CHAPTER IV

Wood Use in the United States

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Summary

Americans currently consume about one-fourth of the world's forest products and have the highest per capita consumption in the world. At the same time, the United States is the world's largest producer of wood products, accounting for about 35 percent of total global output of paper, 45 percent of all plywood, and 20 percent of softwood lumber.[1]

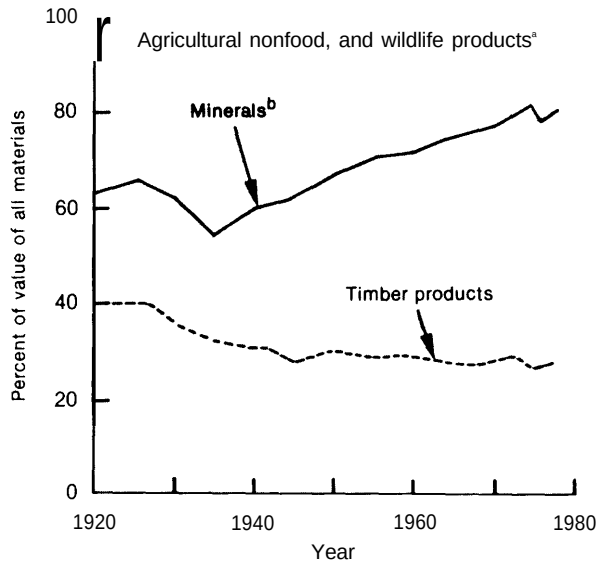
While the contribution of wood to the domestic economy has been declining over the past 50 years (fig, 10), it continues to be valuable in construction, shipping, packaging, and communications. Wood's future role in the national materials mix is difficult to forecast, but wood should continue to be an important raw material in the foreseeable future. Whether its contribution to the economy expands or decreases will depend on several factors:

- the relative availability and price of wood compared to alternative materials,
- technological advances affecting uses for wood and other materials,
- the business acumen of the forest products industry compared to its competitors,
- government policies that encourage or inhibit use of wood relative to other materials, and
- consumer preferences.

Wood is made into thousands of products, but a few uses dominate today's market, Once again, after a period of decline, energy is the highest volume use for wood in the United States. Over half of the wood removed from forests in the early 1980's ultimately was burned for energy. Much of this consisted of pulpmill wastes, but a growing percentage was fuelwood used for residential heat and commercial power, * The forest products industry, which uses waste wood and residues for fuel, accounts for about 65 percent of wood energy use, while the remaining 35 percent is burned for home heating. Future levels of fuelwood use are difficult to predict; however, continued but probably slower growth in residential and commercial use of wood energy is likely in the Eastern United States for at least the next decade.

Over half of the solid wood products consumed, including lumber and plywood and

Figure 10— Relative Importance of Industrial Raw Materials, 1920-77



[a]Includes cotton and other fibers, oils, rubber, furs, hides, and other similar products
[b]Includes mineral construction materials, metal ores, chemical and fertilizer materials, abrasives, and other minerals

SOURCE U S Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United* States, *1952.2030* (Washington, D C U S. Government Printing Off Ice, 1982), p 3

[1]Roger Sed jo and Samuel Radcliffe, *Postwar Trends in U.S. Forest Products Trade,* Resources for the Future Research Paper R-22 (Washington, D.C.: Resources for the Future, 1$)80), p. 595.

*Wood consumption for other forest products decreased in 1981 because of the economic recession while fuelwood consumption continued at a high rate,

other panels, are used in construction, mostly single-family housing. After World War II, a trend toward building large detached homes developed and increased the demand for wood, even though construction methods became more efficient. In the future, growth in housing and related demand for wood may slow due to the higher cost of homeownership, shrinking household size, and possibly an increasing proportion of multifamily dwellings.

Demand for pulp and paper products has grown dramatically in recent decades, and prospects are good for continued growth, However, paper products face increasing competition from other materials, particularly plastics. Electronic communications may alter paper consumption patterns in the future, but the magnitude and direction of possible shifts are uncertain. The immediate effect of computers, word processors, and office copying equipment has been to increase demand for some types of paper.

Forest products have a variety of uses in manufacturing, shipping, and heavy industry. With the exception of pallets, demand for major industrial products made from wood have either leveled off or declined as usage has changed or as other materials have replaced wood. Nevertheless, wood will continue to be valuable for a wide range of minor industrial and specialized applications.

Chemicals and cellulosic fibers are also produced from wood. The $1.5 billion cellulosic fiber industry, which makes rayon and acetate, uses refined wood cellulose as a basic raw material. over $500 million in other silvichemicals are also produced from wood each year. These silvichemicals include lignin byproducts, food additives and flavorings, and naval stores. Wood also can be used to make many products now made with petrochemicals. Production of chemicals as byproducts of wood manufacturing probably will continue, but widespread replacement of chemicals now made from petroleum is unlikely. However, intensified research on wood chemicals, particularly lignin, could lead to new products of considerable value.

Although the United States is the world's largest producer and consumer of wood products, with demand increasing since 1950, wood's importance to the domestic economy has declined. The value of timber products as a proportion of the value of all industrial raw materials has been dropping for more than *50* years, from about *40* percent of the total in 1920 to about 27 percent in 1977. In part, this is because some traditional uses for wood have decreased in importance and because nonrenewable products, such as plastics and metals, are competing successfully in forest products markets. The rising value of nonrenewable raw materials may be other factors accounting for the decline. An expanding role for wood in the economy is possible if the price and availability of nonrenewable materials become less competitive. Otherwise, industrial uses for wood are not likely to expand significantly.

Wood's future also may depend on the development of new wood products to compete with nonwood products as well as the development of composites that combine wood and nonwood materials. For example, new wood building materials are available which could expand current wood markets or open others in the coming years. New super-strength paper and paperboard products, currently in developmental stages, also could have some structural applications. Composite materials made of wood in combination with fiberglass, plastics, or metal have demonstrated superior performance for some applications, but currently are not widespread in use.

In *1980,* the Forest Service issued projections of future timber demand, supply, and consumption as part of an assessment process required by the Forest and Rangeland Renewable Resources Planning Act of 1974. These projections, which are the basis for many Forest Service timber management programs, show rapidly rising timber consumption in the next 50 years, accompanied by rising timber prices and declining softwood timber inventories after 2010_0

According to the projections, timber consumption from domestic forests will rise from over 12 billion cubic feet (ft^3) in 1976 to nearly 23 billion ft^3 in 2030. Consumption of hardwoods is expected to rise somewhat faster than consumption of softwoods, Hardwood consumption, which accounted for less than one-third of the 1976 timber harvest, is expected to reach nearly 40 percent by 2030.

Another change shown in the projections is a substantial shift of harvest from the Pacific Northwest to the South, The South's share of the softwood harvest is projected to increase from 45 percent in 1976 to 53 percent in 2030, and its share of the hardwood harvest from 51 to 59 percent during the same period, Recent data, however, shows larger inventories and faster growth in the Pacific Northwest than the older data indicate, a difference that probably will dampen the regional shift.

The 1980 projections may overstate future timber consumption and price rises due mainly to possible overestimates of demand and underestimates of timber growth. The large projected increase in timber demand in the future stems primarily from assumptions about economic activity, housing starts, and home characteristics that many analysts think are too optimistic, Future timber supply estimates are based on static forest management and short-term supply assumptions that probably understate future growth potential. However, because projections of southern softwood inventories are being revised downward to conform with more recent survey information, the future supply picture is somewhat uncertain. underestimates of future supply also may be offset somewhat by possible overestimates of commercial timber acreage.

The forest products industry employs almost 2 percent of the Nations's full-time work force and contributes almost 2 percent of the gross national product (GNP). The industry contains two major sectors: 1) pulp and paper, and 2) lumber and panels (solid wood), The lumber and panels sector employs more people than does the pulp and paper sector, but pulp and paper contributes a higher value added.

Historically, primary processing operations, including logging, lumber and panel manufacture, pulping, and papermaking have been concentrated where inventories of raw materials are greatest, mostly near the abundant softwood forests of the Pacific coast and the South. Secondary processing (the manufacture of goods such as boxes, cartons, paper products, trusses, and furniture) tends to be located closer to markets, mainly in the Eastern United States.

The financial performance of the forest products industry has been roughly equal to that of other industries over the long term. However, in periods of recession, the lumber and panel products sector has been particularly vulnerable because of its heavy dependence on highly cyclical homebuilding activity.

The forest products industry is fairly competitive, but there are several leading companies. In 1978, the top four firms accounted for nearly 15 percent of sales. One of the major factors that appears to correlate with industry dominance is landownership. The top 40 firms in sales own 80 percent of all forest industry land, which totals 68.8 million acres or about 14 percent of all U.S. commercial forestland. Another factor associated with industry leadership is diversification. The largest firms often produce both paper and solid wood products, while smaller firms are more likely to specialize. Neither landownership nor diversification, however, is necessarily a determinant of industry dominance.

History of Wood Use*

Wood is probably the most versatile of all materials, adaptable to a broad range of uses and functions (table 10). For millenia, wood in its most rudimentary forms—firewood and logs-provided humanity with fuel, water transportation, shelter, and food. Ancient peoples invented ways to extract natural chemicals from it, such as resins, oils, and medicines. The basics of producing paper were known to the Chinese by the first century A. D., and similar processes, developed separately, apparently were known to the Mayas and Incas, In the 19th century, papermaking machines became common in Europe and the United States, enabling high-volume production. Wood's abundance or scarcity among nations has been a contributing impetus to warfare for hundreds of years. For example, colonial resentment of Britain's earmarking of "crown timbers" for shipbuilding is said to have exacerbated tensions leading to the American Revolution.[3] Other instances have occurred as recently as World War 11,[4]

The extensive forests of colonial America were considered to be an obstacle to agriculture and settlement. Nonetheless, the superabundance, low cost, and workability of wood permitted its easy substitution for more suitable, durable, and as-yet unavailable but scarcer materials for shelter, transportation, and tools. The U.S. industrial revolution depended on wood for fuel and tools until fossil fuels, iron and steel replaced it.

Wood was the most important source of energy in the United States a century ago, providing an estimated two-thirds of industrial and residential fuel needs. When the advantages of fossil fuels to an increasingly urbanized and industrialized society became obvious, wood fuel use began to decline, both in proportion to total energy use and in absolute quantities. It recently has increased again as a way to beat rising energy prices.

Wood served an important but temporary function in the development of the early U.S.

[2]Information on the history of wood use can be found in Robert L. Youngs, "Every Age, the Age of Wood," *Interdisciplinary Science Reviews,* vol. 7, No. 3, 1982, pp. 211-219; and in Elgon Glesinger, *The Coming Age of Wood* (New York: Simon & Schuster, 1949).

Table 10.—Representative Uses for Wood

Uses/Examples
Construction:
Residential housing construction and upkeep, mobile homes, and light commercial structures; arches and beams for sports arenas, convention centers, etc.
Communications:
Newsprint, printing papers, and other paper products
Packaging:
Bags, sacks, containers
Furniture manufacturing:
Household and commercial furniture
Shipping:
Pallets, containers, dunnage, blocking, and bracing
Transportation:
Railroad ties, manufacture of railroad cars, boats, and light airframes
Wood fuel:
Fuelwood, woodchips, mill residues, etc.:
Residential home heating and cooking, forest products industry process energy, electricity generation
Liquid and gaseous fuels:
Potential supplement for petroleum and natural gas as a fuel or alternative petrochemical feedstock
Chemicals and cellulosic fibers:
Rayon and cellulose acetate:
Clothing fibers, tires, conveyor and transmission belts, ribbons, films, etc.
Silvichemicals (naval stores and pulping byproducts):
Used in production of synthetic rubber, chewing gum, rosin bags, inks, adhesives, paints, soaps, detergents, solvents, odorants, bactericide, drilling mud thinners, dispersants, leather tanning agents, water treatment, pharmaceuticals, etc.
Food and feed products:
Feed molasses, animal fodder, vanillin flavoring, food grade yeast products
Miscellaneous and specialty products:
Utility poles, pilings, fencing, mine props, cooperage, activated carbon, sporting goods, musical instruments, pencils, caskets, signs and displays, etc.

SOURCE: Off Ice of Technology Assessment.

[3]As discussed in Robert F. Albion, *Forests and Sea Power: The Timber Problem of the Royal Navy* (Cambridge, Mass.: Harvard University Press, 1926), pp. 231-280.

[4]The role of wood in World War 11 is discussed in Elgon Glesinger, *Nazis in the Woodpile: Hitler Plot for Essential Raw Material* (Indianapolis and New York: Bobbs-Merrill, 1942).

network of roads, bridges, and railroads. s In some areas, wooden roads were formed by laying logs in a corduroy pattern; planks or wood blocks also served as road pavement. The tracks, not just the ties, of early railroads were built of wood. In 1910, at the high point of railroad expansion, an estimated one-fourth of all wood consumed in the United States was for railroad ties,[6]

[5]See Don H. Berkebile, "Wooden Roads," Lee H. Nelson, "The Colossus of Philadelphia," and John H. Nelson, "Railroads: Wood to Burn," in *Material Culture of the Wooden Age,* Brooke Hindle (cd.) (Tarrytown, N.}'.: Sleepy Hollow Press, 1981), for a discussion of wood role in early U.S. transportation.

[6]Glesinger, *The Corning Age of Wood,* op. cit.

Advances in technology over the past 100 years have resulted in many new wood products (table 11), a variety of reconstituted structural wood products, and composite products that join wood with other materials to improve its strength. Many of these products have comparable or superior performance to lumber, yet allow fuller recovery of the resource, Much of the paper and paperboard now produced in this country is made from southern pine species, which were considered unsuitable for papermaking before adaptation of the kraft sulfate process in the 1930's. Now, hardwoods are used increasingly throughout the industry as technology expands to take advantage of these cheap and abundant materials.

Table 11 .—Taxonomy of Major Forest Products

Product	Description	Status of lifecycle	Major end use
Lumber type products			
Boards[a]	1" thick, 4" to 16', > 1" wide	M	General purpose
Dimension[a] lumber	2" to < 5" thick, > 2" wide, usually 4' to 16' long solid wood, sometimes edge glued	M	Structural framing
Timbers	5 +' thick, > 4" wide, various lengths; solid or laminated wood	M	Structural framing beams, and large supports
Parallel laminated veneer (PLV)	Usually same dimensions as lumber and timbers, made from wood veneers laminated with parallel grains	G	Structural framing and supports. Can also be used in millwork and molding
Utility poles	9" to 14" diameter, 50' to 80'	M	Transmission lines
Panel type products			
Plywood	Flat panels, usually 4' x 8', less than 1.5" thick, made from wood veneers laminated with grains of adjacent veneers perpendicular. Usually 3 to 5 plies (veneers)	M	Structural sheathing, flooring, and a variety of semistructural uses
Hardwood	Flat panels made of individual wood fibers, usually glued together	M	Floor underpayment, facing for architectural concrete, wall linings, door inserts, stereo, radio and TV cabinetry, and furniture
Particleboard	Flat panels, less than 1.5" thick, cut to size of 4' x 8', composed of very small wood particles glued together	M	Underpayment, furniture core
Medium-density fiberboard	Same as hardboard, with extremely flat, smooth surface and edges	M	Furniture, wall siding
Semirigid insulation board	Flat panels made of individual wood fibers, usually loosely matted, fibers bonded by interfelting	D	Insulation, cushioning
Rigid insulation board	Same as semirigid insulation board	D	Interior walls and ceilings, exterior sheathing
Waferboard	Flat plywood-like panels made with flat, nonalined wafers or large chips of wood glued and pressed together	G	Paneling, substitute for plywood in structural use, wallboard
Oriented strand board (OSB)	Flat plywood-like panels made with aligned strands or ribbon-shaped pieces of wood. Sometimes crossbanded (strands in different layers oriented perpendicular to adjacent layers), sometimes veneered	G	Same as plywood
Corn-Ply	Flat plywood-like panels or lumber-like pieces, with particleboard cores and wood veneer faces	B	Same as lumber and plywood

Table 11 .—Taxonomy of Major Forest Products (continued)

Product	Description	Status of lifecycle	Major end use
Paper products			
Unbleached kraft paper	Brown, somewhat coarse, stiff paper manufactured primarily by the kraft sulfate process from hardwoods and softwoods	M	Heavy packaging, bags, and sacks
Bleached kraft paper	White fine textured paper manufactured by either the kraft sulfite process or the kraft sulfate process from either softwoods or hardwoods. The better papers are provided from softwoods	M	Fine writing and printing papers and paperboard for packaging
Newsprint and ground wood printing papers	Coarse textured paper of low strength and limited durability, which tends to yellow with age. It is manufactured from mechanical and semimechanical (particularly chemically treated) pulp, which uses either hardwoods or softwoods	M	Printing of newspaper and for other printing uses not requiring durability
Corrugating medium	Coarse, low-strength paper produced primarily from sulfite pulping of hardwoods	M	Corrugated boxes as dividers and stiffeners between the paperboard liners
Linerboard	Stiff, durable, thick paper made primarily from unbleached kraft paper made by the sulfate process	M	Heavy duty shipping containers and corrugated boxes
Paperboard	Stiff paper of moderate thickness made primarily from bleached sulfate kraft pulp	M	Milk cartons, folding boxes, and individual packaging
Coated paper	Printing papers that have been coated with materials that improve printability and photo reproduction	M	Magazines, annual reports, and books
Specialty papers	Diverse group of products ranging from thin filter papers to stiff card stock	M	Cigarettes, filter papers, bonded papers (with cotton fibers) index cards, tags, file folders, and postcards
Tissue paper	Thin, soft, absorbent papers manufactured primarily from chemical groundwood pulps	M	Toweling, tissues, and hygenic products
Other products			
Rayon	Synthetic fiber produced by the viscose process using pure cellulose produced by the dissolving pulp process. Rayon has properties similar to cotton	M	Woven cloth as a cotton substitute
Acetate	Synthetic fibers produced from dissolving pulp-like rayon, but further chemical treatment make them water resistant with properties more like nylon or orlon	M	Woven cloth as a substitute for nylon and other petroleum-derived synthetic fibers
Cellulosic films	Film made from dissolving pulp by the rayon and acetate processes, but extruded as sheets of various thicknesses	D	Packaging (cellophane) protective coverings, photographic applications, transparent drafting and graphic materials

NOTE: B = beginning; G = growing; M = mature; D = declining
a Nominal dimensions, i.e., " nominal = 3/4" actual.

SOURCE: Office of Technology Assessment

Uses of Wood

Wood for Energy

Since the 1973 oil embargo, wood has re-emerged as an important domestic source of energy. Energy extracted from wood in 1981, including milling and pulping wastes, represented more than half of all wood removed from U.S. forests that year. Wood fuel is used primarily by the forest products industry, which meets a high proportion of its energy needs by burning wood wastes, and by homeowners for residential heating. The potential of wood as an energy source is analyzed in the 1980 Office of Technology Assessment (OTA)

report, *Energy From Biological Processes.* [7] *New* information on wood energy use recently became available, due to independent surveys conducted by the Department of Energy (DOE) and the Forest Service, Both the DOE survey and the preliminary Forest Service survey show that residential fuelwood use is far greater than previously reported.

Over 130 million dry tons (1 dry ton = 1 cord) of wood were burned for fuel in 1980, according to a DOE survey.[8] This tonnage represents about 2.2 quadrillion Btu (2.2 Quads) of energy—about 3 percent of total domestic energy consumption.[9] On the basis of the more conservative Forest Service estimate of residential fuelwood use, OTA estimates that about 55 percent of all wood removals in the United States in 1980 were consumed for fuel purposes (table 12). *

About 60 percent (81 million short tons) of all wood energy was used by the forest products industry in manufacturing. The remaining 42 million to 48 million short tons were used primarily for residential home heating.

Prospects for Further Growth in Wood Fuel Use

Since the forest products industry already derives a large percentage of its energy requirements from wood, the areas where wood fuel use grows the most in the future probably will be in residential and commercial (e.g., hospital and nonwood manufacturing) applications.

In contrast to wood fuel byproducts used by the forest products industry, residential fuelwood use almost always involves removal of

[7] *Energy From Biological Processes,* vols. I-III (Washington, D. C.: U.S. Congress, Office of Technology Assessment, OTA-E-124, 1980).

[8] U.S. Department of Energy, *Estimates of U.S. Wood Energy Consumption From* 1949 to 1981, stock No. 061-003 -00266-8 (Washington, D. C.: U.S. Government Printing Office, August 1982).

[9] Derived from the U.S. Department of Energy, *Monthly Energy Review,* November 1982.

*In 1981 and 1982, the proportion of removals used as wood fuel probably exceeded 55 percent, due to continued growth in residential fuelwood use and a decline in forest products industry removals resulting from the economic recession.

Table 12.—OTA Calculations of Wood Fuel Removals, 1980

1980 quantitites of wood removed	Million tons of oven-dried wood
Wood (bark excluded) for forest products industry (estimated at 11.6 billion cubic feet)	160
Bark portion of forest products industry removals	21
Residential fuelwood (quantity harvested for use in 1980-81 heating season: 42 million cords, at approximately 1 ton each)	42
Total 1980 quantity of wood removed	223

1980 wood fuel consumption	Quads	Million tons of oven-dry wood needed to produce the equivalent amount of energy
Industrial (including mill residues, and spent pulping liquors)	1.4	81
Residential	0.8	42
Total 1980 wood fuel consumption	2.2	123

NOTE: The ratio of the 1960 wood fuel consumption to the 1960 quantity of wood removed is 123/223 or 55 percent This figure is based on very crude estimates and calculations and provides only a rough approximation of the importance of wood fuels It furthermore is subject to wide fluctuations correpsonding to changes in annual removals of industrial round-wood In 1961, for example, the ratio certainly increased, as removals declined and wood fuel consumption cent i n ued to increase

SOURCES' *Estimates of US. Wood* Energy *Consumption from 1949 to 1981* (Washington, D.C. U S Department of Energy, 1%32), p 95, Kenneth E Skog and Irene A Watterson, *Residential Fuelwood Use in the United States. 198081* (draft report), U S. Department of Agriculture, Forest Service, Forest Products Laboratory, March 1963, p 1, p 17, and table 4, conversation with Robert B Phelps, Research Forester, Demand Price and Trade Analysis, Forest Resource Economics Research Staff, U S. Department of Agriculture, Forest Service, May 26, 1963, letter from John G Haygreen, Professor and Head, Kaufert Laboratory, Department of Forest Products, College of Forestry, University of Minnesota, to James W Curl in, Project Director, Off Ice of Technology Assessment, U.S Congress, letter dated Nov 1962, and conversations with Kenneth E Skog, Research Forester, Engineering and Economics Research, U.S Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, Wis

wood from forests specifically for fuel. Many variables will influence trends in this area, including the abundance and accessibility of fuelwood, the relative price and availability of nonwood fuels, and personal preferences of homeowners. In the short term, all of these variables appear to favor increased fuelwood utilization, although probably not at the rapid rate of increase of the late 1970's.

Current residential fuelwood use is significantly above levels projected by the Forest Service in its 1980 assessment under the Forest and Rangeland Renewable Resources Planning Act of 1974 (Public Law 93-378). The projections said that residential fuelwood use would grow progressively from an estimated 6 million cords in 1976 to 26 million cords in 2030, Recently, however, the Forest Service revised its forecast to reflect new evidence of rapidly increasing consumption. The new forecasts, issued in a draft supplement to the 1980 supplement, show wood fuel use quadrupling within the next 50 years, reaching nearly 200 million cords annually. Much of this increase may reflect rapid growth in commercial use of wood fuels as well as residential fuelwood. While these projections cannot be made with certainty, it does seem probable that wood fuel use will significantly exceed the Forest Service projections made in 1980, even if it falls short of the revised estimates.[10]

Demographic and technological trends favor continued growth in fuelwood use for residential home heating, although probably at slower rates than in the 1970's. In forested regions, fuelwood is easily accessible to the increasing proportion of the population living in suburban and rural communities.

The availability of highly efficient wood burning stoves, inexpensive chain saws, and log splitters makes it possible for many rural and suburban residents to meet a high proportion of their home heating needs from nearby woodlands. In some instances, as in the case of national forests, firewood is provided at little or no cost to people willing to remove it. There has been a tenfold increase in firewood permits issued for national forests since 1971, representing a rise in wood removal from about 400,000 cords per year to about 4 million cords. * Other arrangements such as fuelwood purchasing cooperatives can reduce firewood costs below what individual purchasers must pay.

Increased wood fuel utilization by small nonwood industrial and commercial firms is also probable. Such firms currently account for a small portion of wood fuel consumption, but increasing numbers of companies in regions with abundant wood supplies find wood competitive with petroleum and natural gas fuels.[11] Wood also has certain economic advantages over coal, since wood boilers generally require lower capital investment for air pollution controls. Use of wood fuel in industrial processes and for electricity by public utilities is occurring in some areas,

Wood Fuel Use by the Forest Products Industry

Between 1972 and 1981, wood fuel use by the energy-intensive pulp and paper sector increased from about 40 to 47 percent of the total energy consumed by this part of the forest products industry. Wood fuel provided about 73 percent of the solid wood industry's energy needs in 1981.[12]

Because it already uses most pulping and mill residues, the forest products industry will find it more difficult to burn much more wood, Much of the remaining residues not burned for

[10]The initital estimate and forecast are contained in U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States 1952-2030* (Washington, D. C.: U.S. Government Printing Office, 1982), p. 67; the revised projections are contained in the Forest Service's *Review Draft; America Renewable Resources: A Supplement to the* 1979 *Assessment of the Forest and Rangeland Situation in the United States,* preliminary draft subject to revision, Feb. 4, 1983, p. 15.

*information on fuelwood removals from national forests provided by the Forest Service.

[11]See Charles E. Hewett and William 'r. Gladden, Jr., *Market Pressures to Use Wood as an Energy Resource* (Hanover, N. H.: Dartmouth College, Thayer School of Engineering and Resource Policy Center, June 1982) for regional prices of wood and other fuels on a Btu equivalent basis.

[12]National Forest Products Association, "Industrial Energy Conservation Program 1981 Report for Lumber and Wood Products" (Washington, D. C.: National Forest Products Association, June 24, 1982).

energy are used to make composite wood products or silvichemicals. Further increases in energy self-sufficiency may require the recovery of logging residues now left in the forests, harvesting of wood specifically for fuel use, and the development of more energy-efficient processing methods.

To date, nearly all wood energy is derived from the direct combustion of wood and wood byproducts. Wood also can be gasified or converted to liquid alcohol fuels that could substitute directly for fossil fuels. Several small-scale technologies for wood gasification are commercially available at this time although the Btu content of the gas is low. To date, no commercial facilities to produce alchohol fuels from wood have been constructed. One technological barrier to commercialization is the inability to convert economically large quantities of lignocellulosic materials.[13]

Wood in Construction

With the exception of fuel, more wood is used for construction than for any other single application. In *1976,* construction accounted for about 60 percent of the lumber and two-thirds of the plywood consumed in the United States. Major demand comes from the homebuilding industry, followed by residential upkeep and repair, and nonresidential construction (table 13).

The relationship between new construction and demand for wood has both positive and negative implications for the solid wood products sector. The industry has benefited from the increase in the number and size of new single family homes which has occurred since World War II, because they use more wood than multiunit or manufactured housing. However, residential construction is highly cyclical, with more pronounced highs and lows in economic activity than most other industries. As a result, the solid wood products sector sometimes is strained to meet demand during peak building years, such as the peak between *1972* and 1976 when housing starts exceeded 2 million annually. On the other hand, it sometimes is severely depressed, as has been the case since *1981* when housing starts fell to about 1 million per year. *

The amount of wood used in each housing unit varies according to construction materials and methods, the structure's type and size, architectural design, building codes, and region. Major changes in residential building materials have occurred since 1950, including greater use of plastics, metals, and masonry as substitutes for wood. Modern construction techniques, including use of prefabricated roof trusses and floor joist systems and factory prepared doors, windows, and cabinets, also tend to reduce the amount of wood used per unit of floor space.

Wood nonetheless remains the dominant material for homebuilding. Although wood use per square foot has declined, the overall size of single family houses has increased rapidly in

[13] U.S. Department of Energy, *Report of the Alcohol Fuels Policy Review* (Washington, D. C.: U.S. Government Printing Office, 1979),

*The 1970-82 period saw both the high and low points in new home construction in the post World War 11 period. In 5 years during the 1970's, housing starts exceeded 2 million per year (1971, 1972, 1973, 1977, and 1978). Post-World W'ar 11 low points were in 1975 (1.2 million starts), 1981 (1.1 million), and 1982 (1.1 million).

Photo credit' U S Forest Service

New home construction is the most important single use of solid wood products

Table 13.—Domestic Consumption of Lumber and Panel Products, 1976

End use	Lumber			Plywood			Other panel products				
	Million board feet	Tons (million)	Percent of total lumber	Million square feet (3/8″ basis)	Tons (million)	Percent of total plywood	Million square feet (3/8″ basis)	Tons (million)	Percent of total panels	Total tons (million)	Percent of total wood
Construction	25,246	26.8	59.4	13,585	7.6	66.2	6,795	4.5	50.3	38.9	59.4
New residential	16,555	17.6	39.0	8,410	4.7	41.0	3,540	2.3	26.2	24.6	37.6
New nonresidential	3,001	3.2	7.1	1,825	1.0	8.9	2,160	1.4	16.0	5.6	8.6
Upkeep, repair, and maintenance	5,690	6.0	13.3	3,350	1.9	16.3	1,095	0.7	8.1	8.6	13.1
Railroad and other ties	1,220	1.3	2.9							1.3	
Manufacturing	4,300	4.6	10.2	1,550	0.9	7.5	3,480	2.3	25.7	7.8	11.9
Household furniture	2,540	2.7	5.9	700	0.4	3.4					
Commercial furniture	260	0.3	0.7	220	0.1	1.0					
Other	1,500	1.6	3.5	630	0.4	3.1					
Shipping	6,900	7.3	16.2	738	0.4	3.6				7.7	11.7
Containers	1,140	1.2	2.7	318	0.2	1.6					
Pallets	4,900	5.2	11.5	400	0.2	2.0					
Dunnage, blocking, and bracing	860	0.9	2.0	20	<0.1	<0.1					
Other	4,785	5.1	11.3	4,638	2.6	22.6	3,248[a]	2.1	24.0	9.8	15.0
Total	42,451	45.1	100.0	20,511	11.5	100.0	13,523	8.9	100.0	65.5	100.0

[a]Includes shipping.

SOURCE: Adapted from *An Analysis of the Timber Situation in the United States, 1952-2030* (Washington, D.C. Department of Agriculture, Forest Service, 1982).

the post-World War II era. As a result, the amount of wood used per unit has increased slightly over the last two decades.[14]

Floor area of the average new single family house has increased over 70 percent between 1950 and 1979.[15] The proportion of new single family homes with garages increased from 40 percent in 1950 to 76 percent in 1980, including over 60 percent with room for two or more cars.[16] The exterior walls of 42 percent of all new single-family houses were wood in 1980 as compared to 32 percent in 1959.[17] These architectural trends have been offset somewhat by other trends that reduce wood use, such as more split-level and two-story houses and fewer porch and roof overhangs.

Long-term trends in housing demand depend on several interrelated factors, including:

- demography,
- general economic conditions and per capita income,
- national housing and financial policies,
- housing affordability, and
- cultural and personal housing preferences,

Throughout the 1970's, many housing experts projected a continued upward swing in housing starts through 1990 and perhaps to 2000. The expected increase in housing demand was linked more to the "baby boom" generation reaching prime home-buying age than to economic factors and government policies that affect construction and affordability, The demographic demand for housing in the 1980's and 1990's theoretically should be high. The number of Americans in prime household formation ages (24 to 35) will peak around 1985 and will continue at near record levels until 1990 before tapering off.[18]

The length and severity of the housing downturn in the early 1980's, however, has resulted in reevaluation of these projections. Some analysts anticipate new home construction to rebound to record levels when economic conditions improve, as it did in the seven previous housing cycles after World War II. Others, more pessimistic, say that a profound change is occurring in the U.S. housing market because the cost of homeownership is rising faster than family income, Such conditions are likely to limit the construction of detached single-family homes, and residential housing needs increasingly may be met through rehabilitation of older units, conversion of existing single-family units to multiple units, more new multifamily units, and manufactured housing, These events would reduce projected wood use in new construction but also could expand markets for wood in home improvement.

Pulp and Paper Products

The United States reports the world's highest per capita consumption of paper and paperboard products at 600 pounds per person per year. U.S. production of paper and paperboard amounted to about 64 million short tons in 1981, while domestic consumption amounted to 68 million short tons.[19]

Woodpulp is the primary raw material for all but a small portion of paper products, displacing cotton and other raw materials that dominated in the past. Annual woodpulp production has increased steadily, from about 15 million short tons in 1945 to about 53 million short tons in 1981.[20] Still, the United States imports slightly more pulp than it exports, and it manufactured 53.6 million short tons of pulp into paper and paperboard products in 1981.

Pulp and paper manufacture has grown more efficient as wood prices have risen. Early pulp-

[14] University of Wisconsin Extension, Environmental Awareness Center, Housing *and* Wood *Products Assessment,* final report to the U. S, Congress, office of Technology Assessment, Dec. 10, 1982, p. 21ff.

[15] 1 bid., p. 22. It should be noted that square feet of finished floor area declined slightly in 1980.

[16] Ibid., p. 24.

[17] Ibid., p. 32.

[18] President's Commission on Housing, *Report Of the President's Commission on Housing* (Washington, E). C.: [J, S. Government Printing office, 1982), p. 67.

[19] American Paper Institute, *Statistics of Paper, Paperboard and Wood Pulp— 1982, data* through 1981 (New York; American Paper Institute, 1982), table 1.

[20] 1981 figure is from Ibid., p. 52; 1945 figure is from U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States,* 1$?.52-20.?0, Forest Resource Report No. 23 (Washington, D. C.: U.S. Government Printing office, December 1982), p. 61.

ing processes were limited in the tree species they could use as raw material, but over time the industry has developed processes that can exploit a wider variety of species. Over the past 40 years, for example, hardwood use has increased so that it now accounts for over a quarter of the pulpwood utilized. The industry also relies heavily on chips and sawmill residues that are the byproducts of solid wood product manufacture, to the extent that they comprise over 40 percent of the wood used for pulping. Fifteen million short tons of recycled wastepaper were used in domestic pulp and paper production in 1981, compared to 12 million short tons in 1970.[21]

Research has expanded the number of products that can be made from paper. Several thousand different kinds of paper and paperboard (a stiff, heavy paper) can be manufactured. These range from fluffy absorbent tissues to extremely stiff board-like materials and experimental super-strength papers that match the strength and/or weight characteristics of some light structural metals.

Woodpulp use is evenly split between paper and paperboard production. The most important paper products include printing and writing papers (51 percent), newsprint (17 percent), tissues (14.5 percent), and packaging (17.7 percent) (table 14). Linerboard, a kraft paperboard used for boxes, shipping containers, and packaging, accounted for 46.4 percent of the paperboard produced in 1981. Packaging is a rapidly growing market, comprising nearly 60 percent of domestic paper and paperboard production in 1981.

Increasing domestic and worldwide demand for paper and paperboard are anticipated. The Department of Commerce, for instance, forecasts a 3 percent annual growth rate through

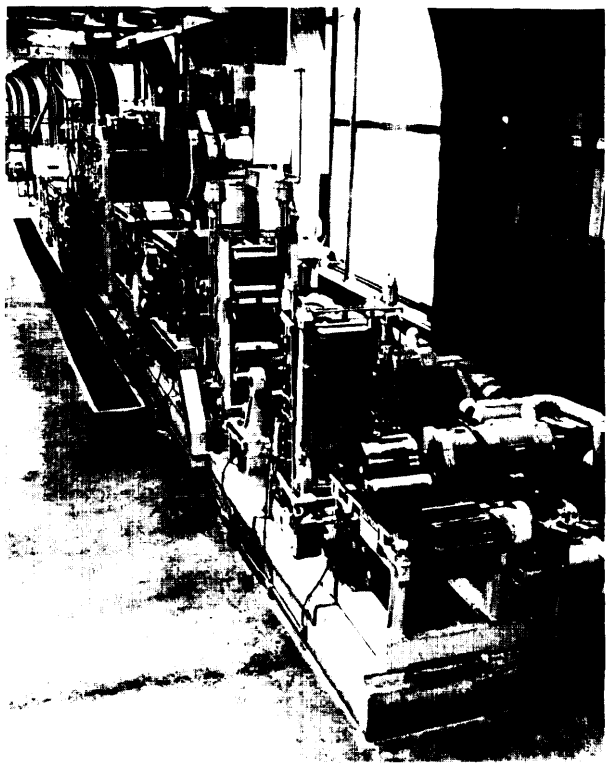


Photo credit: U.S. Forest Service

Researchers at the USDA Forest Products Laboratory are investigating new papermaking technologies

21 American Paper Institute, *Statistics of Paper, Paperboard and Wood Pulp—1982*, p. 50.

Table 14.—U.S. Production of Paper and Paperboard in 1981 and Projected for 1984 (thousand tons)

	1981	1984a
Paperboard	14,558	15,360
Kraft fiberboard	1,067	1,140
Other kraft paperboard	4,717	5,070
Bleached paperboard	3,926	4,100
Recycled paperboard	7,070	7,150
Total paperboard	31,338	33,020
Paper		
Uncoated free sheet	7,882	8,720
Coated free sheet and groundwood	4,951	5,340
Uncoated groundwood	1,440	1,540
Bristols and other	1,530	1,580
Total printing and writing	15,803	17,180
Newsprint	5,238	5,730
Unbleached kraft	3,891	3,760
Bleached regular and industrial	1,603	1,670
Tissue	4,485	4,730
Total paper	31,020	33,070
Total paperboard and paper	62,358	66,090

[a]Morgan Stanley Estimates.

SOURCE: Thomas P. Clephane and Jeanne Carroll, *Linerboard Industry Outlook* (New York Morgan Stanley & Co , 1982), p. 25

1986.[22] Linerboard and high-quality printing papers are expected to have especially promising potential, with anticipated growth rates that are twice that of the paper sector as a whole. particularly high prospects for growth lie in the export markets, especially in the expanding industrial economies of Asia. Continuation of the adverse economic conditions of 1982, however, could dampen these prospects.

Some experts believe that paperboard will account for a larger share of paper sector production due to increased paperboard demand and slower growth in other paper (nonpaperboard) markets. For example, paper has lost part of the packaging market to plastics, although in some instances plastics have been combined with paper to produce composite products. Electronic communications and information processing ultimately may displace some paper now used in writing, copying, printing, and business forms. To date, however, electronic communications have provided high-volume markets for paper use in office copiers and word processing equipment.

[22]U.S. Department of Commerce, Bureau of Industrial Economics, 1982 *U.S. Industrial Outlook* (Washington, D, C.: U.S. Government Printing Office, 1982), p. 43.

Other Wood Products

Furniture and Other Manufactured Products

Wood is an important manufacturing material, Furniture and other products accounted for about 10 percent of lumber, veneer, and plywood and 40 percent of hardboard and particleboard used in 1976.[23] Furniture alone accounted for well over half the wood used in manufacturing, with the remainder used for a variety of small volume items, including signs, displays, sporting goods, musical instruments, boats, tools, and coffins.

After rising during the previous decade, the volume of wood used in furniture and other manufactured goods began to decline during the early 1970's due to the increased use of materials such as metals and plastics, more efficient use of wood in manufacturing, and the small number of new products made from wood. Wood use in furniture also depends on consumer preferences. During the 1960's and 1970's, plastics and metals were substituted for wood in some popular styles of furniture, but between 1972 and 1977, wood apparently regained popularity .24

Shipping and Industrial Uses

During the past 15 years, the production of wooden pallets to store and ship materials has expanded. This growth reflects the increased use of palletized materials handling systems and the increased volume of manufactured goods shipped. The expanded use of pallets has offset the rapid decline in wood used in shipping containers and crates, which have been rapidly replaced by plastic containers and metal barrels. Further increases in pallet production are expected by the Forest Service.[25]

Other industrial markets have declined significantly due to the substitution of other materials and the development of better wood preservatives. Railroad ties, once one of the highest volume uses for wood, accounted for only about 1.5 billion board feet of lumber in

[23]*An Analysis of the Timber Situation*, op.c it,, p. 33.
[24]Ibid., p. 35.
[25]Ibid., p. 37-38.

1976.[26] Nonetheless, demand for railroad ties has edged upwards since the 1960's. Future trends in railroad tie use will depend on the competitiveness of alternatives such as concrete ties and public and private commitment to maintaining, improving or expanding domestic railroads. Other uses for wood, such as telephone poles, pilings, barrel staves, and mine timbers, have declined by about one-third since 1952, to 379 million ft^3 in 1977.

Chemicals and Cellulosic Fibers From Wood

Wood is the primary raw material from which highly refined cellulose is taken to make rayon and cellulose acetate filaments. Rayon and acetate are found in many products, including automobile tires, lacquers, and explosives,

The volume of cellulosic fiber production peaked in 1969,[27] and shipments in 1981 were valued at $1.5 billion.[28] Although the market is now dominated by noncellulosic fibers such as polyester, some analysts believe that wood-based rayon and acetate will become more competitive with noncellulosic fibers produced from petrochemicals if energy costs increase. Cotton is another major competitor with rayon, but the degree to which rayon can displace it will depend on worldwide demand and the supply of cotton. The success of rayon and acetate will depend, too, on improvements made in these fabrics.

The forest products industry also produces silvichemicals valued at over $500 million per year (table 15). Primary silvichemicals include naval stores (e.g., rosin, pine oils, and turpentine) and a variety of byproducts from pulping, including lignin products and vanillin.[29]

Technologies exist for wood to replace virtually all of the chemicals and plastics made from petrochemicals, although the most likely near-term substitute for petroleum is coal.

Some researchers consider wood's potential to be great for providing unique chemicals not now available. Lignin, now primarily burned for energy during the pulping process, may be especially promising. While lignin can be used to make a variety of organic chemicals, it is difficult to process and less than 3 percent remaining after pulping is recoverable for chemical production. Additional research on lignin's complex molecular structure, which is not well understood, is needed before the potential of lignin can be realized. Advances in biotechnology also may increase chemical production from wood.[30]

Nutritional Products

Wood fermented by yeast can produce several high protein products to feed livestock and to supplement human diets. These nutritional products include:

- roughage used in animal and some human foods;
- wood molasses, a sugar substitute;
- single-cell protein for animal and human nutrition; and
- flavorings, such as vanillin.

The value of wood-based feed and food products in 1977 was about $40 million. Vanillin, which is used as a substitute for vanilla beans in ice cream and other products, accounted for three-fourths of this total. al

Advanced Wood Materials

Research by the U.S. Forest Products Laboratory has shown the feasibility of producing paper that is stronger than the wood from which it is made, In fact, this "superpaper" substantially exceeds the specific strength- and stiffness-to-weight ratios of all common structural materials. If such high-strength papers also can be made moisture resistant, maintaining their stiffness and dimensional stability, they could be used for a wide range of applications now served by solid wood, plastics, and

[26] Ibid., p. 30,
[27] Ibid., p. 57.
[28] *1982 U.S. Industrial Outlook*, op. cit., p. 314.
[29] *An Analysis of the Timber Situation*, op. cit., p. 64-67.

[30] See Henry R. Bungay, "Biomass Refining," *Science, Nov. 12*, 1982, pp. 643-646, for a discussion of recent developments.
[31] *An Analysis of the Timber Situation*, op. cit., table 3.36, p. 64.

Table 15.—Production and Value of Silvichemicals in the United States in 1977

Product	Unit	Product ion (millions of units)	Average price[a] ($/unit)	Annual value (millions of dollars)	Average annual growth in production (1963-77) (percent)
Naval stores[b]					
Gum rosin	lb	26	0.27	$7.0	- 15“/0
Steam-distilled rosin	lb	246	0.23	56.6	- 6
Gum turpentine	gal	0.73	1.50	1.0	-1 5
Steam-distilled turpentine	gal	2.54	1.25	3.2	- 8
Pine oil	gal	9.49	**2.00**	19.0	0
Other terpenes	gal	2.32	**1.00**	2.1	
Subtotal				$89.2	
Sulfate mill products					
Crude tall oil	lb	1,518	**0.09**	(c)	+ 3.1
Crude tall oil, used as such or sold	lb	214	**0.09**	19.3	
Distilled tall oil[d]	lb	103	**0.19**	19.6	+ 1.6
Tall oil rosin	lb	406	**0.20**	81.2	+ 2.8
Tall oil fatty acids	lb	359	**0.27**	96.9	+ 3,0
Sulfate turpentine (refined)	gal	20.61	**1.10**	22.7	+ 0.7
Heads fraction, pitch	lb	300[e]	**0.05**[e]	15.0e	
Sulfate lignin	lb	60[e]	**0.05**[e]	3.0[e]	
Dimethylsulfide	lb	8[e]	**0.37**	3.0	
Dimethylsulfoxide	lb	1[e]	**0.54**	0.5[e]	
Subtotal				$261.2	
Sulfite mill products					
Lignosulfonate, Ca-base	lb	534	**0.05**	26.7	
Lignosulfonate, Na-base	lb	109	**0.06**	6.5	
Lignosulfonate, other[f]	lb	516	**0.04**	20.6	
Lignosulfonate, total[f]	lb	1,160	**0.06**	(c)	+ 7.6
Ethyl alcohol, 190-proof	gal	5	**1,00**	**5.0**	+ 2.6
Vanillin	lb	5.6	**5.35**	**30.0**	+ 10.4
Torula food yeast, dry	lb	16	**0.40**	6.4	+ 5.1
Acetic acid, glacial[g]	lb	8	**0,20**		0
Subtotal				$96.8	
Miscellaneous products					
Arabinogalactan		NA	NA	NA	
Charcoal briquettes	lb	1,100	0.06	66.0	+ 1.5
Active carbon, from wood	lb	50[e]	0.25	12.5[e]	
Hemicellulose extract	gal	2	0.09	0.2	
Wax, from bark	lb	1.2	0.22	0.3	
Extracted bark powder	lb	35	0.06		
Subtotal				$81.1	
Grand totoal				$528.3	

NA = Not applicable
[a]Carload or wholesale price, f.o.b mill
[b]Naval stores data pertain to crop year, April 1 to March 31
[c]Value accounted for under other headings
[d]Includuing acid-refined tall oil.
[e]Includinglignosulfonates made from sul fate lignin
'Estimated
[g]Made from NSSC spent pulping liquors

SOURCE Lars C. Bratt, “Wood Derived Chemicals Trends in Production in the U.S. ,“ Pulp *and Paper,* June 1979

metals. When coupled with design innovations for paper-based structural materials, they eventually may play a role in residential construction. However, considerably more research and development are needed before superstrength paper can be marketed.

Solid wood products have been designed to compete directly with structural steel and concrete in some uses. Large laminated beams and arches, frequently bent into various shapes, have entered new markets, including the construction of large indoor sports arenas, convention centers, churches, and domes,

In addition, all-weather wood foundations and underfloor plenum systems can compete with masonry, block or cast-in-place concrete

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in new homes. The all-weather wood foundation is made of preservative-treated plywood and lumber placed partially below ground level, The underfloor plenum system provides a sub-floor area through which warm or cool air can be distributed throughout the house for heating or air-conditioning, thus eliminating ductwork. Properly constructed, the plenum is rot- and insect-resistant.[32] Widespread use of either system would significantly increase wood use in home construction; e.g., the underfloor plenum system requires 20 percent more wood compared to slab built houses.[33]

Though wood foundations are cost competitive with conventional foundations, they are not yet widely accepted. Reasons for this may be related to a conservative building construction industry, buyer reservation, and the reluctance of building tradespeople to adopt new technologies.

Many new wood products displace more traditional wood products such as plywood or lumber rather than competing with other materials. These products may help maintain traditional wood markets but do not usually open new ones. Often the net effect is to reduce the volume of wood used. Prefabricated roof trusses, for example, have not expanded wood markets significantly but have replaced larger dimension lumber in light frame construction.

[32]National Association of Homebuilders Research Foundation, *Plen-Wood System: A Design/Construction Manual* (Rockville, Md.: National Association of Homebuilders Research Foundation).

[33]National Association of Homebuilders Research Foundation, personal communication with W. Davidson, contractor, OTA, January 1983.

Medium-density fiberboard, first produced in the mid-1970's, has rapidly expanded into furniture markets formerly held by particleboard and other panels. New types of particleboard include panels made from strands (thin shavings or slivers of wood), flakes or wafers, sometimes with veneer faces. These panels, first introduced in the United States and Canada in the mid-1970's, compete with softwood plywood in structural uses.

New panel products made from reconstituted wood are expected to replace plywood for sheathing and underpayment (floors). The same trend seems to have occurred in furniture manufacturing where plywood and particleboard have replaced lumber as furniture corestock, and medium-density fiberboard, in turn, has replaced much of the plywood and particleboard. Shipping pallets are replacing wood boxes and containers for materials handling. New types of pallets, made with plywood decking, particleboard, or medium-density fiberboard, may replace some hardwood pallets in the future.

Composites that combine wood with other materials are not common, but their use is growing. Composites made by laminating plastic or metal skins to a wood core are currently used in a number of industrial applications calling for strong, durable, corrosion-resistant materials. Cement board made from wood and cement and insulation made from wood and foam are two other applications of composites. Advanced materials, such as dimension lumber substitutes made from wood particles and high tensile strength glass fibers, could further broaden the range of wood composites.

Projected U.S. Consumption of Timber and Wood Products

For nearly a century, the Forest Service periodically has analyzed the U.S. timber situation. The Forest and Rangeland Renewable Resources Planning Act of 1974 directs the Secretary of Agriculture to prepare an assessment of renewable resources every 10 years. Under the National Forest Management Act of 1976 (Public Law 94-585), the Forest Service also prepares a national renewable resource program updated at 5-year intervals. The latest

assessment, issued in 1980, presents projections of timber demand, supply, and prices through 2030.

From each assessment, alternative programs for the use and management of the Nation's renewable resources are prepared, and these in turn form the basis for formulating Federal budgets. The 1980 assessment forecasts increasing timber scarcity coupled with rising prices and demand for timber products during the next 50 years. This scarcity, according to the Forest Service, will have "significant adverse effects on primary timber processing industries, timber inventories, consumers of wood products, and the environment."[34]

The 1980 projections probably overstate the future scarcity of timber, primarily because of overestimated demand.[35] The forecasts that appear in the 1980 assessment were prepared in the late 1970's, and many significant changes in the Nation's economic outlook have occurred since then that alter expectations about timber demand and other assumptions used in the model. Recognizing these changes, the Forest Service currently is modifying both the 1980 forecasts and the forecasting process to include updated assumptions about future conditions and to provide a range of future outcomes.

While it is useful for planning purposes to project future timber demand and supply, it is important to recognize the shortcomings of mathematical modeling when it is applied to public administration and public policy. The complexity and sophistication of the econometric models used in forecasting often give the illusion of certainty and accuracy, while in fact the most complex models may provide information that is no more reliable than off-the-cuff estimates or professional intuition, The primary value of modeling maybe less in predicting future conditions than in evaluating the relationships between certain economic conditions and the timber situation, The usefulness of the Forest Service's projections for policy-making will be greatly enhanced by considering a range of assumed conditions in developing estimates of future timber situations, rather than merely providing specific estimates of timber demand and supply based on a single or narrow set of assumptions.

The next assessment by the Forest Service probably will describe a broader range of possible futures, The 1980 assessment reflects little recognition and analysis of factors that affect timber consumption and presents only a single most-likely-case scenario—that timber will become more scarce, based on demand rising faster than supply. While this projection is within the range of possible futures, there are two reasons to doubt that it is the most likely outcome: 1) estimates of future economic growth and demand for timber products are too optimistic and are much more likely to be overestimated than underestimated, and 2) while the long-term national timber supply may be understated, projections of supplies of softwoods from certain regions may be overestimated.

Demand Projections

Projections of demand for wood cover a wide range of products, including lumber, panels, fuel, pulp, and paper. Future consumption for all products is linked to the level of general economic activity, and demand for many goods is estimated by indexing product use to the GNP. Demand for wood products used in housing is forecast separately.

Housing Demand

The Forest Service's 1980 assessment forecasts rapidly rising consumption of lumber and plywood as a result of projected high levels of new home construction like those of the early and mid-1970's. Since these projections were made, however, there have been significant changes in the housing market that may have a long-term impact on the strength of future demand, home size and type, and consequently the amount of wood products used in construction. These changes and several others, all point *to* future consumption of wood products

[34] *An Analysis of the Timber Situation,* op. Cit., p. Xxiii.

[35] Personal communication from Bruce R. Lippke, Weyerhaeuser Co., to R. Max Peterson, Chief, Forest Service, Mar. 17, 1983.

below the levels forecasted in the 1980 assessment. A downward revision of Forest Service projections therefore is justified because:

- In the Forest Service model, a substantial portion of future new construction is "replacement" housing, i.e., those units built when existing houses are abandoned or razed. However, the model assumes replacement rates will be sustained at levels much higher than in the past, except during the 1960's when a larger proportion of wartime housing was replaced. Unless repair and remodeling decrease dramatically, it is likely that future replacement rates will be much lower than forecasts indicate. Since housing unit replacements account for nearly half of all future homebuilding used in Forest Service forecasts, adjustment of the replacement rate will substantially effect the projected pace of construction,
- Housing affordability affects housing demand, unit type, and home size, but it is not adequately reflected in Forest Service projections. Home prices increased rapidly relative to household income in the 1970's, partially as a result of inflation and low real interest rates, conditions not likely to be duplicated in at least the next decade or two.
- Reduced housing affordability and household size both point to decreasing home size in the future. However, whether or not average unit size will reach 2,000 ft^2 by 2030, as the Forest Service estimates, is uncertain; it is not unlikely that home size could stabilize or even decrease within 50 years.
- Household size, lifestyle, and consumer preference also could significantly effect the type of housing built. The Forest Service forecasts multifamily and mobile home units declining as a proportion of construction in the future and single-family detached units accounting for a growing share. It is probably equally likely that multifamily units and mobile homes will account for a stable or increasing share of future construction. Single-family homes use more wood products than either multifamily units or mobile homes per unit of floor space.

These are among the many reasons to doubt that the strong homebuilding activity of the past will recur, yet they are not adequately recognized in 1980 Forest Service forecasts, For the last 4 years, the homebuilding industry has been depressed. The extent to which current conditions will continue or how the industry will respond to recovery is unknown. It is possible that a full recovery could lead to more housing construction in the future, particularly since housing demand by the baby boom generation is expected to be strongest in the 1980's. This is based primarily on demographics, however, which is only one of a number of things that affect housing demand.

Demand for Timber in Other Uses

Demand for wood products other than for new housing is, in general, tied to the level of economic activity and population expected in the next 50 years. Forest Service estimates of future GNP and disposable personal income are based on projections made by the Department of Commerce's Bureau of Economic Analysis (BEA). The BEA projections show future annual GNP growth of 2.0 to 3.7 percent, leading to a quadrupling of GNP by 2030 and thus to a substantial increase in demand for wood.

While these GNP forecasts are not inconsistent with past trends, some private sector timber demand forecasts use slightly lower estimates.[36] The 1980 assessment, however, gives little consideration to the effects of different assumed levels of economic growth on wood demand, except to note that consumption of lumber and plywood are insensitive to changes in GNP growth in the short run.[37] There is a great deal of uncertainty in any forecast of eco-

[36] Discussion of timber consumption forecasting models and assumptions used in various models can be found in Perry R, Hagenstein, and William E. Bruner, *Timber and Wood Products Supply and Demand Analysis,* contract report to the U.S. Congress, Office of Technology Assessment, July 2, 1982.
[37] *An Analysis of the Timber Situation,* Op. C it., p. xx.

nomic activity for as long a period as 50 years, and even small changes may have considerable impact on future wood needs, This impact is not adequately recognized in the 1980 assessment.

Supply Projections

Actual future timber supply probably will be much different than projected in the 1980 assessment, but the magnitude and direction of the difference are not clear. Timber supply forecasting is complicated by the fact that the Forest Survey, conducted under Forest Service auspices, which provides information on forest acreage, timber stocking, and growth, is done at 10 to 15 year intervals and is not completed simultaneously in all States (see ch, VI for detailed discussion). At any given time, therefore, forecasters may be using inventory and growth data ranging in age from 1 to 15 years, and, as recent surveys have shown, outdated information can be inaccurate. New surveys completed since the 1980 assessment show that the softwood supply in the Pacific Northwest, present and future, definitely was underestimated, but that the future softwood supply in the South, particularly on nonindustrial private forestland, may be significantly overstated.

Overall, the Forest Service's supply projection process probably produces very conservative estimates of nationwide future timber growth for three reasons:

- Forest Service projections are based on short-term supply curves. These show that even large increases in stumpage prices produce only very modest increases in timber harvest. This relationship seems reasonable in the short run, since it takes 30 or more years to grow mature timber. However, in the longer run, covering the 50-year projection period used in the 1980 assessment, timber supply is probably much more responsive to stumpage prices than short-run analysis indicates. With rising stumpage prices, a much broader range of investments in timber management to increase future supply is feasible,
- The 1980 assessment projections assume no increase in management intensity over 1970's levels, which may be unreasonable because higher stumpage prices probably would prompt many landowners to invest more heavily in timber management.
- The Forest Service forecasts rely on extremely conservative conversion rates to translate wood products consumption into demand for raw timber, The amount of timber required for wood products is affected by manufacturing technology and forest utilization, and there are many currently available technologies that can reduce the amount of roundwood needed to make a wide variety of goods. In addition, technological advances have made it possible for woody biomass, previously considered waste, to be used in product manufacture. Rising stumpage prices are likely to stimulate investment in more efficient manufacturing equipment as well as an increase in use of forest biomass, both of which tend to increase the supply of usable wood. The effects of increased forest utilization and more efficient manufacturing technology probably are understated in the 1980 assessment,

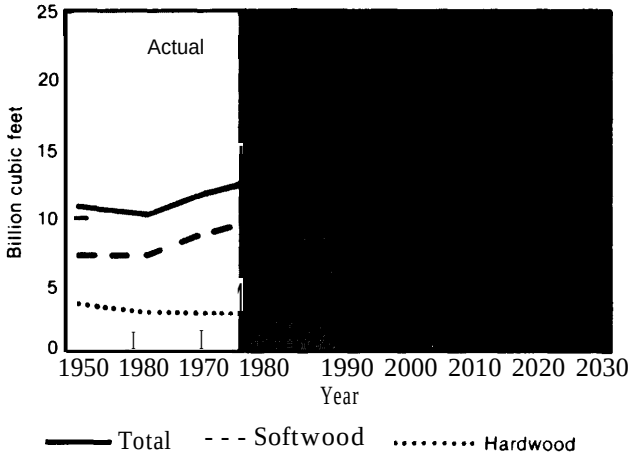
Timber Consumption Projections

According to the 1980 assessment, timber consumption from domestic forests is projected to rise from over 12 billion ft^3 in 1976 to approximately 23 billion ft^3 in 2030 (fig. 11), The greatest rate of projected increase takes place between 1980 and 1990, due mainly to the strong housing demand of the baby boom generation, now entering the 28- to 35-year-old age group of primary homebuyers.*

Most of the increase in timber consumption between 1952 and 1976 was supplied by softwoods, whose use rose from 7.2 billion ft^3 to nearly 9,5 billion ft^3. Hardwood use, in con-

*Forest Service forecasts do not attempt to forecast short-term consumption between 1976 and 1990. The forecasts begin with 1990 consumption. However, attaining these levels by 1990 requires a substantial increase in short-term consumption.

Figure II.—Domestic Timber Consumption, 1952-2030



SOURCE: Adapted from the U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation In the United States, 1952-2030,* Forest Resource Report No. 23 (Washington, D. C.: U.S. Government Printing Office, 19S2), p. 202-215.

trast, remained relatively stable at about 3 billion to 3.5 billion ft^3 By 2030, a large portion of the increased timber consumption from domestic forests is projected to be in hardwoods, primarily for paper, pallets, and hardwood veneer for furniture. Hardwood use is projected to rise to nearly 9.0billion ft^3 up from nearly 2.9 billion ft^3 in 1976–a jump of over 300 percent. Softwood consumption is expected to rise by 50 percent, to 14,0 billion ft^3

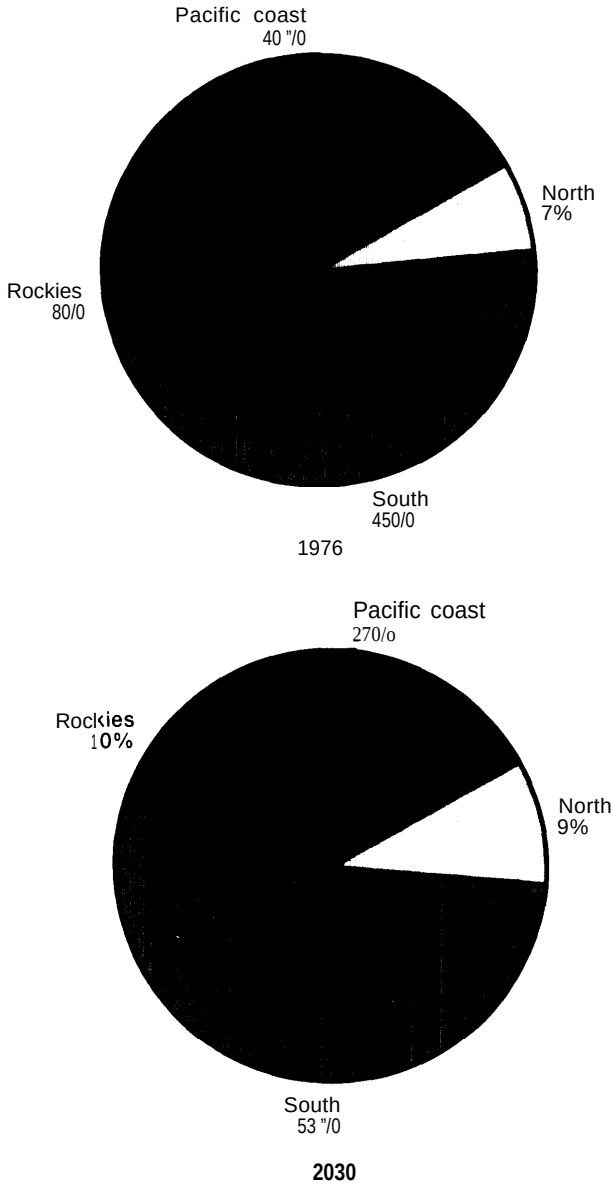
Regional Timber Production

Forecasted regional distribution of timber production through 2030 indicates that softwood operations will continue to shift to the South (fig. 12). This shift projected in the 1980 assessment reflects a decline in production in the Pacific Northwest, thought to be caused by a drop in timber inventories due to overcutting on forest industry land. * Since the 1976 projection was made, however, a resurvey in the Pacific Northwest shows that timber growth on forest industry land is significantly higher than had been previously estimated, and it is likely that new Forest Service projections now in preparation will reveal a much smaller decline in Pacific Northwest harvests. In addition, recent information shows that projected southern softwood supplies are probably too high. Forecasts are being revised to reflect these changes.

In 1976, the South produced 51 percent of the hardwood harvest, with the North produc-

*"Overcutting" means harvesting more than net growth per unit of time, or cutting above the level of sustainable yield.

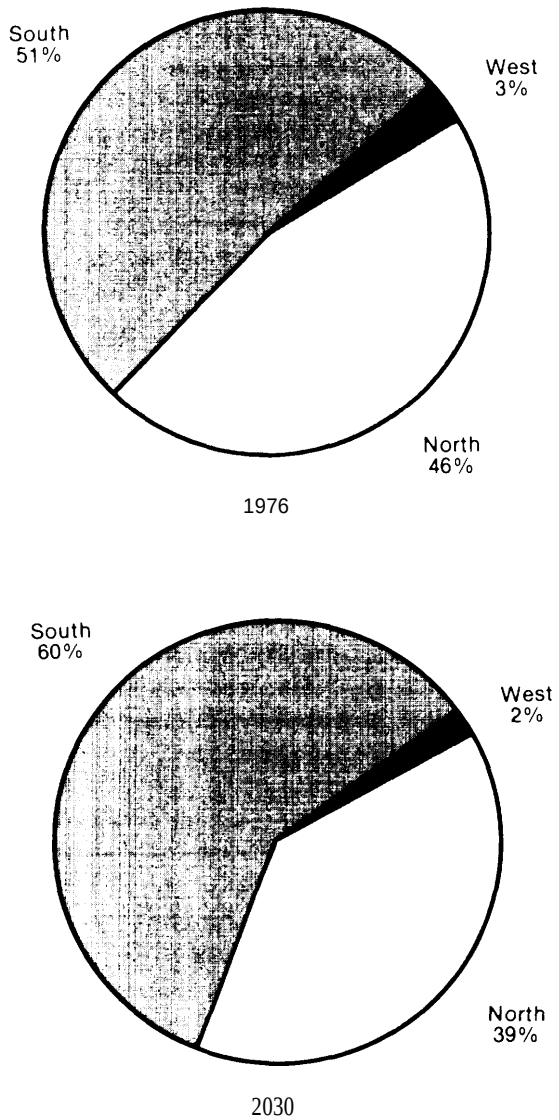
Figure 12.- Softwood Timber Production: Regional Distribution, 1976 and 2030



SOURCE: U.S. Department of Agriculture, Forest Service, *An Analysis of Timber Situation in the United States, 1$52-2030,* Forest Resource Report No. 23 (Washington, D. C.: US. Government Printing Off Ice, 1982), p. 202-215,

ing 46 percent. Only 3 percent came from the Pacific coast. The 1980 assessment shows slight shifts in hardwood production by 2030, with the South's share increasing to 59 percent, the North declining to 39 percent, and the Pacific coast dropping to 2 percent (fig, 13).

Figure 13.—Hardwood Timber Production: Regional Distribution, 1976 and 2030



SOURCE: U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United Stales, 1562-2030,* Forest Resource Report No. 23 (Washington, D.C : U.S. Government Printing Office, 1982), p 202.215

A decline in the share of production does not necessarily mean a decline in actual or volume production. In the Pacific Northwest, where the share of softwood harvest is projected to drop from 31 to 21 percent of the national total, volume production is projected to increase by 70 million ft^3. In the South, where projections indicate an increase from 45 to 53 percent of the national softwood harvest, the increase in volume production is nearly 3.3 billion ft^3.

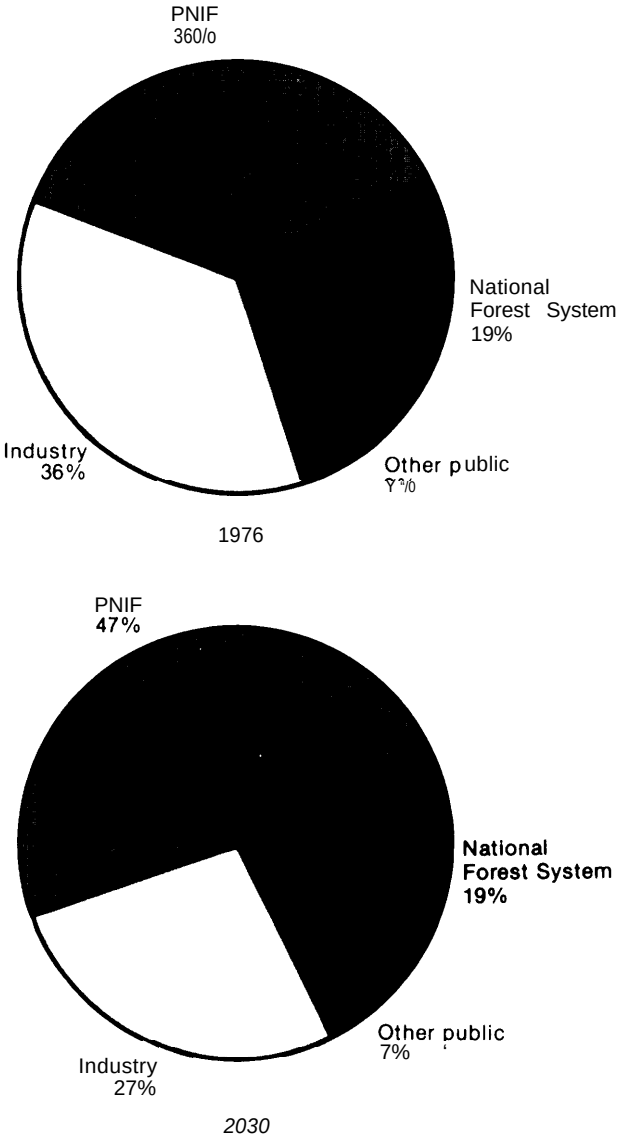
The hardwood situation is similar. The South's hardwood production is expected to more than triple, increasing from 1.7 billion to 5.4 billion ft^3. The North is projected to increase its volume production from 1.5 billion to 3.6 billion ft3. In the West, hardwood harvest levels projected to increase by 37 million ft^3 by 2030.

Harvest by Ownership

Projections of the timber harvest by ownership also show major shifts in the contributions of various forest land owners. In 1976, the private sector accounted for nearly three-fourths of the softwood roundwood supplies, Private industrial and nonindustrial ownerships each produced about 36 percent of the total softwood harvest (fig. 14). The public sector accounted for the remainder, with the National Forest System producing nearly 19 percent of the Nation's softwood harvest,

By 2030, the public sector is expected to contribute a slightly smaller share, while in the private sector, the forest industry's share drops to 27 percent and the nonindustrial landowners' share goes up to 47 percent. For the private nonindustrial group, this change means increasing production by 94 percent over 1976 levels, or by about 3.2 billion ft^3, Despite share decreases, the harvest from forest industry lands is projected to increase slightly, by about 354 million ft^3. Similarly, national forest production is projected to increase by 928 million ft^3, or by about 52 percent over 1976 levels.

Figure 14.—Softwood Timber Production: Distribution **by Ownership, 1976 and 2030**



SOURCE: U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation In the United States 1952-2030,* Forest Resource Report No. 23 (Washington, D. C.: U.S. Government Printing Office, 1982), pp. 202-215.

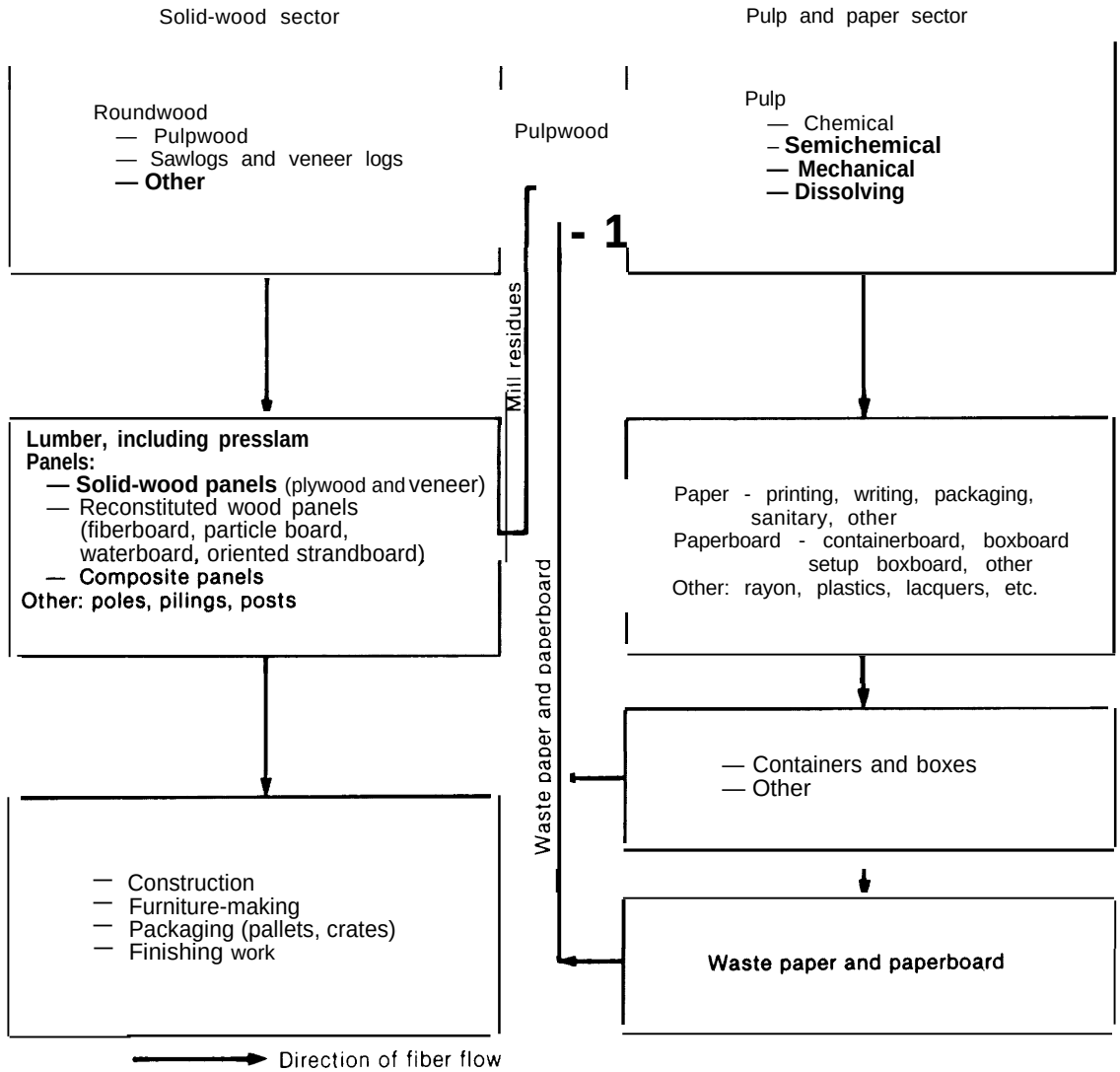
No major changes in regional distribution of hardwood harvests are projected, although all ownerships are expected to-harvest more hardwoods to meet increasing forest products industry needs. The projected increase is greatest from private nonindustrial lands, which are projected to expand hardwood harvests by 180 percent, from 2.5 billion ft^3 to approximately 7 billion ft^3.

The Forest Products Industry

The term "forest products industry" refers to the combination of the pulp and paper products and the solid wood (lumber and panel) products sectors (fig. 15). This industry contributes 1.7 percent of the total gross domestic product (GDP) and employs about the same percentage of the Nation's full-time work force." The pulp and paper sector is the fourth

[38] U.S. Department of Commerce, Bureau of Industrial Economics, *1981 U.S. Industrial Outlook for 200 Industries With Projections for 1985* (Washington, D. C.: U.S. Government Printing Office, 1982), p. 425.

Figure 15.—Schematic of the Forest Products Industry



SOURCE Off Ice of Technology Assessment

largest producer of nondurable goods, and the lumber and panel products sector is the eighth largest producer of durable goods in terms of value of GDP.

The characteristics and performance of the two sectors are quite different. These differences are less, however, in the case of the larger diversified companies that manufacture both solid wood products and pulp and paper. Such firms often own significant amounts of forestland and are major employers in many areas.

Contribution to the Domestic Economy

In 1977, the forest products industry employed about 1.4 million people and contributed over $40 billion in value added. The lumber and panel products sector employs more people than the pulp and paper sector, but the pulp and paper sector ranks higher in value added by manufacturing, which reflects the prevalence of automation in papermills. Lumber and panel products is a significant consumer of adhesives and resins, preserva-

tives, and fire retardants. Pulp and paper is a major user of industrial energy, water, and chemicals.

Primary Processing

primary processors handle the raw wood material. In 1977, they contributed about 43 percent of the total forest products value added and employed 37 percent of the labor force of the forest products industry (table 16). The largest single employers are sawmills and planing mills, which retain 211,300 workers, followed by papermills which employ 127,000 people. Papermills lead primary operations in value added and value of shipments, followed by sawmills and planing mills.

Secondary Processing

Secondary processors in both industry sectors together employ 63 percent of the forest products labor force and contribute 57 percent of total value added. Similar to the primary processors, secondary lumber processors employ more people than do the secondary pulp and paper processors, but the latter contributes a higher value added. When measured by all

Table 16.—Number of Employees, Value Added, and Value of Shipments for Primary and Secondary Forest Products Industry in 1977

Industry	Number of employees (thousands)	Value added by manufacture (million dollars)	Value of shipments (million dollars)
Primary lumber			
Logging camps and contractors	83.3	2,418.7	6,230.1
Sawmills and planing mills	211.3	4,974.8	11,969.3
Total	294.6	7,393.5	
Percent of grand total	20.9	18.4	
Primary paper:			
Pulpmills	16.2	906.1	2,091.1
Papermills (except building paper)	127.0	5,406.6	12,613.3
Paperboard, building paper and board mills	74.6	3,298.9	7,598.0
Total	217.8	9,611.6	
Percent of grand total	15.4	23.9	
Gum and wood chemicals:			
Percent of grand total	**0.3**	**0.4**	
Primary total:			
Percent of grand total	**36.7**	42.8	
Secondary lumber.			
Millwork, plywood, and structural members	**183.3**	4,370.8	10,596.0
Wood containers, and miscellaneous wood products	**50.4**	866.8	2,179.7
Wood buildings and mobile homes	**79.5**	1,789.1	5,147.9
Furniture and fixtures	**196.9**	3,388.1	6,162.9
Total	**510.1**	10,414.8	
Percent of grand total	**36.2**	25.9	
Secondary paper.			
Paperboard containers and boxes	**176.1**	5,296.2	13,350.1
Sanitary paper products	**34.5**	2,194.5	4,921.2
Bags	**48.7**	1,349.6	3,482.3
Other converted paper and paperboard products	**123.5**	3,718.9	***8,029.7***
Total	**382.8**	12,559.2	
Percent of grand total	**27.1**	31.3	
Secondary total:			
Percent of grand total	**63.3**	57.2	
Grand total.	**1,410.1**	40,164.1	

SOURCE: 1977 *Census of Manufacturers, Parts 1 and 2* (Washington, D.C.: U.S. Department of Commerce, Bureau of the Census, 1981).

parameters displayed in table 16, the two largest secondary lumber subgroups are millwork, plywood, structural members, and furniture and fixtures. The two largest paper subgroups are paperboard containers and boxes and the catch-all "other converted paper and paperboard products. " Overall, paperboard containers and boxes contribute the largest value added of the secondary processors, while furniture and fixtures employs the most people.

Consumption of Industrial Commodities

The forest products industry is a major consumer of several industrial commodities, Plywood and other panels, for instance, require significant quantities of adhesives and resins, making plywood manufacture the largest single adhesives market.[39] Other solid wood products use significant amounts of phenol and urea formaldehyde resins, fire retardants, and preservatives, most of which are petroleum-based.

The pulp and paper sector is the sixth largest consumer of chemicals in terms of dollar value purchased. It also uses (but does not consume) more water for processing than any other manufacturing industry and is a leading industrial energy consumer. The pulp and paper sector uses about 7 percent of the Nation's industrial energy and 3 percent of all energy consumed in the United States. Because energy is a significant cost in producing paper, pulp and paper companies have become industrial leaders in energy conservation and cogeneration.

Structure and Performance

The financial performance of the forest products industry is neither better nor worse than that of other industries considered together. In 1980, the wood-based companies among the Fortune 500 trailed other industries in terms of total return to investors, return on stockholders' equity, return on sales, and changes in profits and sales, but 1980 is probably not a fair comparison because of the severe depression in the forest products industry. overall, the pulp and paper sector generally performs as well as the rest of the economy, while solid wood products are subject to wide variations due to their close ties to residential construction.

The performance of any industry—its growth rate, financial performance, ability to innovate, and record in entering new markets and controlling old ones—is related to its structure. Several key structural features appear to affect the performance of the forest products industry, including the degree of competition within in the industry, landownership, product mix, diversification, and sensitivity to economic changes.

Degree of Competition

Industrial structure is commonly thought of in terms of the degree of competition within the industry. An industry is described as "competitive" at one extreme if no firm holds a significant proportion of market power and "monopolistic" at the other extreme if one firm controls the whole industry. While there are probably no industries at either extreme, the forest products industry is generally considered fairly competitive. In 1978, the top four forest products firms accounted for almost 15 percent of all wood-based sales, and the top nine accounted for 22 percent of industry sales. 40

The lumber and panel products sector is commonly described as one of the Nation's most competitive, with over 30,000 companies, while the pulp and paper products sector, with almost 4,000 companies, is less fragmented,

In reality, however, the picture is more complicated than the number of companies alone would indicate, The lumber industry, the most competitive component of the lumber and panel products sector, counts over 8,000 establishments, 80 percent of which employ fewer than 21 people. However, 50 percent of

[39] Peter Gwynne, "Adhesives: Bound for Boundless Growth, " *Technology,* January / February 1982.

[40] Jay O'L$_{aug}$h] in, and Paul V. Ellefson, "U.S. Wood-Based Industry Structure: Part l—Top 40 Companies, " *Forest Products Journal,* October 1981, p.56.

the total domestic lumber output is produced by 10 percent of the mills.[41]

There are fewer mills in the panel products industry—232 softwood veneer and plywood mills, 366 hardwood plywood and veneer mills, and 68 particleboard mills, employing about 77,000 people. Whether or not the panel products industry as a whole is more or less competitive than the lumber industry is unknown,

The pulp and paper sector is less competitive than any major part of the lumber and panel products sector. There are over 4,000 pulp and paper establishments, but the 10 largest firms account for over half the pulp, paper, and paperboard products manufactured in the United States.[42]

Forest Land Ownership

The fastest growing companies in the forest products industry often own substantial timber acreage.[43] In 1977, the industry owned about 14 percent "of all commercial forestland or 69 million acres.[44] The top 40 firms accounted for 80 percent of this acreage. The same firms accounted for 40 percent of all domestic wood-based sales in 1978.[45]

Wood is a major portion of the production cost of lumber, plywood, and paper. Timber is estimated to account for 72 percent of the cost of manufacturing lumber, 46 percent of the cost of making plywood, 30 percent of the cost of making linerboard, and 18 percent of the cost of manufacturing white papers.[46] Timber costs have stimulated the many dominant forest products firms to maintain fee simple ownership of land, usually near company mills.[47] Fee simple ownership gives a company a strong bargaining position with neighboring private nonindustrial timber owners as well as a source of less expensive timber when stumpage prices increase. This may serve as a "yardstick" for establishing the local price of timber.

While forest land ownership may be a wise business strategy for forest products firms, it can cause local problems. In some southern communities, timber industry land "banking" may affect the availability of land for community development, housing, and other purposes.[48]

Access to high-quality timber has figured prominently in the performance of the forest products industry. Since colonial times, industry concentration has shifted from the Northeast, through the Great Lakes States and the South, across the Rockies, and to the west coast to harvest available mature, high-quality timber and is continuing to shift back to the South to take advantage of low-cost, fast-growing softwood stumpage. Expansion of the industry to the Great Lakes and the Northeast may be expected in the next several decades to utilize the large inventories of hardwoods growing in those regions.

Product Mix and Diversification

Product diversification is another factor that may be important to the growth of forest products firms. The largest firms tend to produce both pulp and paper and solid wood products. Only 12 of the largest 40 companies specialize in one or the other. Smaller firms often specialize in particular items.

Diversification outside the industry, however, appears to offer no particular advantage.[49] During the past 30 years, a number of energy, packaging, and conglomerate firms have entered the forest products industry to diversify their operations. The financial performance of

[41] U.S. Congress, office of Technology Assessment, Current *and Future Uses of Wood, vol.* II *1983,* draft.
[42] Ibid.
[43] Thomas P. Clephane and Jeanne Carroll, *Timber Ownership, Valuation, and Consumption Analysis for 87 Forest Products, Paper, and Diversified Companies (New* York: Morgan Stanley Investment Research, 1980), p. 4.
[44] *An Analysis of the Timber Situation,* op. *cit.,* p. 149.
[45] O'Laughlin and Ellefson, "U.S. Wood-Based Industry Structure, " op. cit., p. 56.
[46] Clephane and Carroll, *Timber Ownership, Valuation, and Consumption Analysis,* op. cit., pp. 3-4.
[47] 1 bid., pp. 58-93.
[48] Jean S. Moorefield, *Draft—Forest Products Industry: Socio-economic Issues Related to Industry Expansion,* contract report to the U.S. Congress, Office of Technology Assessment, 1982, p. 14.
[49] Jay O'Laughlin and Paul V, Ellefson, New *Diversified Entrants Among U.S. Wood-Based Companies: A Study of Economic Structure and Corporate Strategy,* Station Bulletin 541, Forestry Series 37 (St. Paul, Minn.: University of Minnesota Agricultural Experiment Station, 1982), p. 25.

these diversified companies in terms of stock performance, growth, and profit is not clearly better or worse than the performance of companies whose major line of business is wood-based.

Sensitivity to Economic Activity

There are major differences in how the solid wood products and the pulp and paper sectors respond to economic conditions. Because pulp and paper firms make a variety of products for a diverse mix of end uses, their growth pattern follows that of the general economy.[50] Such is not the case for solid wood products companies. Nearly half of the lumber and panels produced are used in new residential construction. The homebuilding industry, in turn, maybe the most volatile and unstable industry in the United States, as it is extremely sensitive to a number of economic and financial variables.[51] Thus, the solid wood products sector is also volatile, which may explain why the dominant firms often make a mix of paper and solid wood products rather than rely exclusively on one product line.

Innovation

The forest products industry has a modest record in developing new products and entering new markets. It devotes most of its research and development effort to internal process innovation,

Three components of the lumber and panel products sector are among the 45 rapid growth industries whose compound annual growth rates were between 6 and 20 percent during the period from 1972 to 1978. These components included wood pallets and skids, wood kitchen cabinets, and structural wood members (e.g., laminated beams and arches). Most rapid-growth industries attribute their success to new product development, but this does not appear to be true for the forest products industry. Historically, new products from the forest products industry have replaced established wood products rather than other materials, and many markets formerly dominated by wood products have been eroded by nonwood materials.

Reliable figures on the level of effort and type of research supported by the forest products industry are unavailable (see p. _____ for discussion of research and development). It is unusual for mature industries like the forest products industry to be dynamic and innovative, The industry is primarily "resource" oriented. Therefore, innovation seems to be generally confined to exploring new uses for wood rather than how wood might be used in conjunction with other materials.

Regional Distribution

Primary wood processing facilities generally are found where raw materials are most plentiful—on the Pacific coast and in the South. Lumber and plywood panels usually are manufactured in the Pacific Northwest and the South, and nonplywood panel products manufacture is concentrated in the Great Lakes States and the Northeast. Most pulp and paper manufacturing occurs in the South, and secondary paper products are made mainly in the Northeast, both near the largest markets. Location of secondary manufacturing facilities also depends on transportation costs and other factors,

Lumber

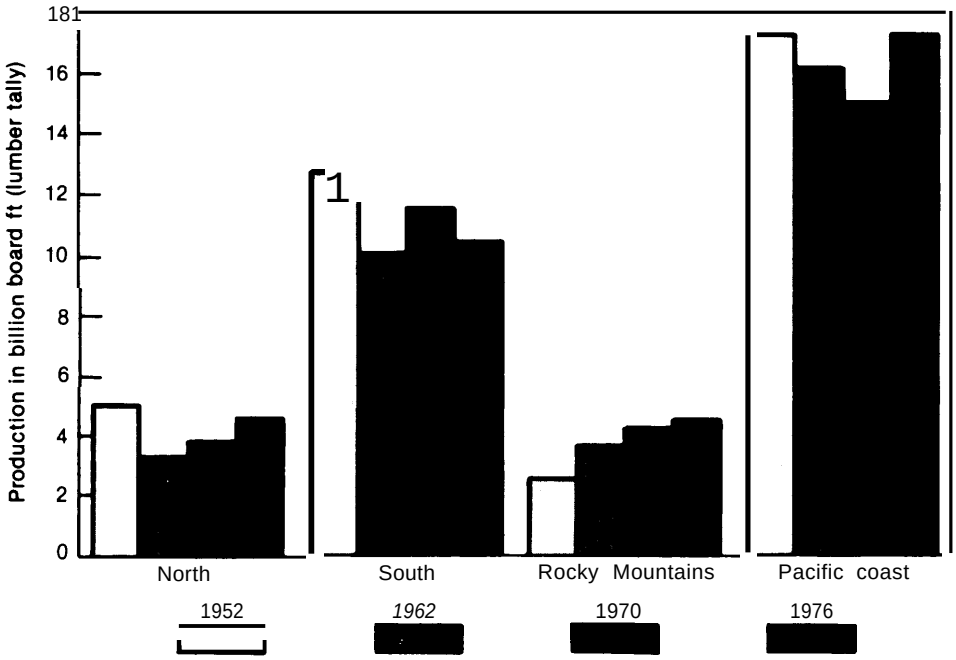
Ninety-four percent of 1umber is produced in the South and the West, where high-quality softwoods are abundant. There are more mills in the South, but Western mills are generally larger and produce over two-thirds of the total U.S. lumber output. The North and East produce only 6 percent of the total U.S. lumber output (fig, 16).

Plywood and Other Panels

The plywood industry requires high-quality softwood logs, and therefore it too is located primarily in the South and West. Plywood panel production, now about evenly divided between the South and Pacific coast, has been growing rapidly in the South since the early

[50] *1982 U.S. Industrial Outlook*, op. cit., p. 39.
[51] Kidder, Peabody & Co., *Forest Products Industry*, pp. 5-13.

Figure 16.–U.S. Lumber Production by Region, 1952-76



SOURCE: U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States 1952-2030,* Forest Resource Report No. 23 (Washington, DC.: U.S. Government Printing Office, 1982), p, 220.

1960's (fig. 17). In 1979, the Pacific coast produced nearly 47 percent of all U.S. plywood panels, the South 42 percent, and the Rocky Mountain States the remainder.

Plywood accounts for about 96 percent of all panel production. Most of the expansion in the panel products industry, however, is in nonplywood, unveneered panels like waferboard and oriented strand board. Manufacturing capacity for these products is in the North Central and Northeastern States and future growth is expected to center there.

Pulp and Paper

Over half of America's pulp and paper manufacturing capacity is concentrated in the South, whose share of total pulp production was 48 percent in 1947 but grew to 69 percent by 1976. The West produced 17 percent of the Nation's pulp in 1976; the remaining 14 percent came from the East and North Central areas .52

[52]Joan E. Huber, *The Kline Guide to the paper Industry* (Fairfield, N. J.: Charles H. Kline & Co., 1980), pp. 39-40.

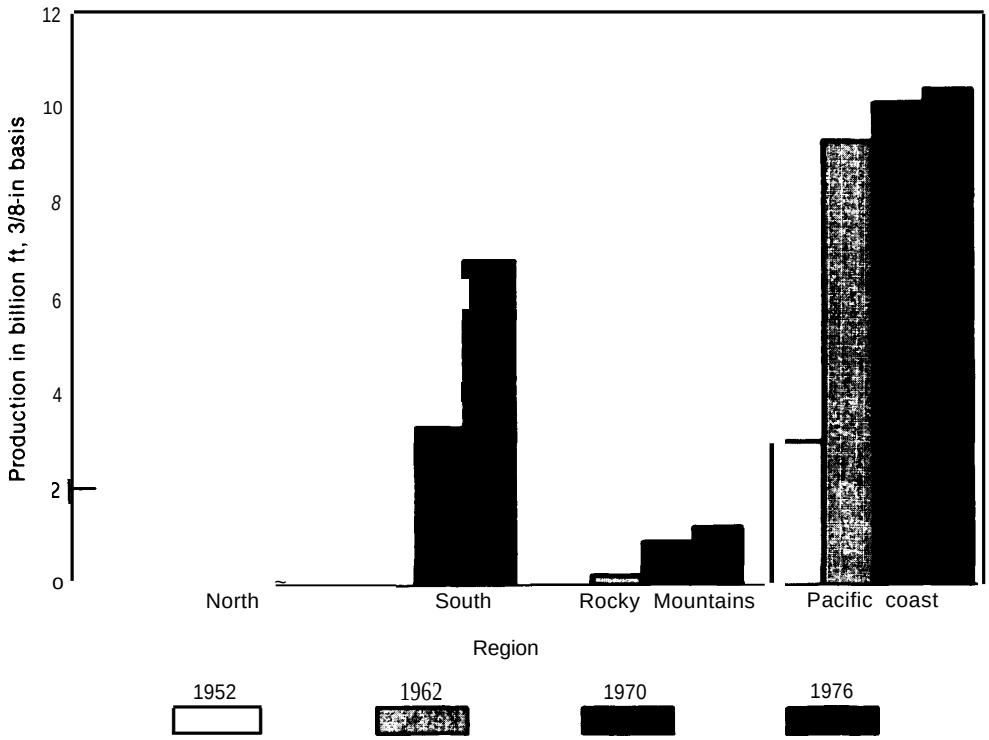
Sixty-two percent of the secondary manufacturing capacity of the paper industry, which makes containers, bags, sanitary products, and stationery, is located near major markets in the New England, North Central, and Middle Atlantic regions.

Wood Fuel

Reliable data is not available on wood fuel producers, but their locations may be inferred from patterns of consumption. Since the low value of wood fuel does not encourage long-distance transport, production generally takes place close to consumers.

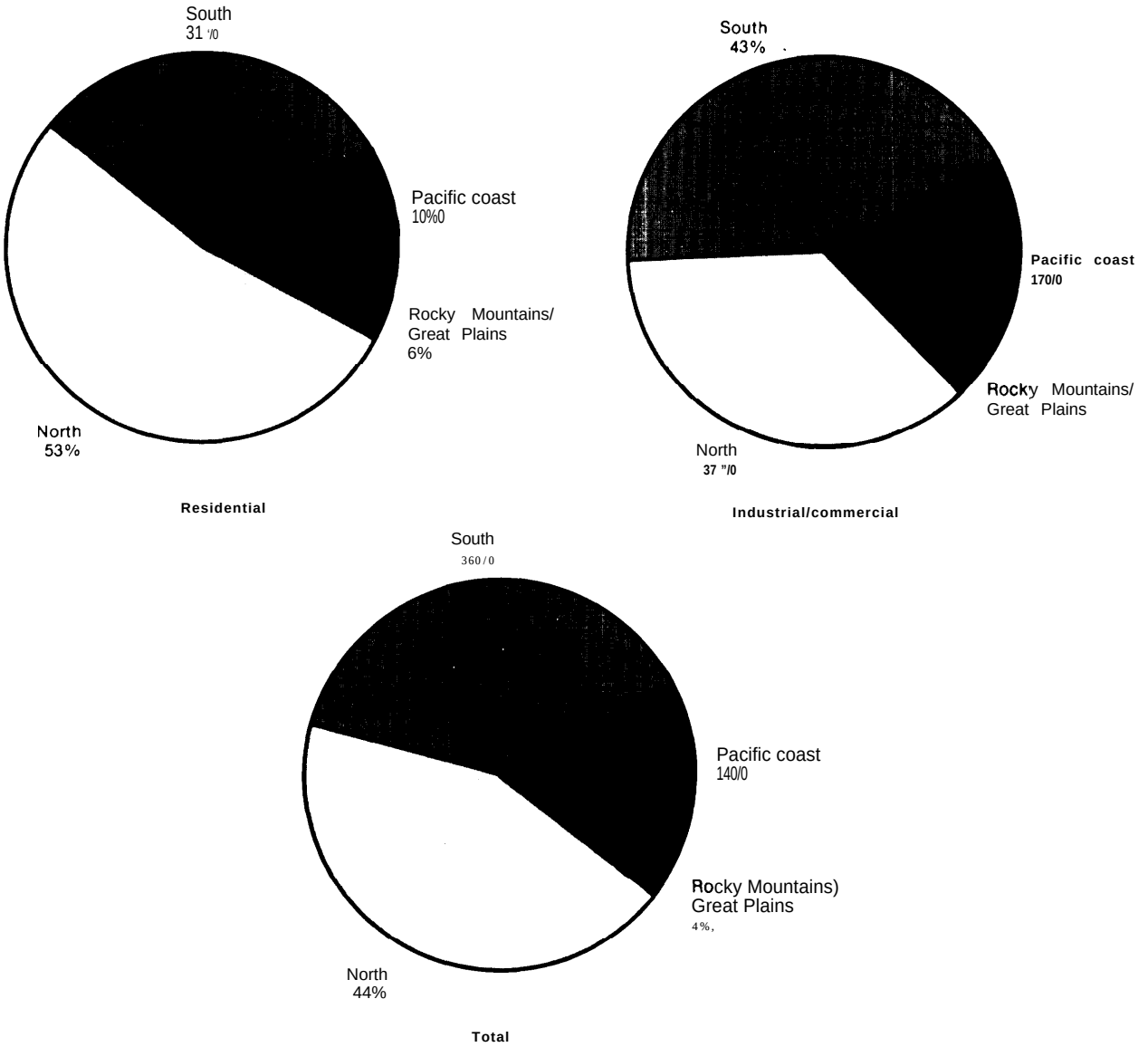
The North and South are by far the leading consumers of wood fuel (fig. 18), with residential and industrial/commercial use at its greatest in these regions. High levels of home fuelwood consumption in the North probably reflects the abundance there of inexpensive low-quality fuelwood used for heating, and in the South they reflect the paper industry's burning of wood waste to power its mills.

Figure 17.–Softwood Plywood Production by Region, 1952-76



SOURCE U.S. Department of Agriculture. Forest Service. *An Analysis of the Timber Situation in the United States 1952-2030,* Forest Resource Report No. 23 (Washington, D.C.: U.S. Government Printing Office, 19S2), p. 222

Figure 18.— Regional Wood Fuel Consumption in 1981



SOURCE: Energy Information Administration, U.S. Department of Energy, *Estimates of U S. Wood Energy Consumption From 1959 to 1981*, DOE/EIA-03, Dist. Cat UC-13 (Washington, D.C.: U.S. Government Printing Office, 19S2).