste and loss: 10 percent for lumber, 5 percent for structural and nonstructural panels, and 2 percent for engineered wood products.

## **Timber Products Consumption in New Residential Construction**

New residential construction is the construction of new housing units—single-family houses, multifamily (apartment) buildings, and mobile homes. Overall construction for each housing type is measured annually by the U.S. Department of Commerce, Bureau of the Census (USDC Bureau of the Census 2000a, 2000b). Measures of activity in each form the basis for estimating timber products consumption.

New housing construction has long been the largest single market in the United States for timber products. In 1998, more than one-third of the lumber, more than one-half of the structural panels, and about one-fifth of the nonstructural panel products consumed in the United States were used in the construction of new housing units. Amounts of timber products consumed in new residential construction are largely dependent on the numbers and types of housing units built, their average size, and the amounts and types of wood products used per housing unit.

## **New Housing Unit Production**

In 1998, nearly 2.0 million housing units were produced in the United States (table 2). Nearly 1.3 million of these units were new single-family houses, with the remaining being nearly equally divided between new multifamily units and new mobile homes. Total housing unit production in 1998 was higher than any year since 1986, but well below record high levels achieved during the 1970s (fig. 2). Many factors affect housing production, including overall performance of the economy, interest rates, household formations, vacancy and replacement rates, and conversion of existing structures to alternative uses, which can cause annual production to differ substantially from year to year, and from decade averages. For example, total housing unit production reached record high levels in the early 1970s, fell dramatically in the mid-1970s, and then rose again. This cyclic nature of new housing production is characteristic of the market and was repeated again in the 1980s and 1990s. Timber products consumption for new housing is greatly affected by this cyclic nature of the market.

Timber products consumption is not only affected by the absolute numbers of housing units produced but also by the types of units produced. Single-family houses dominate the new housing market and account for a large proportion of the timber products used. Variations in the proportion of all new single-family to all housing affect total timber products consumption. During the 1990s, single-family houses accounted for about 67 percent of all housing units produced, a more than 20-percent increase from the previous three decades, but below the 1950s average when single-family houses accounted for nearly 83 percent of all new housing units (fig. 3). Multifamily housing was about 16 percent of all housing in the 1990s, down by about 50 percent from the previous three decades. Much of the decline in the proportion of multifamily housing to all housing between the 1980s and 1990s was caused by speculative multifamily housing overbuilding in the mid-1980s, and demographic shifts in the population, which resulted in increased demand for single-family over multifamily houses. Mobile homes accounted for about 17 percent of all units produced in the 1990s. Aside from slight decade variations, mobile homes as a proportion of all housing remained fairly constant since its emergence as an important source of housing during the late 1950s.

## **Timber Products Use Per Housing Unit**

In 1998, the average single-family house used about 14,400 board feet of lumber, 12,800 square feet of structural panels, and 2,500 square feet of nonstructural panels, up from 14,100 board feet of lumber, 12,000 square feet of structural panels, and 2,300 square feet of nonstructural panels in 1996 (table 3). (These volumes include the lumber and panel equivalents of the volumes of engineered wood products used.) Multifamily units used, on average, about one-third of the lumber and structural panels, and slightly more than one-half of the nonstructural panels used in single-family houses. Mobile homes used more lumber, structural panels, and nonstructural panels than multifamily units, and nearly as many nonstructural panels as single-family units.

**Table 2—Average annual new conventional housing units started and mobile homes shipped in the United States, by type of unit, 1950-98**

Year	Conventional housing starts			Mobile homes shipped	Total
	Single family	Multi-family	Total		
<i>Thousands</i>					
1950-59 <sup>a</sup>	1,345	187	1,533	94	1,627
1960-69 <sup>a</sup>	924	482	1,406	206	1,612
1970-79 <sup>a</sup>	1,143	625	1,768	366	2,134
1980	852	440	1,292	222	1,514
1981	705	379	1,084	241	1,325
1982	663	400	1,062	240	1,302
1983	1,068	636	1,703	296	1,999
1984	1,084	665	1,750	295	2,045
1985	1,072	670	1,742	284	2,025
1986	1,179	626	1,805	244	2,050
1987	1,146	474	1,620	233	1,853
1988	1,081	407	1,488	218	1,706
1989	1,003	373	1,376	198	1,574
1980-89 <sup>a</sup>	985	507	1,492	247	1,739
1990	895	298	1,193	188	1,381
1991	840	174	1,014	171	1,185
1992	1,030	170	1,200	211	1,410
1993	1,126	162	1,288	254	1,542
1994	1,198	259	1,457	304	1,761
1995	1,076	278	1,354	340	1,694
1996	1,161	316	1,477	363	1,840
1990-96 <sup>a</sup>	1,047	236	1,283	262	1,545
1997	1,134	340	1,474	354	1,828
1998	1,271	346	1,617	373	1,990
1990-98 <sup>a</sup>	1,081	260	1,341	284	1,626

<sup>a</sup> Average for period.

Sources: Haynes 1990, USDC Bureau of the Census 2000a, 2000b.

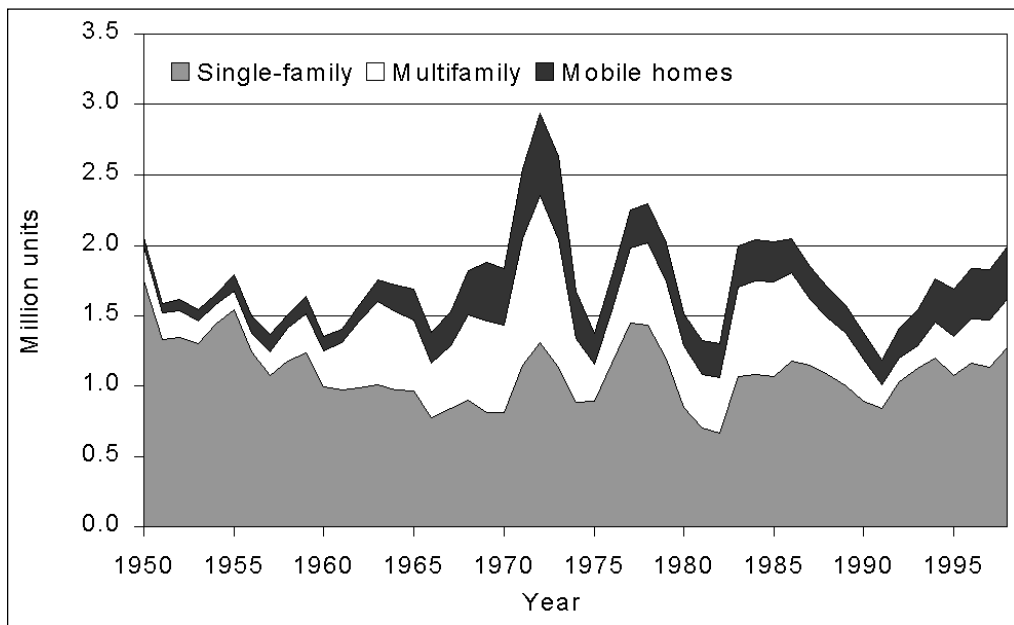


Figure 2—New housing unit production, by type of unit, 1950-98.

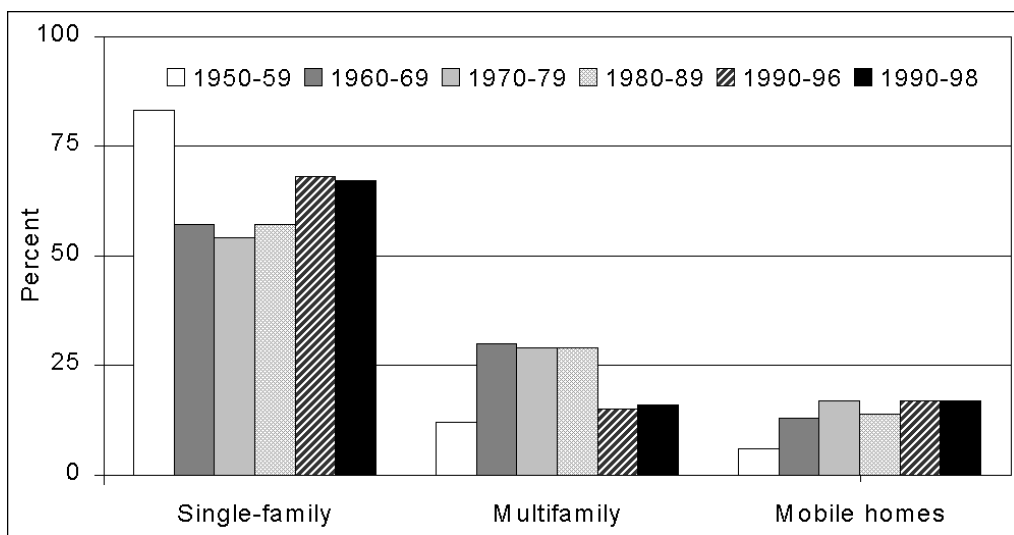


Figure 3—Percentage of housing units produced, by type of unit, period averages, 1950-98.

**Table 3—Production and timber products used in new housing, by product and type of unit, 1962-98**

Year and type of unit	Lumber <sup>a</sup>				Structural panels <sup>b,c</sup>				Nonstructural panels <sup>b,d</sup>			
	Units produced	Floor area per unit	Use per		Total use	Square foot of floor area	Use per		Total use	Square foot of floor area	Use per	
			Sq. ft	Million bd. ft			---Bd. ft---	Million sq. ft			---Sq. ft---	Million sq. ft
<b>1962:</b>												
Single family	991	1,346	11,289	11,387	8.46	2,936	2,961	2.20	1,788	1,804	1.34	
Multifamily	472	972	2,641	5,602	5.76	898	1,904	1.96	598	1,268	1.30	
Mobile homes	118	610	180	1,525	2.50	101	855	1.40	146	1,240	2.03	
Total	—	—	14,109	—	—	3,934	—	—	2,532	—	—	
<b>1970:</b>												
Single family <sup>e</sup>	813	1,500	9,717	11,953	7.97	4,007	4,929	3.29	3,678	4,525	3.02	
Multifamily	621	995	3,515	5,663	5.69	1,406	2,265	2.28	768	1,238	1.24	
Mobile homes	401	732	764	1,904	2.60	455	1,134	1.55	852	2,124	2.90	
Total	—	—	13,996	—	—	5,868	—	—	5,299	—	—	
<b>1976:</b>												
Single family <sup>e</sup>	1,162	1,700	15,706	13,511	7.95	7,420	6,383	3.75	5,902	5,078	2.99	
Multifamily	375	940	1,921	5,123	5.45	984	2,622	2.79	351	937	1.00	
Mobile homes	246	966	653	2,654	2.75	301	1,225	1.27	926	3,763	3.90	
Total	—	—	18,280	—	—	8,705	—	—	7,180	—	—	
<b>1986:</b>												
Single family <sup>e</sup>	1,179	1,825	16,829	14,269	7.82	9,798	8,308	4.55	6,048	5,128	2.81	
Multifamily	626	911	2,955	4,720	5.18	1,568	2,505	2.75	532	850	.93	
Mobile homes	244	1,110	1,059	4,335	3.91	393	1,608	1.45	928	3,800	3.42	
Total	—	—	20,842	—	—	11,759	—	—	7,508	—	—	
<b>1996:</b>												
Single family	1,161	2,120	16,329	14,066	6.63	13,957	12,022	5.67	2,676	2,305	1.09	
Multifamily	316	1,070	1,507	4,768	4.46	1,165	3,687	3.45	427	1,351	1.26	
Mobile homes	363	1,380	1,945	5,355	3.88	1,874	5,158	3.74	758	2,085	1.51	
Total	—	—	19,781	—	—	16,996	—	—	3,861	—	—	
<b>1998:</b>												
Single family	1,271	2,190	18,352	14,434	6.59	16,282	12,807	5.85	3,166	2,490	1.14	
Multifamily	346	1,065	1,712	4,954	4.65	1,425	4,124	3.87	454	1,313	1.23	
Mobile homes	373	1,450	2,100	5,630	3.88	1,688	4,525	3.12	909	2,437	1.68	
Total	—	—	22,164	—	—	19,395	—	—	4,529	—	—	

<sup>a</sup> Includes softwood and hardwood lumber, glulam timbers, and lumber I-joist flanges.

<sup>b</sup> Square feet, 3/8-in basis.

<sup>c</sup> Includes softwood plywood, oriented strand board, waferboard, structural composite lumber, and wood I-joist webs.

<sup>d</sup> Includes hardwood plywood, particleboard, medium-density fiberboard, hardboard, and insulation board.

<sup>e</sup> Wood products use revised from 1989 RPA Assessment.

Sources: Haynes 1990, USDC Bureau of the Census 1999, 2000a, 2000b, and Forest Service estimates based on Anderson and McKeever 1991, McKeever and Phelps 1994, Wood Products Promotion Council 1996, and Wood Products Council 1999b.



**Table 3a—Revisions to timber products used for new single-family housing in the United States, specified years 1970-86**

Year	Lumber <sup>a</sup>				Structural panels <sup>b,c</sup>				Nonstructural panels <sup>b,d</sup>				
	Units produced	Floor area per unit	Use per		Total use	Square feet of floor area	Use per		Total use	Square feet of floor area	Use per		
			Thousand	Sq. ft			Million bd. ft	Million sq. ft			Unit	Square feet of floor area	Unit
1970:													
Original	813	1,500	9,157	11,265	7.51	3,768	4,635	3.09	2,085	2,565	1.71		
Revised	—	—	9,717	11,955	7.97	4,007	4,930	3.29	3,678	4,525	3.02		
Difference (%)	—	—	6	6	6	6	6	6	6	6	6		
1976:													
Original	1,162	1,700	14,386	12,375	7.28	6,462	5,560	3.27	3,320	2,855	1.68		
Revised	—	—	15,706	13,510	7.95	7,420	6,385	3.75	5,902	5,080	2.99		
Difference (%)	—	—	9	9	9	15	15	15	78	78	78		
1986:													
Original	1,179	1,825	15,304	12,975	7.11	7,985	6,770	3.71	3,250	2,755	1.51		
Revised	—	—	16,829	14,270	7.82	9,798	8,310	4.55	6,048	5,130	2.81		
Difference (%)	—	—	10	10	10	23	23	23	86	85	86		

<sup>a</sup> Includes softwood and hardwood lumber, and glulam timbers.

<sup>b</sup> Square feet, 3/8-in basis.

<sup>c</sup> Includes softwood plywood, oriented strand board, and waferboard.

<sup>d</sup> Includes hardwood plywood, particleboard, medium-density fiberboard, hardboard, and insulation board.

Sources: Haynes 1990, and Forest Service estimates based on Anderson and McKeever 1991, and McKeever and Phelps 1994.

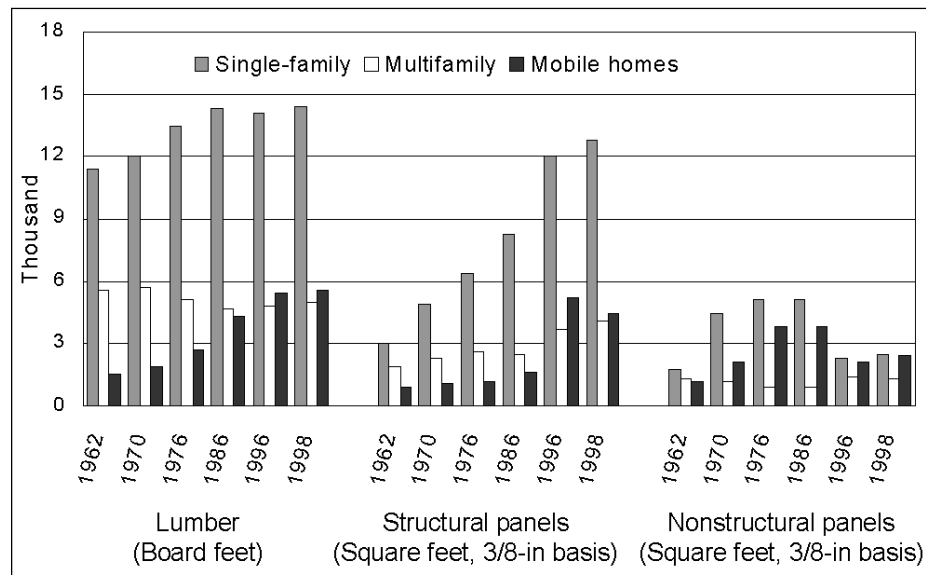


Figure 4—Timber products used per unit for new residential construction, by type of unit, selected years 1962-98.

Timber products use per housing unit, use per square foot of floor area, and total timber products use in 1970, 1976, and 1986 were revised from previous estimates based on new information in Anderson and McKeever 1991 and McKeever and Phelps 1994. Table 3a shows the revisions to total timber products use, use per unit, and use per square foot of floor area.

Types and amounts of timber products used per housing unit have changed over the past 35 years. In general, the use of all wood products tended to increase in single-family houses and mobile homes from 1962 through 1986 (fig. 4). No clear trends in wood products use were evident for multifamily housing during this period. Since 1986, lumber and structural panels tended to increase in all housing types, whereas nonstructural panel use tended to decrease in single-family and mobile homes, and increase in multifamily units. These per-unit trends resulted from changes in average housing unit size, wood products use per square foot of floor area, structural and architectural characteristics of the units, and materials substitution.

**Trends in unit size**—The average size of a housing unit directly affects the amount of timber products required to build it. New single-family houses averaged 2,190 square feet of floor area in 1998, up from 2,120 square feet in 1996, and 365 square feet greater than in 1986 and 844 square feet greater than in 1962 (table 3). With few exceptions, the long-term trend in single-family houses has been toward increasing average size (fig. 5). Between 1950 and 1989, average house size increased 1.8 percent per year. Since 1990, the rate of growth slowed to about 0.6 percent per year. Expectations are for steady size increases into the 21<sup>st</sup> century, but at current, lower growth rates. Growth in average size, in part a reflection of steadily rising real disposable personal income between 1962 and 1998, contributed to the increases in the use of lumber and structural panels per house over the 35-year period.

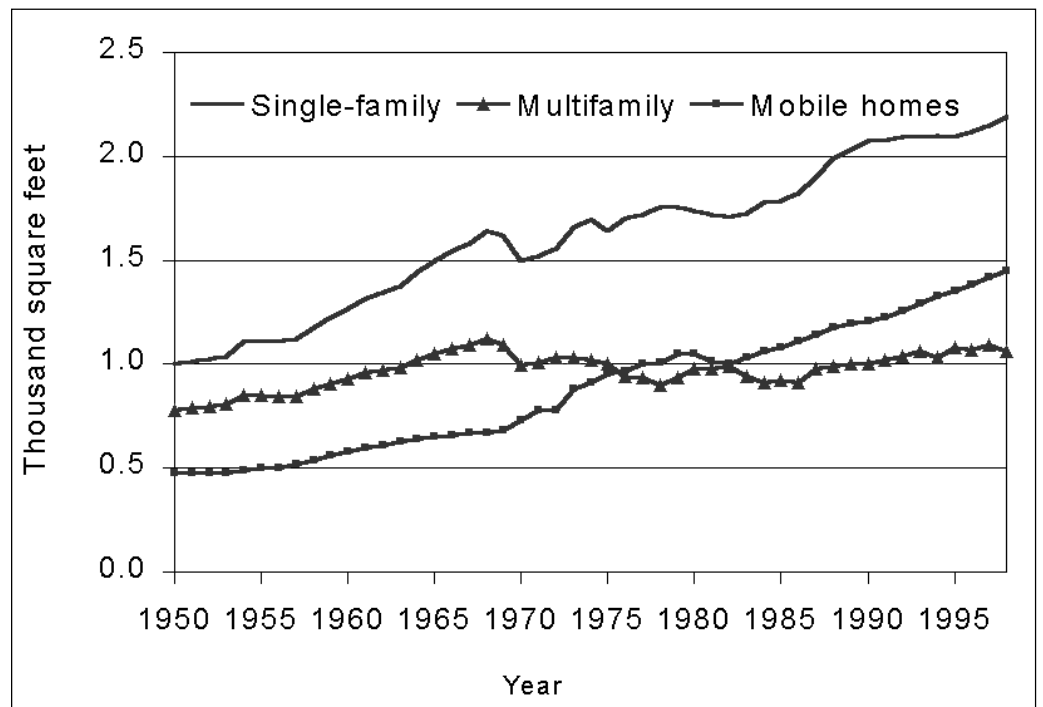


Figure 5—New housing unit average floor area, by type of unit, 1950-98.

Multifamily housing averaged 1,065 square feet per unit in 1998, 5 square feet below the 1996 average, but 154 square feet higher than in 1986, and 93 square feet higher than in 1962 (table 3). Unit size increased steadily during the 1950s and 1960s, increasing from 780 square feet in 1950 to 1,095 square feet in 1969 (fig. 5). Average unit size then began to decline in the early 1970s and continued to decline through the late 1970s. Since then, average size has remained around 1,000 square feet of floor area. Near-term expectations are for average sizes at or near the 1,000-square feet mark.

The average mobile home in 1998 had 1,450 square feet of floor area, 70 square feet greater than 1996, 340 square feet greater than 1986, and over two times the area in 1962 (table 3). Mobile homes have shown the most dramatic and steady increases in size of all housing types since 1950. Between 1950 and 1998, average size increased 2.3 percent per year, compared to 1.6 and 0.7 percent per year for new single-family and new multifamily houses, respectively. This growth rate is expected to continue. Much of the increase in size is attributable to changes in the types of units being produced. In the early 1960s, most mobile homes were single units, 10 feet or less in width and typically 29 to 45 feet long. 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 multisection units. In 1976, nearly half were 14 feet wide, whereas double-wide mobile homes accounted for about a fourth of total shipments. This trend continued through the 1980s and 1990s. In 1987, more than 37 percent of all mobile homes placed at building sites were multisection units, and by 1998, more than 58 percent were multisection units averaging 1,640 square feet of floor area (Manufactured Housing Global Network 1998, USDC Bureau of the Census 2000b).

**Trends in timber products use per square foot of floor area**—Timber products use per housing unit is affected not only by the size of the unit but also by the average amounts of timber products used per square foot of finished floor area. In 1998, lumber use per square foot of floor area averaged 6.6 board feet in single-family houses, 4.7 board feet in multifamily units, and 3.9 board feet in mobile homes (table 3). Lumber use per square foot of floor area in new single-family houses fell between 1962 and 1970, increased through the 1970s and 1980s, and fell again in the late 1990s. Since 1962, lumber use per square foot of floor area fell in multifamily units, and increased rapidly through 1986 and then fell in mobile homes.

Structural panel use per square foot of floor area in 1998 averaged 5.8 square feet in single-family, 3.9 square feet in multifamily, and 3.1 square feet in mobile home units (table 3). With the exception of mobile homes in 1976 and 1998, the overall trend in structural panel use has been steadily increasing in all housing types.

Nonstructural panel use per square foot of floor area in 1998 was 1.1 square feet for single-family houses, 1.2 square feet for multifamily units, and 1.7 square feet for mobile homes (table 3). Nonstructural panel use per square foot of floor area showed divergent trends by housing type. Single-family use increased through 1970 and then fell, multifamily use fell steadily, and mobile home use increased through 1976 and then fell. The net result of these changes was a small overall decline in nonstructural panel use per square foot of floor area between 1962 and 1998.

When converted to cubic feet and combined, all wood products use per square foot of floor area in 1998 averaged about 0.79 cubic feet in single-family houses, 0.15 cubic feet in multifamily units, and 0.14 cubic feet in mobile homes. Although annual variations in use are common, combined wood products use per square foot of floor area in single-family houses and in multifamily units has remained fairly stable over the past 20 years. In 1976, 0.81 cubic feet of wood per square foot of floor area was used in single-family houses, and 0.17 cubic feet in multifamily units. In contrast, mobile home usage nearly doubled since 1976, from 0.08 cubic feet.

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, and their relation to new single-family houses, follows. Many of these relations, although specific to single-family houses, also apply to both multifamily units and mobile homes.

**Structural and architectural characteristics of new housing units**—Structural and architectural characteristics of new housing units can greatly affect both total amounts of timber products required to build the unit, as well as amounts needed per square foot of floor area. Characteristics of specific interest that directly affect timber products use are foundation type, number of stories, type of exterior wall covering, presence and size of garages, and presence of porches and decks. Changes in the frequency in which these characteristics appear over time help explain some of the variation in timber products use per square foot of floor area.

Nearly all single-family houses in the United States are built with either a full foundation or on a concrete slab. Concrete slab foundations greatly reduce the amount of timber products required to build a house because they effectively eliminate ground-level floor framing and decking. In 1998, 45 percent of all new houses were built on concrete slab foundations, compared to 44 percent in 1996. In 1962, slab foundations accounted for about 36 percent of all foundations. The percentage of new houses built on slabs then

fell to just under 30 percent in the late 1960s. The 1970s through mid-1980s saw increasing use of slab foundations, reaching an all-time high of 51 percent in 1983. Between 1983 and 1992, slab foundations fell to 38 percent of all foundations. Since 1992, the use of slab foundations has been fairly constant at just under half of all new house foundations. No near-term change in the market share for concrete slab foundations is expected.

Number of stories also affects timber products consumption. Multiple-story houses require less roof area to cover a given floor area, thereby lowering total wood products use and construction costs per square foot of floor area. Also, multiple-story construction allows enlarging house size without increasing the size of the building lot. In 1998, nearly half (48 percent) of all new single-family houses were two or more stories. This is also the 1990s decade average. The percentage of multistory houses has steadily increased over the past 35 years, from about one-fourth of all houses in the 1960s, to one-third in the 1970s, and just under half in the 1980s and 1990s. Little near-term change in multistory market share is expected.

Timber products use per square foot of floor area also is affected by the types of principal exterior siding material used. In 1998, just 16 percent of all single-family houses used wood as the principal siding material, compared to 22 percent in 1996, and 43 percent in 1986. During the past 35 years, use of wood siding increased steadily from about one-fourth of all siding in 1962 to just over 40 percent in the early to mid-1980s. Since then, alternative siding materials again began to capture large shares of the market. Much of the decline in use during the 1990s was a direct result of the rapid adoption of vinyl as the siding material of choice.

The presence and size of garages affects timber products consumption. In 1998, 86 percent of all new single-family houses were built with garages, up from 63 percent in 1962. More importantly was the rapid increase in the size of the garage. In 1998, 79 percent of all houses had two or more car garages compared to 78 in 1996, 60 percent in 1986, and just 39 percent in 1970.

Porches and wooden decks, each of which can require substantial volumes of timber products, became popular starting in the 1980s. In 1998, 79 percent of all new houses were built with a porch, a deck, or both, up by about 3 percent from 1996. Little change in the decade average of 78 percent is expected.

Rising land costs apparently have resulted in somewhat smaller lot sizes and in increased construction of attached single-family units such as townhouses and condominiums. These units are characterized by having one or more common walls, usually concrete or masonry, which consequently lowers the volumes of exterior wall framing, sheathing, and siding required.

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. 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 in new housing**—Materials substitution is an ongoing process in the new residential construction market and has had dramatic impacts on the types and amounts of timber products used to build new housing units over time. Most substitution favors newly developed wood products, which are better able to meet specific construction needs, either in terms of product performance or cost. Substitution by nonwood building products also occurs but typically not to the extent of wood for wood substitution. During the 1960s and 1970s, softwood plywood and nonstructural panels made major inroads in floor, wall, and roof decking and sheathing markets at the expense of lumber. In the late 1980s and 1990s, OSB began capturing shares from both softwood plywood and nonstructural panels. The overall result of these substitutions was a steadily declining use per square foot of floor area for lumber, increasing use of structural panels, and a rise and subsequent fall in nonstructural panel use per square foot of floor area.

Engineered wood products—wood I-joists, glulam timbers, and structural composite lumber—are emerging as the new substitute material for lumber in many framing applications in the 1990s. Each is specifically designed to replace larger dimension timber, which has become more scarce and costly in recent years, and each is produced from more plentiful smaller dimension, lower quality timber (McKeever 1997). Although engineered wood products are currently somewhat more costly than their solid sawn counterparts, growing acceptance and use likely will bring their costs down. Expectations are for continued substitution of engineered wood for lumber in new residential construction in the coming years.

Many nonwood building materials have captured market share in new residential construction. Noteworthy examples include the substitution of asphalt for wood roof shingles, carpet and vinyl for hardwood flooring, metal and vinyl for wood exterior siding, foamed plastic sheathing for structural and nonstructural panel sheathing in exterior walls, metal and plastic for wood millwork and cabinets, and plastic lumber for decks and other outdoor uses. Aluminum and steel have found limited use as alternative framing materials in light frame construction. Although current price relations favor lumber over metal framing, metal framing has less price volatility than lumber, which may encourage its use. Also, the steel industry is actively promoting the use of steel for residential framing. Currently, about 1 percent of all single-family exterior walls and 5 to 8 percent of all interior walls are metal framed (Wood Products Council 1999b).

Another area of potential substitution is by building products made from recycled wood and fiber, or the reuse of salvaged building materials. The idea of reusing building products or making new products from recycled material is not new. Nearly all roofing felt and gypsum wall board are made from recycled materials. Decorative beams and interior wall coverings are made from resawn lumber salvaged from old buildings. Several nonstructural panel manufacturers now augment mill furnish with material from recycled solid wood products. Widespread use of building materials from recycled solid wood waste is still in the developmental stages but warrants attention in the future.

### **Total Timber Products Use in New Housing**

The 1,271 thousand single-family houses, 346 thousand multifamily units, and 373 thousand mobile homes produced in 1998 required an estimated 22.2 billion board feet of lumber, 19.4 billion square feet of structural panels, and 4.5 billion square feet of nonstructural panels to build (table 3, fig. 6). These volumes include the actual amounts of each wood product used along with allowances for onsite waste. Also included are amounts of engineered wood products consumed in 1998 converted to equivalent amounts of lumber and structural panels.

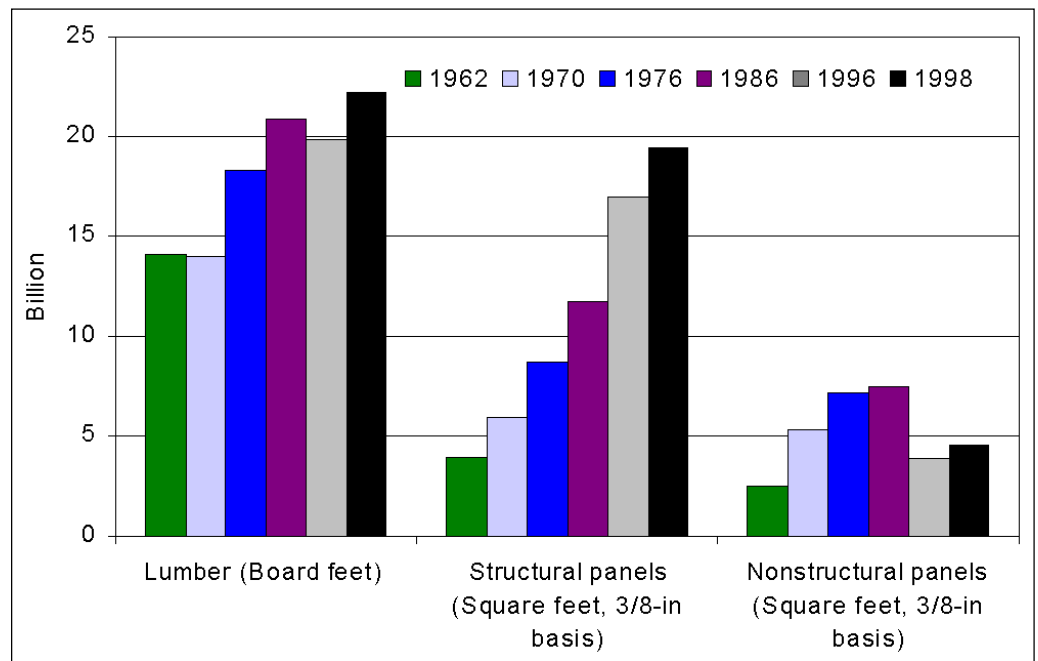


Figure 6—Timber products used for new residential construction, by product, selected years 1962-98.

Total lumber consumption for new housing in 1998 was up by about 2.4 billion board feet from 1996, and 1.3 billion board feet from 1986 levels. Much of the increase in lumber use was from higher levels of single-family housing production and an increase in average house size. These increases more than offset effects from lower use per square foot of floor area in all housing types except mobile homes. Total lumber use in 1998 was well above levels measured during the previous 35 years.

Structural panel consumption for new housing rose steadily between 1962 and 1998, with average gains per year between 1996 and 1998 being well above annual gains of previous periods. Much of the increase between 1986 and 1998 was attributable to rapid gains in market share of OSB in both the structural and nonstructural panels markets. About two-thirds (67 percent) of all structural panels consumed in 1998 for new single-family and multifamily housing was OSB, compared to about 62 percent in 1996, and 13 percent in 1986.

Nonstructural panel consumption in new housing in 1998 increased by about 0.7 billion square feet from 1996, but was well below consumption in the 1970s and 1980s. Total use in 1998 was about 3.0 billion square feet below that of 1986, and also below, although to a lesser extent, amounts used in 1970 and 1976. Part of the decline was due to the large loss in wood exterior siding between 1986 and 1998, and substitution of OSB and nonwood sheathing materials for nonstructural panel sheathing.

In 1998, an estimated 544 million linear feet of wood I-joists, 188 million board feet of glulam timbers, and 40 million cubic feet of SCL were used for new single-family and multifamily construction, and mobile home production (table 4). Lumber and structural panel consumption with engineered wood product volumes removed was 21.9 billion board feet and 17.0 billion square feet, respectively. Nonstructural panel consumption

**Table 4—Timber products used in new residential construction and mobile homes, by construction type and timber product, 1996 and 1998**

Timber product	Unit of measure	Single family			Multifamily			Mobile homes			Total		
		Total use	Use per		Total use	Use per		Total use	Use per		Total use	Use per	
			Unit	Square foot of floor area		Unit	Square foot of floor area		Unit	Square foot of floor area		Unit	Square foot of floor area
		<i>Million</i>		<i>Million</i>		<i>Million</i>		<i>Million</i>		<i>Million</i>		<i>Million</i>	
1996:													
Lumber—													
Softwood	(Bd. ft)	15,670	6.37	1,441	4,562	4.26	1,751	4,819	3.49	18,862	10,251	5.71	
Hardwood	(Bd. ft)	446	.18	48	152	.14	21	58	.04	515	280	.16	
Total		16,116	6.55	1,489	4,714	4.41	1,772	4,878	3.53	19,378	10,531	5.87	
Structural panels <sup>a</sup> —													
Softwood plywood	(Sq. ft)	4,717	1.92	438	1,388	1.30	258	711	.52	5,414	2,942	1.64	
OSB	(Sq. ft)	7,909	3.21	612	1,936	1.81	1,528	4,205	3.05	10,049	5,461	3.04	
Total		12,626	5.13	1,050	3,324	3.11	1,786	4,916	3.56	15,462	8,403	4.68	
Nonstructural panels <sup>a</sup>	(Sq. ft)	2,676	1.09	427	1,351	1.26	758	2,085	1.51	3,861	2,098	1.17	
Engineered wood—													
Wood I-joists	(Lf) <sup>b</sup>	339	.14	47	148	.14	2	6	( <sup>c</sup> )	388	211	.12	
Glulam timbers	(Bd. ft)	163	.07	10	31	.03	2	( <sup>c</sup> )	( <sup>c</sup> )	174	95	.05	
Structural composite lumber	(Cf) <sup>d</sup>	20	.01	2	6	.01	2	( <sup>c</sup> )	( <sup>c</sup> )	23	13	.01	
1998:													
Lumber—													
Softwood	(Bd. ft)	17,592	6.32	1,636	4,734	4.44	2,073	5,556	3.83	21,301	10,704	5.77	
Hardwood	(Bd. ft)	516	.19	55	158	.15	25	67	.05	595	299	.16	
Total		18,108	6.50	1,690	4,892	4.59	2,098	5,623	3.88	21,896	11,003	5.93	
Structural panels <sup>a</sup> —													
Softwood plywood	(Sq. ft)	4,635	1.66	465	1,345	1.26	547	1,465	1.01	5,646	2,837	1.53	
OSB	(Sq. ft)	9,595	3.45	761	2,202	2.07	1,039	2,784	1.92	11,395	5,726	3.09	
Total		14,230	5.11	1,225	3,547	3.33	1,586	4,250	2.93	17,041	8,563	4.61	
Nonstructural panels <sup>a</sup>	(Sq. ft)	3,166	1.14	454	1,313	1.23	909	2,437	1.68	4,529	2,276	1.23	
Engineered wood—													
Wood I-joists	(Lf) <sup>b</sup>	482	.17	58	168	.16	3	9	.01	544	273	.15	
Glulam timbers	(Bd. ft)	173	.06	13	38	.04	2	5	( <sup>c</sup> )	188	95	.05	
Structural composite lumber	(Cf) <sup>d</sup>	33	.01	4	12	.01	3	8	.01	40	20	.01	

<sup>a</sup> Square feet, 3/8-in basis.

<sup>b</sup> Linear feet.

<sup>c</sup> Less than 0.005.

<sup>d</sup> Cubic feet.

Source: Forest Service estimates based on Wood Products Promotion Council 1996, and Wood Products Council 1999b.



## **Timber Products Consumption in Residential Upkeep and Improvements**

### **Residential Upkeep and Improvement Expenditures**

remained at 4.5 billion square feet. Engineered wood products use in 1998 was up from use in 1996 but was still small when compared to lumber and structural panel use. Expectations are for increasing market shares for engineered wood products in coming years, primarily at the expense of lumber.

The upkeep and improvements to residential units in the existing housing stock are an important market for timber products. Included are many and varied upkeep and improvement activities and projects, some of which require substantial amounts of timber products, some of which do not. Overall, about 22 percent of all lumber, 21 percent of all structural panels, and 12 percent of all nonstructural panels consumed in the United States in 1998 were used for residential upkeep and improvements. 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.

Annual activity in the residential upkeep and improvements market is measured by the U.S. Department of Commerce, Bureau of the Census in terms of dollars of expenditure (USDC Bureau of the Census 2000e). Expenditures, when converted to constant 1992 dollars, totaled more than \$109 billion in 1998 (table 5). This was down by about \$5 billion dollars from 1996 expenditures, \$2 billion from 1986, and \$11 billion below the record high level of \$121 billion set in 1994 (fig. 7). Between 1984 and 1985, the Bureau of the Census revised its expenditures estimation procedure. Estimated expenditures in 1984 increased from \$79 billion under the old estimation procedure to \$89 billion (fig. 7). Because of this change, comparison of expenditures before and after 1984 may not be strictly valid. With the exception of temporary declines in the early 1960s and 1980s, total expenditures rose fairly steadily between 1950 and 1984. Since 1986, total expenditures averaged about \$114 billion annually.

Timber products consumption for residential upkeep and improvements is not so much affected by total expenditures, as by the types of expenditures in a given year. Three major activity types are tracked—maintenance and repairs, additions and alterations, and major replacements. Maintenance and repairs expenditures are for upkeep of the residential property rather than additional investment in the property. Examples include painting, plumbing repairs, and roof repairs. Addition and alteration expenditures are for enlargements to, or improvements to or within the residential structure or the property. Examples include room additions, basement conversions, and outside deck additions. Major replacements are construction improvements to the property and are closely related to maintenance and repair. The scope of the project defines its classification. Repairing an existing roof is maintenance; replacing the entire roof is a major replacement. Of these three expenditure types, additions and alterations are the most wood intensive and important in determining overall levels of timber products consumption.

Between 1986 and 1998, expenditures for major replacements were fairly stable at about \$21 billion (fig. 7). Maintenance and repair expenditures increased through 1990, peaking at about \$57 billion before steadily falling to \$34 billion in 1998. Maintenance and repair expenditures averaged \$45 billion per year for the period. Expenditures for additions and alterations fluctuated widely during the period, reaching a high of nearly \$56 billion in 1996 and a low of \$34 billion in 1991. Average annual additions and alterations expenditures for the period were \$48 billion.

**Table 5—Expenditures and timber products used for residential upkeep and improvements in the United States, by product, 1962-98**

Year	Total expenditures	Lumber <sup>a</sup>		Structural panels <sup>b,c</sup>		Nonstructural panels <sup>b,d</sup>	
		Total use	Use per \$1,000 of expenditure	Total use	Use per \$1,000 of expenditure	Total use	Use per \$1,000 of expenditure
	Million 1992\$	Million bd. ft	Bd. ft	Million sq. ft	Sq. ft	Million sq. ft	Sq. ft
1962	44,471	4,330	97	1,670	38	1,400	31
1970	52,007	4,975	96	2,320	45	1,655	32
1976	63,811	6,255	98	3,245	51	2,190	34
1986 <sup>e</sup>	111,237	15,441	139	7,014	63	4,251	38
1996	114,035	15,361	135	7,538	66	3,184	28
1998	109,405	14,108	129	7,269	66	2,710	25

<sup>a</sup> Includes softwood and hardwood lumber, glulam timbers, and lumber for wood I-joint flanges.

<sup>b</sup> Square feet, 3/8-in basis.

<sup>c</sup> Includes softwood plywood, oriented strand board, waferboard, structural composite lumber, and wood I-joint webs.

<sup>d</sup> Includes hardwood plywood, particleboard, medium-density fiberboard, hardboard and insulation board.

<sup>e</sup> Wood products use revised from 1989 RPA Assessment.

Sources: Haynes 1990, USDC Bureau of Census 2000e, and Forest Service estimates based on McKeever and Anderson 1993 and Wood Products Council 1999a.

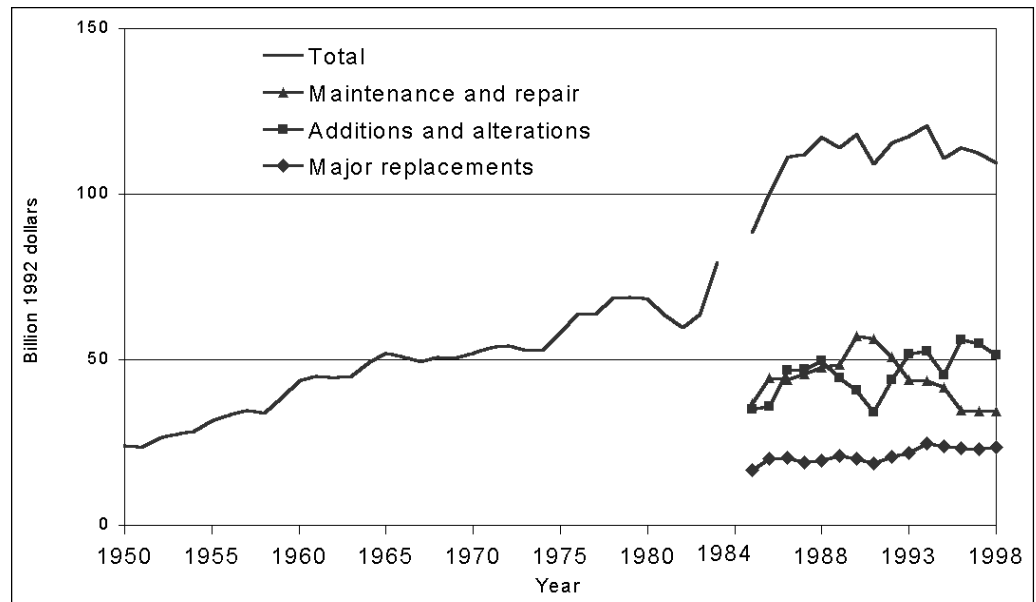


Figure 7—Expenditures for residential upkeep and improvements, 1950-98.

**Timber Products Use Per \$1,000 of Residential Upkeep and Improvement Expenditures**

Timber products use per \$1,000 of constant dollar expenditure measures the relative amounts of each timber product used per unit of upkeep and improvement activity. Before 1991, these use factors were based on limited case study and anecdotal information. A comprehensive study conducted in 1991 indicated that much more timber was being used per \$1,000 of expenditure than previously estimated (McKeever and Anderson 1993), and use factors differed considerably for each of the three expenditure types mentioned above. Results from a study conducted by the Wood Products Council (1999a) confirm these higher use factors. Based on use factors by expenditure type in 1991 and 1997, and trends in timber products use in new single-family residential construction between 1986 and 1998, overall timber products consumption per \$1,000 of constant dollar expenditure estimates were made for 1996 and 1998, and previously reported estimates for 1986 were revised. Materials and construction techniques used for residential upkeep and improvement addition and alteration projects are similar to those used for new construction. Changes in how new single-family houses are built are indicative of how residential additions and alterations are built. Trends in the types and amounts of timber products used to build new single-family houses were used to adjust timber products use per \$1,000 of constant dollar construction value for 1986, and for years between the comprehensive 1991 and 1997 end-use studies. Estimates of timber products use before 1986 were not revised because of the revisions to expenditures data made in 1984 by the Bureau of the Census. Comparisons between 1986 and later years to years before 1986 may not be valid. Table 5a shows the revisions in total timber products use and use per \$1,000 of expenditure in 1986.

Use per \$1,000 of constant (1992 \$) expenditures in 1998 was estimated to be 129 board feet of lumber, 66 square feet of structural panels, and 25 square feet of non-structural panels (table 5). These use factors are averages weighted over all expenditure types. Revised use per \$1,000 of constant expenditures in 1986 was estimated to be 139 board feet of lumber, 63 square feet of structural panels, and 38 square feet of nonstructural panels (table 5a). Use factor differences between 1986 and 1998 reflect relative levels of expenditures between expenditure types, as well as actual changes in the types and amounts of wood products used.

**Total Timber Products Use in Residential Upkeep and Improvements**

The upkeep and improvement of residential structures and properties consumed an estimated 14.1 billion board feet of lumber, 7.3 billion square feet of structural panels, and 2.7 billion square feet of nonstructural panels in 1998 (table 5, fig. 8). Total lumber use in 1998 was about 1.3 billion board feet below use in both 1996 and 1986. Structural panel use remained fairly constant between 1986 and 1998, averaging about 7.3 billion square feet, while nonstructural panel use decreased by nearly 36 percent over the 12-year period.

In 1998, an estimated 87 million linear feet of wood I-joists, 6 million board feet of glulam timbers, and 5 million cubic feet of SCL were used for residential upkeep and improvements (table 6). About 90 percent of these engineered wood products were used for additions and alterations, 8 percent for major replacements, and 2 percent for maintenance and repairs. Lumber and structural panel consumption with engineered wood product volumes removed was 13.4 billion board feet and 7.2 billion square feet, respectively. Nonstructural panel consumption remained at 2.7 billion square feet. Eighty-two (82) percent of all the lumber, 50 percent of all the structural panels, and 84 percent of all the nonstructural panels were used for additions and alterations. The

**Table 5a—Revisions to timber products used for residential upkeep and improvements in the United States, 1986**

Year	Total expenditures <i>Million 1992\$</i>	Lumber <sup>a</sup>		Structural panels <sup>b,c</sup>		Nonstructural panels <sup>b,d</sup>	
		Total use <i>Million bd. ft</i>	Use per \$1,000 of expenditure <i>Bd. ft</i>	Total use <i>Million sq. ft</i>	Use per \$1,000 of expenditure <i>Sq. ft</i>	Total use <i>Million sq. ft</i>	Use per \$1,000 of expenditure <i>Sq. ft</i>
1986:							
Original	111,237	9,935	89	6,170	55	3,160	28
Revised	—	15,441	139	7,014	63	4,251	38
Difference (%)	—	55	55	14	14	35	35

<sup>a</sup> Includes softwood and hardwood lumber, and glulam timbers.

<sup>b</sup> Square feet, 3/8-in basis.

<sup>c</sup> Includes softwood plywood, oriented strand board, and waferboard.

<sup>d</sup> Includes hardwood plywood, particleboard, medium-density fiberboard, hardboard and insulation board.

Sources: Haynes 1990, and Forest Service estimates based on McKeever and Anderson 1993.

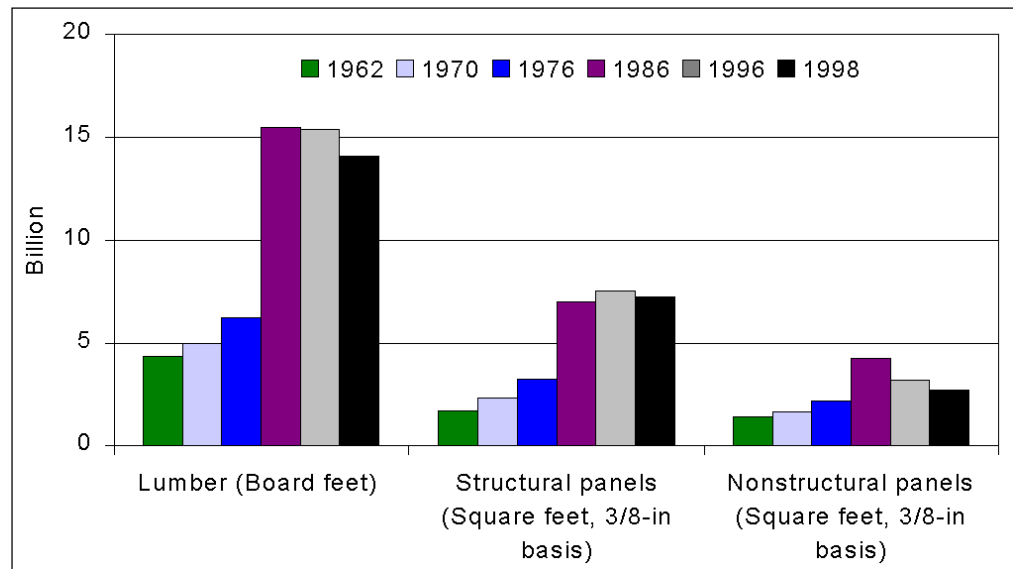


Figure 8—Timber products used for residential upkeep and improvements, by product, selected years 1962-98.

**Table 6—Expenditures and timber products used for residential upkeep and improvements, by expenditure type and timber product, 1996 and 1998**

Year, expenditures, and timber product	Maintenance and repairs			Additions and alterations			Major replacements			Total
	Total use	Per-cent	Use per \$1,000 of expenditure	Total use	Per-cent	Use per \$1,000 of expenditure	Total use	Per-cent	Use per \$1,000 of expenditure	
	Million		Million	Million		Million	Million		Million	
1996:										
Expenditures	34,818	31	—	56,003	49	—	23,211	20	—	114,032
Lumber—										
Softwood	1,182	8	33.96	11,241	76	200.71	1,177	8	50.73	14,797
Hardwood	12	2	.34	385	69	6.87	161	29	6.92	557
Total	1,194	8	34.30	11,625	76	207.59	1,338	9	57.65	15,354
Structural panels <sup>a</sup> —										
Softwood plywood	412	8	11.82	3,067	56	54.76	2,004	37	86.33	5,482
OSB	165	8	4.73	1,192	58	21.28	698	34	30.08	2,054
Total	576	8	16.55	4,259	57	76.04	2,702	36	116.40	7,537
Nonstructural panels <sup>a</sup>	130	4	3.73	2,701	85	48.22	354	11	15.24	3,184
Engineered wood—										
Wood I-joists	2	2	.05	77	90	1.37	7	8	.29	85
Glulam timbers	( <sup>c</sup> )	2	( <sup>c</sup> )	5	90	.09	( <sup>c</sup> )	8	( <sup>c</sup> )	6
Structural composite lumber	( <sup>c</sup> )	2	( <sup>c</sup> )	5	90	.08	( <sup>c</sup> )	8	( <sup>c</sup> )	5
1998:										
Expenditures	34,354	31	—	51,531	47	—	23,520	21	—	109,404
Lumber—										
Softwood	1,147	9	33.39	10,630	82	206.28	1,125	9	47.84	12,902
Hardwood	12	2	0.34	348	67	6.75	161	31	6.84	520
Total	1,159	9	33.73	10,977	82	213.03	1,286	10	54.68	13,422
Structural panels <sup>a</sup> —										
Softwood plywood	390	7	11.35	2,671	50	51.83	2,234	42	95.00	5,295
OSB	154	8	4.48	949	51	18.42	771	41	32.76	1,874
Total	544	8	15.84	3,620	50	70.25	3,005	42	127.76	7,169
Nonstructural panels <sup>a</sup>	64	2	1.87	2,267	84	44.00	379	14	16.10	2,710
Engineered wood—										
Wood I-joists	2	2	.05	79	90	1.40	7	8	.30	87
Glulam timbers	( <sup>c</sup> )	2	( <sup>c</sup> )	5	90	.09	( <sup>c</sup> )	0	.00	6
Structural composite lumber	( <sup>c</sup> )	2	( <sup>c</sup> )	5	90	.08	( <sup>c</sup> )	0	.00	5

<sup>a</sup> Square feet, 3/8-in basis.

<sup>b</sup> Linear feet.

<sup>c</sup> Less than 50,000.

<sup>d</sup> Less than 0.005.

<sup>e</sup> Cubic feet.

Sources: USDC Bureau of the Census 2000e, and Forest Service estimates based on McKeever and Anderson 1993, and Wood Products Council 1999a.

## **Timber Products Consumption in New Nonresidential and Railroad Construction**

remaining amounts were divided between maintenance and repair, and major replacement activities. Engineered wood products use in 1998 was up from use in 1996 but was still small when compared to lumber and structural panel use. Expectations are for increasing use of engineered wood products for residential upkeep and improvements.

The construction of new nonresidential buildings and other nonresidential structures in the United States in 1998 used about 7 percent of all the lumber, 8 percent of all the structural panels, and 6 percent of all the nonstructural panels consumed domestically. The construction of new railways, and the maintenance of existing track required an additional 1 percent of the lumber consumed. Also, small amounts of lumber and structural panels were used for rail car repair.

New nonresidential construction in the United States is a diverse mixture of new buildings and other structures, and construction that does not include a building or structure as such. Two logical categories of new nonresidential construction are identified: (1) nonresidential buildings (includes stores, restaurants, office buildings, warehouses, hotels and motels, factories, schools, religious buildings, hospitals, and nonresidential farm buildings) and (2) all other types of nonresidential construction (typically does not include a building, such as streets and highways; water and sewer systems; dams; military, conservation, and development projects; railroad construction except new and replacement track; and other similar types of nonbuilding construction).

Timber products consumption for new nonresidential construction is dependent on the numbers, types, and sizes of buildings and other structures built, and the amounts and types of building products used in their construction. Because of the diversity inherent in new nonresidential construction, activity in this sector is measured in the total annual value of new construction put in place.

## **Value of New Nonresidential Construction**

Total value for all new nonresidential construction in 1998, measured in constant 1992 dollars, was about \$323 billion, \$43 billion greater than the average for the period 1990-98, and \$36 billion greater than 1996 (USDC Bureau of the Census 2000c) (table 7). The value of new buildings in 1998 was \$214 billion dollars (66 percent of total expenditures), and set a record high level of new construction. Other types of nonresidential construction totaled \$109 billion in 1998. Since 1950, decade averages for total value of new nonresidential construction rose steadily from \$124 billion in the 1950s to \$280 billion in the 1990s. The record high level of other types of nonresidential construction also was set in 1998 at \$109 billion. Annual fluctuations in new nonresidential construction value are common and are caused by response to changing economic conditions (fig. 9). Other nonresidential construction rose steadily from 1950 through 1969 and then leveled off at around \$100 billion per year through 1998. The construction of new buildings also rose fairly steadily from 1950 through 1969. Since then, construction value for buildings has fluctuated widely, by as much as \$25 billion per year.

## **Timber Products Use per \$1,000 of Nonresidential Construction Value**

In 1998, 14.3 board feet of lumber, 8.9 square feet of structural panels, and 4.0 square feet of nonstructural panels were used for every \$1,000 of nonresidential constant dollar construction value (table 8). As might be expected, use per \$1,000 for buildings was greater than that for other types of construction, about three times greater for lumber and structural panels. In general, the use of lumber, structural panels, and nonstructural panels per \$1,000 of constant construction value has been declining since 1986. The greatest declines have been in other nonresidential construction, with average declines ranging from one-third to one-half. Timber products use per \$1,000 of construction value differed considerably over the years. Some of the variation was due to the mix of buildings and other projects built in a given year. Also, some of the variation

**Table 7—Value of new nonresidential construction in the United States, by type of construction, 1950-98**

Year	Buildings <sup>a</sup>		Other types <sup>b</sup>		Total	
	Value	Average annual rate of change	Value	Average annual rate of change	Value	Average annual rate of change
	<i>Million 1992\$</i>	<i>Percent</i>	<i>Million 1992\$</i>	<i>Percent</i>	<i>Million 1992\$</i>	<i>Percent</i>
1950-59 <sup>c</sup>	74,465	5.2	49,866	5.3	124,331	5.3
1960-69 <sup>c</sup>	127,924	4.8	82,454	4.1	210,378	4.5
1970-79 <sup>c</sup>	135,245	.5	95,415	.9	230,660	.7
1980	149,778	.9	100,196	-2.3	249,974	-.4
1981	155,811	4.0	97,498	-2.7	253,309	1.3
1982	157,621	1.2	92,884	-4.7	250,505	-1.1
1983	144,330	-8.4	89,138	-4.0	233,468	-6.8
1984	166,471	15.3	96,064	7.8	262,535	12.5
1985	189,188	13.6	99,013	3.1	288,201	9.8
1986	178,040	-5.9	101,042	2.0	279,082	-3.2
1987	175,994	-1.1	99,206	-1.8	275,200	-1.4
1988	181,069	2.9	95,943	-3.3	277,012	.7
1989	187,240	3.4	95,743	-.2	282,983	2.2
1980-89 <sup>c</sup>	168,554	2.3	96,673	-.5	265,227	1.2
1990	190,192	1.6	96,865	1.2	287,057	1.4
1991	165,503	-13.0	99,439	2.7	264,942	-7.7
1992	153,862	-7.0	106,311	6.9	260,173	-1.8
1993	152,982	-.6	103,763	-2.4	256,745	-1.3
1994	156,639	2.4	102,483	-1.2	259,122	.9
1995	172,074	9.9	100,883	-1.6	272,957	5.3
1996	188,477	9.5	98,355	-2.5	286,832	5.1
1990-96 <sup>c</sup>	168,533	-.1	101,157	.2	269,690	0
1997	204,973	8.8	101,836	3.5	306,809	7.0
1998	214,115	4.5	108,718	6.8	322,833	5.2
1990-98 <sup>c</sup>	177,646	1.3	102,073	1.3	279,719	1.3

<sup>a</sup> 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.

<sup>b</sup> 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.

<sup>c</sup> Average for period.

Sources: Haynes 1990, USDC Bureau of the Census 2000c.

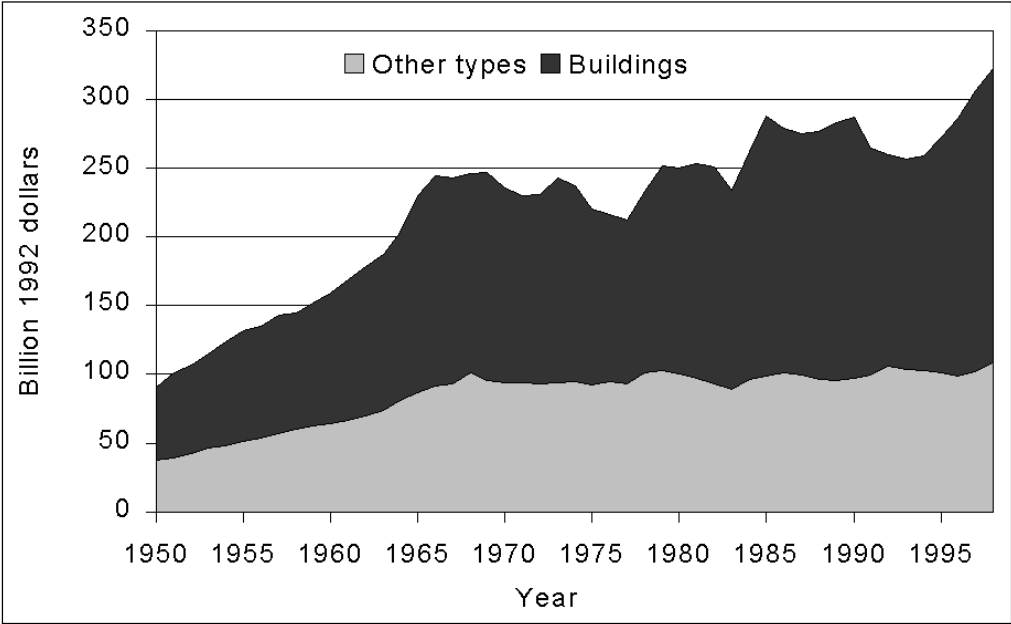


Figure 9—Value of new nonresidential construction, by type of construction, 1950-98



**Table 8—Construction value and timber products used in new nonresidential construction, by product, 1962-98**

Year	Lumber <sup>a</sup>			Structural panels <sup>b c</sup>		Nonstructural panels <sup>b d</sup>	
	Construction value	Total use	Use per	Total use	Use per	Total use	Use per
			\$1,000 of construction value		\$1,000 of construction value		\$1,000 of construction value
<i>Million 1992\$</i>	<i>Million bd. ft</i>	<i>Bd. ft</i>	<i>Million sq. ft</i>	<i>Sq. ft</i>	<i>Million sq. ft</i>	<i>Sq. ft</i>	
Buildings:							
1962	108,556	2,180	20.1	1,150	10.6	799	7.4
1970	141,006	2,232	15.8	1,175	8.3	1,101	7.8
1973	148,453	2,430	16.4	1,326	8.9	1,200	8.1
1976	121,087	1,920	15.9	1,085	9.0	1,079	8.9
1982	157,621	2,947	18.7	1,959	12.4	1,280	8.1
1986	178,040	3,350	18.8	2,430	13.6	1,425	8.0
1996	188,477	3,580	19.0	2,148	11.4	1,134	6.0
1998	214,115	4,054	18.9	2,471	11.5	1,242	5.8
Other types:							
1962	69,655	1,120	16.1	480	6.9	91	1.3
1970	94,030	1,298	13.8	665	7.1	89	.9
1973	93,791	1,265	13.5	823	8.8	104	1.1
1976	95,102	1,080	11.4	785	8.3	117	1.2
1982	92,884	820	8.8	608	6.5	90	1.0
1986	101,042	830	8.2	630	6.2	85	.8
1996	98,355	511	5.2	371	3.8	45	.5
1998	108,718	563	5.2	408	3.8	43	.4
Total nonresidential:							
1962	178,211	3,300	18.5	1,630	9.1	890	5.0
1970	235,036	3,530	15.0	1,840	7.8	1,190	5.1
1973	242,244	3,695	15.3	2,149	8.9	1,304	5.4
1976	216,189	3,000	13.9	1,870	8.6	1,196	5.5
1982	250,505	3,767	15.0	2,567	10.2	1,370	5.5
1986	279,082	4,180	15.0	3,060	11.0	1,510	5.4
1996	286,832	4,091	14.3	2,519	8.8	1,179	4.1
1998	322,833	4,617	14.3	2,879	8.9	1,285	4.0

<sup>a</sup> Includes softwood and hardwood lumber, glulam timbers, and lumber for wood I-joint flanges.

<sup>b</sup> Square feet, 3/8-inch basis.

<sup>c</sup> Includes softwood plywood, oriented strand board, waferboard, structural composite lumber, and wood I-joint webs.

<sup>d</sup> Includes hardwood plywood, particleboard, medium-density fiberboard, hardboard and insulation board.

Sources: Haynes 1990, USDC Bureau of the Census 2000c, and Forest Service estimates based on McKeever and Adair 1998.

was due to increasing use of concrete and steel construction systems in place of wood. Between the mid-1980s and mid-1990s, the overall share of wood-framed construction fell in all major building applications (floors, exterior and interior walls, and roofs). During this same period, the share of concrete construction increased in all major building applications, and metal construction increased in some applications (interior walls and roofs) and decreased in others (floors and exterior walls) (McKeever and Adair 1998). The greatest loss for wood was in interior walls where its share fell by 22 percent. Shifts away from wood to concrete and metal construction were an important factor in the overall reduction in timber products use per \$1,000 of construction value between 1986 and 1998.

Other complex technological and institutional forces also contributed to variations in timber use per \$1,000 of construction value, and the decline experienced between 1986 and 1998. These included the increasing use of reusable concrete forms, increasing use of precast and prestressed concrete beams and other structural members, and other construction innovations such as slipform and tilt-up wall construction.<sup>3</sup> Also, metal buildings, once limited mostly to warehouses and industrial buildings, became widely used in medium-sized, low-rise office buildings, motels, and shopping centers. Restrictive codes and other building regulations were also instrumental in limiting wood use in some types of buildings and locations (Goetzl and McKeever 1999). Building codes currently are being revised and changed. The International Building Code (IBC) is a new, improved, state-of-the-art national building code, which is just now beginning to be implemented. The effect this will have on timber products consumption in new nonresidential construction is still unclear.

Conversely, the development and acceptance of engineered wood products helped offset losses to timber products from other nonwood building products. Not only are engineered wood products substituting for lumber in traditional wood-framed applications, but also for nonwood applications. Also, new, innovative wood systems are emerging. One example is the panelized roof system developed by APA-The Engineered Wood Association (1996). Panelized roofs were developed to compete directly with metal roof systems on large industrial buildings. Panelized roofs are made from wood I-joists and softwood plywood or OSB panels, assembled on the ground in sections, and lifted into place. Panelized roofs have gained building code acceptance, and widespread builder acceptance in the Western United States owing to its lower cost and construction time compared to conventional metal roof systems. Only limited penetration into the nonresidential metal roof market in other parts of the country has yet been achieved.

### **Total Timber Products Use in New Nonresidential Construction**

In 1998, 4.6 billion board feet of lumber, 2.9 billion square feet of structural panels, and 1.3 billion square feet of nonstructural panels were used for new nonresidential construction in the United States (table 8). Included with lumber and structural panel estimates are the equivalent volumes of engineered wood products consumed. All

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<sup>3</sup> Slipform wall construction: Concrete forms used for multistory wall construction that are slipped or raised to the next level as the previous concrete pour begins to cure. Tilt-up wall construction: Concrete is poured in a flat slab on the ground and then tilted up to form a wall section. Concrete forms are usually used around the perimeter and on the bottom. Concrete also can be poured onto another concrete slab using plastic sheets or a release agent without the use of concrete forms on the bottom.

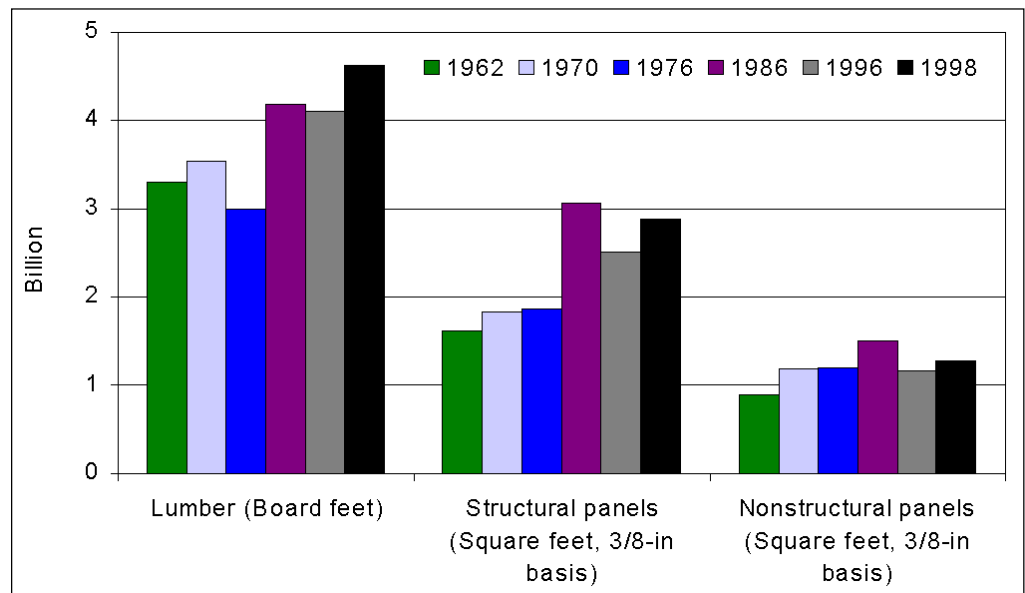


Figure 10—Timber products used for new nonresidential construction, by product, selected years 1962-98.

estimates include allowances for onsite loss and waste. These volumes amount to increases from 1996 ranging from 9 percent for nonstructural panels to 14 percent for structural panels. Nonresidential buildings accounted for a large proportion of all timber products consumed—88 percent of the lumber, 86 percent of the structural panels, and 97 percent of the nonstructural panels used for new nonresidential construction.

Lumber usage for new nonresidential construction increased by more than 400 million board feet between 1986 and 1998 (table 8). During the same period, structural and nonstructural panel use decreased by about 200 million square feet each. Much of the change was due to increased construction values coupled with declining wood products use per \$1,000 of construction. Increased use of concrete and metal construction systems at the expense of wood in new buildings was also a contributing factor. Lumber and structural panel consumption in 1998 was greater than consumption in the 1960s and 1970s (fig. 10). Nonstructural panel consumption was below consumption in 1986, being nearly equal to levels of consumption in the 1970s. The substitution of structural panels and nonwood panels in traditional nonstructural panel applications was the principal reason for this decline.

Engineered wood products consumption in 1998 for new nonresidential construction was estimated to be 88 million linear feet of wood I-joists, 140 million board feet of glulam timbers, and 2 million cubic feet of structural composite lumber (table 9). Lumber and structural panel consumption with engineered wood product volumes removed was 4,463 million board feet and 2,634 million square feet, respectively. Engineered wood products therefore accounted for about 3 percent of the lumber and 8 percent of the structural panel use reported in table 9. Although engineered wood products use in 1998 was small compared to lumber and structural panels, increases in use from 1996 ranged from 23 percent for glulam timbers to 25 percent for wood I-joists. Expectations are for increasing market shares as new building systems using these new engineered wood products are developed and adopted.

**Table 9—Construction value and timber products used in new nonresidential construction, by product, 1996 and 1998**

Year, construction value, and timber product	Unit of measure	Total use	Use per \$1,000 of construction value
<i>Million</i>			
1996:			
Construction value	(1992\$)	286,832	—
Lumber	(Bd. ft)	3,967	13.830
Structural panels <sup>a</sup> —			
Softwood plywood	(Sq. ft)	1,348	4.698
Oriented strand board	(Sq. ft)	976	3.402
Total		2,323	8.100
Nonstructural panels <sup>a</sup>	(Sq. ft)	1,179	4.109
Engineered wood—			
Wood I-joists	(Lf) <sup>b</sup>	71	.246
Glulam timbers	(Bd. ft)	114	.397
Structural composite lumber	(Cf) <sup>c</sup>	1	.005
1998:			
Construction value	(1992\$)	322,833	—
Lumber	(Bd. ft)	4,463	13.825
Structural panels <sup>a</sup> —			
Softwood plywood	(Sq. ft)	1,475	4.570
Oriented strand board	(Sq. ft)	1,159	3.590
Total		2,634	8.160
Nonstructural panels <sup>a</sup>	(Sq. ft)	1,285	3.981
Engineered wood—			
Wood I-joists	(Lf) <sup>b</sup>	88	.273
Glulam timbers	(Bd. ft)	140	.434
Structural composite lumber	(Cf) <sup>c</sup>	2	.005

<sup>a</sup> Square feet, 3/8-in basis.

<sup>b</sup> Linear feet.

<sup>c</sup> Cubic feet.

Sources: USDC Bureau of the Census 2000c, and Forest Service estimates based on McKeever and Adair 1998.

## **Timber Products Use in Railroad Construction**

About 825 million board feet of lumber and 20 million square feet of structural panels were used in 1998 by the railroad industry in the United States for the construction of new track and for the maintenance of existing track and rolling stock. About 85 percent of the lumber, 700 million board feet, was used for the 17.5 million crossties, and bridge and switch ties installed during 1998 (table 10). (Bridge and switch ties are measured in crosstie equivalents; that is, the number of crossties that would have the same volume of timber as that in the bridge and switch ties.) More than 90 percent of all ties used in 1998 were hardwood. The remaining 125 million board feet of lumber and all of the structural panels were used to repair and refurbish railroad cars in industry-owned facilities.

During the 1950s, more than 32 million rail ties were installed, on average, per year (table 10). Installations during the 1960s dropped to just 18 million ties per year but rebounded to over 26 million during the 1970s (fig. 11). A high of 30 million tie installations occurred in 1976. In the 1980s, installations again fell from nearly 28 million ties in 1980 to around 17 million in 1990. Since 1990, about 17 million ties have been installed annually. On average, a standard railroad crosstie contains 40 board feet of lumber. Thus, the nearly 18 million ties installed in 1998 contained about 700 million board feet of lumber (fig. 12). Because of the constant volume of lumber per tie, trends in lumber use are the same as for tie installations.

Year-to-year variations in tie installations are largely due to short-term economic factors. Long-term trends have resulted from fundamental changes in the railroad industry and its operations over the past 35 years. The miles of maintained track dropped by more than 18 percent during the 1960s and 1970s, the outgrowth of restructuring and streamlining systems and operations (Association of American Railroads 1984, 1987). Miles of maintained track continue to decline. Between 1988 and 1995, reported miles of maintained track fell by 2 percent per year (Railway Tie Association 1998). This trend is expected to continue. Despite these declines, annual wood crosstie, and bridge and switch tie installations remain strong.

## **Timber Products Consumption in Manufacturing**

Manufacturing industries in the United States produce various products. Some of these products are made entirely from wood, some from combinations of wood and nonwood materials and many with no wood at all. Many wood and nonwood products require the use of wood jigs, models, patterns, flasks, and other wood products during their production. Overall, manufacturers used about 13 percent of all lumber, 11 percent of all structural panels, and 48 percent of all nonstructural panels consumed in the United States in 1998. The USDC Bureau of the Census measures activity in all major manufacturing industries annually (USDC Bureau of the Census 1995, 1998, 2000d). Annual value of industry shipments was used here to estimate timber products consumption.

For this analysis, manufactured goods were divided into three major commodity groups: (1) household furniture, (2) commercial and institutional furniture, and (3) other products (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, textile machinery supplies, and other manufactured products not included elsewhere in this report). Although the "other products" group accounts for much of the total industry shipments, timber products consumption for individual manufactured products is relatively small; therefore, they have been combined.

**Table 10—Number and volume of wood railroad ties installed in the United States, 1950-98<sup>a</sup>**

Year	Crossties		Switch and bridge ties <sup>b</sup>		Total	
	Number	Volume	Number	Volume	Number	Volume
	<i>Thousand</i>	<i>Million bd. ft</i>	<i>Thousand</i>	<i>Million bd. ft</i>	<i>Thousand</i>	<i>Million bd. ft</i>
1950-59 <sup>c</sup>	29,523	1,151	2,775	111	32,298	1,262
1960-69 <sup>c</sup>	17,152	686	1,297	52	18,450	738
1970-79 <sup>c</sup>	24,518	981	1,863	75	26,381	1,055
1980	26,247	1,050	1,625	65	27,872	1,115
1981	26,719	1,069	1,325	53	28,044	1,122
1982	20,811	832	1,225	49	22,036	881
1983	20,553	822	1,225	49	21,778	871
1984	24,863	995	1,550	62	26,413	1,057
1985	23,434	937	1,625	65	25,059	1,002
1986	20,412	816	1,625	65	22,037	881
1987	17,081	683	1,186	47	18,267	731
1988	15,600	624	1,116	45	16,715	669
1989	14,898	596	1,082	43	15,980	639
1980-89 <sup>c</sup>	21,062	842	1,358	54	22,420	897
1990	16,033	641	1,136	45	17,170	687
1991	14,414	577	1,059	42	15,474	619
1992	15,769	631	1,124	45	16,892	676
1993	15,373	615	1,105	44	16,478	659
1994	14,523	581	1,064	43	15,587	623
1995	14,296	572	1,086	43	15,382	615
1996	16,131	645	1,133	45	17,264	691
1990-96 <sup>c</sup>	15,220	609	1,101	44	16,321	653
1997	16,250	650	1,125	45	17,375	695
1998	16,375	655	1,125	45	17,500	700
1990-98 <sup>c</sup>	15,463	619	1,106	44	16,569	663

<sup>a</sup> Includes ties for replacement and new installations. Based on data for class 1 railroads adjusted to include all railroads.

<sup>b</sup> Crosstie equivalents.

<sup>c</sup> Average for period.

Sources: Haynes 1990, Association of American Railroads 1984, 1987, Railway Tie Association 1998, and Forest Service estimates.

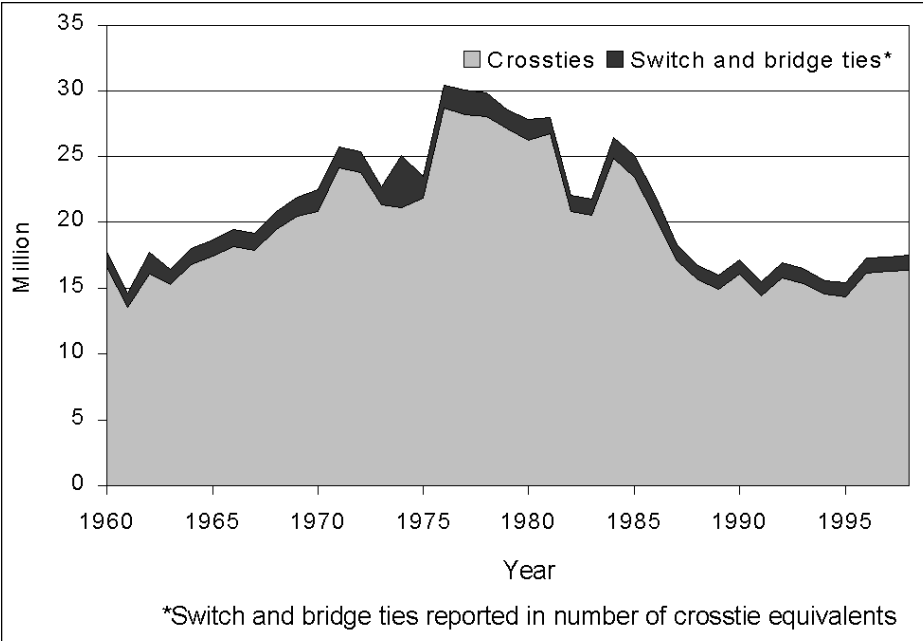


Figure 11—Wooden crosstie, and switch and bridge tie consumption, 1960-98.

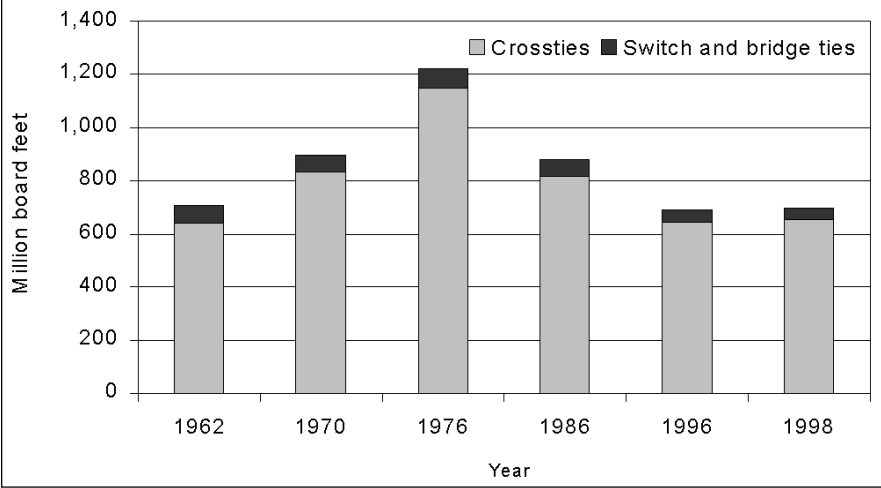


Figure 12—Lumber used for wooden crossties, and switch and bridge ties, selected years 1962-98.

In addition to the three commodity groups defined as manufacturing, substantial amounts of timber products are used to produce pallets, containers, prefabricated wooden buildings, structural wood members, mobile homes, millwork and cabinets, and flooring. To avoid double counting, timber products consumption for these products is included in those sections of this report dealing with packaging and shipping, and residential and nonresidential construction, and are not included here.

Recent trends in wood products use for manufacturing reflect changing aspects of both the manufactured products themselves, the industries that produce them, and the consumers that demand them. Some of these aspects include differential growth in production and shipments of finished products, materials substitution within products, technological changes in the manufacturing process, and consumer preferences. All these factors have affected the kinds and amounts of wood and nonwood materials used for manufacturing in the United States.

### **Shipments of Manufactured Products**

Total shipments of manufactured products in the three commodity groups, measured in constant 1992 dollars, totaled \$3,562 billion in 1998, up from \$3,312 billion in 1996, and \$2,576 billion in 1986 (table 11). This record level of shipments in 1998 was nearly four times greater than in 1950, and nearly 40 percent greater than in 1986 (fig. 13). In general, manufacturing shipments closely follow overall trends in the economy. Periods of minor economic slowdown as experienced in the early 1970s and early 1990s, as well as more dramatic economic recessions in the mid-1970s and mid-1980s were readily apparent by marked drops in total product shipments. Notwithstanding, overall growth in manufacturing shipments has been fairly steady, averaging about 2.8 percent per year since 1950.

In 1998, household furniture shipments totaled \$25.0 billion, and commercial and institutional furniture shipments totaled \$31.4 billion (table 11). From 1950 through 1986, household furniture shipments consistently exceeded shipments of commercial and institutional furniture. Then in 1987, commercial and institutional furniture shipments for the first time exceeded that for household furniture, and have done so since. Since 1987, shipments of commercial and institutional furniture have grown at an average annual rate of 3.5 percent per year, compared to just 1.5 percent for household furniture, and 2.4 percent for other products.

### **Timber Products Use Per \$1,000 of Manufacturing Shipments**

Divergent trends in the use of lumber, and structural and nonstructural panels per \$1,000 of constant 1992 dollar product shipments have been experienced over the past five decades. In 1948, 4.6 board feet of lumber, 0.4 square feet of structural panels, and 0.9 square feet of nonstructural panels were used, on average, for every \$1,000 of product shipments (table 12). Lumber use per \$1,000 of shipments dropped steadily in the 1950s, 1960s and 1970s before leveling off at around 2.4 board feet per \$1,000 of shipments in the 1980s and 1990s. Structural panel use per \$1,000 of product shipments was fairly constant through the 1960s and 1970s, and then increased in the 1980s and 1990s to 0.9 square feet. Nonstructural panel use increased steadily, reaching 3.2 square feet per \$1,000 of product shipments in 1998.

Timber products use per \$1,000 of shipments, and total timber products use in 1986 was revised from previous estimates based on new information in Adair (1994) and Virginia Polytechnic Institute (1991, 1993a, 1993b). Table 12a shows the revisions in total timber products use and use per \$1,000 of shipments in 1986. The trends reported above reflect the revised 1986 estimates.



**Table 11—Value of manufacturing shipments in the United States, by commodity group, 1948-98**

Year	All products <sup>a</sup>		Household furniture		Commercial and institutional furniture		Other products <sup>b</sup>	
	Value	Annual rate of change	Value	Annual rate of change	Value	Annual rate of change	Value	Annual rate of change
	<i>Billion 1992\$</i>	<i>Percent</i>	<i>Billion 1992\$</i>	<i>Percent</i>	<i>Billion 1992\$</i>	<i>Percent</i>	<i>Billion 1992\$</i>	<i>Percent</i>
1948	859.4	—	8.6	—	2.1	—	848.8	—
1950	935.7	4.3	9.7	6.6	2.7	13.0	923.3	4.3
1955	1,239.3	5.8	12.4	5.0	3.9	7.5	1,223.0	5.8
1960	1,336.9	1.5	12.9	.7	5.9	8.7	1,318.1	1.5
1965	1,749.3	5.5	17.1	5.8	8.0	6.3	1,724.2	5.5
1970	1,972.1	2.4	18.9	2.0	10.0	4.6	1,943.3	2.4
1975	2,033.5	.6	15.4	-4.0	9.6	-.7	2,008.6	.7
1976	2,224.6	9.4	17.3	13.0	10.0	3.7	2,197.3	9.4
1977	2,381.6	7.1	18.8	8.1	12.0	20.0	2,350.9	7.0
1978	2,484.4	4.3	19.9	6.3	12.8	6.9	2,451.7	4.3
1979	2,506.7	.9	18.5	-7.1	12.8	( <sup>c</sup> )	2,475.4	1.0
1980	2,363.1	-5.7	16.8	-9.5	12.4	-2.8	2,333.9	-5.7
1981	2,362.8	( <sup>c</sup> )	16.3	-2.8	12.2	-1.9	2,334.3	( <sup>c</sup> )
1982	2,186.4	-7.5	15.0	-7.9	13.4	9.6	2,158.0	-7.6
1983	2,307.7	5.5	16.4	9.4	14.3	7.0	2,277.0	5.5
1984	2,509.8	8.8	17.6	7.1	16.3	13.9	2,476.0	8.7
1985	2,598.8	3.5	18.0	2.7	17.6	7.9	2,563.2	3.5
1986	2,575.8	-.9	19.9	10.1	18.8	7.1	2,537.1	-1.0
1987	2,743.2	6.5	21.2	6.5	21.6	14.5	2,700.5	6.4
1988	2,862.1	4.3	21.0	-.9	22.0	2.2	2,819.1	4.4
1989	2,839.8	-.8	20.8	-.6	22.1	.5	2,796.9	-.8
1990	2,820.9	-.7	20.1	-3.7	21.9	-.9	2,778.9	-.6
1991	2,772.2	-1.7	19.6	-2.2	20.7	-5.9	2,731.9	-1.7
1992	2,923.1	5.4	20.7	5.5	23.0	11.4	2,879.4	5.4
1993	2,990.0	2.3	21.6	4.3	24.6	6.8	2,943.8	2.2
1994	3,158.3	5.6	23.0	6.4	25.8	5.0	3,109.5	5.6
1995	3,279.5	3.8	23.0	( <sup>c</sup> )	27.3	5.8	3,229.3	3.9
1996	3,312.2	1.0	23.3	1.5	27.8	1.9	3,261.1	1.0
1997	3,388.8	2.3	24.2	3.6	32.2	15.7	3,332.4	2.2
1998	3,562.0	5.1	25.0	3.4	31.4	-2.4	3,505.6	5.2

<sup>a</sup> Includes furniture and 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 report.

<sup>b</sup> Includes all manufactured products except furniture, 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 report.

<sup>c</sup> Less than 0.05 percent.

Sources: Council of Economic Advisors 2000, USDC Bureau of the Census 1995, 1998, and Forest Service estimates.

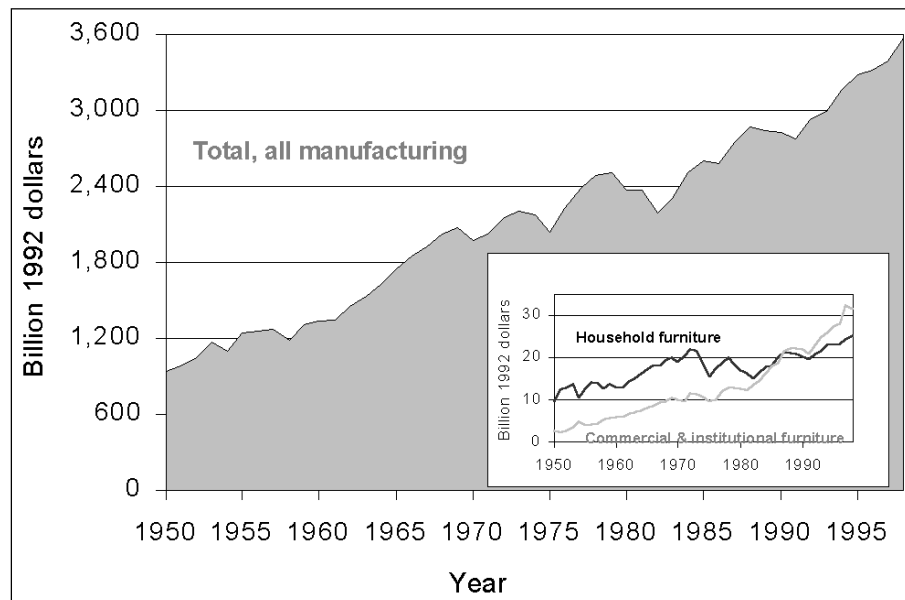


Figure 13—Value of manufacturing shipments, by commodity type, 1950-98.

**Table 12—Timber products used, and use per \$1,000 of product shipments in manufacturing in the United States, by product, 1948-98<sup>a</sup>**

Year	Shipments <i>Billion 1992\$</i>	Lumber <sup>b</sup>		Structural panels <sup>c,d</sup>		Nonstructural panels <sup>c,e</sup>	
		Total <i>Million bd. ft</i>	Per \$1,000 of shipment <i>Bd. ft</i>	Total <i>Million sq. ft</i>	Per \$1,000 of shipment <i>Sq. ft</i>	Total <i>Million sq. ft</i>	Per \$1,000 of shipment <i>Sq. ft</i>
1948 <sup>e</sup>	859	3,924	4.57	363	0.42	763	0.89
1960	1,337	3,865	2.89	910	.68	1,378	1.03
1965	1,749	4,609	2.63	811	.46	2,083	1.19
1970	1,972	4,670	2.37	902	.46	3,128	1.59
1976	2,225	4,864	2.19	1,132	.51	4,583	2.06
1986 <sup>f</sup>	2,576	6,067	2.36	1,758	.68	6,789	2.64
1996	3,312	7,867	2.38	3,154	.95	9,902	2.99
1998	3,562	8,377	2.47	3,735	1.10	10,926	3.22

<sup>a</sup> Includes all 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.

<sup>b</sup> Includes softwood and hardwood lumber.

<sup>c</sup> Square feet, 3/8-in basis.

<sup>d</sup> Includes softwood plywood, oriented strand board, and waferboard.

<sup>e</sup> Includes hardwood plywood, particleboard, medium-density fiberboard, hardboard and insulation board. In 1948 includes only hardwood plywood.

<sup>f</sup> Wood products use revised from 1989 RPA Assessment.

Sources: Council of Economic Advisors 2000, USDC Bureau of the Census 1995, 1998. Haynes 1990, and Forest Services estimates based on McKeever and Martens 1983, Adair 1994, 1999, and Virginia Polytechnic Institute 1991, 1993a, 1993b.

**Table 12a—Revisions to timber products use for manufacturing, 1986**

Year	Shipments	Lumber <sup>a</sup>		Structural panels <sup>b,c</sup>		Nonstructural panels <sup>b,d</sup>	
		Total	Per \$1,000 of shipment	Total	Per \$1,000 of shipment	Total	Per \$1,000 of shipment
	<i>Billion 1992\$</i>	<i>Million bd. ft</i>	<i>Bd. ft</i>	<i>Million sq. ft</i>	<i>Sq. ft</i>	<i>Million sq. ft</i>	<i>Sq. ft</i>
1986:							
Original	2,576	4,803	1.86	1,257	0.49	7,750	3.01
Revised	—	6,067	2.36	1,758	.68	6,789	2.64
Difference (%)	—	26	26	40	40	-12	-12

<sup>a</sup> Includes softwood and hardwood lumber.

<sup>b</sup> Square feet, 3/8-in basis.

<sup>c</sup> Includes softwood plywood, oriented strand board, and waferboard.

<sup>d</sup> Includes hardwood plywood, particleboard, medium-density fiberboard, hardboard and insulation board.

Sources: Haynes 1990, and Forest Service estimates based on Adair 1994, and Virginia Polytechnic Institute 1991, 1993a, 1993b.

Trends in timber products consumption per \$1,000 of shipments reflect numerous and diverse changes in the materials and technologies used to manufacture products, and changes in consumer preferences for specific products and the materials from which they are made. For example, the decline in the use of lumber and the fairly steady use of structural panels per \$1,000 of shipments during the 1960s, 1970s, and 1980s reflects, in part, substitutions of alternative materials for wood. Most notable of these was plastics as a substitute for wood in household furniture in the late 1960s and early 1970s, especially in highly ornate, detailed furniture parts and styles (Clark 1971). By the mid-1970s and 1980s, the use of plastics in furniture stabilized and began to drop. A return to more traditional furniture styles and materials in recent years helped spark a resurgence in the use of wood in household furniture. Fiberglass, reinforced plastics, and metals also captured market share at the expense of wood in various products such as commercial and institutional furniture, boats, and toys. Their lower cost and performance characteristics have helped these nonwood materials maintain market share. Trends also reflect, to some extent, the mix of manufactured products consumed annually.

Nonstructural panels were also instrumental in the decline in the use per \$1,000 of lumber and structural panels in many manufactured products, particularly household furniture. For example, particleboard is used extensively for panel corestock, and hardboard has replaced plywood for components such as drawer bottoms and backs of case goods. The superior edge-working characteristics of MDF have been a major factor in its substitution for lumber, plywood, and particleboard. Inroads by nonstructural panels were evident by its steadily rising use per \$1,000 over the past 48 years (table 12).

### **Total Timber Products Use in Manufacturing**

The consumption of timber products in manufacturing reached record high levels in 1998 when nearly 8.4 billion board feet of lumber, 3.7 billion square feet of structural panels, and 10.9 billion square feet of nonstructural panels were used (table 12, fig. 14). These levels represented increases of 6 percent for lumber; 18 percent for structural panels; and 10 percent for nonstructural panels over 1996 consumption levels; and 38, 112, and 60 percent, respectively, for lumber, structural panels, and nonstructural panels over 1986 consumption levels. This increase was due, in part,

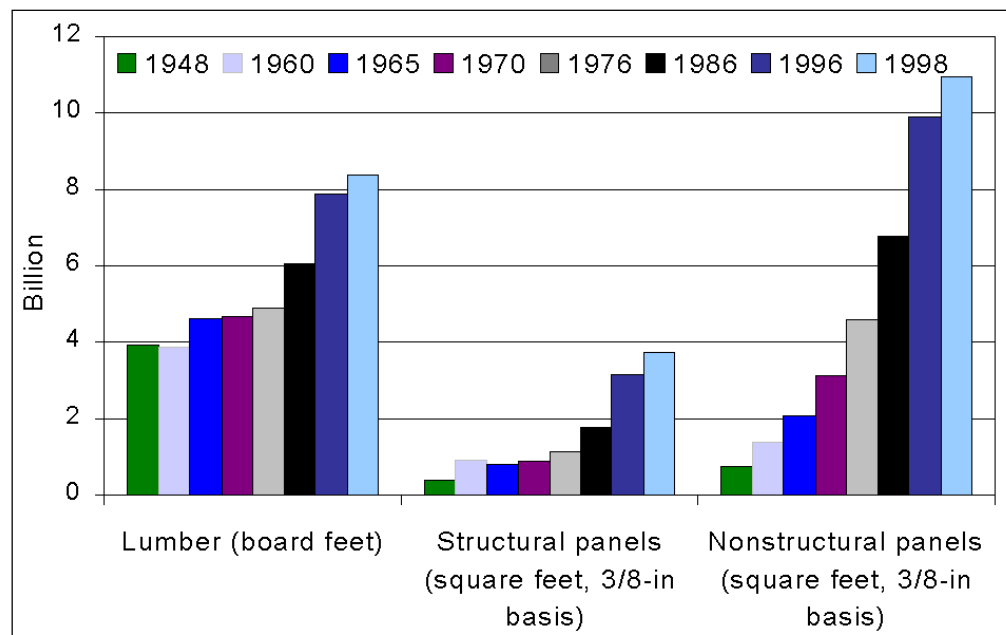


Figure 14—Timber products used for manufacturing, selected years 1948-98.

to the nearly 40-percent increase in product shipments since 1986, and partly to a renewed interest in wood by both manufacturers as an industrial raw material, and by consumers in finished products. Studies conducted in the 1990s by APA-The Engineered Wood Association (Adair 1994, 1999) and by Virginia Polytechnic Institute (1991, 1993a, 1993b) indicated substantially higher levels of wood products use by manufacturing industries than would be expected from trends in industry shipments alone, and from levels of use in earlier industrial wood use studies (McKeever and Martens 1983). Timber products have regained some of the market share lost to other nonwood products during the 1960s, 1970s, and early 1980s.

Total lumber consumption for manufacturing increased by about 0.7 billion board feet between 1948 and 1965, and then remained fairly steady through 1976 increasing by less than 0.3 billion board feet (table 13). Consumption then increased dramatically by more than 1.2 billion board feet in 1986, 1.8 billion board feet in 1996, and 0.5 billion board feet in 1998. Household furniture has consistently been the mainstay of lumber use in manufacturing. Lumber use reached nearly 3.0 billion board feet in the late 1960s through 1986, increased to nearly 4.1 billion board feet in 1996, and 4.4 billion board feet in 1998. Lumber use for other products as a percentage of household furniture fluctuated widely over the years, from a low of 45 percent in 1965 to 98 percent in 1976. Lumber use for other products is currently about 72 percent of household furniture lumber use. These two commodity groups, household furniture and other products, accounted for 7.5 of the 8.4 billion board feet of lumber consumed for manufacturing in 1998, about 90 percent of the total (table 13). Commercial and institutional furniture used just 0.8 billion board feet of lumber in 1998.

Aside from a slight decline in the late 1960s, structural panel use increased steadily between 1948 and 1998. Consumption in 1998 was 3.7 billion square feet, up from 3.2 billion in 1996, and over two times that of 1986 (table 13). Other products manufacturing has been the primary market for structural panels in manufacturing since 1960.

**Table 13—Timber products used in manufacturing in the United States, by product and commodity group, 1948-98**

Year and commodity group	Lumber <sup>a</sup>	Structural panels <sup>b c</sup>	Nonstructural panels <sup>b d</sup>
	<i>Million bd. ft</i>	<i>— — — Million sq. ft— — —</i>	
1948:			
Household furniture	1,970	195	397
Commercial and institutional furniture	321	90	184
Other products <sup>e</sup>	1,633	78	182
Total	3,924	363	763
1960:			
Household furniture	2,116	351	719
Commercial and institutional furniture	289	137	322
Other products <sup>e</sup>	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 <sup>e</sup>	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 <sup>e</sup>	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 <sup>e</sup>	2,262	710	2,200
Total	4,864	1,132	4,583
1986 <sup>f</sup> :			
Household furniture	2,969	235	2,186
Commercial and institutional furniture	536	357	2,447
Other products <sup>e</sup>	2,562	1,167	2,157
Total	6,067	1,758	6,789
1996:			
Household furniture	4,072	647	3,181
Commercial and institutional furniture	762	754	4,660
Other products <sup>e</sup>	3,033	1,753	2,062
Total	7,867	3,154	9,902
1998:			
Household furniture	4,375	868	3,355
Commercial and institutional furniture	847	1,004	5,279
Other products <sup>e</sup>	3,155	1,862	2,291
Total	8,377	3,735	10,926

<sup>a</sup> Includes softwood and hardwood lumber.

<sup>b</sup> Square feet, 3/8-in basis.

<sup>c</sup> Includes softwood plywood, oriented strand board, and waferboard.

<sup>d</sup> Includes hardwood plywood, particleboard, medium-density fiberboard, hardboard and insulation board. In 1948 includes only hardwood plywood.

<sup>e</sup> 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.

<sup>f</sup> Wood products use revised from 1989 RPA Assessment.

Sources: Haynes 1990, and Forest Services estimates based on McKeever and Martens 1983, Adair 1994, 1999, and Virginia Polytechnic Institute 1991, 1993a, 1993b.

## **Timber Products Consumption in Packaging and Shipping**

In 1998, about 50 percent of all structural panels was used for other products. Commercial and institutional furniture, once the smallest market for structural panels, exceeded the use for household furniture in 1998 by about 16 percent.

Manufacturing is the principal market for nonstructural panels in the United States. In 1998, nearly half (48 percent) of all nonstructural panels, 10.9 billion square feet, was used for manufacturing, nearly 1.0 billion square feet more than in 1996, and about 60 percent more than in 1986 (table 13). Commercial and institutional furniture was the principal nonstructural panel market in 1998, accounting for about 48 percent of total use. Household furniture was second at 31 percent of total use. Consumption for other products used the remaining 21 percent.

Overall, household furniture was the most important market for lumber, particularly high-quality and preferred species, in manufacturing in 1998. Other products manufacturing was the most important market for structural panels, and commercial and institutional furniture was the most important manufacturing market for nonstructural panels.

Substantial amounts of timber products are used annually in the United States to produce pallets, boxes, crates, hampers, baskets, and other wooden containers; and for the dunnage, blocking, and bracing required in the transportation, handling, and storage of industrial, agricultural, and military products. Overall, 7.2 billion board feet of lumber, 622 million square feet of structural panels, and 127 million square feet of nonstructural panels were used in 1998 for packaging and shipping (table 14). Lumber and structural panel consumption were at all time highs in 1998. These volumes accounted for 11 percent of all the lumber, 2 percent of all the structural panels, and 1 percent of all the nonstructural panels consumed domestically in 1998.

Lumber and structural panel consumption for packaging and shipping increased between 1986 and 1998 (fig. 15). Nonstructural panel consumption steadily decreased, continuing a trend begun in 1960. Lumber consumption for packaging and shipping is largely dependent on new pallet consumption. In the early 1990s, the rapid development and acceptance of pallets made from salvaged discarded pallets, and a reduction in the average amount of lumber needed to build a pallet, resulted in a somewhat reduced rate of growth in lumber consumption for packaging and shipping.

## **Wooden Pallet Production**

The wooden pallet industry has changed much over the past 5 to 10 years, and change continues. While overall pallet production generally has continued, its 35-year overall upward trend, the rate of growth in the use of pallets made from new lumber has leveled off or decreased. The recovery, repair, reuse, and recycling of pallets has grown rapidly during the 1990s. In 1998, an estimated 34 percent (1 in 3) of all pallets were made from recycled pallet lumber, compared to 29 percent in 1996, and only about 2 percent in 1992 (fig. 16). Many states and municipalities ban the landfilling of used pallets; others recover landfilled pallets for reuse or conversion into products with little or no value. The recovery of pallet material at landfills for repairing and remanufacturing pallets could be the next major recovery-reuse step. Trends of reduced new material use, increased recovery and repair, and decreased landfilling are expected to continue at moderate rates.

## **Timber Products Consumption in Wooden Pallets**

An estimated 6.6 billion board feet of new lumber, 463 million square feet of structural panels, and 110 million square feet of nonstructural panels were used to produce the 441 million new pallets made in the United States in 1998 (table 15). An additional 224 million recovered-repaired pallets also were made, requiring an estimated 3.4 billion board feet of recycled pallet lumber. These amounts represent increases over 1996 of about 790 million board feet of new lumber, and 75 and 13 million square feet of structural and nonstructural panels, respectively.

**Table 14—Timber products used in shipping in the United States, by product and end use, 1948-98**

Year and commodity group	Lumber <sup>a</sup>	Structural panels <sup>b c</sup>	Nonstructural panels <sup>b d</sup>
	<i>Million bd. ft</i>	<i>— — — — Million sq. ft — — —</i>	
1948:			
Wooden containers	3,997	313	(e)
Pallets	220	1	(e)
Dunnage, blocking, and bracing	740	(e)	(e)
Total	4,957	314	(e)
1960:			
Wooden containers	1,866	304	821
Pallets	1,550	16	3
Dunnage, blocking, and bracing	800	(e)	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 <sup>f</sup> :			
Wooden containers <sup>d</sup>	275	85	41
Pallets <sup>d</sup>	5,457	305	104
Dunnage, blocking, and bracing	170	5	3
Total	5,902	395	148
1996:			
Wooden containers	390	137	12
Pallets	5,823	388	97
Dunnage, blocking, and bracing	192	6	3
Total	6,405	535 <sup>g</sup>	112
1998:			
Wooden containers	424	148	13
Pallets	6,611	463	110
Dunnage, blocking, and bracing	199	6	4
Total	7,235	622 <sup>g</sup>	127

<sup>a</sup> Includes softwood and hardwood lumber.

<sup>b</sup> Square feet, 3/8-in basis.

<sup>c</sup> Includes softwood plywood, oriented strand board, and waferboard.

<sup>d</sup> Includes hardwood plywood, particleboard, medium-density fiberboard, hardboard and insulation board. In 1948 includes only hardwood plywood.

<sup>e</sup> Less than 500,000 units.

<sup>f</sup> Wood products use revised from 1989 RPA Assessment.

<sup>g</sup> Structural panel total includes an additional 4.6 million square feet of structural panels used for the repair of pallets and containers in 1996 and 1998.

Source: National Wooden Pallet and Container Association 1987, 1999, Haynes 1990, and Forest Service estimates based on McKeever et al. 1986, Adair 1994, Bush and Araman 1997a, and West 2000.

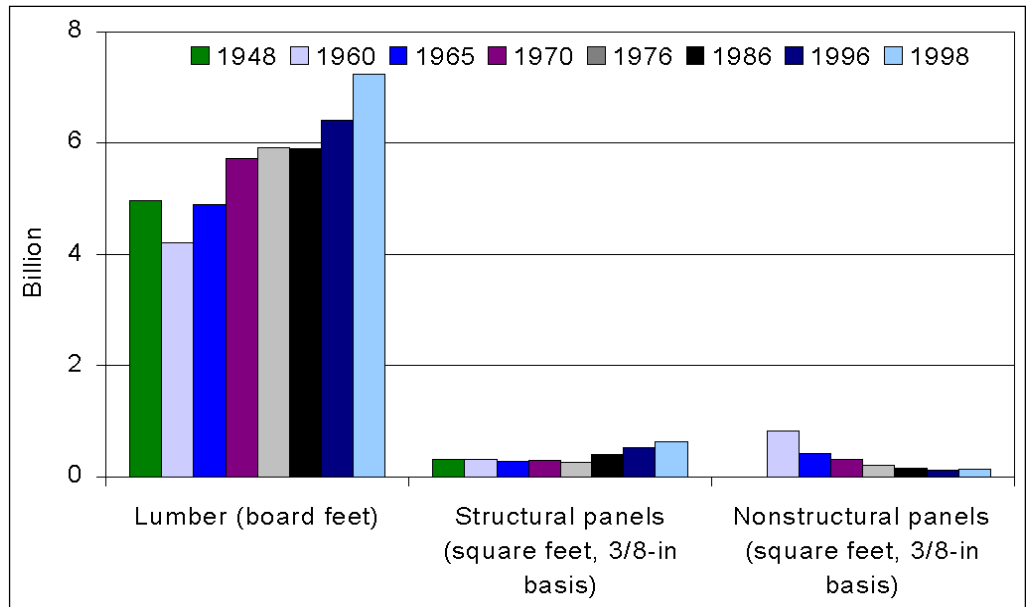


Figure 15—Timber products used for packaging and shipping, selected years 1948-98.

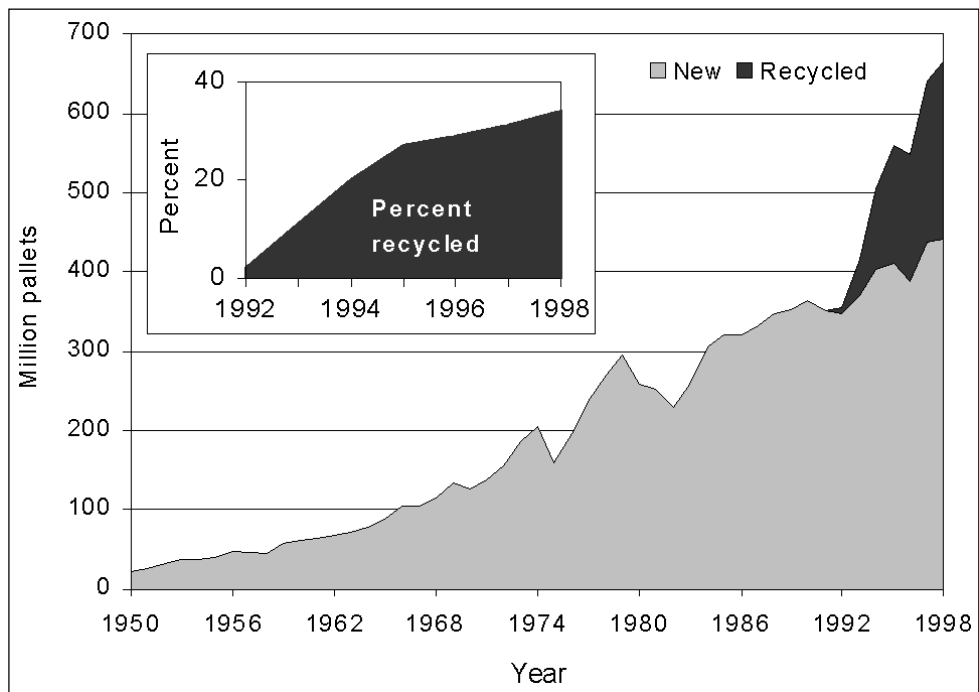


Figure 16—New and recycled wooden pallet production, 1950-98.



**Table 15—Timber products used in the manufacture of pallets in the United States, by product, 1960-98**

Year	Pallet production	Lumber <sup>a</sup>		Structural panels <sup>b c</sup>		Nonstructural panels <sup>b d</sup>	
		Total use	Use per pallet	Total use	Use per pallet	Total use	Use per pallet
		<i>Million</i>	<i>Million bd. ft</i>	<i>Bd. ft</i>	<i>Million sq. ft</i>	<i>Sq. ft</i>	<i>Million sq. ft</i>
1960	62	1,550	25	16	0.26	3	0.05
1965	88	2,200	25	62	.70	18	.20
1970	126	3,150	25	105	.83	44	.35
1976	196	4,900	25	157	.80	78	.40
1986 <sup>e</sup>	321	5,457	17	305	.95	104	.32
1996	388	5,823	15	388	1.00	97	.25
1998	441	6,611	15	463	1.05	110	.25

<sup>a</sup> Includes softwood and hardwood lumber.

<sup>b</sup> Square feet, 3/8-in basis.

<sup>c</sup> Includes softwood plywood, oriented strand board, and waferboard.

<sup>d</sup> Includes hardwood plywood, particleboard, medium-density fiberboard, hardboard and insulation board.

<sup>e</sup> Wood products use revised from 1989 Assessment.

Sources: National Wooden Pallet and Container Association 1987, 1999, Haynes 1990, and Forest Service estimates based on McKeever et al. 1986, Adair 1994, Bush and Araman 1997a, and West 2000.

The use of lumber for pallets has increased dramatically since the early 1960s when the estimated 62 million pallets produced used about 1.6 billion board feet of lumber, 16 million square feet of structural panels, and 3 million square feet of nonstructural panels. The rapid increase in pallet production since then 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, growth in industrial and agricultural production has led to increased demand in those sectors of the economy where pallet systems already were established. 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. During the next 10 years (1976 through 1986), pallet production increased by nearly two-thirds to 321 million units; however, lumber consumption only rose 11 percent to 5.5 billion board feet because of increased efficiency in lumber use per pallet. Nonstructural panel use per pallet also declined. Structural panel use per pallet continued to increase.

Estimated pallet production, wood products use per pallet, and total wood products use in 1986 were revised from previous estimates based on new information in McKeever et al. (1986), Adair (1994), Bush and Araman (1997b), and West (2000). Table 15a shows the revisions in pallet production and wood products in 1986. The trends reported above reflect the revised 1986 estimates.

Over the years, pallet manufacturers have used less lumber to make pallets. Lumber use per pallet decreased on average from 25 to 17 board feet between 1976 and 1986, and then to 15 board feet between 1986 and 1996 (table 15) (Bush and Araman 1997a, McKeever et al. 1986). These reductions are due, in part, to computerized pallet design, other design improvements, and thinner, more optimally designed, wood components. Thinner components also are used for limited-use shipping pallets. The thinner

**Table 15a—Revisions to timber products use for pallets, 1986**

Year	Pallet produc- tion	Lumber <sup>a</sup>		Structural panels <sup>b c</sup>		Nonstructural panels <sup>b d</sup>	
		Total use	Use per pallet	Total use	Use per pallet	Total use	Use per pallet
		<i>Million</i>	<i>Million bd. ft</i>	<i>Bd. ft</i>	<i>Million sq. ft</i>	<i>Sq. ft</i>	<i>Million sq. ft</i>
1986:							
Original	373	6,341	17	321	0.86	187	0.50
Revised	321	5,457	17	305	.95	104	.32
Difference (%)	-14	-14	—	-5	10	-44	-35

<sup>a</sup> Includes softwood and hardwood lumber.

<sup>b</sup> Square feet, 3/8-in basis.

<sup>c</sup> Includes softwood plywood, oriented strand board, and waferboard.

<sup>d</sup> Includes hardwood plywood, particleboard, medium-density fiberboard, hardboard and insulation board.

Sources: Haynes 1990, and Forest Service estimates based on McKeever et al. 1986, Adair 1994, Bush and Araman 1997b, and West 2000.

materials have been forced by increases in wood costs, with pallet price increases being less than that required to cover the higher wood costs. The production of limited-use shipping pallets, and substitution of other wood and of nonwood materials for lumber also have contributed to the decrease in lumber use per pallet.

Solid wood is the dominant pallet material in the United States with an estimated market share of over 90 percent. Within this market, hardwood lumber is the most commonly used material. Softwood lumber, however, is an important wood pallet material and may be used in place of hardwoods for reasons such as relative cost, local availability, weight, or when pallets manufactured from dry wood are required. In addition, hardwood-softwood combination pallets are sometimes manufactured. Currently, about 28 to 30 percent of new pallet lumber is softwood species.

Structural panels, primarily softwood plywood, also are used in pallets. These materials may be used in combination with solid wood (as in a panel deck, solid wood block combination pallet) or alone (as in a panel deck / panel block pallet). Typical use is for block pallets (as compared to stringer pallets), which are likely to become more prevalent due in part to ease of handling. Increased adoption of automated handling systems and corresponding dimensional tolerance requirements are likely to provide additional market opportunities for panel pallets.

The recovery-repair industry has made a major impact on the pallet industry. Recovered-repaired pallets typically sell for 25 to 50 percent less than new pallets, and typically perform as well as new pallets. They just do not look as nice as new pallets. Several other factors have contributed to the recent, rapid growth of pallet recycling by the industry:

- Increased awareness of the environment and activities that affect the environment have caused a previously unconcerned public to question the use of new wood for pallets.
- Pallet companies, concerned with the availability and price of new lumber and cants, have found it economically advantageous to repair pallets and salvage material from used pallets.

- Pallet disposal costs can be significant, and increasing attention is being paid to reducing or avoiding these costs.
- Barriers to entry into pallet recycling are relatively low.
- Public concerns over the capacity and environmental aspects of landfills have resulted in some facilities banning pallets.

In 1998, an estimated 250 million pallets were recovered by the pallet industry. This was 70 million more than in 1996, and about 185 million more than in 1992. These 250 million recovered pallets contained an estimated 3.8 billion board feet of lumber. About 3.4 billion board feet, 90 percent, of this material was used to repair, rebuild, and manufacture recycled pallets in 1998.

**Alternative materials used in pallets**—Several materials compete with solid wood in the pallet market. The most prevalent are plastics (various types, including plastic-wood composites) and corrugated paperboard.

Plastic pallets are used by 20 percent of firms in the meat industry, 17 percent of firms in the food industry, and 12 percent of firms in the construction industry (McCurdy and Phelps 1996). A study conducted by Engle et al. (1994) found that 22 percent of a sample of grocery distribution companies used plastic pallets in 1994, and 6 percent predicted that they would discontinue the use of wood pallets by 1997. Thirty-seven percent of the companies predicted they would use plastic pallets in 1997. Plastic pallets enjoy perceived advantages in this important market with regard to quality, durability, cost per use, handling safety, and overall performance.

Many plastic pallet designs are at a disadvantage when compared to wood on certain structural characteristics and price. Structural (strength) problems are overcome with some designs. However, purchase price, which may be five times that of a comparable wood pallet, often limits plastic pallet use to systems where owners can maintain control of the pallet (e.g., the closed loop from a grocery distributor to captive retail stores and back). In this setting, however, buyers may place more weight on cost per use, a criterion where plastic enjoys a perceived advantage because of the perception of high durability.

Successful plastic pallet designs have found a niche at the high end of the market. In contrast, corrugated paperboard pallets are developing a niche at the low end where purchase price and reduced disposal problems are important. Accordingly, corrugated pallets are most often found in open-loop systems (i.e., systems where the pallet purchaser does not maintain possession and control of the pallet). McCurdy and Phelps (1996) found that corrugated fiber pallets were used by 24 percent of firms in the health-pharmaceuticals industry, 6 percent of firms in the construction industry, and 4 percent of firms in the food industry. Engle et al. (1994) found that 0.5 percent of grocery distributors used corrugated pallets for shipping dry goods in 1994.

Corrugated paperboard is most often used to construct relatively light-weight pallets and, consequently, enjoys a perceived advantage in handling safety. Their primary advantage, however, is that they greatly reduce disposal and recycling problems; corrugated pallets can be placed into existing, and often well-established, corrugated recycling systems.

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, as measured in constant 1992-dollar value of shipments, was \$848 million in 1998 (table 16). This represents an increase of about 10 percent from 1996,

## Timber Products Consumption in Wooden Containers

**Table 16—Value of shipments and timber products used in the manufacture of wooden containers in the United States, by product, specified years 1960-98**

Year	Value of wooden container shipments	Lumber <sup>a</sup>		Structural panels <sup>b c</sup>		Nonstructural panels <sup>b d</sup>	
		Total use	Use per dollar of shipments	Total use	Use per dollar of shipments	Total use	Use per dollar of shipments
		<i>Million 1992\$</i>	<i>Million bd. ft</i>	<i>Bd. ft</i>	<i>Million sq. ft</i>	<i>Sq. ft</i>	<i>Million sq. ft</i>
1960	1,259	1,866	1.482	304	0.242	821	0.652
1965	1,350	1,829	1.355	203	.150	393	.291
1970	1,388	1,754	1.264	174	.125	262	.189
1976	940	822	.875	97	.103	113	.120
1986 <sup>e</sup>	601	275	.457	85	.141	41	.068
1996	781	390	.500	137	.175	12	.015
1998	848	424	.500	148	.175	13	.015

<sup>a</sup> Includes softwood and hardwood lumber.

<sup>b</sup> Square feet, 3/8-in basis.

<sup>c</sup> Includes softwood plywood, oriented strand board, and waferboard.

<sup>d</sup> Includes hardwood plywood, particleboard, medium-density fiberboard, hardboard and insulation board.

<sup>e</sup> Wood products use revised from 1989 Assessment.

Sources: Council of Economic Advisors 2000, Haynes 1990, USDC Bureau of the Census 1995, 1998, and Forest Service estimates based on Adair 1994, 1999, and Bush and Araman 1997b.

and 40 percent from 1986, but about a 40-percent decline from the 1960s and early 1970s when shipments averaged \$1.3 billion per year. Much of the decline in the mid-1970s and 1980s reflected a 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 40 years. Other factors contributed to the decline, including lower costs of substitute containers and their superior adaptability to automated packaging and shipping operations, and lower shipping weights for competing packaging materials. 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. Recent increases in wooden container shipments reflect record high overall levels of manufacturing in the United States.

The use of lumber per constant dollar of wooden container shipments has been fairly stable over the past decade, averaging about 500 board feet per \$1,000 (table 16). Structural panel use per \$1,000 has increased in recent years, averaging about 175 square feet during the 1990s. Nonstructural panel use per \$1,000 of shipments has fallen steadily since 1960 and is currently about 15 square feet. These changes reflect 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.

Total timber products use for wooden containers in 1998 was above that in 1996 and 1986, but substantially below levels achieved in the 1960s and 1970s (tables 14 and 16). In 1998, 424 million board feet of lumber, 148 million square feet of structural

**Table 16a—Revisions to timber products use for wooden containers, 1986**

Year	Value of wooden container shipments	Lumber <sup>a</sup>		Structural panels <sup>b c</sup>		Nonstructural panels <sup>b d</sup>	
		Total use	Use per dollar of shipments	Total use	Use per dollar of shipments	Total use	Use per dollar of shipments
		<i>Million 1992\$</i>	<i>Million bd. ft</i>	<i>Bd. ft</i>	<i>Million sq. ft</i>	<i>Sq. ft</i>	<i>Million sq. ft</i>
1986:							
Original	601	275	0.457	47	0.078	53	0.088
Revised	—	—	—	85	.141	41	.068
Difference (%)	—	—	—	80	80	-23	-23

<sup>a</sup> Includes softwood and hardwood lumber.

<sup>b</sup> Square feet, 3/8-in basis.

<sup>c</sup> Includes softwood plywood, oriented strand board, and waferboard.

<sup>d</sup> Includes hardwood plywood, particleboard, medium-density fiberboard, hardboard and insulation board.

Sources: Haynes 1990, and Forest Service estimates based on Adair 1994, and Bush and Araman 1997b.

panels, and 13 million square feet of nonstructural panels were used to produce wooden containers. These volumes are about 10 percent greater than in 1996, but range from 15 to 95 percent of use in 1970.

Structural and nonstructural panel use per dollar of wooden container shipments and total structural and nonstructural panel use in 1986 were revised from previous estimates based on new information in Adair (1994), and Bush and Araman (1997b). Table 16a shows the revisions in total structural and nonstructural panel use and use per dollar of wooden container shipments in 1986. The trends reported above reflect the revised 1986 estimates.

**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 (table 14). Since 1986, modest increases in lumber and fairly constant structural and nonstructural panel use has been seen. Nearly 200 million board feet of lumber, 6 million square feet of structural panels, and 4 million square feet of nonstructural panels were consumed for dunnage in 1998 (table 14). Timber products consumption trends reflect growth in containerized and bulk shipments of manufactured and agriculture goods, and increased use of palletized transportation systems.

**Timber Products Consumption in Other Uses**

In addition to the major end uses discussed above, an estimated 6.9 billion board feet of lumber, 0.9 billion square feet of structural panels, and 3.4 billion square feet of nonstructural panels were used in 1998 for other purposes (table 17). These other uses 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; made-on-the-job products such as advertising and display structures; and various other activities not captured elsewhere in this report.

No historical data on the consumption of timber products in these various and varied end uses exist. Accordingly, amounts used for these purposes in the years reported in table 17 were estimated by subtracting volumes of timber products consumed in the specific end uses discussed above from estimated total consumption of each product.

**Table 17—Timber products used for other purposes in the United States, by product, 1962-98<sup>a</sup>**

Year	Lumber <sup>b</sup>	Structural panels <sup>c d</sup>	Nonstructural panels <sup>c e</sup>
	<i>Million bd. ft</i>	<i>Million sq. ft</i>	<i>Million sq. ft</i>
1962	7,349	1,314	1,342
1970	6,666	2,983	1,892
1976	4,286	2,566	1,590
1986	3,824	1,730	1,037
1996	6,958	830	2,743
1998	6,874	890	3,385

<sup>a</sup> 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 various miscellaneous products and uses.

<sup>b</sup> Includes softwood and hardwood lumber.

<sup>c</sup> Square feet, 3/8-in basis.

<sup>d</sup> Includes softwood plywood, oriented strand board, and waferboard.

<sup>e</sup> Includes hardwood plywood, particleboard, medium-density fiberboard, hardboard and insulation board.

Sources: Haynes 1990, Howard 2001, tables 6, 7, 9, 10, 13, and 14 of this report, and Forest Service estimates.

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

These residuals probably include some lumber and panel products that properly belong in the construction, manufacturing, or shipping sectors of this report, and also include any statistical discrepancies associated with the estimates of production, imports, and exports used in estimating total consumption.

Estimated apparent domestic timber products consumption (total and per capita), and consumption in major end-use markets are presented in tables 18, 20, and 22 for 1998 and specified years for which complete end-use market data are available. Information on total domestic production, foreign trade, and apparent domestic timber products consumption are reported in tables 19, 21, and 23 annually for the years 1950 through 1998. Apparent domestic timber products consumption is defined to be total production of a specific product, plus amounts imported, minus amounts exported.

Information on timber products production and foreign trade comes from various published public and private sources. Periodically, adjustments and modifications are made to the data. Recent adjustments to the lumber production data over the past 25 years have resulted in levels of production and consumption different from those reported in previous Forest Service timber analyses (Haynes 1990). Minor adjustments to structural and nonstructural panel production data also were made. See Howard (2001) for sources of information on timber products production and foreign trade.

## **Recent Trends in Lumber, Structural Panels, Nonstructural Panels, and Engineered Wood Products Consumption, Trade, and Production**

## Lumber

**Consumption**—Lumber consumption in the United States in 1998 for all uses totaled 64.2 billion board feet, 2.9 billion board feet greater than in 1996, and 6.8 billion board feet greater than in 1986. In fact, lumber consumption in 1998 was greater than in any year in the past five decades (tables 18 and 19, figs. 17 and 18). Consumption in 1998 also exceeded levels in the early 1900s, when lumber was the most important raw material used in the United States for construction, manufactured products, and shipping.

Per capita consumption in 1998 was 238 board feet, 7 board feet greater than in 1996, but the same as in 1986. Per capita consumption in 1998 was greater than in any year during the 1960s and 1970s (table 18, fig. 17). Per capita consumption, however, was below averages for most years before 1960, and dramatically below the early 1900s when consumption exceeded 500 board feet per person.

Nearly 57 percent of the lumber consumed in 1998 was used for housing—61 percent for construction of new units and 39 percent for the upkeep and improvement of existing units. New nonresidential construction (including railroads) accounted for about 8 percent. Additionally, the “all other” category includes an unknown amount of lumber used for other construction purposes such as nonresidential upkeep and improvements. Manufacturing accounted for 13 percent of lumber consumption, and shipping (pallets, containers, and dunnage) 11 percent. The remaining 11 percent was for all other uses.

In 1998, 52.0 billion of the 64.2 billion board feet of lumber consumed in the United States was softwood species, about 80 percent (table 18, fig. 17). Slight annual variations in the percentage of softwood and hardwood lumber used are common, and are a result of differing levels of activity in the various end-use markets, and variations in species consumption between them. About 97 percent of the lumber used in new housing in 1998 was estimated to have been softwood species, up from 93 percent in 1962. In contrast, only 33 percent of the lumber used in shipping was softwood, down from 40 percent in 1962. The increase in percentage of softwood lumber use in housing was largely due to a decline in hardwood flooring use, and rapid increase in house size requiring larger amounts of softwood dimension lumber for framing. The rapid and continued growth in the use of hardwood pallets for materials handling and transportation was the principal cause for the increased percentage of use of hardwood lumber in shipping. Even with the variations caused by differences in end-use markets, softwood lumber consumption as a percentage of total lumber consumption has remained around 80 percent since the 1950s.

**Trade**—Net foreign trade (imports minus exports) is an important component of total domestic consumption. In 1998, lumber imports to the United States from all countries totaled 19.0 billion board feet, whereas exports from the United States to all countries totaled just 2.2 billion board feet (table 19). The difference, 16.8 billion board feet, was net foreign trade, and represented lumber consumption in the United States in excess of what was produced domestically. About 26 percent of total domestic lumber consumption in 1998 was from net imports. The United States was a net importer of softwood lumber in 1998, with 33 percent of consumption coming from net imports. In contrast, the United States was a net exporter of hardwood lumber in 1998 with exports exceeding imports by 0.5 billion board feet.

**Table 18—Lumber consumption in the United States, by per capita use, softwoods and hardwoods, and end use, 1962-98**

Year	Total	Per capita	End use								
			Species group		Construction			Total	Manufac- turing	Packag- ing and shipping	All other <sup>b</sup>
			Soft- woods	Hard- woods	New housing	Residential upkeep and improve- ments	New nonresi- dential construc- tion <sup>a</sup>				
			Million bd. ft	Bd. ft	Million bd. ft	Million bd. ft	Million bd. ft				
1962	39,079	209	30,774	8,305	14,110	4,330	4,200	22,640	4,540	4,550	7,349
1970	40,731	199	32,192	8,539	13,995	4,975	4,700	23,670	4,670	5,725	6,666
1976	44,071	202	36,046	8,025	18,280	6,255	4,470	29,005	4,865	5,915	4,286
1986	57,379	238	47,146	10,233	20,840	15,440	5,310	41,590	6,065	5,900	3,824
1996	61,273	231	49,498	11,775	19,780	15,360	4,905	40,045	7,865	6,405	6,958
1998	64,199	238	52,011	12,189	22,165	14,110	5,440	41,715	8,375	7,235	6,874
----- Percent softwood lumber -----											
1962					93	97	74	90	52	40	84
1986					97	97	75	94	49	32	96
1996					97	96	78	95	40	31	90
1998					97	96	77	94	40	33	96

<sup>a</sup> Includes lumber for railroad ties and railcar repair.

<sup>b</sup> 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 various miscellaneous products and uses.

Sources: Haynes 1990, Howard 2001, tables 6, 7, 9, 10, 13, and 14 of this report, and Forest Service estimates.

Note: Product use by market has been rounded to the nearest 5 million bd. ft. Data may not add to totals because of rounding.



**Table 19—Lumber consumption, imports, exports, and production in the United States, by softwoods and hardwoods, 1950-98**

Year	Consumption			Imports <sup>a</sup>			Exports <sup>a</sup>			Production		
	Total	Softwood	Hardwood	Total	Softwood	Hardwood	Total	Softwood	Hardwood	Total	Softwood	Hardwood
----- Million bd. ft -----												
1950	40,913	33,366	7,546	3,423	3,140	283	518	407	111	38,007	30,633	7,374
1951	38,718	30,867	7,851	2,512	2,250	262	998	876	122	37,204	29,493	7,711
1952	39,216	31,935	7,281	2,482	2,267	215	727	566	162	37,462	30,234	7,228
1953	38,911	31,629	7,282	2,759	2,527	233	643	513	131	36,795	29,615	7,180
1954	38,702	31,553	7,149	3,063	2,855	209	718	585	133	36,357	29,283	7,074
1955	40,132	32,489	7,643	3,593	3,327	266	841	652	189	37,380	29,815	7,565
1956	40,740	32,689	8,051	3,405	3,131	274	761	571	191	38,097	30,129	7,968
1957	36,684	29,189	7,495	2,958	2,712	246	811	623	188	34,537	27,100	7,437
1958	37,730	29,983	7,747	3,390	3,155	235	727	550	177	35,068	27,379	7,689
1959	42,318	33,643	8,676	4,064	3,742	322	787	608	179	39,042	30,509	8,533
1960	37,741	29,618	8,123	3,931	3,639	291	861	694	167	34,671	26,672	7,999
1961	37,161	29,461	7,700	4,258	4,013	245	773	618	155	33,676	26,066	7,610
1962	39,079	30,774	8,305	4,893	4,584	309	760	629	131	34,946	26,819	8,127
1963	41,149	31,841	9,309	5,335	5,032	303	875	743	132	36,689	27,552	9,137
1964	42,849	33,390	9,459	5,223	4,918	305	956	812	144	38,582	29,284	9,298
1965	43,048	33,414	9,634	5,232	4,898	334	919	779	140	38,735	29,295	9,440
1966	42,795	32,758	10,037	5,200	4,779	421	1,023	868	155	38,618	28,847	9,771
1967	41,494	32,005	9,489	5,141	4,798	343	1,130	965	164	37,483	28,172	9,311
1968	43,013	34,046	8,967	6,154	5,809	345	1,162	1,048	114	38,020	29,285	8,735
1969	42,228	33,172	9,055	6,301	5,854	447	1,142	1,024	118	37,069	28,342	8,727
1970	40,731	32,192	8,539	6,114	5,778	337	1,243	1,116	128	35,860	27,530	8,330
1971	44,981	36,337	8,644	7,590	7,232	358	1,094	933	160	38,486	30,039	8,447
1972	47,474	38,769	8,706	9,434	8,985	449	1,428	1,191	237	39,469	30,975	8,494
1973	47,981	38,853	9,128	9,569	9,020	549	1,966	1,753	213	40,378	31,586	8,792
1974	41,658	32,959	8,699	7,271	6,821	450	1,765	1,567	199	36,152	27,704	8,448
1975	38,408	31,065	7,343	5,976	5,724	252	1,618	1,405	213	34,051	26,747	7,304
1976	44,071	36,046	8,025	8,247	7,959	288	1,846	1,606	241	37,670	29,693	7,977
1977	49,284	40,679	8,606	10,713	10,370	344	1,666	1,428	238	40,237	31,737	8,500
1978	51,491	42,556	8,935	12,215	11,853	361	1,741	1,354	387	41,017	32,057	8,960
1979	50,127	40,804	9,323	11,530	11,153	376	2,142	1,781	361	40,740	31,432	9,308
1980	42,775	33,812	8,963	9,866	9,573	293	2,494	2,007	488	35,403	26,246	9,157
1981	39,272	31,980	7,292	9,523	9,232	291	2,406	1,928	479	32,156	24,676	7,480
1982	38,744	30,939	7,805	8,957	8,779	178	1,996	1,627	369	31,783	23,787	7,996
1983	47,863	39,397	8,466	11,706	11,512	194	2,336	1,841	495	38,493	29,726	8,767
1984	52,121	42,304	9,817	12,980	12,727	253	2,123	1,597	526	41,264	31,174	10,090
1985	53,355	43,865	9,490	14,356	14,057	299	1,919	1,513	406	40,918	31,321	9,597
1986	57,379	47,146	10,233	14,050	13,771	279	2,421	1,898	523	45,750	35,273	10,477
1987	60,943	49,985	10,958	14,649	14,210	439	3,204	2,460	744	49,498	38,235	11,263
1988	59,228	48,348	10,880	13,807	13,473	334	4,450	3,255	1,195	49,871	38,130	11,741
1989	60,636	49,075	11,561	15,277	14,909	368	4,242	3,379	863	49,601	37,545	12,056
1990	57,438	45,725	11,713	13,132	12,875	257	3,806	2,941	865	48,112	35,791	12,321
1991	52,088	41,621	10,467	11,756	11,515	241	3,997	3,055	942	44,329	33,161	11,168
1992	55,821	45,103	10,718	13,475	13,190	285	3,603	2,613	990	45,949	34,526	11,423
1993	57,204	45,688	11,516	15,430	15,086	344	3,392	2,345	1,047	45,166	32,947	12,219
1994	59,833	48,175	11,658	16,606	16,224	382	3,265	2,156	1,109	46,492	34,107	12,385
1995	59,504	47,563	11,941	17,556	17,202	354	2,929	1,872	1,057	44,877	32,233	12,644
1996	61,273	49,498	11,775	18,398	18,021	377	2,878	1,789	1,090	45,754	33,266	12,488
1997	62,924	51,021	11,904	18,451	18,000	451	2,871	1,646	1,224	47,344	34,667	12,677
1998	64,199	52,011	12,189	19,012	18,463	549	2,189	1,129	1,060	47,377	34,677	12,700

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

<sup>a</sup> Softwood includes small volumes of mixed species not classified as either softwood or hardwood.

Sources: Ulrich 1989 and Howard 2001.

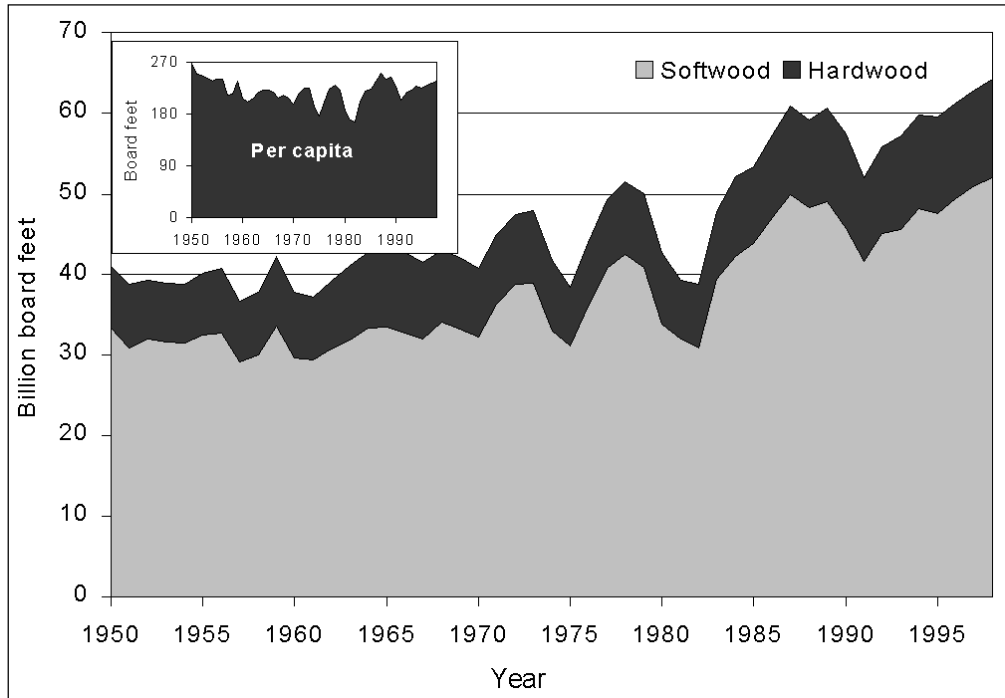


Figure 17—Lumber consumption, by species group and per capita, 1950-98.

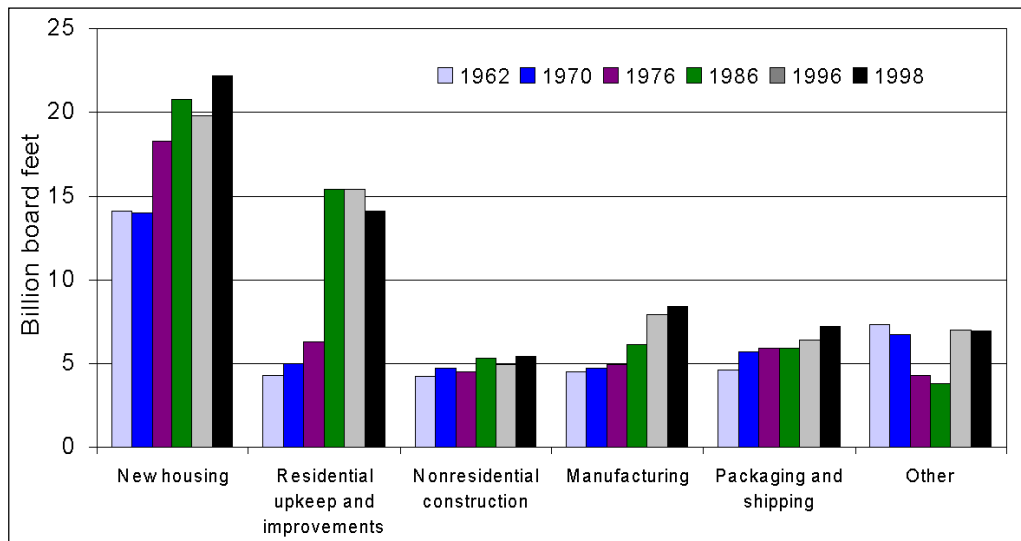


Figure 18—Lumber consumption, by major end use, selected years 1962-98.

Lumber exports grew fairly steadily from 1950 through the late 1980s, reaching a record high of nearly 4.5 billion board feet in 1988 (table 19). Since then, lumber exports have fallen steadily to 2.9 billion board feet in 1996, and 2.2 billion board feet in 1998. Many factors contributed to the decline in lumber exports in recent years. Some of these were reduced softwood sawtimber supplies, particularly from the Pacific Northwest, changing economic conditions in the major importing countries, strength of the U.S. dollar in relation to other world currencies, and increased levels of exports from other major timber-producing countries. In 1996, Japan was the largest single foreign market for U.S. lumber, accounting for about 33 percent of all exports (Howard 2001). By 1998, exports to Japan fell by half owing largely to the Asian economic recession. Canada and the European Community each accounted for about 26 percent of the lumber exported from the United States in 1998. Central and South America accounted for just 1 percent, and all other countries 31 percent.

About 52 percent of total exports in 1998 were softwood species, 1.1 billion board feet (table 19). During the 1950s through early 1970s, softwood lumber accounted for about 84 percent of total exports. Since then, the share of total exports of softwood lumber has fallen from around 78 percent in the 1980s to an average 68 percent in the 1990s. Japan was the most important softwood lumber export market in 1998 at 26 percent of all softwood lumber exports (Howard 2001). Canada and the European Community accounted for 20 and 18 percent, respectively, followed by Central and South America at less than 1 percent. All other countries accounted for the remaining 34 percent.

Lumber imports to the United States totaled 19.0 billion board feet in 1998, nearly nine times the amount exported (table 19). With few exceptions, lumber imports to the United States have grown steadily since 1950. Nearly all of the growth was in softwood lumber imports. In 1950, softwood lumber imports totaled 3.1 billion board feet. By 1998, softwood lumber imports reached a record high 18.5 billion board feet, a more than 15 billion board feet increase. In contrast, hardwood lumber imports were 0.3 billion board feet in 1950, and 0.5 billion board feet in 1998.

Canada has always been the principal source of both softwood and hardwood lumber imported into the United States. In 1998, 96 percent of all imports were from Canada (Howard 2001). This percentage has changed little since 1950, ranging from a low of 94 percent in 1973 to more than 98 percent in 1991 and 1992. In 1998, nearly 97 percent of all softwood lumber and 71 percent of all hardwood lumber imports to the United States were from Canada. Hardwood imports from Canada as a percentage of total hardwood imports fell fairly steadily from 1950 through the 1970s. Since then, Canada's share of the U.S. hardwood lumber import market has risen.

**Production**—Total lumber production in 1998 was 47.4 billion board feet, slightly above the 1990s average of 46.2 billion board feet, but below the record level of 49.9 billion board feet in 1988 (table 19). Lumber production has always been sensitive to changing demands in domestic and export markets, resulting in substantial yearly variations. Production swings of nearly 7 billion board feet per year have been observed. Despite these variations, total domestic lumber production between 1950 and the mid-1980s averaged around 37 billion board feet per year. The late 1980s saw rapid increases in lumber production, with an all-time record high level being reached in 1988. Since then, lumber production has averaged about 47 billion board feet annually.

More than 34.7 billion board feet of softwood lumber and 12.7 billion board feet of hardwood lumber were produced in the United States in 1998, up from 33.3 and 12.5 billion board feet, respectively, in 1996 (table 19). Softwood lumber accounted for nearly 73 percent of all lumber produced in 1998. Although the softwood share of the lumber market has fluctuated since 1950, the trend has been away from softwood in favor of hardwood lumber. In 1950, softwood lumber accounted for about 81 percent of total lumber production, compared to 73 percent in 1998. In contrast, hardwood lumber accounted for 19 percent of production in 1950. The 12.7 billion board feet of hardwood lumber produced in 1998 was the largest amount ever produced and accounted for 27 percent of total U.S. lumber production.

## Structural Panels

**Consumption**—Structural panel consumption in the United States in 1998 for all uses totaled 34.8 billion square feet, 3.2 billion square feet greater than 1996, 9.1 billion square feet greater than 1986, and substantially above total use in any year in the past five decades (tables 20 and 21, figs. 19 and 20). Consumption in 1998 was nearly 4 times the consumption in 1962, and 14 times the consumption in 1950. Structural panel consumption increased 5.6 percent per year, on average, since 1950.

Per capita structural panel consumption in 1998 was 129 square feet, 8 percent greater than in 1996, and 20 percent greater than in 1986 (table 20, fig. 19). Per capita consumption increased steadily over the years, from about 17 square feet in 1950 to 51 square feet in 1962 to the current level of 129 square feet. Since 1950, per capita structural panel consumption increased by about 4.3 percent per year.

Nearly 85 percent of all the structural panels consumed in 1998 were used for construction. About 65 percent of the structural panels used were for new residential construction, 25 percent for residential upkeep and improvements, and 10 percent for new nonresidential construction. In addition, an undetermined amount of structural panels used for nonresidential upkeep and improvements were included in the “all other” category of use. Manufacturing uses accounted for almost 11 percent of total structural panel consumption, and shipping about 2 percent. All other uses accounted for the remaining 3 percent.

Structural panel consumption in 1998 consisted of 17.2 billion square feet of softwood plywood (about 49 percent of total consumption), and 17.6 billion square feet of OSB (51 percent) (table 21). With the exception of recession years, structural panel consumption increased steadily from 1950 through 1998. The share of softwood plywood, however, fell steadily since the development and rapid market acceptance of OSB in the mid-1970s. In 1998, for the first time ever, OSB captured more than half of the structural panel market. Much of the decline in softwood plywood and rapid increase in OSB market shares were due to changes in the timber resource in the United States, and resulting OSB cost advantages. (McKeever 1997). Softwood plywood is made primarily from Douglas-fir and southern pines. Reductions in old-growth Douglas-fir timber supplies from national forests in the West resulted in a dramatic decline in the industry. Mills dependent on this timber were forced to close or drastically curtail production. At the same time, OSB production, which was based on lower cost and previously underutilized hardwood species such as aspen and poplar, increased rapidly to fill the void. The net result was a rapidly expanding OSB industry with increasing market share, and a stagnating softwood plywood industry with declining market share (Spelter et al. 1997). Expectations are for continued penetration by OSB into softwood plywood markets.

**Table 20—Structural panel consumption in the United States, by per capita use, panel type, and end use, 1962-98**

Year	Total	Per capita	Panel type		End use						
			Soft-wood plywood	OSB <sup>a</sup>	Construction			Total	Manufacturing	Packaging and shipping	All other <sup>c</sup>
					New housing	Residential upkeep and improvements	New nonresidential construction <sup>b</sup>				
	<i>Million sq. ft</i>	<i>Sq. ft<sup>d</sup></i>	-----		<i>Million sq. ft<sup>d</sup></i> -----						
1962	9,509	51	9,509	( <sup>e</sup> )	3,935	1,670	1,650	7,255	730	210	1,314
1970	14,228	69	14,228	( <sup>e</sup> )	5,870	2,320	1,870	10,060	900	285	2,983
1976	17,816	82	17,736	80	8,705	3,245	1,910	13,860	1,130	260	2,566
1986	25,740	107	21,567	4,173	11,760	7,015	3,080	21,855	1,760	395	1,730
1996	31,590	119	18,018	13,572	16,995	7,540	2,535	27,070	3,155	535	830
1998	34,810	129	17,191	17,619	19,395	7,270	2,900	29,565	3,735	620	890
			-----		<i>Percent softwood plywood</i> -----						
1986					82	84	85	83	—	—	—
1996					38	73	58	52	—	—	—
1998					37	68	56	48	—	—	—

<sup>a</sup> Includes oriented strand board and waferboard.

<sup>b</sup> Includes structural panels for railcar repair.

<sup>c</sup> 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 various miscellaneous products and uses.

<sup>d</sup> Square feet, 3/8-in basis.

<sup>e</sup> Less than 500,000 square feet.

Sources: Haynes 1990, Howard 2001, tables 6, 7, 9, 10, 13, and 14 of this report, and Forest Service estimates.

Note: Product use by market has been rounded to the nearest 5 million square feet. Data may not add to totals because of rounding.

**Table 21—Structural panel consumption, imports, exports, and production in the United States, by type, 1950-98**

Year	Consumption <sup>a</sup>			Imports <sup>a</sup>			Exports <sup>a</sup>			Production <sup>a d</sup>		
	Total	Soft-wood plywood	OSB <sup>b</sup>	Total	Soft-wood plywood	OSB <sup>b</sup>	Total	Soft-wood plywood	OSB <sup>b</sup>	Total	Soft-wood plywood	OSB <sup>b</sup>
----- Million sq. ft -----												
1950	2,551	2,551	( <sup>e</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>e</sup> )	3	3	( <sup>e</sup> )	2,554	2,554	( <sup>e</sup> )
1951	2,867	2,867	( <sup>e</sup> )	4	4	( <sup>e</sup> )	4	4	( <sup>e</sup> )	2,867	2,867	( <sup>e</sup> )
1952	3,038	3,038	( <sup>e</sup> )	1	1	( <sup>e</sup> )	13	13	( <sup>e</sup> )	3,050	3,050	( <sup>e</sup> )
1953	3,660	3,660	( <sup>e</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>e</sup> )	10	10	( <sup>e</sup> )	3,670	3,670	( <sup>e</sup> )
1954	3,897	3,897	( <sup>e</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>e</sup> )	7	7	( <sup>e</sup> )	3,904	3,904	( <sup>e</sup> )
1955	5,067	5,067	( <sup>e</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>e</sup> )	8	8	( <sup>e</sup> )	5,075	5,075	( <sup>e</sup> )
1956	5,225	5,225	( <sup>e</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>e</sup> )	15	15	( <sup>e</sup> )	5,240	5,240	( <sup>e</sup> )
1957	5,445	5,445	( <sup>e</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>e</sup> )	15	15	( <sup>e</sup> )	5,460	5,460	( <sup>e</sup> )
1958	6,328	6,328	( <sup>e</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>e</sup> )	12	12	( <sup>e</sup> )	6,340	6,340	( <sup>e</sup> )
1959	7,756	7,756	( <sup>e</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>e</sup> )	72	72	( <sup>e</sup> )	7,828	7,828	( <sup>e</sup> )
1960	7,814	7,814	( <sup>e</sup> )	11	11	( <sup>e</sup> )	13	13	( <sup>e</sup> )	7,816	7,816	( <sup>e</sup> )
1961	8,576	8,576	( <sup>e</sup> )	13	13	( <sup>e</sup> )	14	14	( <sup>e</sup> )	8,577	8,577	( <sup>e</sup> )
1962	9,509	9,509	( <sup>e</sup> )	13	13	( <sup>e</sup> )	17	17	( <sup>e</sup> )	9,513	9,513	( <sup>e</sup> )
1963	10,208	10,208	( <sup>e</sup> )	10	10	( <sup>e</sup> )	18	18	( <sup>e</sup> )	10,216	10,216	( <sup>e</sup> )
1964	11,656	11,656	( <sup>e</sup> )	5	5	( <sup>e</sup> )	28	28	( <sup>e</sup> )	11,679	11,679	( <sup>e</sup> )
1965	12,422	12,422	( <sup>e</sup> )	5	5	( <sup>e</sup> )	30	30	( <sup>e</sup> )	12,447	12,447	( <sup>e</sup> )
1966	13,011	13,011	( <sup>e</sup> )	3	3	( <sup>e</sup> )	48	48	( <sup>e</sup> )	13,056	13,056	( <sup>e</sup> )
1967	12,876	12,876	( <sup>e</sup> )	3	3	( <sup>e</sup> )	85	85	( <sup>e</sup> )	12,958	12,958	( <sup>e</sup> )
1968	14,641	14,641	( <sup>e</sup> )	10	10	( <sup>e</sup> )	64	64	( <sup>e</sup> )	14,695	14,695	( <sup>e</sup> )
1969	13,510	13,510	( <sup>e</sup> )	15	15	( <sup>e</sup> )	199	199	( <sup>e</sup> )	13,694	13,694	( <sup>e</sup> )
1970	14,228	14,228	( <sup>e</sup> )	2	2	( <sup>e</sup> )	114	114	( <sup>e</sup> )	14,340	14,340	( <sup>e</sup> )
1971	16,539	16,539	( <sup>e</sup> )	3	3	( <sup>e</sup> )	99	99	( <sup>e</sup> )	16,635	16,635	( <sup>e</sup> )
1972	18,109	18,109	( <sup>e</sup> )	6	6	( <sup>e</sup> )	221	221	( <sup>e</sup> )	18,324	18,324	( <sup>e</sup> )
1973	17,943	17,903	40	9	9	( <sup>e</sup> )	411	411	( <sup>e</sup> )	18,345	18,305	40
1974	15,400	15,340	60	4	4	( <sup>e</sup> )	542	542	( <sup>e</sup> )	15,938	15,878	60
1975	15,336	15,266	70	7	7	( <sup>e</sup> )	791	791	( <sup>e</sup> )	16,120	16,050	70
1976	17,816	17,736	80	12	12	( <sup>e</sup> )	716	716	( <sup>e</sup> )	18,520	18,440	80
1977	19,197	19,107	90	18	18	( <sup>e</sup> )	287	287	( <sup>e</sup> )	19,466	19,376	90
1978	19,834	19,729	105	63	63	( <sup>e</sup> )	298	298	( <sup>e</sup> )	20,069	19,964	105
1979	19,398	19,278	120	27	27	( <sup>e</sup> )	402	402	( <sup>e</sup> )	19,773	19,653	120
1980	16,455	15,997	458	360	37	323	373	373	( <sup>e</sup> )	16,468	16,333	135
1981	16,686	16,096	590	349	30	319	686	686	( <sup>e</sup> )	17,023	16,752	271
1982	16,219	15,403	816	268	9	259	452	452	( <sup>e</sup> )	16,403	15,846	557
1983	20,670	18,924	1,746	423	18	405	574	574	( <sup>e</sup> )	20,821	19,480	1,341
1984	22,324	19,603	2,721	727	48	679	371	371	( <sup>e</sup> )	21,968	19,926	2,042
1985	23,366	19,903	3,463	848	54	794	321	321	( <sup>e</sup> )	22,838	20,169	2,669
1986	25,740	21,567	4,173	723	63	660	614	614	( <sup>e</sup> )	25,631	22,118	3,513
1987	27,068	22,232	4,836	889	129	760	796	796	( <sup>e</sup> )	26,975	22,899	4,076
1988	27,110	21,691	5,419	911	96	815	1,004	1,004	( <sup>e</sup> )	27,203	22,599	4,604

**Table 21—Structural panel consumption, imports, exports, and production in the United States, by type, 1950-98 (continued)**

Year	Consumption <sup>a</sup>			Imports <sup>a</sup>			Exports <sup>a</sup>			Production <sup>a d</sup>		
	Total	Soft-wood plywood	OSB <sup>b</sup>	Total	Soft-wood plywood	OSB <sup>b</sup>	Total	Soft-wood plywood	OSB <sup>b</sup>	Total	Soft-wood plywood	OSB <sup>b</sup>
----- Million sq. ft -----												
1989	26,207	19,991	6,216	1,160	49	1,111	1,442	1,442	( <sup>e</sup> )	26,490	21,385	5,105
1990	26,075	19,344	6,731	1,351	38	1,313	1,613	1,613	( <sup>e</sup> )	26,337	20,919	5,418
1991	23,901	17,358	6,544	1,016	28	988	1,379	1,322	57	24,265	18,652	5,613
1992	26,113	17,937	8,176	1,619	47	1,572	1,491	1,442	49	25,985	19,332	6,653
1993	27,051	17,946	9,105	2,203	41	2,163	1,470	1,409	60	26,317	19,315	7,002
1994	28,469	18,474	9,995	2,635	47	2,588	1,289	1,211	78	27,124	19,638	7,486
1995	29,196	18,160	11,036	3,274	60	3,214	1,348	1,267	82	27,270	19,367	7,903
1996	31,590	18,018	13,572	4,500	85	4,414	1,405	1,248	157	28,495	19,181	9,314
1997	32,158	16,519	15,639	5,376	104	5,272	1,715	1,548	167	28,497	17,963	10,534
1998	34,810	17,191	17,619	6,671	179	6,492	864	764	100	29,003	17,776	11,227

<sup>a</sup> Square feet, 3/8-in basis.

<sup>b</sup> Includes oriented strand board and waferboard.

<sup>c</sup> Less than 500,000 square feet.

<sup>d</sup> Includes production from both domestic and imported species.

<sup>e</sup> Not available.

Sources: Ulrich 1989, Adair 2000, and Howard 2001.

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

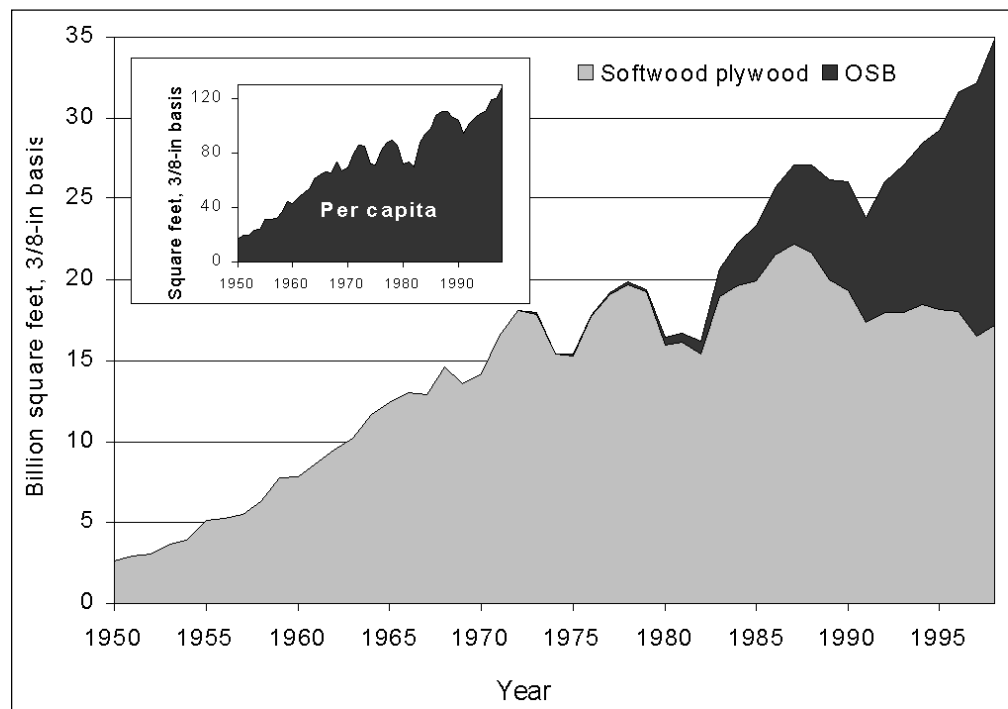


Figure 19—Structural panel consumption, by panel type and per capita, 1950-98.

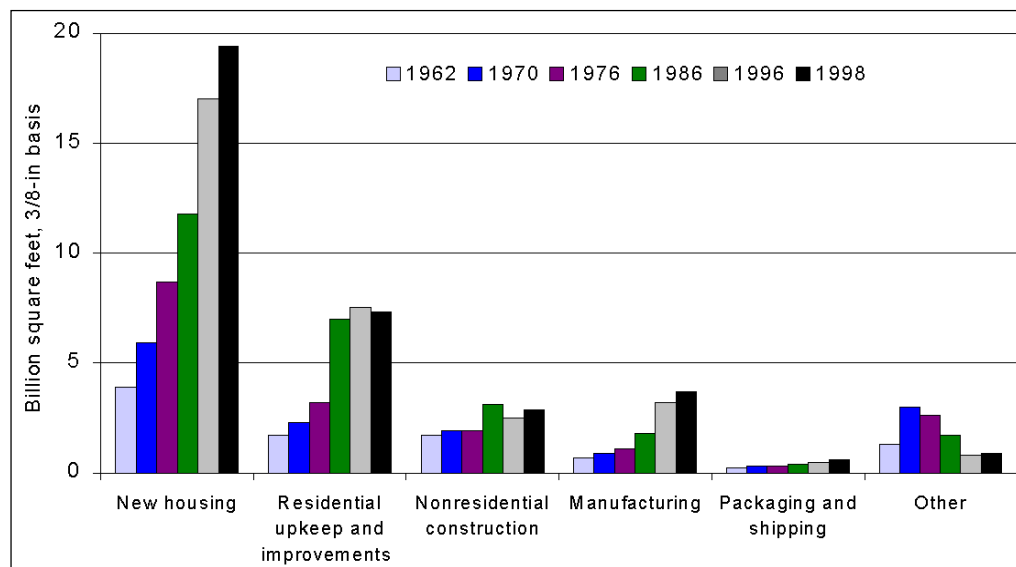


Figure 20—Structural panel consumption, by major end use, selected years 1962-98.

**Trade**—Structural panel imports in 1998 were nearly 6.7 billion square feet, and exports were 0.9 billion square feet, resulting in net imports of nearly 5.8 billion square feet (table 21). About 17 percent of domestic consumption in 1998 was from net imports.

Total structural panel exports varied greatly between 1950 and 1987, remaining well below 1 billion square feet. The overall trend during this period, however, was for increased levels of export. In 1988, exports exceeded 1.0 billion square feet for the first time, and increased rapidly over the next several years. The record high level of exports was set in 1997 at more than 1.7 billion square feet. Exports fell in 1998 to less than 1.0 billion square feet owing largely to unfavorable economic conditions in importing countries. Since 1990, exports have averaged about 1.4 billion square feet per year. Nearly all structural panel exports historically have been softwood plywood. Collection of oriented strand board exportation data began in 1991. By 1998, OSB exports were estimated to be about 0.1 billion square feet, 12 percent of all structural panel exports. Currently, about 3 percent of total domestic structural panel production is exported. Principal foreign markets include the European Common Market countries (35 percent of total exports), Canada (27 percent), Caribbean countries (16 percent), and Mexico (15 percent) (Adair 2000).

Structural panel imports were negligible in the 1950s and 1960s (table 21). In the mid-1970s, the importation of structural panels began in earnest and has increased steadily ever since. Imports in 1998 were nearly five times those in 1990. Nearly all the growth in structural panel imports has been in OSB. In 1998, OSB imports totaled 6.5 billion square feet, 97 percent of all structural panel imports. Softwood plywood imports peaked in 1987 at about 0.1 billion square feet, fell through the early 1990s, and then increased. A new high of nearly 0.2 billion square feet was achieved in 1998. Currently, all OSB imports, and about 70 percent of the softwood plywood imports to the United States are from Canada (Adair 2000).



**Production**—Total domestic structural panel production in 1998 was 29.0 billion square feet, a new record high, and more than 11 times the production in 1950 (table 21). Since net imports are fairly small compared to consumption (averaging about 6 percent during the 1990s), overall trends discussed earlier for structural panel consumption also apply to structural panel production.

The South was by far the leading structural panel-producing region in the United States in 1998 with production totaling 19.7 billion square feet, more than two-thirds of total domestic production (Adair and Bean 1999). The West (Pacific coast and Rocky Mountain regions) was second at 19 percent of domestic production, followed by the North (Northeast and Midwest regions) at 13 percent. Dramatic regional shifts in production occurred between 1986 and 1998. In 1986, the South accounted for 48 percent of total production, the West 43 percent, and the North 9 percent (Anderson 1987). Reduced timber supplies from national forests in the West, coupled with rapidly expanding OSB capacity in the Midwest and South caused major industry shifts from the West to the South and North. Continued reductions of production in the West, with increases in both the South and North are expected (Adair and Bean 1999).

Oriented strand board accounted for more than one-third (39 percent) of total structural panel production in 1998, its highest share of total production ever (table 21). The OSB share of production was lower than its share of consumption because net imports of structural panels were nearly all OSB. Since 1950, the OSB share of total structural panel production increased steadily. The South was the largest OSB-producing region in the United States in 1998 accounting for 66 percent of total production (Adair and Bean 1999). This is a dramatic change from 1986 when the North accounted for 75 percent of all domestically produced OSB. The North was the second largest OSB producer in 1996 with a nearly 34-percent market share, down from 75 percent 10 years earlier (Anderson 1987). Oriented strand board production in the West was small at less than 1 percent of domestic production. Nearly 70 percent of all softwood plywood was produced in the South in 1998, with just over 30 percent in the West. No softwood plywood was produced in the North in 1998.

## Nonstructural Panels

**Consumption**—Nonstructural panel (hardwood plywood, particleboard [including MDF], hardboard, and insulation board) consumption totaled nearly 23.0 billion square feet in 1998, up from 21.0 billion square feet in 1996, and setting a new record high level of production (tables 22 and 23, figs. 21 and 22). Consumption in 1998 was nearly three times the consumption of 1962, and nearly five times that of 1950.

Per capita nonstructural panels consumption in 1998 was 85 square feet, 6 square feet greater than 1996, but about 3 square feet less than in 1986 (table 22). The record high level of per capita nonstructural panel consumption was set in 1987 at 93 square feet. Per capita consumption increased fairly steadily from 1950 through 1973 (fig. 21). During the next 20 years, consumption became erratic with annual changes of up to 27 percent being experienced. During the 1990s, per capita nonstructural panel consumption averaged about 76 square feet per year.

Manufacturing was the most important market for nonstructural panels in 1998, accounting for nearly half (48 percent) of total consumption. This was nearly 2.5 times the percentage used for manufacturing in 1962, and resulted from large and increasing amounts of particleboard and MDF used for furniture production. Most of the remainder in 1998 was used in construction: 20 percent in new residential construction, 12 percent in residential upkeep and improvements, and 6 percent in nonresidential construction. Less than 1 percent was used for shipping.

**Table 22—Nonstructural panel consumption in the United States, by per capita use, panel type, and end use, 1962-98**

Year	Total	Per capita	Panel type			
			Hard-wood plywood	Particle-board <sup>a</sup>	Hard-board	Insulation board
	<i>Million sq. ft<sup>b</sup></i>	<i>Sq. ft<sup>b</sup></i>	<i>Million sq. ft<sup>b</sup></i>			
1962	7,967	43	2,405	816	903	3,843
1970	13,482	66	3,785	3,702	1,667	4,328
1976	17,045	78	3,360	6,898	2,287	4,500
1986	21,247	88	4,500	11,386	2,141	3,220
1996	20,978	79	3,286	12,730	1,669	3,293
1998	22,960	85	3,876	14,223	1,568	3,293

Year	End use						
	Construction			Total	Manufac-turing	Packag-ing and shipping	All other <sup>c</sup>
New housing	Residential upkeep and improvements	New nonresi-dential construc-tion					
	<i>Million sq. ft<sup>b</sup></i>						
1962	2,530	1,400	890	4,820	1,580	225	1,342
1970	5,300	1,655	1,190	8,145	3,130	315	1,892
1976	7,180	2,190	1,305	10,675	4,585	195	1,590
1986	7,510	4,250	1,510	13,270	6,790	150	1,037
1996	3,860	3,185	1,180	8,225	9,900	110	2,743
1998	4,530	2,710	1,285	8,525	10,925	125	3,385

<sup>a</sup> Includes medium-density fiberboard.

<sup>b</sup> Square feet, 3/8-in basis.

<sup>c</sup> 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 variety of miscellaneous products and uses.

Sources: Haynes 1990, Howard 2001, tables 6, 7, 9, 10, 13, and 14 of this report, and Forest Service estimates.

Note: Product use by market has been rounded to the nearest 5 million square feet. Data may not add to totals because of rounding.

**Table 23—Nonstructural panel consumption, imports, exports, and production in the United States, by type, 1950-98**

Year	Consumption						Imports			Exports			Production							
	Total	Hard-wood ply-wood	Par-ticle board <sup>a</sup>	Hard-board	Insul-ation board	Total	Hard-wood ply-wood	Par-ticle board <sup>a</sup>	Hard-board	Insul-ation board	Total	Hard-wood ply-wood	Par-ticle board <sup>a</sup>	Hard-board	Insul-ation board	Total	Hard-wood ply-wood	Par-ticle board <sup>a</sup>	Hard-board	Insul-ation board
1950	4,613	1,240	42	299	3,032	45	45	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	69	( <sup>c</sup> )	( <sup>c</sup> )	6	63	4,637	1,195	42	305	3,095
1951	4,628	1,245	60	275	3,048	49	49	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	78	( <sup>c</sup> )	( <sup>c</sup> )	4	73	4,657	1,197	60	278	3,121
1952	4,663	1,284	66	311	3,001	60	60	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	68	( <sup>c</sup> )	( <sup>c</sup> )	6	61	4,670	1,224	66	318	3,063
1953	5,140	1,382	84	405	3,269	155	155	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	69	( <sup>c</sup> )	( <sup>c</sup> )	4	64	5,054	1,228	84	409	3,333
1954	5,468	1,421	96	418	3,533	397	306	( <sup>c</sup> )	23	68	74	1	( <sup>c</sup> )	5	68	5,168	1,116	96	422	3,533
1955	6,444	1,795	140	510	3,999	567	442	( <sup>c</sup> )	37	88	84	2	( <sup>c</sup> )	6	76	5,975	1,355	140	494	3,987
1956	6,574	1,844	222	530	3,979	649	498	( <sup>c</sup> )	52	99	91	1	( <sup>c</sup> )	6	84	6,032	1,347	222	499	3,964
1957	6,268	1,773	366	565	3,564	716	597	( <sup>c</sup> )	55	64	79	1	( <sup>c</sup> )	6	72	5,634	1,177	366	519	3,572
1958	6,778	1,792	500	614	3,872	775	643	( <sup>c</sup> )	53	79	60	2	( <sup>c</sup> )	6	52	6,061	1,151	500	564	3,845
1959	7,792	2,281	592	722	4,197	1,131	938	( <sup>c</sup> )	97	96	59	3	( <sup>c</sup> )	5	51	6,764	1,346	592	674	4,152
1960	6,894	1,815	536	735	3,808	858	715	( <sup>c</sup> )	83	60	57	2	( <sup>c</sup> )	6	49	6,079	1,102	536	643	3,797
1961	7,254	2,029	652	795	3,777	855	727	( <sup>c</sup> )	94	33	64	3	( <sup>c</sup> )	5	56	6,475	1,305	652	718	3,800
1962	7,967	2,405	816	903	3,843	1,064	891	( <sup>c</sup> )	121	52	64	2	( <sup>c</sup> )	6	56	6,994	1,516	816	815	3,847
1963	8,706	2,617	994	1,017	4,079	1,178	935	( <sup>c</sup> )	148	93	75	1	( <sup>c</sup> )	7	67	7,630	1,683	992	903	4,052
1964	9,753	2,950	1,280	1,094	4,429	1,354	1,040	( <sup>c</sup> )	161	149	81	2	( <sup>c</sup> )	10	69	8,493	1,912	1,276	956	4,349
1965	10,408	3,090	1,664	1,127	4,527	1,346	1,047	( <sup>c</sup> )	191	100	69	6	( <sup>c</sup> )	7	56	9,161	2,049	1,656	974	4,483
1966	10,726	3,322	2,065	1,208	4,131	1,498	1,254	( <sup>c</sup> )	153	89	83	8	( <sup>c</sup> )	11	64	9,272	2,076	2,063	1,028	4,105
1967	10,950	3,152	2,331	1,156	4,311	1,490	1,244	( <sup>c</sup> )	152	92	82	8	( <sup>c</sup> )	4	60	9,540	1,916	2,333	1,013	4,279
1968	12,934	3,881	2,978	1,375	4,700	2,221	1,886	( <sup>c</sup> )	208	125	99	14	( <sup>c</sup> )	13	60	10,868	2,009	2,988	1,237	4,635
1969	14,031	3,960	3,589	1,607	4,875	2,493	2,107	( <sup>c</sup> )	231	131	146	16	( <sup>c</sup> )	16	87	11,708	1,869	3,593	1,416	4,831
1970	13,482	3,785	3,702	1,667	4,328	2,341	2,047	( <sup>c</sup> )	151	137	171	58	( <sup>c</sup> )	26	68	11,232	1,796	3,716	1,461	4,259
1971	16,477	4,451	4,976	1,865	5,185	2,922	2,542	( <sup>c</sup> )	16	153	169	15	( <sup>c</sup> )	40	87	13,784	1,924	5,000	1,742	5,119
1972	18,976	5,160	6,409	2,109	5,297	3,699	3,156	( <sup>c</sup> )	28	161	238	26	( <sup>c</sup> )	34	88	15,658	2,030	6,471	1,933	5,224
1973	19,069	4,294	7,148	2,326	5,300	3,097	2,527	( <sup>c</sup> )	34	187	343	40	( <sup>c</sup> )	44	105	16,311	1,807	7,268	2,017	5,219
1974	15,813	2,977	6,325	2,175	4,336	2,000	1,644	( <sup>c</sup> )	14	96	488	68	( <sup>c</sup> )	58	136	14,199	1,401	6,537	1,885	4,376
1975	14,182	2,902	5,300	2,087	3,892	2,086	1,918	( <sup>c</sup> )	32	48	391	68	( <sup>c</sup> )	53	103	12,328	1,052	5,436	1,894	3,947
1976	17,045	3,360	6,898	2,287	4,500	2,698	2,356	( <sup>c</sup> )	120	60	404	79	( <sup>c</sup> )	62	102	14,825	1,083	6,938	2,262	4,543
1977	18,903	3,371	8,210	2,675	4,647	2,921	2,254	( <sup>c</sup> )	162	143	366	70	( <sup>c</sup> )	58	112	16,394	1,187	8,020	2,571	4,616
1978	19,784	3,647	8,720	2,791	4,627	3,364	2,492	( <sup>c</sup> )	301	185	319	30	( <sup>c</sup> )	26	141	16,832	1,185	8,456	2,608	4,583
1979	18,593	3,191	8,040	2,830	4,532	2,973	2,070	( <sup>c</sup> )	277	184	296	29	( <sup>c</sup> )	34	65	15,892	1,150	7,766	2,563	4,413
1980	15,450	2,196	7,202	2,295	3,757	2,031	1,198	( <sup>c</sup> )	172	133	363	40	( <sup>c</sup> )	29	83	13,677	1,038	6,886	2,047	3,707
1981	14,428	2,411	7,044	2,150	2,824	2,318	1,482	( <sup>c</sup> )	189	139	485	47	( <sup>c</sup> )	57	147	12,613	976	6,770	2,035	2,832

Million sq. ft.<sup>b</sup>

**Table 23—Nonstructural panel consumption, imports, exports, and production in the United States, by type, 1950-98 (continued)**

Year	Consumption					Imports					Exports					Production				
	Total	Hard-wood plywood	Par-ticle board <sup>a</sup>	Hard-wood plywood	Insul-ation board	Total	Hard-wood plywood	Par-ticle board <sup>a</sup>	Hard-wood plywood	Insul-ation board	Total	Hard-wood plywood	Par-ticle board <sup>a</sup>	Hard-wood plywood	Insul-ation board	Total	Hard-wood plywood	Par-ticle board <sup>a</sup>	Hard-wood plywood	Insul-ation board
1982	14,832	3,213	7,128	2,036	2,455	3,711	1,869	1,532	153	157	228	41	82	16	89	11,312	1,385	5,678	1,862	2,387
1983	19,052	4,168	9,120	2,567	3,197	5,228	2,729	1,988	239	272	266	41	94	20	111	14,176	1,480	7,226	2,434	3,036
1984	20,315	3,948	10,214	2,497	3,656	5,792	2,480	2,662	269	381	285	37	108	21	119	14,837	1,505	7,660	2,279	3,393
1985	20,877	4,356	10,584	2,305	3,632	6,446	3,058	2,670	261	457	333	44	118	64	107	14,755	1,342	8,032	2,100	3,281
1986	21,247	4,500	11,386	2,141	3,220	6,697	3,171	2,790	285	451	450	61	172	61	156	15,024	1,390	8,768	1,941	2,925
1987	22,550	5,268	12,084	2,015	3,184	7,545	3,803	3,100	277	364	545	60	226	90	169	15,543	1,524	9,210	1,819	2,989
1988	22,340	4,711	12,478	1,876	3,276	7,168	3,262	3,268	211	427	808	104	326	107	271	15,914	1,552	9,536	1,706	3,120
1989	18,492	3,356	9,840	1,801	3,495	3,485	1,935	850	239	461	1,167	119	666	142	240	16,202	1,541	9,656	1,732	3,273
1990	17,562	3,033	9,492	1,730	3,307	2,991	1,649	726	230	387	1,316	153	746	184	233	15,877	1,537	9,512	1,675	3,153
1991	16,772	2,695	9,308	1,659	3,109	2,472	1,429	586	190	267	1,425	231	738	202	255	15,685	1,496	9,460	1,632	3,097
1992	17,895	2,834	10,114	1,669	3,277	3,143	1,729	810	190	413	1,671	318	788	279	287	16,423	1,423	10,092	1,758	3,151
1993	19,181	2,989	11,312	1,634	3,247	3,482	1,745	1,144	213	380	1,487	268	636	306	277	17,208	1,511	10,804	1,749	3,144
1994	20,590	3,203	12,542	1,552	3,293	3,975	1,646	1,550	373	407	1,461	244	594	397	227	18,236	1,801	11,586	1,735	3,113
1995	19,990	3,483	11,656	1,557	3,293	4,362	1,892	1,680	384	407	1,574	250	638	459	227	17,213	1,842	10,614	1,643	3,113
1996	20,978	3,286	12,730	1,669	3,293	4,124	1,695	1,628	394	407	1,261	251	308	475	227	18,125	1,842	11,410	1,760	3,113
1997	21,734	3,584	13,382	1,475	3,293	4,775	2,007	1,927	435	407	1,277	254	377	420	227	18,277	1,831	11,832	1,500	3,113
1998	22,960	3,876	14,223	1,568	3,293	5,586	2,250	2,505	424	407	992	206	270	290	227	18,366	1,831	11,988	1,433	3,113

Million sq. ft.<sup>b</sup>

<sup>a</sup> Includes medium-density fiberboard.

<sup>b</sup> Square feet, 3/8-in basis.

<sup>c</sup> Less than 500,000 square feet.

Sources: Ulrich 1989 and Howard 2001.

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

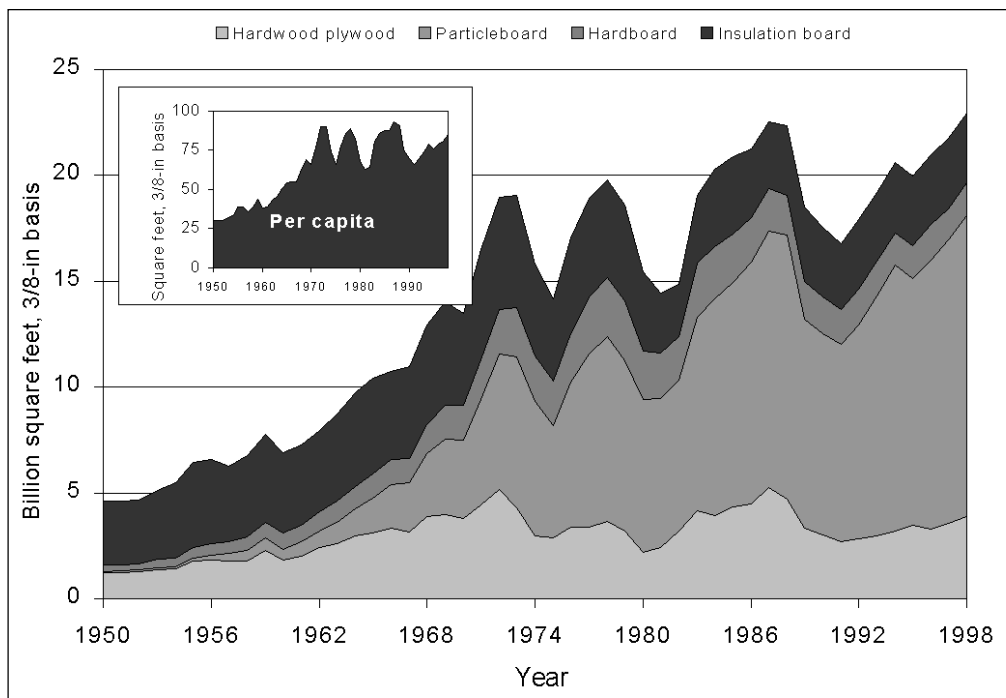


Figure 21—Nonstructural panel consumption, by panel type and per capita, 1950-98.

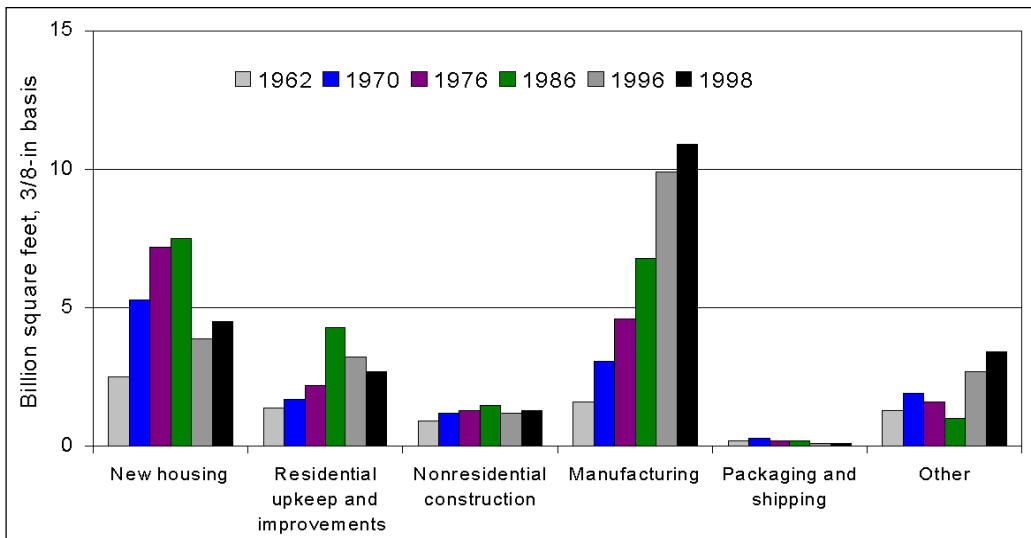


Figure 22—Nonstructural panel consumption, by major end use, selected years 1962-98.

## Engineered Wood Products

Particleboard consumption in 1998 was 14.2 billion square feet, 62 percent of all nonstructural panels consumed, and a new record high level of consumption (table 23). Hardwood plywood consumption was second highest at 3.9 billion square feet, followed by insulation board and hardboard. Consumption of each nonstructural panel type increased fairly rapidly between 1950 and 1965. Particleboard consumption continued to grow through 1988, while other nonstructural panels consumption tended to level off or decline. Since 1988, consumption of each nonstructural panel type has been fairly constant, with only particleboard showing any real upward tendency.

**Trade**—The United States is a net importer of nonstructural panels. In 1998, imports totaled 5.6 billion square feet, exceeding exports by 4.6 billion square feet (table 23). Imports of hardwood plywood and particleboard were nearly equal in 1998 at 2.3 and 2.5 billion square feet, respectively. Imports of hardboard and insulation board were also equal at 0.4 billion square feet. Exports of nonstructural panels totaled just under 1.0 billion square feet in 1998, below the 1990s decade average of nearly 1.4 billion square feet. Total exports in 1998 were nearly equally divided among all nonstructural panel types.

**Production**—Total nonstructural panel production in 1998 was about 18.4 billion square feet, a new record (table 23). Long-term nonstructural panel production has tended upward, primarily owing to rising particleboard production, and more recently hardwood plywood production. In 1998, particleboard accounted for just over 65 percent of all nonstructural panels production, insulation board for 17 percent, hardwood plywood 10 percent, and hardboard just 8 percent.

**Consumption**—Engineered wood products are composite wood products designed to substitute directly for dimension lumber in many building and structural applications. Included in this group of products are prefabricated wood I-joists, glulam timbers, and structural composite lumber (see table 1 for specific types of SCL). Some of these products have been available for 20 or more years; some are fairly recent developments. It has been in the past 10 years or so that engineered wood products have begun to make important inroads into traditional lumber markets. The lumber used to produce glulam timbers, and used for wood I-joist flanges is included with the lumber consumption and production data in table 19; the OSB and softwood plywood used to produce wood I-joist webs are included with the structural panel consumption and production data in table 21. Laminated veneer lumber is the only SCL product for which production or consumption data are currently available, and although LVL is made from laminated veneers similar to softwood plywood, its production and consumption are not included with the structural panel data in table 21. No production or consumption data for PSL or OSL are available.

Engineered wood products are relatively new products and occur at fairly low levels of use compared to lumber and panel products. Because of these low levels of use, consumption estimates in specific end-use markets are difficult to make precisely. The estimates of engineered wood products consumption reported earlier in this report for new residential construction, residential upkeep and improvements, and new nonresidential construction probably overstated actual consumption in both 1996 and 1998. They should be viewed as relative measures of use of these emerging wood products, not absolute levels of use. Consumption estimates in this section of the report are based on reported levels of production and trade by APA-The Engineered Wood Association (Adair 2000), and are better, more reliable estimates of overall levels of engineered wood products consumption.

## Fuelwood Consumption and Production

In 1998, about 40 million cubic feet of LVL, 267 million board feet of glulam timbers, and 624 million linear feet of wood I-joists were consumed in the United States (fig. 23, table 24). These amounts represent percentage increases of 33, 13, and 40 percent, respectively, over 1996, and are record high levels of consumption for both LVL and wood I-joists. In addition to the LVL, sizeable amounts of other structural composite lumber products (PSL and OSL) also were consumed in 1998, and were estimated to be about 50 percent of LVL consumption. During the 1990s, LVL increased at an average rate of more than 12 percent per year, while wood I-joist consumption increased by nearly 23 percent per year. Glulam timbers consumption fluctuated during the 1990s ranging from a low of about 230 million board feet in 1995 to a high of 320 million board feet in 1990. The record high level of consumption of glulam timbers was 330 million board feet in 1986. Expectations are for increasing levels of consumption for all engineered wood products (Adair 2000).

**Trade**—Information on the international trade of engineered wood products is limited, partially because many of the newer products do not yet have established foreign markets. Nearly all of the trade in LVL (and other SCL products) and wood I-joists is between the United States and Canada. Nearly all imports of glulam timbers to the United States are from Canada, whereas nearly all glulam timber exports are to Asian markets. Net foreign trade (imports minus exports) in engineered wood products is small compared to total consumption. In 1998, net foreign trade amounted to 2 percent for LVL and 1 percent for wood I-joists. Glulam timbers was probably somewhat higher at about 3 to 4 percent.

**Production**—In 1998, 41 million cubic feet of LVL, 286 million board feet of glulam timbers, and 619 million linear feet of wood I-joists were produced in the United States (table 24). Production of LVL and wood I-joists were substantially higher than in 1996, and in 1998 were at all-time record high levels of production. Glulam timber production fell by 23 million board feet between 1996 and 1998, and was 44 million board feet below the record high level of production set in 1986. With net foreign trade being small for engineered wood products, consumption and production trends are nearly identical.

In 1998, wood energy consumption in the United States was about 2.4 quadrillion ( $10^{15}$ ) BTU's (Quad), or about 2.5 percent of the total 97 Quad consumed (table 25). Wood energy comes from several wood-derived fuels—roundwood from forests used directly for fuel, wood and bark residue from primary and secondary wood products processing, black liquor from pulping, and wood waste from construction and demolition. In 1996, about 23 percent of wood-derived fuels was roundwood, 38 percent was mill and other wood waste, and 39 percent was black liquor. These fuels were used in four main sectors: residential heating, the forest products and other industry, commercial buildings, and electric power generation plants. In 1998, about 18 percent of wood energy was used in residential heating, 80 percent by industry, and 2 percent in commercial buildings and electric utilities (fig. 24). Wood energy makes a direct demand on forest resources through roundwood use. But only a portion of roundwood (about 35 percent) currently comes from growing stock on timberland, which is the predominant source for pulpwood and sawlogs. The share of wood energy coming from roundwood increased sharply in the late 1970s through the mid-1980s when fossil fuel prices rose sharply, but has decreased since the mid-1980s with the drop in fossil fuel prices.

**Table 24—Engineered wood products consumption, imports, exports, and production in the United States, 1980-98**

Year	Consumption			Imports			Exports			Production		
	Lami- nated veneer lumber	Glulam timbers	Wood I-joists	Lami- nated veneer lumber	Glulam timbers	Wood I-joists	Lami- nated veneer lumber	Glulam timbers	Wood I-joists	Lami- nated veneer lumber	Glulam timbers	Wood I-joists
	<i>Million cf<sup>a</sup></i>	<i>Million bd. ft</i>	<i>Million lf<sup>b</sup></i>	<i>Million cf<sup>a</sup></i>	<i>Million bd. ft</i>	<i>Million lf<sup>b</sup></i>	<i>Million cf<sup>a</sup></i>	<i>Million bd. ft</i>	<i>Million lf<sup>b</sup></i>	<i>Million cf<sup>a</sup></i>	<i>Million bd. ft</i>	<i>Million lf<sup>b</sup></i>
1980	3.0	204.4	45.0	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	3.0	204.4	45.0
1981	4.0	190.0	45.0	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	4.0	190.0	45.0
1982	4.0	164.3	54.0	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	4.0	164.3	54.0
1983	5.0	192.0	63.0	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	5.0	192.0	63.0
1984	5.0	229.2	72.0	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	5.0	229.2	72.0
1985	7.0	246.4	90.0	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	7.0	246.4	90.0
1986	8.0	330.4	99.0	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	8.0	330.4	99.0
1987	9.0	278.9	108.0	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	9.0	278.9	108.0
1988	11.0	298.0	108.0	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	11.0	298.0	108.0
1989	12.0	321.8	117.0	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	12.0	321.8	117.0
1990	16.0	323.7	121.5	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	16.0	323.7	121.5
1991	16.0	264.5	157.5	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	16.0	264.5	157.5
1992	16.8	257.9	252.0	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	16.8	257.9	252.0
1993	20.8	238.8	358.2	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	20.8	238.8	358.2
1994	22.5	263.6	379.8	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	( <sup>c</sup> )	22.5	263.6	379.8
1995	26.5	231.7	358.8	0.5	( <sup>c</sup> )	1.9	1.1	50.0	1.1	27.1	281.7	358.0
1996	30.1	236.0	445.0	.6	( <sup>c</sup> )	2.4	1.2	73.0	1.3	30.8	309.0	444.0
1997	35.9	256.0	549.2	.7	( <sup>c</sup> )	3.8	1.5	44.0	1.6	36.7	300.0	547.0
1998	40.1	267.0	624.3	.8	( <sup>c</sup> )	7.1	1.6	19.0	1.9	41.0	286.0	619.0

<sup>a</sup> Cubic feet.

<sup>b</sup> Linear feet.

<sup>c</sup> Not available.

Source: Adair 2000, Howard 2001, and Forest Service estimates.



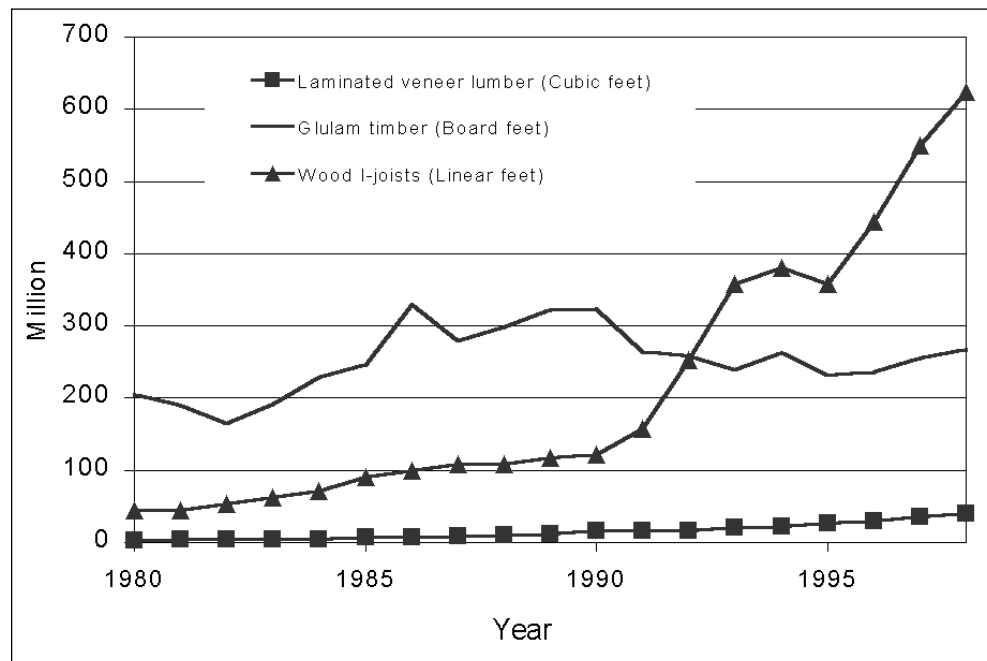


Figure 23—Engineered wood products consumption, by type, 1980-98.

Table 25—Wood and black liquor fuel consumption in the United States, 1977-98

Sector	Year											
	1977	1983	1986	1990	1991	1992	1993	1994	1995	1996	1997	1998
	----- Quadrillion BTUs -----											
Roundwood and mill residue		1.92			1.50							1.79
Black liquor	.81	.82	.90	.97	1.02	1.04	1.04	1.09				1.09 1.14
Total		2.74			2.52							2.78
Dept. of Energy total	1.84	2.64	2.65	2.16	2.15	2.25	2.23	2.31	2.42	2.47	2.35	2.39

Sources: Roundwood and mill residue: 1983: See source note table 34 in Haynes 1990; 1991: Energy Information Administration 1994; Black liquor: 1977 to 1994: American Forest & Paper Association 1996, 1999. Department of Energy total: 1977: USDE Energy Information Administration 1982; 1983 to 1998 except 1986: USDE Energy Information Administration 1998a, 1998b, 1999a; 1986: USDE Office of Policy Planning and Analysis 1988.

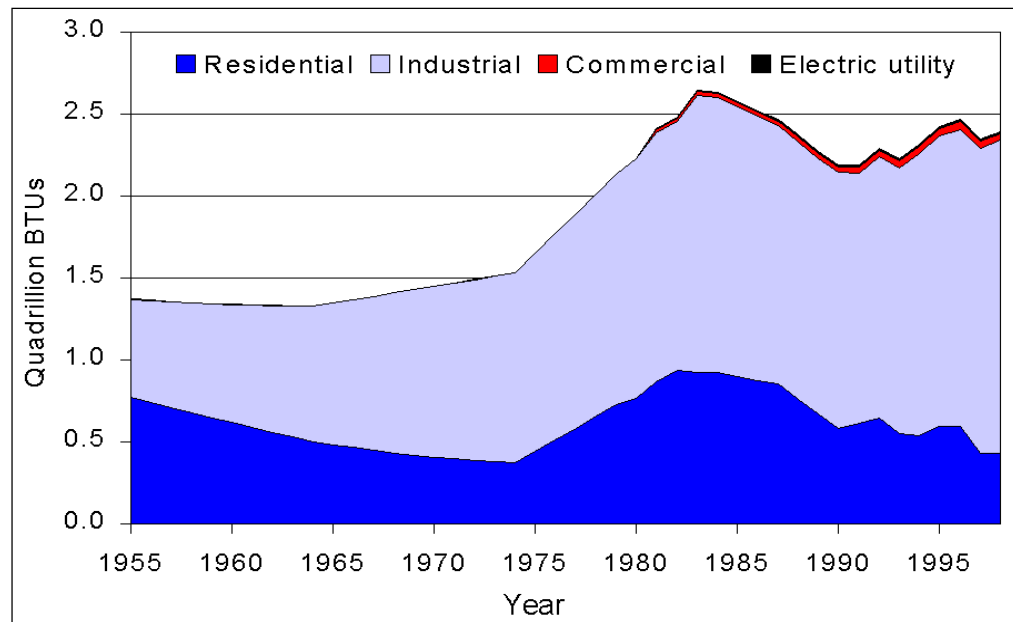


Figure 24—Wood energy consumption, by sector, 1955-98.

Total wood energy consumption in 1998, 2.4 Quad, was lower than the recent peak level of 2.6 to 2.7 Quad, which probably occurred in 1984 or 1985 (table 25). Residential fuelwood use, and industrial use of mill waste and black liquor, grew 8 percent per year and 3 percent per year, respectively, between 1973 and 1985 (fig. 24). Together they made up more than 99.6 percent of wood-derived fuel use in 1985. Use in the residential sector declined after 1984 with declines in fossil fuel prices while industrial use declined briefly then increased. Average deflated residential fuel prices decreased between 1984 and 1986—27 percent for heating oil, 9.5 percent for natural gas, and 1.6 percent for electricity (fig. 25).

Roundwood use for fuel has been declining since 1984 both in absolute terms, and as a share of total wood-derived fuel. In 1986, roundwood use, primarily used by households, was about 29 percent of total wood energy use.<sup>4</sup> By 1996, roundwood provided about 23 percent of total wood energy (0.57 of 2.78 Quad). As the largest portion of roundwood use, household consumption dropped from 3.9 billion cubic feet in 1984 to 3.4 billion in 1987, to 2.3 billion in 1990, and to 1.7 billion in 1997 as estimated by the USDE Residential Consumption Survey (tables 26 and 27, fig. 26).

Less than half of the roundwood used for fuel (35 percent) comes from the merchantable stem portion of growing stock trees on timberland. Most comes from other sources—tops, branches, and trees of nonmerchantable species or trees not on timberland (table 27). As households (the major users of roundwood for fuel) increased their use in the 1970s and 1980s, they sought out nongrowing stock sources much more than growing stock sources. Between 1970 and 1986, the portion of fuelwood from nongrowing stock increased by a factor of 10 while the portion from growing stock

<sup>4</sup> Fraction of wood fuel from round wood in 1986 = 3.1 billion cubic feet/(4 billion cubic feet per Quad) 2.65 Quad = .29 (tables 25 and 27)

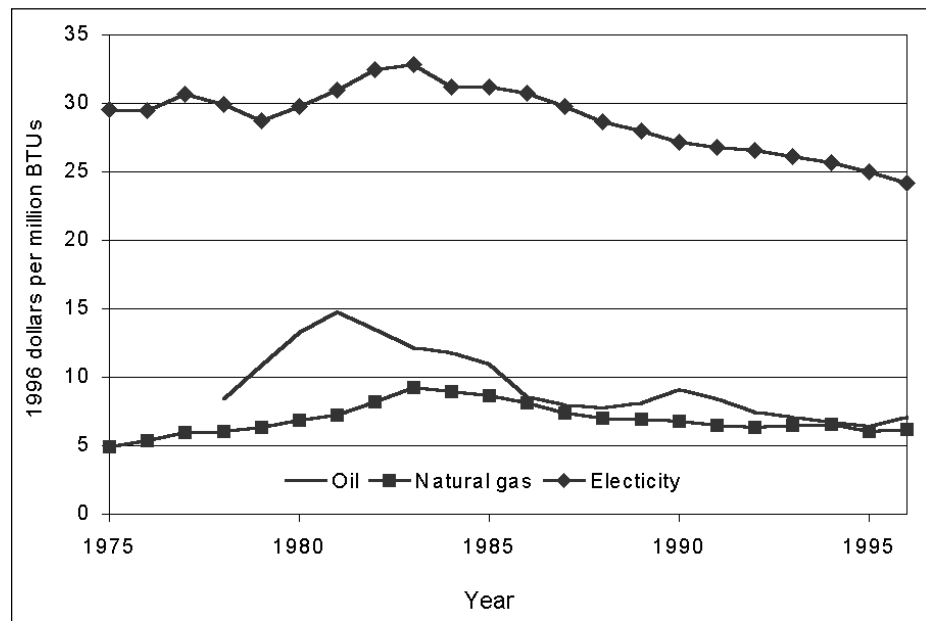


Figure 25—Residential prices for electricity, fuel oil, and natural gas, 1975-96.

**Table 26—Roundwood and wood and bark residue consumed for energy production in the United States, by end user, 1972-97**

Sector	Year										
	1972	1976	1983	1986	1990	1991	1992	1993	1995	1996	1997
----- Million cf <sup>a</sup> -----											
Residential			3,722		2,304			2,170			1,695
Wood products industry			1,650		1,024						
Pulp and paper industry:											
Hog wood	160	281	785	932	911	888	887	814	773		
Bark	318	323	419	472	462	512	527	571	552		
<b>Total</b>	<b>478</b>	<b>604</b>	<b>1,204</b>	<b>1,404</b>	<b>1,373</b>	<b>1,400</b>	<b>1,414</b>	<b>1,385</b>	<b>1,325</b>	<b>1,350</b>	<b>1,381</b>
Nonforest products industry			184		171						
Commercial buildings			80		107			157	161	175	150
Utilities			32		43	36	39	39	39	43	39
<b>Total</b>			<b>6,872</b>		<b>5,022</b>						

<sup>a</sup> Cubic feet.

Conversion factors: 17.2 million BTU per ton; 32.6 cubic feet per lb.; 79.2 cubic feet per cord.

Sources: Residential: See source note table 27. Wood products industry: 1983: Goetzl and Tatum 1983; 1990: USDE Energy Information Administration 1994; Pulp and paper industry: 1972-95: American Forest & Paper Association 1996, 1999; Nonwood products industry, commercial buildings, and utilities: 1983: USDE Energy Information Administration 1984, 1990: USDE Energy Information Administration 1994; Commercial buildings, utilities: 1991-93: USDE Energy Information Administration 1995b; 1994-97: USDE Energy Information Administration 1999a.

**Table 27— Wood energy production and consumption in the United States, by wood source and end user, 1952-97**

Sector	Year												
	1952	1962	1970	1976	1980	1984	1986	1987	1990	1991	1993	1996	1997
----- Million cf <sup>a</sup> -----													
Production of roundwood for all users:													
Merchantable stem of growing stock trees on timberland	965	517	311	334			798			848		799	
Other trees/sources	1,042	606	227	267			2,316			2,339		1,484	
Total	2,008	1,123	538	601			3,114			3,187		2,283	
Consumption of roundwood and mill residue in homes <sup>b</sup> :													
Merchantable stem of growing stock trees on timberland					559								
Other trees/sources					2,544								
Mill residue					223								
Total <sup>b</sup>	3,597	2,240	1,603	1,926	3,326	3,881		3,382	2,304		2,170		1,695
Mill residue used for fuel													
wood residue excluding bark	2,486	900	727	752			1,400			2,518		2,131	

<sup>a</sup> Cubic feet.

<sup>b</sup> Volume in cords times 79.2 cubic feet per cord.

Sources: Production and mill residue: 1952: USDA Forest Service 1958; 1962: USDA Forest Service 1965; 1970: USDA Forest Service 1973; 1976: USDA Forest Service 1982; 1986: Waddell et al. 1989; 1991: Powell et al. 1993.

Consumption in homes: 1952 to 1976: USDE 1982; 1980: Skog and Watterson 1986; 1984: USDE Energy Information Administration 1986; 1987: USDE Energy Information Administration 1989; 1990: USDE Energy Information Administration 1993; 1993: USDE Energy Information Administration 1995a; 1997: USDE Energy Information Administration 1999b.

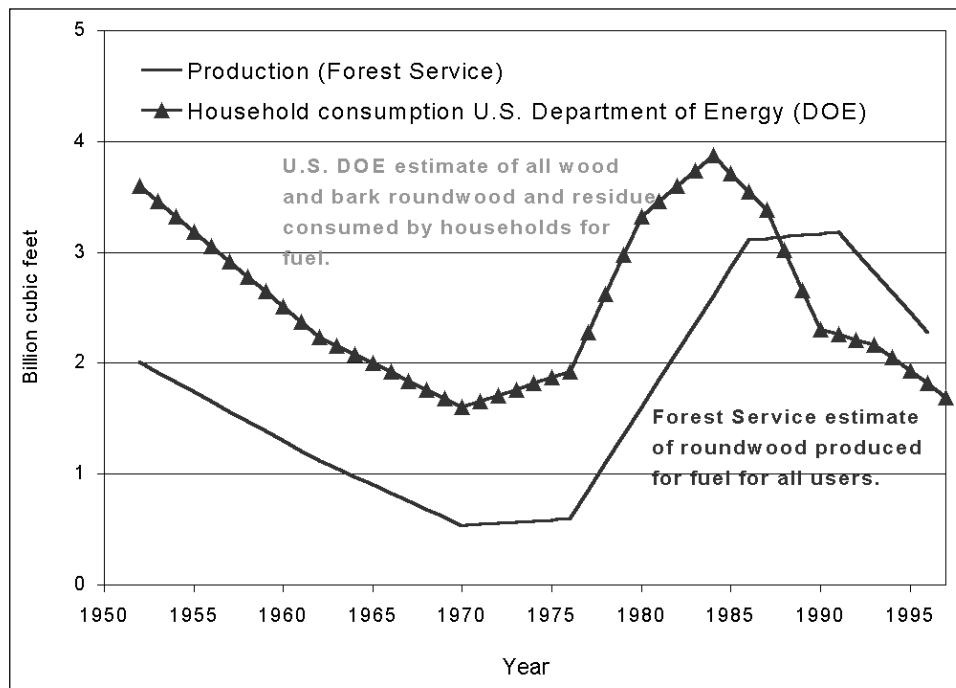


Figure 26—Production of roundwood for fuel, and consumption of roundwood and residue by households for fuel, 1952-97.

increased by a factor of 2.5 (table 27). While roundwood use for fuel increased from 1970 to 1984 then declined (table 27, use in homes), mill residue for fuel increased from 0.72 billion cubic feet in 1970 to 1.4 billion cubic feet in 1986, to 2.52 billion cubic feet in 1991, but has declined to 2.13 billion cubic feet in 1996 (table 27).

The USDA Forest Service estimates suggest roundwood production for fuel (harvest) was almost constant between 1986 and 1991, at 3.1 and 3.2 billion cubic feet, respectively, and declined to 2.3 billion cubic feet in 1996. The 1991 and 1996 Forest Service estimates may be too high if lower USDE survey estimates of household consumption are correct. The USDE estimates that roundwood and residue consumption by households decreased substantially between 1984 and 1997, from 3.9 to 1.7 billion cubic feet (fig. 26). For both the Forest Service and USDE estimates to be correct, a substantial amount of roundwood fuelwood use was shifted from households to other users between 1986 and 1997. But this is not likely given the estimate that industry only used 0.8 million cubic feet of roundwood for fuel in 1994. Most wood energy for industry is from mill residue and black liquor. If almost all roundwood used for fuel still goes for household burning, then the 1991 and 1997 Forest Service production estimates are too high.

Before 1986, USDE household consumption estimates are higher than Forest Service roundwood production estimates (fig. 26). Department of Energy estimates could be higher than Forest Service estimates because (1) they include fuelwood taken from land, such as cities, not included in the Forest Service estimates before 1986, (2) they include some mill residue used for fuel by households, and (3) we have used somewhat high conversion factors to convert USDE cord and tonnage estimates to cubic feet.

## **Other Industrial Timber Products Consumption**

In addition to the solid wood products described above, various other industrial round-wood products are consumed in the United States each year, including cooperage logs, poles and pilings, fence posts, hewn ties, round mine timbers, box bolts, excelsior bolts, shingle bolts, and other miscellaneous items. In 1998, 485 million cubic feet of these other timber products were consumed in the United States (table 28). This was 15 million cubic feet below consumption in 1996, and 60 million cubic feet below the 1990s average of 545 million cubic feet. Average other timber products consumption in the 1990s was about the same as that in the mid-1960s, but below the 1950s, and especially below the early 1900s when consumption exceeded 2,000 million cubic feet per year. Nearly 60 percent of total consumption was from softwood species in 1998. International trade in these products is small, making consumption roughly equal to production.

Definitive data on the amounts of specific other timber products produced annually are not available. Many products, however, are treated with preservatives to help resist fungal and insect damage. Amounts of these treated products give some insights into the relative amounts of individual products produced. About 43 percent of the other timber products produced annually in the United States were treated with preservatives in the 1990s (Howard 2001). This was up from the 1980s when treated wood accounted for about a third of all other timber products.

Poles, pilings, and larger timbers used for construction and maintenance of utility lines and other structures, and for construction of docks, bridges, and buildings accounted for 35 percent and 25 percent of all treated other timber products, respectively. Their combined use was down from the 1980s when these products accounted for about 75 percent of all treated other products. Fence and other smaller round and split posts for farm and residential fencing and other purposes accounted for about 10 percent of all treated other products. During the 1980s and 1990s, posts averaged about 8 percent of all treated other timber products. Other treated products, including crossarms, landscape timbers, highway posts and guardrails, mine ties and timbers, crossing planks and other products accounted for the remaining treated other timber products. This category of products increased from about 18 percent of all treated other products in the 1980s but has remained fairly constant at around 30 percent in the 1990s.

## **Improvements in Utilization**

Over the past decades, many improvements have been made in the processing efficiency of converting timber harvested from the Nation's forests into wood products. Much of the impetus for these improvements has been from generally rising long-term timber stumpage prices and the changing nature of the timber resource. Improvements include more efficient and complete use of logs at the mill; new technologies, which increase product yield per unit of wood input; and development of new wood products, which require less wood per unit of output than traditional wood products. Examples include the increased use of slabs, edgings, sawdust, veneer cores, shavings, and other wood processing byproducts for pulp, particleboard, and similar products. In addition, there is the development of thinner saws, computer-controlled head rigs, and innovations such as best opening face in the lumber industry; powered back-up rolls, spindle-less lathes, and automated handling systems in the plywood industry, and the development of LVL, OSL, PSL, and wood I-joists to replace solid sawn lumber. These developments have all substantially increased timber conversion efficiency by increasing product yield per unit of wood input and have helped offset reductions in timber supplies from national forests, and a general decline in overall timber size and quality.

**Table 28—Other industrial timber products consumption, 1950-98<sup>a</sup>**

Year	Total	Softwood	Hardwood	Year	Total	Softwood	Hardwood
----- Million cf <sup>b c</sup> -----				----- Million cf <sup>b c</sup> -----			
1950	770	360	410	1975	385	235	150
1951	730	340	390	1976	380	240	140
1952	695	325	370	1977	385	240	145
1953	675	320	355	1978	395	240	155
1954	655	310	345	1979	410	245	165
1955	630	300	330	1980	415	245	170
1956	605	295	310	1981	425	245	180
1957	580	285	295	1982	435	248	187
1958	560	275	285	1983	445	249	196
1959	535	270	265	1984	455	250	205
1960	510	255	255	1985	465	256	209
1961	490	250	240	1986	476	257	219
1962	465	240	225	1987	495	277	218
1963	515	270	245	1988	510	270	240
1964	540	285	255	1989	555	294	261
1965	560	300	260	1990	562	298	264
1966	565	310	255	1991	551	292	259
1967	515	285	230	1992	610	323	287
1968	485	265	220	1993	621	329	292
1969	455	250	205	1994	576	305	271
1970	425	230	195	1995	513	272	241
1971	415	230	185	1996	500	265	235
1972	405	230	175	1997	485	257	228
1973	405	235	170	1998	485	257	228
1974	395	235	160				

<sup>a</sup> Includes cooperage logs, poles and piling, fence posts, hewn ties, round mine timbers, box bolts, excelsior bolts, chemical wood, shingle bolts, and miscellaneous items.

<sup>b</sup> Roundwood equivalent.

<sup>c</sup> Cubic feet.

Source: Ulrich 1989, Howard 2001.

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