

WOOD USE AND TRADE

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Introduction

Wood is a natural product of the growth of trees. It is primarily composed of hollow, elongated, spindle-shaped cells that are arranged more or less parallel to each other in the direction of the tree trunk. This makes wood basically fibrous in nature. The characteristics of these fibrous cells and their arrangement in the tree strongly affect wood's physical and mechanical properties, as well as its grain patterns and workability. In its thousands of years of use, these properties have become familiar, but not well understood. They are becoming understood as a result of research during the past century.

Humans throughout history have used wood. The *International Book of Wood* records that "Man has no older or deeper debt than that owed to trees and their wood." The Bible notes that Noah built the ark from gopher wood, the first Ark of the Covenant was made from acacia wood, and the cedars of Lebanon formed Solomon's temple. Today wood is still a primary building material and fills many specialized needs in industrial and consumer use as well as in scientific and military applications.

Historical Overview

Wood has been one of humankind's most important raw materials for at least a hundred thousand years, for building and manufacture of tools, weapons, furniture, and other commodities of daily life. Wood was used early in human existence because it was available, had many useful properties, and no elaborate tools were needed to work it. However, in the early days the characteristics of the wood, rather than the tools available, were primarily responsible for the quality of products made from

it. By 5000 BC copper tools began to be available and made possible improved craftsmanship, which is evident in some surviving relics of the time. By about 2600 BC wood was being used for coffer and chests for storage of precious possessions. The first coopering to make barrels was evident in records from about 2800 BC. Wood use and wood craftsmanship continued to develop over the years. Where wood was readily available, it was used widely for materials of industry, war, transportation, construction, and daily life.

Through the eighteenth century in Europe, wood was the principal material for construction of buildings and for tools, machines, vehicles, buckets, furniture, and barrels, plus many other articles of defense, transportation, and daily life. Wood was a basic material of the Industrial Revolution. The first printing press was made with wooden type in Germany in about 1450, although the Chinese are reported to have used woodblock printing about 700 years earlier than that. From its initiation in Germany, the printing press spread rapidly through Europe and continued to use wooden type for a hundred years. Most of the machines and inventions essential to establishing the machine age were developed in wood. Wood played a dominant role in industrial operations. About the sixteenth century in Europe, ready availability of wood began to diminish due to heavy demand for both fuel and materials and expansion of agriculture to feed the increasing population, which removed much of the land base for growing wood. In North America, wood use reached a plateau during the middle to late nineteenth century. Seemingly inexhaustible forests and other material resources were exploited to feed rapidly growing economic needs. Railroads, telegraph lines, steel mills, and other industries consumed wood at a rapidly increasing rate.

Wood in Construction

Wood has been, and still is, a particularly versatile and useful building material in its many forms and adaptations. Until the relatively recent development of metallic and plastic structural materials, it was the only material from which complete structural

frameworks could be built. Wood structures built at various times and places have reflected the kind and quality of timber available and the culture and way of life of the people concerned. In earliest times, pole structures were built from small trees growing along the rivers. The techniques used by these early humans have been carried down over the ages and are very similar to those used by nomadic peoples today. However, the ability to erect permanent structures has been basic to most significant developments in the use of wood building materials. In zones that were well forested with plentiful timber, structures were built using solid walls of tree trunks or heavy planks. In other areas, wood has been used in more refined ways using careful design and engineering.

Europe

In Neolithic Europe walls of timber houses were frequently made of split trunks set vertically in or on the ground or on a bottom sill plate. Examples excavated from moor settlements in Germany demonstrated this type of construction. The mortise-and-tenon type of construction using heavy beams began early in history and continued through the Iron Age up to Norman times. A Viking fortress built in Denmark in about AD 1000 had this kind of construction, as did stave churches built during that century. Later construction used similar principles but employed vertical squared lumbers or sawed planks. Early French settlers along the Mississippi River brought this palisade type of house construction to North America. Construction in wood during the eleventh to the fourteenth centuries in Europe took advantage of Gothic construction, a concept in which the roof timbers formed an integral part of the frame and the principal framing members were typically large and heavy. This type of construction persisted until the seventeenth century in Europe but variations of it were used in America even into the nineteenth century.

North America

Wood construction has had an interesting evolution in North America because of the relatively abundant timber resource and the scattered development of much of the country. Native Indians in the forested areas of eastern and northwestern America built homes and community houses from indigenous woods. In the eastern United States these structures were commonly made of poles covered with bark and palisades of vertical logs were used for protection. The Indians along the northern Pacific Coast built houses from planks of split cedar or redwood and even had gabled roofs and decorative carving. In

some of the sparsely forested areas of the Great Plains and western mountains, Indians built frames of timber and covered them with earth to make strong, permanent dwellings. The architectural designs used by early American colonists were based very much on those of their homelands adapted to the climatic and cultural differences of the colonies. The log cabin, which had been used for almost 3000 years in Europe, was introduced into North America by Scandinavian immigrants in the seventeenth century and was adopted in the eighteenth century by Scottish-Irish immigrants. In the far northwest, explorers and settlers from Russia moved south from Alaska and built houses, forts, and churches of log cabin type construction.

New England immigrants from England during the seventeenth and eighteenth centuries built their dwellings by following the pattern of the English timber-frame house with wattle daub or brick between the framing members. The classical 'salt box' type of house evolved from adaptations of that pattern to provide more protection against the severe weather. Exteriors of brick or stone were more likely to be used on houses in the middle Atlantic and southern states, but they had elaborately decorated interiors. The fact that in the colonial days timber was readily available for building led to the preference for detached or free-standing homes, as compared with the typical row house in much of Europe and other parts of the world.

Public buildings of North America followed similar trends in the eighteenth century. Churches were made, simply or ornately, of wood using many of these types of construction. Many of the public buildings in eastern America were made of both wood and brick in ways that took advantage of the good features of both materials. Wood is still the principal construction material for housing in North America and in Scandinavia and other parts of the world where timber supplies are plentiful and the tradition of wood construction remains strong. Until well into the nineteenth century, this was true also of building construction other than housing. Problems of fire and the need for high-rise buildings to conserve land space have contributed to the demise of wood frame construction in the centers of large cities.

A concept gaining increased attention is reuse of construction wood as buildings are removed or reconstructed. Under some social and economic conditions, this may provide an additional source of wood materials. Research is providing information on properties of such wood. That is being carried forward into grading systems that provide information on the suitability of reuse of deconstruction wood under specified conditions.

Wood for Weapons and Tools

Wood was a key material for building the weapons, equipment, and tools needed for military, industrial, and domestic use from ancient well through medieval times. Military devices, such as the battering ram, the scaling ladder, and the catapult were made of wood and much attention was given to their effective design. The reason for this widespread use of wood was its high strength to weight ratio, which made it valuable for many structural applications just as it is now. One of the oldest weapons recovered is the pointed end of a spear made of yew from the Lower Paleolithic era found waterlogged in an English bog. New techniques for working wood led to much more efficient use of wood in a variety of materials for tools and military supplies as well as for daily living. In the Neolithic era, about 2000 BC, improved tools were developed and have been found in the records of those times. The lathe was used from the Mediterranean area to northern Europe by about 1500 BC. By about 700 BC the plow made of wood was in common use. Early efforts to make weapons and tools from wood began the concept of selecting particular woods for specific uses depending on their properties and performance characteristics. Early selection was based on experience but observation of performance led to more effective use of wood for both weapons and tools of many kinds.

Wood for Transport

Wood has played an important role in the transportation of people and products for thousands of years. This has been both as a material for constructing vehicles and as a fuel for driving them.

Land Vehicles

In northern Europe as far back as 7000 BC sledges made of wood were used for transport. These were for heavy loads such as stones; archeologists believe that the massive stones of Stonehenge must have been moved on wood sledges placed on rollers. From the roller developed the concept of wheels. Pictures of wheels date from 3500 BC and wheeled vehicles have been found in tombs dating from 3000 to 2000 BC. The spoked wheel is a development of medieval times and in classical Greece both the spoked wooden wheel and a three-part solid wooden wheel were in common use. Solid wheels of plank were used on farm carts, and wheels with 10 to 14 spokes have been found in Roman forts of northern England of that period. Inserting rods of wood into grooves and placing them so that they would turn between the hub and the axle made the first roller bearings.

Railroads and Roads

Railroads well into the nineteenth century, the early twentieth century, and to some extent even today use wood for tracks, sleepers, bridges, trestles, tunnel linings, sheds, and stations. Through the nineteenth century wood was also heavily used for fuel. Nineteenth-century public transport in cities was mostly of wood vehicles including horse cars, electric trolleys, cable cars, carriages, and buggies. During the period from about 1820 to 1860 in America, roads made of planks laid across parallel rows of timbers imbedded in the earth were widely used. When they were in good condition, these were the best roads in the country and more than 3000 km of such roads were built in the middle years of the century. However, they were excessively expensive to maintain and they gradually disappeared from use.

Bridges

Before effective wood preservation systems were developed, wood bridges were built with advanced design concepts, and covered bridges were common in North America and parts of Europe. Walls and roofs were designed to protect the wood framework of the bridge from deterioration. Covered bridges were gradually replaced as new techniques of wood preservation provided more economical means of protection and as iron, steel, and concrete became more common materials for bridge construction. A resurgence of timber use in bridge construction occurred in late twentieth century and continues as the technology of bridge design and protection is developed and as the economy and environmental soundness of such structures is recognized.

Water Transport

One of the first uses for wood for water transport was probably a raft or hollowed-out log. The Egyptians had made boats of reeds by about 4000 BC and the earliest wooden ships copied the form of these reed boats. As cedar was imported from Lebanon, larger ships were built in Egypt. The barge built for Queen Hatshepsut in 1500 BC to transport granite obelisks from Aswan to Thebes had a displacement of some 6800 tons and needed 30 oar-powered tugs to tow it. Theophrastus, a pupil of Aristotle, was one of the earliest students of wood and published information on wood structure and properties. He also was involved with shipbuilding woods in ancient Greece. He noted that they were silver fir, fir, and cedar – silver fir for light strong construction and fir for decay resistance and cedar in Syria and Phoenicia because of lack of fir.

The Phoenicians had large galleys with two banks of oars, called biremes. With these they dominated trade in the Mediterranean for a thousand years before the time of Christ. The Vikings had wooden ships that were at least 25 m long. Design of wooden ships evolved over the years up to the nineteenth century, by which time paddlewheel steamboats were cruising the major rivers of the United States and consuming large quantities of wood fuel in the process. American clipper ships built of wood were the fastest seagoing ships of the late nineteenth century. The sleek shape and large expanse of sail enabled them to reach speeds of over 30 km per hour. However, by the 1880s iron steamships dominated the fleets of most naval powers and the economics of the use of wooden ships became unfavorable.

Shipping Containers and Pallets

Wood has provided containers for the world's goods for hundreds of years, its economy, availability and natural strength facilitating its use for chests, boxes, and crates. The engineering design of boxes and crates was greatly accelerated by wartime needs to ship material securely. This was particularly accelerated during the two world wars of the twentieth century, in which long-distance shipping of material became essential. During World War II design of wooden containers was further advanced, but research led also to substantial improvement in the design and use of corrugated fiberboard containers. Such containers were made weather resistant and highly resistant to the rigors of shipping. The economy and convenience of such containers contributed strongly to the decline of wooden containers, a decline that still continues.

The middle of the twentieth century saw the emergence of wooden shipping pallets for transporting goods of all kinds. As the need arose for efficient bulk shipment of corrugated containers, and as forklifts became available, shippers turned to pallets as a means of consolidating containers to expedite such shipments. Many manufacturers who had been making wooden boxes turned to making pallets, and many new pallet companies emerged as the pallet industry began to grow in the latter half of the twentieth century. This growth began in the United States and by the end of the century had grown to the point where pallets were the primary use for much hardwood lumber, especially the lower grades. Pallet production in America has grown from 25 million units per year in the 1950s to over 500 million in the late 1990s. Production of new pallets is supplemented by their repair and reuse. It is estimated also that about 71% of these are made from recycled lumber

or other recycled material. As the forklift truck became available around the world, use of wooden pallets has followed and international trade in pallet lumber and pallets expanded using both hardwoods and softwoods.

Aircraft

Use of wood in aircraft is a relatively modern concept, though wood has been used in aircraft construction since the beginning of aviation. This reached a peak during the early and mid twentieth century in World Wars I and II. Although many woods have been used, Sitka spruce has been favored because of its high strength to weight ratio and ready availability in large sizes as clear, straight-grained material. Aluminum alloys, steel, composites, and new materials have taken over the structural role in commercial and major military aircraft, but wood is still used extensively for light aircraft.

Wood for Furniture

Wooden furniture appears to have been developed first in Europe about 3000 BC. Its development related very closely to the development of tools for working the wood. Reeds and rushes had earlier been used for furniture and early wood furniture designs copied the style of that material. Well-refined woodworking was employed when copper tools became available. These made possible much more precise careful operation of material for furniture and much more refined furniture. Shortages of furniture wood, which was a commodity of some rarity in many parts of the world, led to the early improvements in economical wood use. Planks cut from the same log were laid side by side and carefully fitted together. Defects were cut out and replaced. Furniture and cabinet-making reached a high level of sophistication in several areas of Europe by the sixteenth century. New designs and styles were developed and executed by outstanding designers and furniture makers. New styles of furniture were developed in Italy, England, and France as the Renaissance led to the improvements available in the Middle Ages. The furniture and interior furnishings used in colonial America were first quite simple and usually homemade. However, the new world contained a rich array of woods suitable for and available for furniture and other similar uses. The highly skilled craftsmen who had served their apprenticeship came to America took advantages of the wood, and from their skills developed in Europe became designers and manufacturers of high-quality furniture in styles that were both excellent copies of the European styles and original designs conceived in America.

Wood Use Today

Wood production throughout the world has continued to increase over the years. In the latter half of the twentieth century, increasing from something over 2 billion m³ to nearly 3.5 billion m³ (Figure 1). There is a marked difference, however, in the nature of wood production in the developed world and that in the developing world (Figures 2 and 3). Forty-seven percent of the world's wood production is for industrial roundwood, the wood used for a wide variety of wood and paper products (Figure 2). Fifty-three percent is for wood fuel, primarily in the developing world (Figure 3).

Increasing amounts of the world's wood supply are from plantations, even though plantations occupy a very small proportion of the forest area. Forest plantations provide a critical substitute for wood supply from natural forests, for both industrial wood and fuelwood. Industrial wood plantations account for only about 3% of the world's forest area, but are estimated to supply about 35% of the world's roundwood. Furthermore, this proportion is increasing

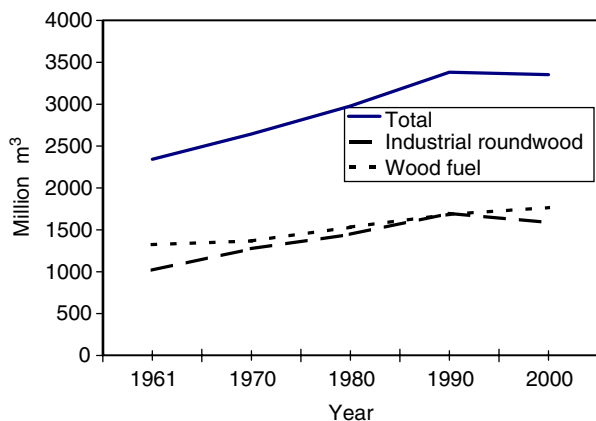


Figure 1 World wood production. Data from FAOSTAT Database 2002.

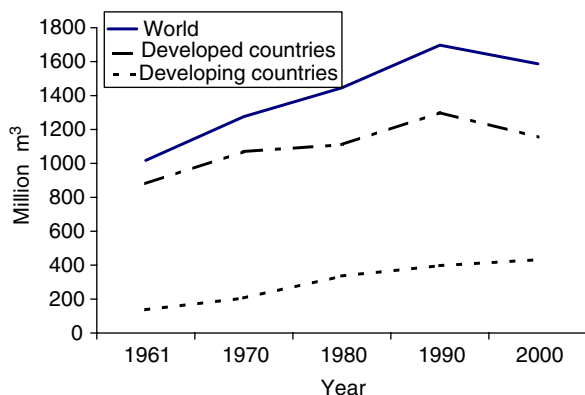


Figure 2 World industrial roundwood production. Data from FAOSTAT Database 2002.

steadily, supplying increasing quantities of wood that poses new challenges by having different working characteristics and physical and mechanical properties than wood from the natural forest.

Research and its prudent application in the industry are also making possible conservation of the timber supply in the natural forest by effective and economical use of a wide range of timber previously considered unsuitable or uneconomic for use. Wood plastic composites are a new development in wood product production. They represent a new blending of the wood industry and the plastics industry. A wide variety of wood plastic composites are entering the market, especially for products like decking. This product may be encouraged by environmental pressure on, and increasing cost of, wood preservation.

Wood industries are continually adapting to changes in raw materials, particularly those due to the increased supply of plantation wood and to the introduction of additional species into the supply chain. These adaptations are leading to increased emphasis on engineered wood products and new composites, some of which are taking markets formerly served by plywood and lumber. Improved technology and the reduced availability of some traditional forest-based raw materials have encouraged innovative ways of expanding the wood supply and effective use of residues and waste.

Assumptions of continued economic growth and its effect on wood use indicate that consumption of industrial wood products will continue to increase in the future. Economic studies forecast continuing expansion of gross domestic product and increased demand for wood products at national, regional, and global levels. Increased demand for wood fuel is not related in the same way to economic growth, but may be expected by the rapid increase in population of regions of the world where it is most common.

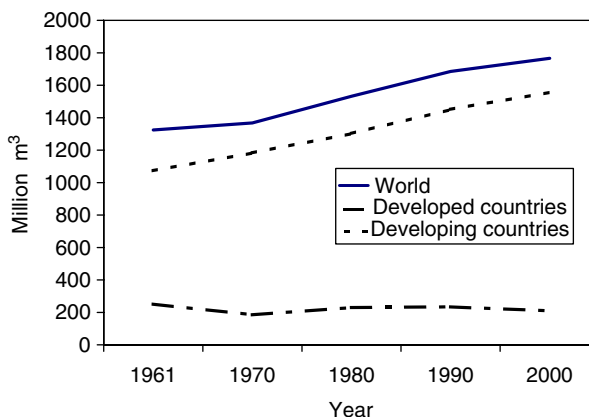


Figure 3 World wood fuel production. Data from FAOSTAT Database 2002.

Articles that follow in this section describe the current situation in wood use over a wide range of applications and employing much modern science and technology. New technologies have been developed to use the wood resource prudently to meet an increasing variety of consumer needs and provide dependable long-term service.

See also: **Solid Wood Products:** Construction; Logs, Poles, Piles, Sleepers (Crossties); Glued Structural Members; Lumber Production, Properties and Uses; Structural Use of Wood; Wood-based Composites and Panel Products. **Wood Formation and Properties:** Chemical Properties of Wood; Mechanical Properties of Wood; Physical Properties of Wood. **Wood Use and Trade:** Environmental Benefits of Wood as a Building Material.

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International Trade in Wood Products

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Global Forest Resources

The *Forest Resources Assessment* (2000 Summary Report) of the Food and Agricultural Organization (FAO) of the United Nations indicates that the

world's forests total 3.867 billion ha in 2000, or 29% of the world's land area. Of this, 47% are tropical forests, 9% subtropical, 11% temperate, and 33% boreal. Over the past half century the area of temperate and boreal forest has remained relatively stable, even modestly expanding in recent decades, while net deforestation occurred at a rate of 9 million ha annually during the 1990s, almost entirely in the tropical and subtropical forests.

Production and Consumption

The world requires approximately 1.5 billion m³ of harvested wood annually to produce the manufactured wood and paper products it consumes. The developed countries account for over 70% of industrial roundwood (log) production and nearly 75% of the wood and paper production consumed. The global value of primary forest products (wood, pulp, and paper) in 1999 are estimated by the FAO at approximately US\$750 billion, with about US\$350 billion for pulp, paper, and paperboard products and \$400 billion for solid wood products. Developed countries of the Organization for Economic Co-operation and Development (OECD) account for over 80% of this production. Tropical solid wood products, coming primarily from the developing world, are estimated at about US\$28 billion. Total international trade in forest products was estimated at about US\$135 billion in 1996 or roughly 18% of the total value of production.

The United States and Canada account for approximately 35% of global demand for wood and paper products and the European countries of the OECD account for about 25%. All developed countries account for about 75% of world consumption, while 25% is consumed by developing countries.

Table 1 presents the volume of timber harvest by major regions in a recent year while **Table 2** provides information on the value of exports, imports, and net forest product trade in a similar year. The high-harvest countries are almost all major forest-product exporters, although some, most notably the United States, are net importers due to very high demand levels. Thus, while we focus on the value of net forest products exports, this figure is also a good proxy for harvest levels.

Why Trade?

In general, forest products trade flows from countries with abundant forest resources to countries with more modest forest resources. However, raw forest resources are often transported to an intervening regional location for initial or subsequent processing.