WOOD IN AMERICAN LIFE

U.S. Department of Agriculture
Forest Products Laboratory

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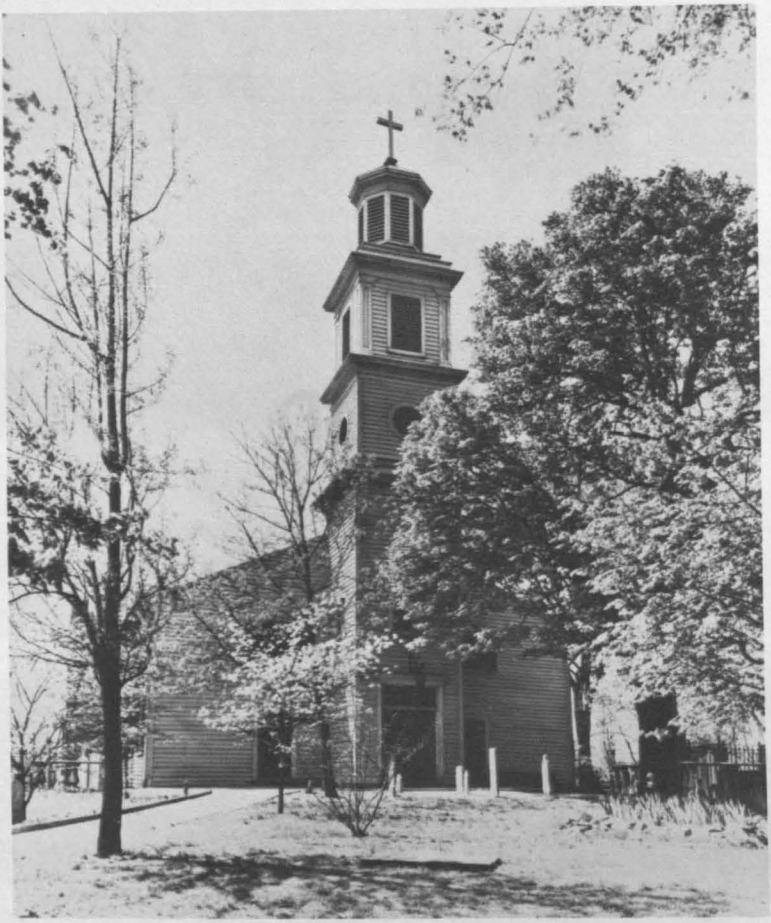

White clapboard Saint Johns Church, Richmond, Virginia, where Patrick Henry addressed the Second Virginia Convention and concluded: "I know not what course others may take; but as for me, give me liberty or give me death." (Photo ca. 1920. Courtesy Valentine Museum, Richmond Va.)

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Foreword

The causes leading to the revolt of the American colonists against Great Britain 200 years ago were many. The spark that ignited the inevitable conflict might well be credited to the fiery patriot Patrick Henry. On March 23, 1775, Henry addressed the Second Virginia Convention in the white clapboard Saint John's Church in Richmond, Virginia, and concluded with the unforgettable, "I know not what course others may take; but as for me, give me liberty or give me death." Two men in the audience--George Washington and Thomas Jefferson--were to be instrumental in founding the United States.

Earlier in his speech Patrick Henry had made a statement also of great significance then but one that is even more significant today: "We are not weak if we make proper use of those means which the God of nature hath placed in our power."

Today, what Patrick Henry meant by "those means" is only conjecture. Uppermost in his mind must have been the indomitable spirit of the colonists determined to be independent and free. Certainly Henry could not have been thinking of a well-trained and well-equipped army and navy, but of the available natural resources that make an effective fighting force possible. This must have crossed his mind as part of "those means." A most readily available and important resource for both the military and the civilian populations, as Patrick Henry knew, was wood. It was used for ship-building, wagons, barracks, fortifications, homebuilding, fuel; verily, a multitude of purposes.

This story traces the use of the still important wood resource that "the God of nature hath placed in our power." The changes and developments in wood usage are a little-known but an important part of U.S. history. Therefore, wood usage through four periods of U.S. history is presented.

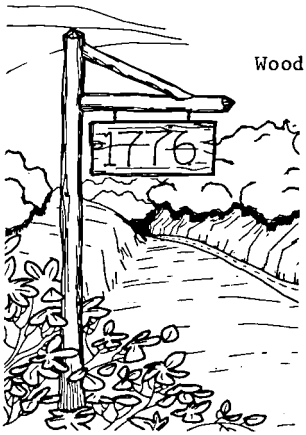
For obvious reasons in this Bicentennial Year, the periods of 1776 and 1976 were chosen. Inclusion of the 1876 period was a somewhat arbitrary choice, but fortunate. By 1876, the United States had determined by a bloody struggle that it would go forward as one nation. The Industrial Revolution was at hand, and the first public concerns for the conservation of national resources were being heard.

The story of wood that emerges is many faceted--from wanton waste to wise use. As research findings and improved equipment became available, a gradual improvement in use was evident. Each use must be evaluated for "wise" use on the basis of the social, political, and economic conditions existing at a particular time. Readily apparent, however, is the fact that the practices of the past and the present will not meet the needs of the future.

The period of 2076 is included for the specific purpose of focusing attention on the steps that must be taken to insure the United States an adequate supply of wood for the future.

The 1776 and 1876 sections were written by Lawrence S. Klepp, a freelance writer. Most of the source material for the two sections is from the library of the State Historical Society of Wisconsin, Madison.

The 1976 section was written by Lawrence S. Klepp, Dr. Herbert O. Fleischer, and W. G. Youngquist using in part source material supplied by the following staff members of the U.S. Forest Products Laboratory: Lida W. McBeath, Andrew J. Baker, James F. Laundrie, Gunard Hans, Roger L. Tuomi, Lee R. Gjovik, Erwin H. Bulgrin, Dr. Robert H. Gillespie, J. Dobbin McNatt, Alan D. Freas, Donald J. Fahey, Fred Werren, George A. McSwain, Dr. Harold Tarkow, Thomas H. Ellis, John W. Koning, Dr. Jerome F. Saeman; and by Dr. John N. McGovern, Department of Forestry, University of Wisconsin-Madison. Dr. Fleischer served as Director of the Forest Products Laboratory until his retirement, July 1975; W. G. Youngquist, as Assistant to the Director until his retirement, December 1974. The 2076 section was written by Dr. Fleischer and W. G. Youngquist. Sketches are by Jay Faber, a student in landscape architecture at the University of Wisconsin-Madison. Overall supervision and guidance were provided by W. G. Youngquist. Lida W. McBeath served as editor.



SECTION ONE

Wood in the New Nation

Even with the help of the Bicentennial ceremonies, Americans of today do not find it easy to imagine their country as it was 200 years ago. A visitor to the Thirteen Original States when they were declaring their independence would have discovered a sparsely populated, mostly rural nation, with the wilderness never far away.

In 1776, nine out of ten Americans lived in the country. The largest city, Philadelphia, had a population of only 34,000; New York, 22,000; and Boston, 15,000. About 2-1/2 million Americans were scattered along the Eastern Seaboard from Maine to the border of Florida. In the North, most Americans lived on compact, almost self-sufficient farms or in small villages. In the South, some lived on great plantations and produced tobacco and other staple crops; some lived on small farms.

The towns, both North and South, were prosperous and to a large extent depended on the export and trade of agricultural commodities. However, the towns also served as centers for a variety of small industries and crafts.

Maritime industries were concentrated in New England; glassware factories, rum distilleries, iron foundries, sawmills, and other manufactures could be found throughout the states.

The population of both town and country was increasing rapidly. This was partly because of the large families standard at that time--an average of about eight children--and because of the waves of immigration from the Old World. Probably two-thirds of Americans in 1776, excluding native Indians, were immigrants or the children of immigrants. There were Germans and Scotch-Irish in Pennsylvania; Dutch in New York; English, Irish, Swedes, Scots, Swiss, and French scattered throughout the country; and African blacks, brought

by force as slaves, mostly in the South. All added ethnic differences to the geographical and religious differences that led the British government, among others, to assume that the states could not cooperate, let alone form a lasting union. Common opposition to the British and a growing sense of American identity did overcome differences between the states, but not without frequent difficulties.

In 1776, about a fourth of the population lived in the "back country" away from the older coastal settlements. The frontier society was a source of differences and was already contributing its distinctive social customs, dress, speech, and political interests to American life. Settlers were moving westward along the rivers. A few had crossed the Appalachian Mountains into the Ohio Valley, but the woods and prairies extending from the mountains west to the Mississippi were still mainly inhabited by Indian tribes and French fur trappers. Spain held the French-speaking town of New Orleans and the trans-Mississippi West.

In the Southwest there was a long-established Spanish-Indian culture, and Spanish religious orders were extending missions along the California coast. On the Great Plains, the Plains Indians were enjoying their Golden Age, using the descendants of Spanish horses to create a prosperous nomadic culture based on buffalo hunting.

Use and Abuse of Forests

The West in 1776 was almost uninterrupted wilderness. Even in most of the Thirteen Original States the dominant geographical feature was a dense wilderness of forest, not farmland. When the settlers arrived, the continuous eastern forest, extending from Maine to Florida and west to the Mississippi Valley, encompassed more than a million square miles.

For the European colonists from lands with only a few scattered woods left, the dark and impenetrable forest that crowded the seashore and harbored Indians and wild animals must have been an implacable, haunting presence. But they quickly took a practical view. In 1630 the Reverend Frances Higginson wrote:

> For Wood there is no better in the World... here being foure sorts of oke differeing in the leafe, timber, and colour, all excellent good. There is also good ash, elme, willow, birch, beech, saxafras,

> juniper, cipres, cedar, spruce, pine, firre, that will yeeld abundance of turpentine, pitch, tarre, masts, and other materials for building of ships and houses.[1]

From the time of the first settlers, trees were cut for ships and houses, but there were more trees than could be used. For the colonists the forest was as much an obstacle as a resource; it had to be cleared quickly for planting crops. Cutting trees was not only slow and laborious for large areas, it was dangerous and required expert felling to avoid accidents.

The settlers frequently adopted the Indian method of girdling trees, stripping a ring of bark from a tree. This killed the tree, literally "cut its throat!" Crops could be planted around the leafless trees; the timber would eventually rot and could be dragged away. In 1776 this practice was still common as testified by British officer Thomas Aubury. In his letters he describes vast fields full of great, dead trees, with large branches and whole trunks that continually fell to the ground with a horrible crash.[2]

A method of clearing still more wasteful and dangerous than girdling, also adopted from the Indians, was setting fires deliberately. Farmers would burn the forest not only to clear land, but simply to get rid of insects and animals or to encourage the growth of grass. Hunters left their campfires burning against trees. Pioneers in 1776 thought no more of burning a forest than of burning a weed patch. In 1762 a fire burned 50 miles from the White Mountains of New Hampshire to the Maine coast and consumed sawmills, farms, and cattle. Throughout the summer in the Virginia mountains there were numerous large fires mostly caused by teamsters who neglected to extinguish their campfires.

Americans are so well versed in conservation and the esthetic value of forests today that it is difficult to realize the antagonism with which most early Americans regarded the forest. Aside from being an obstacle to the farmer, the forest was associated with hostile Indians, dangerous animals, insects, and fevers. Except in parts of New England and in areas of Pennsylvania settled by Germans, a farmer often cut down every tree in sight of his cabin and left nary a one even for shade or decoration.

The practical implications of the waste were impatiently brushed aside. If the question of conservation was raised, the answer was the American forests were so vast, they were

inexhaustible. This was the myth of inexhaustibility. The myth, itself, proved to be almost inexhaustible. It is not surprising that it got started. Most colonists immigrated from the British Isles, where a few hundred acres of woods were a great forest; in America they found forests many times the size of England itself. These attitudes prevailed in 1776 and long afterward. Yet in some localities there were shortages of wood, and a few local conservation measures were taken. A few perceptive men could see the possibility of more serious shortages. Because wood was almost the only fuel and the main raw material of 18th century America, it was rapidly consumed even by the relatively small population.

In 1720, Daniel Neal, in his History of New England, estimated that 6 million [evidently lineal] feet of timber were cut each year in New England. Later in the century, Benjamin Rush, in a letter to Thomas Jefferson, wrote that 6,000 maple trees were destroyed in clearing the average New York or Pennsylvania farm. Much of this was for firewood. Coal was not yet mined in large quantities in America, and in 1776 the war cut off the small supply from England. The Franklin stove had only begun to be introduced into American homes. One of Ben Franklin's most valuable inventions, it heated a house much more efficiently than did the traditional large open fireplace; therefore, it consumed less wood. The New England home might burn from 20 to 60 cords of wood each year in its fireplace [one cord equals a stack of wood 4 ft wide, 8 ft long, and 4 ft high]. The citizens of Massachusetts, then, would have used more than 750,000 cords a year for firewood, mostly oak, ash, hickory, and hard maple.

In Rhode Island, all trees suitable for firewood had been cut by 1738; then wood had to be brought by boat from Long Island and elsewhere. There were no longer forests very close to any of the coastal cities to provide fuel, and the long transportation often drove the prices beyond what the poor could afford.

In New York, where more than 20,000 cords of wood were annually burned in fireplaces and stoves, a newspaper in 1761 called the situation alarming, and stated, "Wood grows scarcer and dearer every year, whilst the demand increases with the growth of the City."[3]

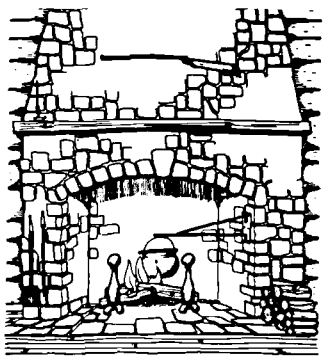
Boston obtained most of its firewood by boat from Penobscot, Maine, but also depended on wood that was brought overland by cart or sled. In both Boston and New York, peddlers from the country often fleeced city dwellers, and laws

were passed to regulate price and quality. In New York and Philadelphia, as prices rose, charitable organizations distributed firewood to the poor. This could be called America's first fuel crisis.

Plenty of forest remained, of course, but was increasingly remote and confined to areas not easily logged. By 1750, the forests in the major river valleys of the East were exhausted. Because of poor transportation, forests away from rivers or in mountainous country were practically inaccessible. Later, to be sure, these forests could be logged, and there was no impending danger of the absolute exhaustion of the eastern forest. However, for those who cared, the immediate situation had ominous aspects. In 1763, John Bartram, calling attention to the clearing of Pennsylvania lands "quite to the mountains," said, "What our people will do for fencing and firewood fifty years hence, I can't imagine."[4]

By the end of the 18th century, warnings multiplied. Fearing for the future of the American Navy, John Jay wrote to President Washington, "There is some reason to apprehend that masts and ship-timber will, as cultivation advances, become scarce, unless some measures be taken to prevent their waste, or provide for the preservation of a sufficient fund of both."[5]

In 1798, an article in the Weekly Magazine, "On the Importance of Preserving Our Forests," urged that setting fires be regulated by law, that forest preserves be established, that forests with esthetic as well as practical value be cared for along rights-of-way and in scenic areas. A German physician and forester, Johann David Schoepf, toured the country after the War of Independence, and summarized the situation acutely:



In America there is no sovereign right over forests and game, no forest service. Whoever holds new land . . . controls it as his exclusive possession . . . . It will not easily come about therefore that, as a strict statutory matter, farmers and landowners will be taught how to manage their forests so as to leave for their grandchildren a bit of wood over which to hang the tea-kettle. Experience and necessity must here take the place of magisterial provision.[6]

Experience and necessity, however, were slow in teaching conservation to a people under the spell of a myth of forest inexhaustibility. Some magisterial provision was necessary from the beginning. Unfortunately, it was often too little and too late.

The first conservation law in America was passed by Plymouth Colony in 1626. To prevent inconveniences that might befall a plantation by the want of timber, the sale or transport of timber out of the colony was prohibited without the approval of the governor and council. In several colonies a series of laws followed that regulated cutting and distributing timber. William Penn, in founding Pennsylvania in 1681, stipulated that 1 acre of forest be left for every 5 acres cleared, and that special care be taken to preserve oak.

The British government tried to impose laws preserving large white pines for shipmasts, but the laws were widely resented and flagrantly violated. To prevent erosion, Massachusetts tried to regulate cutting timber on beaches. Legislation regulating fires was common throughout the Colonies. In 1772, New York enacted a minimum cutting diameter to insure reforestation. But the laws were difficult to enforce, especially in the back country, where carelessness and hostility were the prevailing attitudes toward the forest. Nevertheless, the laws reflect an early awareness of a need for a conservation policy, an awareness that finally developed into the conservation movement and the improvements in forest management of the 19th and 20th centuries.

Lumbering in 1776

The prominence of the forest in early American life was shared by the lumber industry; it is appropriate that the word "lumber" was given its present meaning by Americans in the 17th century. In all new settlements, lumbering was on a small scale, and the methods were primitive. Because transportation was poor, early lumbering enterprises were small and dispersed, and supplied mainly local needs. The location of the lumber industry on a larger scale, as it developed into the most important colonial industry, depended on the presence of valuable timber and large streams. Whether large or small scale, the method of lumbering was much the same. Trees were felled with axes, stripped of branches, and cut into logs. Oxen hauled the logs on scoots, heavy sledlike vehicles, to a riverbank, where they were stacked in piles. When spring came, the logs were floated downstream to a sawmill.

Lumbering for export was concentrated in a few regions, especially New England, with its abundance of waterpower and its stands of white pine, which were excellent for shipmasts. The trees along the upper Hudson River provided New York with wood for housing and shipbuilding. Philadelphia was supplied with timber from the Delaware valley, and Pennsylvania oak was used for shipmasts and spars. The pine forests of the Carolinas and Georgia were chiefly exploited for naval stores—pitch, tar, and turpentine. By 1776, however, the southern live oak had been found unsurpassed for shipbuilding, which with lumbering spread southward.

The leading lumbering region in 1776 was Maine, which then was a part of Massachusetts. Lumbermen in the 18th century were a unique breed, as they have been since, known for their rugged, and sometimes pugnacious, individualism. Their rough-and-ready way of life was already part of American folklore. Maine lumbermen so much resented the British Broad Arrow policy, by which trees marked with an arrow were reserved for the Royal Navy and could not be cut, that timber may be included with "tea, taxes, and tyranny" as a cause of the American Revolution.

The feudal principle of the Royal forest, successive Acts of Parliament, and exasperated British forest surveyors did not impress the New England woodsmen. They did not appreciate seeing the best stands of white pine and oak set aside; they went right ahead and cut them in defiance of the law. Eventually, British attempts to enforce the law or to seize illegally cut timber were resisted with violence.

The first sea skirmish of the Revolution, called the Lexington of the Seas by James Fennimore Cooper, occurred off Machias, Maine, in May of 1775. The skirmish was over a shipment of pine lumber that townsmen prevented a British ship from commandeering. The ship was chased, captured, renamed Liberty, and decorated with evergreens. Since New England woodsmen were already fighting the British, they readily joined forces with the armed rebellion as it spread through the rest of the country.

The early resistance of the lumber regions cost the British their supply of masts. When the last American shipments were cut off in July 1775, the British neglected to revive their lapsed timber agreements with Sweden; they thought the Revolutionary War would be over quickly. However, the Royal Navy was in a state of disrepair toward the end of the War and failed to give its usual good performance against the French. This prevented the Royal Navy from effectively supporting British troops.

The earliest methods of cutting logs into planks were to split them with a tool called the froe or to saw them by a method called pit sawing. This sawing was frustrating, with one man in a pit, and another straddling the log, while working with a vertical saw.

The first power-driven sawmill in America was established in 1633, on the Falls of Piscataqua between Maine and New Hampshire. This was many years before sawmills appeared in England. Sawmills multiplied quickly along streams that could be used both for power and transport, and laid a basis for a large lumber industry and a rapid advance in wood construction.

The Dutch introduced windmills for power; windmills were still common in 1776, but the standard sawmill was operated by water power. The saw was attached to one end of a wooden beam that joined a crank on a water wheel; the log moved on a cogwheel-driven carriage (an American invention) against the saw. The wheels and the cogs were of wood, preferably hickory.

The early mills could saw more wood in an hour than 10 men could saw in a day. Soon multiple saws, or gangsaws, were added; some could cut 14 planks at a time. Sawmills were the vanguards of progress; towns frequently grew up around them. Sawmills were flourishing throughout the country in 1776 and produced planks, clapboards, shingles, staves, and shipbuilding parts.

Forest Products and Industries

In 1776 a number of important industries were closely related to lumbering: Manufacture of naval stores, charcoal, and potash; and the tanning industry. Naval stores include turpentine as well as pitch, tar, and resin. All were indispensable in shipyards for protecting surfaces and calking seams of wooden ships. The naval industry was spread all along the coast, but especially in the Carolinas and Georgia where southern pine provided an ideal source, was prevalent, and the harvesting season was long. Workers chipped a flat surface on the trunks and drew off the amber-colored resin from which turpentine was distilled. Tar was produced by melting the resinous juices from deadened wood and further heated to make pitch. A single cord of longleaf pine produced 40 or 50 gallons of tar.

Charcoal was a versatile substance in 1776. It was the fuel used in iron making and in glassmaking; it was also used to make gunpowder, printers' ink, and black paint; and it served as a filter to purify liquids, as a deodorizer, and as insulation for ice storage. In the home, the uses of charcoal were more surprising. It served as good toothpowder; a small dose, swallowed, was said to "settle the stomach."

Charcoal is produced by slowly burning wood with a restricted supply of air, which eliminates virtually all water and gases, leaving more or less pure carbon. In the 18th century the wood was burned in brick kilns or in earth-covered mounds with vents to control combustion. Constant attendance was required for weeks at a time, and occasionally emergency measures were undertaken to prevent explosion of gases.

The ashes of green sap-filled hardwoods provided potash and with further refinement a product called pearl ash. Both were needed as alkalis in the manufacture of soap and glass. The process was simple--the wood ash was boiled down into a thick brown salt. Thus, it was a common household industry, or else was carried on in village shops. It was a ready source of cash to the farmer clearing his land; either he could gather and sell ashes to the manufacturer or he could make the potash.

The farmer and his family derived many other homemade products from their woodlot. Maple sugaring was a major activity in late winter in the North, and innumerable medicinal concoctions were made from tree barks, roots, and leaves.

Sassafras had long been considered a sovereign remedy, and had been one of the reasons the English were eager to start productive colonies here. Sassafras leaves were boiled to make a spring tonic. Ground holly bark was used for relief of the ague; slippery elm, for sore throat. The twigs of black spruce were boiled and sweetened to make "spruce beer," rich in vitamin C, and so a cure for scurvy. Root beers and a tonic beer were made from birch sap.

Dyes were extracted from bark; deep brown from butternut, gold from tuliptree, yellow from birchbark oil, which also was made into a perfume. Red oak bark yielded a furniture stain. A farmer could count on finding the honey and wax left by bees in hollow trees; a very large hollow beech tree or a walnut tree might contain 200 pounds of clear honey.

Tanning, a major industry, was dependent on a supply of tree bark. Animal hides were soaked in a lye made from wood ash to remove the hair, placed in an astringent solution of tannic acid, or tannin, made from crushed oak or hemlock bark and water. The solution, absorbed by the hides, turned them into heavy, impermeable leather. Newly crushed bark would be added to the solution periodically, and the "spent" bark sold as fuel. The bark was provided by farmers or was a byproduct of lumbering. In some places, there were tanbark mills to grind the bark.

The vats, barrels, and most of the tools and machinery used in tanning were of wood; this was true for almost all industries of the time. Printing was on small hand presses; working parts were of iron, but the heavy frames were of wood.

A cider press was a wheel made of a thick oak plank that turned on a wooden axis drawn by a horse. A carpenter's braces were of wood except for an inset of metal to hold the bit. Planes were of wood except for the blade. Gristmills, rag-carpet machines, corn shellers, boring engines, cotton balers, and spinning and weaving equipment were made almost wholly of wood.

Firewood as well as charcoal was used as an industrial fuel. In the salt-boiling industry, which made salt out of seawater, it took a cord of wood to boil 11 bushels of salt out of the brine. From woodpiles to ball bearings (of close-grained hardwood), wood was an essential resource of 18th century industry.

Wood from Woodlots

The domestic life of Americans in 1776 most clearly and richly exemplifies the Age of Wood of that time. Most Americans 200 years ago, as has been noted, lived on a farm. A farmer was likely also to be a part-time lumberman, carpenter, cooper, and wood-carver. With the rapid growth in population, demand for wood products increased.

A farmer could obtain a steady income by chopping hardwood for charcoal kilns, firewood for villagers, and tunnel timbers for local mines. He cut timber when he had no other chores. The winter's major occupations were restocking the firewood supply and carving treen, the woodenware and implements a family used each day. Virtually every object on a farm and in a home was wholly or partly made of wood: House, barn, and outbuildings; fencing; vehicles; implements; tools; furniture; and utensils.

An average farmer may have been hostile to the forest before it had been cleared sufficiently for planting crops, but for the wood from his woodlot he had a sensitive and discriminating appreciation. It must have inspired a certain reverence as well. Wood was considered a substance with a soul, easily worked yet stronger by weight than iron, versatile and capable of great beauty, and full of its own character yet receptive to the character and purposes of a craftsman. Had wood not been so common, transformation of it into a whole world of objects, useful or beautiful but usually both, might have seemed miraculous. Undoubtedly, a farmer and his family felt for these objects--all made by hand, most often by his own, and each, therefore, unique--a sense of value and a familiarity and pride of possession that cannot be felt today for mass-produced goods.

A farmer, like a lumberman, depended on his ax for cutting wood, and learned to use it with considerable dexterity. Early settlers had found the European ax, almost unchanged since Roman times, too awkward to meet the challenge of American forests. By the 18th century, a new American ax had been developed. It was made heavier, with the handle set forward, so that it cut deeply and precisely with a graceful and balanced swing rather than a strenuous one. The long, thin handle was usually of ash or hickory. Every community had a craftsman who specialized in making ax handles; he designed them to have an individualized balance and feel that suited a particular owner. The American ax became a symbol of the free and resourceful spirit of the frontiersman.

Other axes and tools were available for working the felled timber: A pitching ax, a broadax, and an adz (a hoe-shaped ax) for trimming logs; a mortise ax and a post ax. With these and a crosscut saw, maul, and wedges, a farmer could undertake whatever construction was necessary. He could turn out his own shingles, planks, and staves, using a drawknife for tapering.

Log Cabins and Virginia Fences

A pioneer clearing a new farm in 1776 would likely build, first, a log cabin for the family home. Prominent as the log cabin is in American folklore, it was, in fact, imported from Europe. The Puritans in New England never lived in log cabins. At first they copied the Indians' U-shaped huts of bent saplings that were covered with thatch or bark. Sometimes they built over cavelike excavations in hillsides. But they quickly developed the New England saltbox, a wood-framed house with clapboard sheathing.

The standard log cabin was a traditional Scandinavian structure introduced by the Swedes on the Delaware River in 1638. It was not found elsewhere until after 1700, when Scotch-Irish immigrants began to copy it. Because it was easily built and repaired, warm, dry, durable, and bullet-proof, it was rapidly adopted as the ideal structure for the frontier. Not only houses, but churches, schools, and other public buildings were made of logs.

An average log cabin required about 80 logs, as well as smaller timbers to form gables and shakes--usually of pine or cypress--for the roof. If the floor was not simply packed dirt, it was made of puncheons, split logs flat-side up. A ceiling of clapboards formed a sleeping loft; a notched log served as a ladder. The door might be a single plank from a large tree or made of clapboard with leather or hickory hinges. The chimney would be cat and clay--heavy sticks embedded in clay or mortar. A mixture of moss, clay, sticks, and straw filled gaps in the logs. If there were windows, they would be sliding boards or crossbars with greased paper. Wooden pegs called treenails (pronounced "trunnels") held the roof structure together; the wall logs were notched. "Raising" a log cabin was often a community project, with the four best axmen stationed at the corners to do the notching. In the isolation of the wilderness, the log cabin could be put up by a man and his wife in a few days.

Furnishings were as simple as the house: A bedframe of poles attached to a wall, a split-slab table with legs set into the floor, three-legged stools that would not rock on the uneven surface, wooden pins in the walls for hanging clothing.

After a farmer finished his cabin, he would construct in the same simple manner whatever outbuildings he needed: Sheds, outhouse, barn, and smokehouse. Eventually he was likely to improve the cabin. He might add a second story, and sheath the exterior with clapboards. He might build a second cabin with carefully squared logs and mortise-and-tenon fastening to make it airtight and perhaps include amenities such as a staircase and room partitions. He might connect the new and the old cabins with a covered passageway, called a dogtrot or breezeway, forming what was known as a two-pens-and-a-passage house.

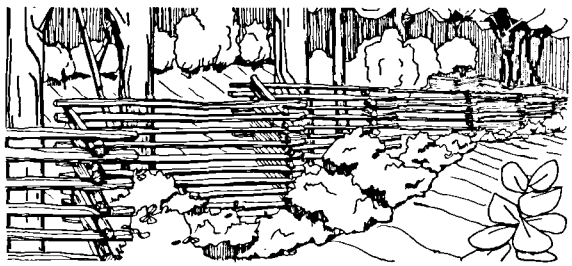
A fireplace in a log cabin, as in larger houses in established settlements, was designed for logs 2 or 3 feet thick. The forests allowed Americans to enjoy bigger fires than those in European castles. The hearth was the center of

family life: Cooking, reading, sewing, whittling, conversation, and courtship. The fireplace was not an efficient way of heating a house. Most of the heat escaped up the chimney, and it could be very cold a few feet away from the hearth. However, the fireplace radiated a spiritual warmth and cheer that no other heating system has equaled.

Settlers had local preferences in species and combinations of firewood; in Maine, they liked hemlock with snow dumped on to keep it burning longer. In fall, a farmer's woodpile would be as large as his cabin, to provide him with from half to a full cord of wood a day in winter.

As a farmer cleared his fields, he surrounded them with fences, another convenience Americans owed to their forests. In Europe, with wood rare, hedges and ditches were more common boundaries. The most primitive fences, put up with a minimum of time and labor, were barriers of branches and trunks or stumps with their roots turned up. More permanent were the Swedish post-and-rail fence--often of locust, a species extremely resistant to decay--and the Pennsylvania fence with cedar posts and chestnut poles.

The most common fence other than in New England where stones were used was the Virginia rail fence, known also as snake fence or zigzag fence. Like the log cabin, it is characteristically American, although it originated in



Scandinavia or, perhaps, Germany. Its advantages made it popular. It did not depend on posts, which were placed in the ground, and it did not require nails, digging, auger work, tying, and mortising. It could easily be torn down, moved, or repaired; all it required was a large amount of wood. It was made by interlocking at an angle sets of 6 to 10 rails. At each angle, the stakes were crossed with a single heavy rail, called the rider, to hold them down. The zigzag fence averaged 7 or 8 feet in height, and required vast amounts of timber. About 26,500 rails were needed for every 4 miles of fence. The preferred species were locust, redcedar, chestnut, black walnut, and hickory. As long as the woods were abundantly available, the Virginia fence remained the most popular American fence.

Woods and Their Uses

Each species of wood has its own properties. The pioneer quickly learned to appreciate the shades of difference between the various species, finding for each its best use. For special purposes, he combined species. A rocking chair, for instance, might contain 10 or 15 species of wood, each with a specific property. Pegs would be made of a hardwood; softwoods cradled load, and springy woods carried weight. Rockers of black walnut would not creep forward as would those of maple or hickory made slick by wear.

A chair might be put together without nails or glue by inserting parts made of seasoned wood into parts made of green wood, which, drying, would shrink and lock tight. Even a fishing rod made of three pieces was of different species: Ash for the first joint; hickory, for the second; and bamboo, the tip. Since properties of woods change with weather by warping and contracting or expanding, it was a fine art to match woods acting in opposite ways to keep joints tight. Treenails, used in this way, were more reliable than iron nails.

An expert on the distinctive properties and potentials of different species of woods could be found on every farm. Thus choice of a particular species of wood for a particular purpose was likely to prevail throughout the country, if the wood was available. Everyone knew, for instance, that in the absence of iron, blackgum (tupelo) wood made the best plowshares because its tortuous grain prevented splitting and chestnut that resisted weather well made good fence rails but poor firewood because it would shower sparks when burning. This uniformity extended even to the whittled toys children made. In every colony, bows and arrows were commonly of hemlock and whistles of chestnut or willow. But the uses of the more important woods were so numerous that each species is best considered separately.

Maple, because of its hardness, smoothness, and attractive color, was one of the most popular furniture woods and dominated household woodenware. The lady of the house presided over a kitchen well-equipped with innumerable wood implements, gadgets, and machines that allowed her, starting from scratch, to make bread, cheeses, cider, and other foods to provide three abundant meals a day.

Kitchen implements commonly made of maple included rolling pins, mashers, meat pounders, chopping boards, breadboards, pie crimpers, butter molds, boxes of all shapes, sizes, and purposes (tinder boxes, spice boxes, pillboxes), scoops, funnels, sieves, butter churns, and mortars and pestles for grinding grain, salt, and herbs. Among wooden mechanical devices were apple parers and vegetable slicers (with metal blades), apple grinders for cider, cherry pitters, cheese presses and drainers, lemon squeezers, and sugar and flour sifters.

The settlers copied an Indian technique and hollowed out maple burls, a knotlike growth with dense, tough, convoluted grain, to make durable and attractive bowls. Other tableware, such as trenchers, trays and platters, noggins, or pitchers, spoons and ladles, salt containers, eggcups, and tankards were often made of maple. Pails, piggins, tubs, washboards, clothespins, and buttons too, were made of maple. The shoe cobbler made his lasts of maple. Curly maple was used for musical instruments such as fiddles and dulcimers. Red maple was frequently selected for spinning wheels and tool handles. Maple was also valued as a firewood; its ashes could be used as a fertilizer and in soapmaking.

Poplar was another wood often chosen for kitchenware; it is soft, even textured, easy to work, and has no taste or odor. It was splinted to make baskets. A wood used more commonly for baskets was hickory, a tough, springy wood. Young trees were cut in winter when sap was not flowing; the trees were well soaked and pounded before being cut into flexible splints that were woven into baskets.

Ash splints, strong and supple and easily peeled from small twigs, were also woven into attractive baskets, as were "willow whips," thin, cordlike branches of green willow. Both hickory and ash were carved into basket hoops. Clothes hampers, cradles, market baskets, and similar indipensable containers, of assorted shapes and sizes, were made in this manner. Apart from basketry, hickory was used for tools, wagon wheels, furniture, and fences. Torches were made from hickory bark, and, of course, the wood served an educational purpose in schools--the long-remembered "hickory stick." Ash was notable for its versatility. The wood is white, hard, resilient, and durable. These qualities were valued by wheelwrights, cartwrights, and makers of furniture and tool handles. Coopers used ash for barrel and keg hoops; black ash and swamp ash were converted into hoop poles.

Beech, a heavy, hard, attractive wood unaffected by water, was usually reserved for household ware that received rough usage, such as rolling pins, meat pounders, and scoops. Chestnut, a lighter weight but also a very durable wood, was used for the same purposes, as well as for fencing and construction.

Oak could be relied on wherever great strength was needed; the proverbial "strong as an oak" testifies to its reputation. Oak with other woods, like hemlock and tupelo, was chosen by carpenters for floors of bridges, stables, and warehouses. In the home, table boards and boxes were often oak, and in the well there was likely to be an oaken bucket. White oak was the preferred wood for ship timbers and beams in dams and bridges, where it lasted although alternately wet and dry. It served well in wagon and coach frames, coach wheel spokes, harrow teeth, treenails, and whiphandles. White oak was selected for barrels and casks holding liquids; red oak, for flour and sugar barrels.

Pine served the most purposes with least difficulty of all of the woods in American forests. It was common in all kinds of construction; it was used in large quantities in bridges, ships, and houses. Inside a home, pine was made into handsome flooring, ceilings, and paneling. In architecturally ambitious houses, it was used for carved woodwork, shelves, and cupboards. Ordinary furniture was customarily made of pine. Pine was used in the grammar school. There were hornbooks, slabs that held lesson cards in place; a blackboard, a slab painted black; and benches. Powder horns, essential in a frontier household, were made of pine.

The unsurpassed excellence of white pine for shipmasts gave it an importance in the War of Independence. Because it is soft and easily worked as well as strong, it had many other uses as well. It was much used for clapboards, chair seats, tubs, barrels, buckets, cheese and butter boxes, knife trays, as well as other kitchen implements.

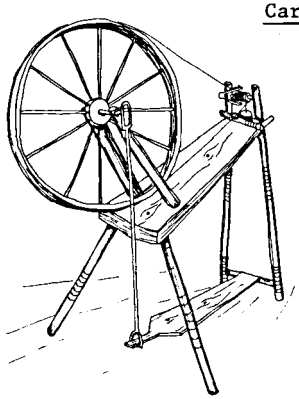
Pitch pine was known as candlewood because its splinters could be used as tapers for conveying flame from one fireplace to another, and its knots were used as torches for outdoor lighting, carried in iron cages held on a pole. Gathering pitch pine knots was a routine farm chore in the fall. Pine wood was good kindling, but rarely used for fuel because it burned too quickly and gave out sparks. Pine roots and branches were sometimes woven into baskets.

Birch was an abundant and remarkably versatile wood, lightweight, hard, and strong. Canoes were made from green birchbark, which has much oil in it and sheds water well. Homemade brooms were made of slivers or twigs of birch tied to a birch handle. Branches were bent into hoops for barrels. Staves, pail handles, gunstocks, pegs, boxes, washboards, and clothespins were often made of birch. The beautiful brown heartwood of black and red birch, easily split and turned, was highly esteemed by furniture makers. The inner bark of birch was sometimes used as writing paper in schools; ordinary paper, made from rags, was relatively expensive. In the north woods, hunters fashioned horns for moosecalls from birchbark. The bark was also used to make boxes. Birch burns slowly and gives out great heat; therefore, it was used in bake ovens. Lye was obtained from its ashes for making soap and bleaching clothes.

Cedar, smooth, light, strong, and water-resistant, was ideal for small boats and shingles, and made good pails, firkins, churns, washtubs, and keelers (milktubs). Balladeers fashioned guitars out of cedar. Redcedar was frequently used for chests and other furniture, coffins, and barrels.

Black walnut was then, as now, an excellent wood for furniture. It was abundant enough to be used even for fencing, as well as for gunstocks and assorted objects of decorative qualities, such as musical instruments and checkerboards. Cherry was another valuable wood used for furniture of great beauty.

Carpenters and Coopers



Every craftsman in a village shop of 1776 had his preferences in wood species. In a carriage shop, which turned out not only coaches and shays but also wagons, buckboards, and oxcarts, selection was ash, cherry, and poplar for the body of a carriage, and usually hickory or maple for wheels and running gear. The wood was seasoned by exposure to sun and air for at least 2 years. Butternut wood, which is lightweight and durable, was frequently chosen for paneling in coaches. A wheelwright also used the smooth, tough wood of sycamore for wagon wheels and white elm, hickory, and gum wood that would not split for hubs. Spinning wheels and the smaller flax wheels with rims of very thin split wood were made of hardwoods.

Shuttles (frequently of persimmon wood), hand reels, hand looms, spools, and other wooden implements used in spinning and weaving in a home or in shops were manufactured by a carpenter. In his shop a carpenter produced pine and cedar shingles and clapboards, maple and pine four-post beds, chests and other furniture, tools and farm implements, and all of the smaller woodenware that was not ordinarily carved or put together in a home. Bowls, plates, and similar items were called turner's ware because they were made on a lathe. A carpenter, therefore, used the whole range of American woods.

Laurel wood was so often made into spoons in Pennsylvania that it came to be known as spoonwood. Out of buckeye wood, the carpenter gouged cradles and sugar troughs or sliced it into trays and trenchers. Dogwood was turned into mallets, vises, horse-collars and mill-wheel cogs; sycamore, aside from wheels, into windlasses and pulley blocks; and tulip-tree wood, into boxes. The stringy inner bark of red and white elms was adopted for bedcords and chair bottoms. Water pipes and pumps were made from pine, hemlock, poplar, and especially baldcypress, which is virtually unaffected by water. Carpenters also undertook all varieties of construction, using in addition to oak, other woods such as hemlock, tupelo, yellow-poplar, and larch.

The importance of a cooper's shop has already been suggested; not only barrels indispensable for shipping and storage were turned out, but also other staved vessels, such as tubs, buckets, churns, and pipes. These smaller items were classified as "white cooperage"; the woods used included pine, beech, maple, birch, and hickory. Basswood, instead of being cut into staves, was hollowed out to make casks, vats, and even beehives; it was also used for grain boxes and corn-grinding mortars.

Two kinds of barrels were used: "Tight," or "wet," and "slack," or "dry." "Tight" barrels had to be watertight, because they would contain wines, molasses, and other liquids. They required considerable skill, and white oak was the wood chosen for them. "Slack" barrels were used for grain and sugar, and required less skill. They were made of a variety of woods, red oak, maple, elm, ash, hickory, chestnut, and pine. A cooper and his apprentice could make two white oak "tight" barrels a day and four or five red oak "slack" ones.

Farmers were proficient in finding shapes as well as kinds of wood to suit their purposes. A sapling that had grown curved around a log or rock could be carved into a scythe; twisted parts of large branches were converted into parts for harnesses and ox yokes. Ox yokes were curved, with four holes for two oxbows, locked with a wooden key.

Ash or hickory, being strong and lightweight, were used for yokes; pliable green walnut and red elm were used for bows; as they dried they hardened into permanent form. Forked sticks became pokes and yokes kept on the necks of barnyard animals to prevent them from escaping through fences; the sticks became divining rods, too. Saplings bent at the root were ideal for sled runners. Straight sticks were used for beanpoles and whipstocks.

Sections of hollow hemlock logs made feed boxes, troughs, and salt mortars; sometimes slices of solid logs were used as cart wheels. Knots and burls of elm, ash, birch, chestnut, walnut, and maple were fashioned into cups and bowls; pieces of hornbeam, into hinges and latches. Blocks of wood were hollowed to make large wooden shoes for humans and for horses to walk on swampy ground. Pieces of elm rind made natural chair seats and baskets. Certain kinds and shapes of wood could be assembled into traps for small and sometimes large animals; a forceps-shaped log trap was used for bears.

Every wooden implement around the farm--which means virtually every implement--resulted from an ingenious and intricate collaboration with the shape and the quality of a piece of timber. This involved subtle and precise splitting, sawing, carving, or bending of wood into shovels, rakes, hayforks, flails, hoes, billhooks, ladders, plow moldboards, even wooden spades and plowshares. But this, of course, could be said of every wooden building, ship, piece of furniture. No wonder Thomas Jefferson at Monticello wrote in a letter, "I have thought myself obliged to decline every application which has been made me for timber of any kind, without that resource I could not have built as I have done, nor could I look forward with any comfort."[7]

Colonial Furniture

The fact that wooden articles could be not only artful and well made but also of high artistic quality is obvious if the fine furniture of the 18th century is considered. In the small towns in 1776, a carpenter still made the furniture, but in cities furniture making was divided among a number of craftsmen: Joiners, turners, cabinetmakers, chairmakers, upholsterers, and carvers. In a village carpenter shop, the

furniture produced was still as plain as it had been in the 17th century. There were strong, simple, straight-backed chairs; benches (forms and settles); stools of maple or other hardwoods; long, heavy oak tables; and four-post beds and built-into-a-corner "jack" beds. The chairs and benches were dignified, but not comfortable; they lacked upholstery, and people sat straight backed. Furniture that could serve more than one purpose was preferred: Chairs with backs that could be dropped to form tables and high-backed settles that could be converted into beds.

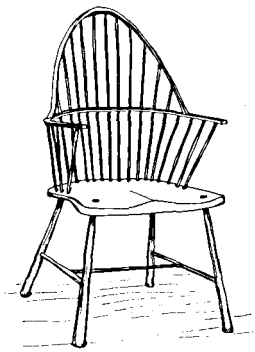
In the course of the 18th century, in well-appointed households of towns and cities, however, the plain-style furniture had been replaced by the elegant styles of fashionable European furniture. Many of the cabinetmakers in cities had served their apprenticeships in England, then immigrated to America.

American craftsmen faithfully copied English styles even while they were joining the movement for political independence. Nevertheless, a distinct American accent did develop within certain of the established styles. There were characteristic American preferences, such as substituting native American woods like tuliptree, poplar, and cherry, for the European woods. Occasionally the early Americans were influenced by ethnic styles, such as the heavy Dutch furniture and the brightly painted furniture of the Pennsylvania Germans. Furthermore, each craftsman had his own ideas. Each of his pieces had some characteristic deviation that was his stylistic signature, and distinguished his work from other American craftsmen as well as from that of the English. Subtle differences were seen in furniture according to the city in which a piece was made; each city, such as Boston, New York, Philadelphia, and Charleston had its local preferences.

The prevailing wood for fine furniture was walnut, either solid or veneered, although maple was still frequently used, especially for parts subject to heavy wear or strain. Cherry, pine, and other woods also continued to be used. For both walnut and maple furniture, a painted finish was customary. After about 1750, mahogany, imported from the West Indies, began to a certain extent to replace walnut for fine cabinetwork.

Walnut lent itself to the graceful curvilinear shaping characteristic of the Queen Anne style, dominant in the early 18th century. This style was never surpassed for lightness, simple elegance, and integrated design. Its elongated S-curve motif emerged in the silhouette of all of its parts.

The Chippendale chair had straight rather than curved front legs, scroll and leaf carving, and Chinese ornamental touches. About 1776, new kinds of furniture were gaining acceptance, including the loveseat, chairs and couches with upholstered backs, side chairs, padded wing chairs, and the rocking chair, a recent American invention. The rocking chair has sometimes been attributed to Franklin, who owned one. Actually its inventor is not known. Someone thought of putting rockers on an ordinary chair, which is how almost all rocking chairs were made until about 1800.



The most popular chair in America in 1776 was the Windsor chair. English in origin, it was lightweight, strong, and was of a simplicity that inspired native craftsmen to develop the style into more elegant forms than the original. The back of the chair was curved, and of slender spindles. The toprail usually extended into arms; sometimes the chair was equipped with a writing arm. In America the seat was often of pine, and the spindled back of hickory, which being supple and strong yielded comfortably to the back pressure of the sitter. The Windsor chair was the favorite chair of John Adams. For the porch at Mount Vernon, George Washington ordered 24 oval back chairs from Philadelphia, where the finest chairs in this style were made.

The dining table was a square dropleaf table. It had matching semicircular end tables that could be added to extend the table or they could be joined to form a separate serving table. For general purposes, there was a long "stretcher" table with drawers.

In 1776, coffee drinking was in a coffeehouse and tea drinking in a home around a delicate tea table. However, it is not known whether the Boston Tea Party discouraged the use of tea tables along with the use of tea. Folding card tables were a popular innovation. During the 18th century card playing had "caught on" in America, even among the descendants of New England Puritans.

During the 18th century, in most households, the plain chest was replaced by a chest of drawers, either a tall chest called a highboy or a lower one, a dressing table with drawers called a lowboy. In New England these chests were elaborated by a blockfront. The front was cut so that surfaces at each end were raised and the center recessed. This was an original American contribution to furniture style. The highboys and even larger pieces called double chests were massive and from 7 to 8 feet high, indicative of the large dimensions of the well-appointed American room in 1776.

A piece of furniture that had become more sophisticated was the desk. Originally just a writing board, it was succeeded by a slant-top desk, then by a secretary desk, in which a bookcase or cabinet was added to the writing desk. Often it had fine carving. Among the smaller pieces in the fashionable household were candlestands and a corner cupboard for porcelain and other valuable houseware. The cupboard either stood independently or was built into the paneling. Mirrors were large, and decorated with carved walnut or mahogany frames. Beds were four-posters, often with carved ornaments, and were curtained.

In 1776, the impressive and dignified grandfather clock stood in the hall to keep time. The clockcase and the works, too, were commonly made of wood. The case was expensive. Often a family bought the works first, and suspended them on a wall. When enough money was set aside, the cabinetmaker came to the house and constructed a case. It was most likely made of walnut, although mahogany was a common alternative. Pine, recently the leading wood, was also still used. The case was plain, or, in affluent households was blockfronted and elaborately carved with scrolls, and shell motifs. The cases made in 1776 in Pennsylvania and Newport, Rhode Island, were unsurpassed by the best European work of the time.

The most prominent craftsmen achieved a high level of art; their furniture was virtually flawless. John Cogswell of Boston became famous for his bombé, or kettle-shaped, furniture. In Newport, the Goddards and Townsends formed a cabinetmakers' cooperative and created the first block-fronted furniture. Philadelphia possessed a strong furniture-making tradition. As early as 1722, one hundred chairmakers and cabinetmakers were established there, and in 1776 they were turning out Chippendale furniture of outstanding beauty, design, and richness of carving. Thomas Affleck and William Savery of Philadelphia and Gilbert Ash of New York were well known for their excellent Chippendale furniture.

Almost all of the leading furniture craftsmen contributed their skills, both industrial and military, to the cause of American independence; several made especially memorable contributions. Upon arrival in Philadelphia as a delegate to the Continental Congress, Thomas Jefferson stayed with Benjamin Randolph, an eminent cabinetmaker. Jefferson showed Randolph a design for a small portable desk. Randolph made the desk, and in the summer of 1776 Jefferson composed the Declaration of Independence on it. Randolph served as an officer in the Philadelphia City Troop, and was with Washington when he crossed the Delaware in December of the same year.

Philadelphia cabinetmaker Francis Trumble was honored by receiving two orders to supply Windsor chairs and other furniture for Independence Hall. British soldiers stationed there during the British occupation of Philadelphia kept warm by burning all of Trumble's original furniture! Quaker David Evans of Philadelphia, forbidden by his religion to bear arms, produced tentpoles, camp chairs, and cots for use in the field.

American Architecture

Like furniture, American architecture developed from crude but sturdy beginnings to high levels of sophistication and artistic refinement. In New England, the first permanent dwellings built by the Puritans were modeled on the old English timber-frame house with wattle and daub or brick infill between the exposed framing members. An overhanging second story was frequently used simply because this was the common style in English towns. The wattle and daub construction did not provide sufficient insulation against the cold New England winter. Exteriors were soon sheathed with oak or pine clapboards, the brick excluded, and the wooden frame improved to withstand the abrupt changes of climate. This resulted in the characteristic New England saltbox, practical and unpretentious, and still the prevailing style of house in 1776.

In cities, clapboards might be painted, but in small towns and in the countryside they were left natural to weather. Painting was considered somewhat ostentatious, and until the 19th century was not customary. A roof was usually covered with cypress shingles. On the interior, pine paneling and wide, sometimes doubled, floorboards provided further protection against the cold. A house was most likely to be rectangular, with a fireplace at one end.

The first architects of the saltbox houses were master carpenters who, like the cabinetmakers, had served apprenticeships in England. In 1776, designing and building ordinary houses was still by local carpenters. A carpenter made up what he lacked in materials by using skill and imagination. His houses always had individual character while conforming to the general style.

In the Middle States and the South, although wooden houses were common, the preferred building materials were brick and stone. The Dutch in New York decorated the interiors of their houses with woodwork elaborately carved with considerable originality and frequently painted white. For the hot summers, they invented a traditional feature of American houses, the front porch. Meanwhile the veranda with columns was becoming customary on plantation houses in the South. The German settlers in Pennsylvania built a kind of log house that was more permanent and required more painstaking labor than the standard log cabin. Made of carefully squared, precisely placed timbers, it had a second story that usually rested on wooden columns, often richly carved.

In the West in 1776 beyond the frontier, several unrelated traditional styles of architecture made use of wood. Indian tribes of the eastern and northwestern coastal forests skillfully erected buildings of wood; they also made their canoes, sleds, weapons, and implements of wood. In the East, the Indians built huts, wigwams, and long community houses that incorporated frameworks of poles covered with birch or elm bark, and they built log palisades to protect villages. Even on the Plains and in the western mountains, some tribes acquired timber and made strong permanent dwellings of log frames covered with earth. In the forests of gigantic redwood, cedar, fir, and spruce of the northern Pacific coast, Indians

had an economy and culture based on wood. They used wood for totem poles and their houses with gabled roofs, skillfully and firmly constructed out of planks of split cedar or redwood, and decorated with carvings.

The French settlers in the Mississippi Valley had the palisade house, of vertical logs set in the ground or in a foundation. In New Orleans, wooden buildings like the more common of stone and brick had galleries and outside staircases, and were raised on a high foundation as a precaution against floods.

The Spanish in the Southwest chose adobe for their missions and forts. Wood, however, was used for the heavy roof beams, doors, window frames, simple furniture, and the gallery, or covered walk which was of heavy carved beams and brackets resting on round wooden columns. In 1776, the Spanish were extending their missions and outposts northward in California. This was partly because they were worried about the Russians, who were exploring southward from Alaska, building log houses, forts, and churches.

Although the use of brick and stone increased in the Thirteen Colonies during the 18th century, wood in 1776 remained the principal building material and far surpassed its rivals in range and versatility. This fact startled most of the Europeans drawn to America by the War. They had forgotten how recently in their history wood construction had been common in their cities. After closer observation, their initial perplexity frequently gave way to expressions of admiration. Boston is described in a passage from a travel diary of the Abbé Robin, Chaplain of the French army during the War:

> The construction of the houses is surprising to European eyes. They are entirely of wood, not built in the heavy and somber fashion of our ancient towns, but regularly and well-lighted. The carpenter-work is neat and well done, and the outsides are of thin and smooth planks, overlapping like the tiles of our roofs; they are painted gray, adding greatly to the pleasing appearance. The roofs are ornamented with balustrades, doubtless because of fires; the foundations consist of a wall about a foot high--one sees at a glance how much healthier these houses must be than ours.[8]

By 1776, American architecture in wood had approached the level of the most accomplished European architecture. As in Europe, the best 18th-century American architecture was due to architects collaborating with skilled artisans.

Architecture was part of a gentleman's education. An architect was ordinarily an amateur engaged in some other profession, like Andrew Hamilton, a lawyer, who designed Independence Hall; Washington, who contributed to the design of several buildings; or Jefferson, who was one of the finest architects of that period. At the same time, however, master carpenters who specialized in building fine houses had achieved a wide knowledge of their subject and, with it, something close to professional status.

Both architects and master carpenters usually worked without blueprints. They made sketches as construction progressed, and consulted the architectural handbooks, mostly English, which set forth the stylistic conventions of the period. Georgian was the conventional style; it is popularly known today as Colonial. Its stately, symmetrical forms, which produced the most popular style of domestic architecture in U.S. history, were derived from classical and Renaissance sources, and were formulated early in the century. By 1776, the style was beginning to develop into a new, more direct imitation of classicism called Classical Revival, of which Jefferson's designs were the first great American examples.

The only major difference between English and American Georgian was American Georgian houses were often built of wood, especially in New England, where the tradition of wood construction was strongest. Because stone was the conventional material depicted in style handbooks, the wood was sometimes grooved, beveled, and painted and sanded to resemble cut stone. One of the finest examples is the Lee Mansion in Marblehead, Massachusetts, erected in 1768. The most famous American house of the time, Washington's Mount Vernon, has exterior walls of planks of longleaf pine, beveled, and painted with a sand finish to imitate stone masonry.

Even in American brick and stone Georgian houses, however, the elaborate door and window enframements were customarily of carved wood. Sometimes the entire front was of wood, with brick gable ends, which allowed greater freedom to embellish the front windows and door with carving. Oddly enough, the entirely wooden Georgian houses of New England were plain, and had very little carved decoration on the exterior; this was perhaps due to a lingering puritanical prejudice against any display of luxury.

The wood trim on the exterior of a Georgian house was usually painted white. The doorways were made especially impressive by elaborate carving. Flanking a paneled double door there would be pilasters surmounted by intricately

carved panels, or capitals, which supported the entablature, the triangular or arch-shaped projection over the door. There might be similar entablatures above windows. The carving above a door was often topped by a carved pineapple, a symbol of hospitality. On the roof, flatter than those of earlier houses, was a balustrade, or captain's walk, a fenced enclosure painted white.

All Georgian houses had rich woodwork in interiors. In early houses, entire rooms were wood paneled. After 1750, wallpaper and hangings began to replace some of the paneling, although the Lee house in Marblehead has a room that is paneled with mahogany. Above the fireplace in the Lee house is an elaborate panel with delicately carved pendants of flowers, fruits, and leaves; on either side are pilasters, capitals, and other precisely rendered classical motifs. Most fireplaces in Georgian homes offered similar displays of a woodcarver's art.

The thick walls of a house created deep window recesses, which were faced with paneling hinged near the windows to form shutters. Staircases were wide and imposing; ends of steps were exposed and carved; balustrades were turned and often carved. In the Graeme Park Mansion in Horsham, Pennsylvania, a good example of Georgian stone construction, stairs and banisters are of heavy white oak, and the remaining woodwork is of yellow pine. Woodwork was customarily painted in one flat color, such as strong gray-blue, dark red, or olive-green, rather than the white or pastels that today are associated with colonial interiors.

Churches followed the pattern of domestic architecture; they developed from a plain to an ornate style. In both phases, they were frequently made of wood. A typical early church is the Old Meeting House in Hingham, Massachusetts, built in 1680, said to have been constructed by ships' carpenters. It is a square, has plain clapboard walls, a balustrade, and a small pointed spire. During the 18th century, churches adopted the dignified classical detail and other carved decoration of the Georgian style, and added tall, graceful spires of bell towers that were almost always wooden. Paneling and woodwork of the interiors were more austere than in Georgian homes, but were executed equally skillfully. The galleries might be supported by pillars finely carved into the classical orders. A wooden canopy was often placed above the carved wooden pulpit as a sounding board. Pews were high backed. Woodwork both inside and out was commonly painted white. A famous wooden church of that time is St. John's in Richmond, Virginia. In this white, clapboard church, Patrick Henry delivered his "Give me liberty or give me death!" speech.

The finest public building of the time is also the most famous, Independence Hall, the Old State House, in Philadelphia. It is an excellent example of Georgian in the brick-and-wood combination. The white wooden superstructure for the clock is a pleasing constrast with the deep red brick of the tower. A wooden balustrade painted white adds grace and lightness. The roof was originally covered with cedar shingles made from submerged logs of New Jersey's cedar swamps. On the interior, the woodwork is particularly ornate, and executed in a bold and masterly fashion. There are fluted pillars and pilasters with richly carved Roman capitals, intricate egg-and-dart and leaf designs, elaborately wrought brackets under the treads of the stairs, and impressive pediments above doors and mantels.

Independence Hall also provides an example of how American architecture already reflected social and political conditions different from those of Europe. Its plan, although modeled after English palaces, was adjusted to accommodate large democratic assembly rooms rather than the small audience chambers appropriate for royalty.

The detached, or freestanding, house had become the standard American dwelling, a reflection of American individualism made possible by the ready availability of construction materials, especially wood.

Wooden Vehicles

Travel in 1776 was slow and without much comfort. Several kinds of vehicles were commonly used: A small coach; a shay or sedan chair, an original American two-wheeled vehicle that could seat two and had its carriage suspended on hickory springs; a gig, a light, open one-seat conveyance drawn by one horse. But these were mostly confined to cities, since roads between cities were generally very poor. In winter in the North, sleighs provided a smooth ride. A slow and jolting ride was available between major cities by stagecoach, which in good weather took 2 days for the 90 miles between New York and Philadelphia. The fastest and most comfortable means of overland travel was still by horseback.

For farmers and freight carriers the most simple vehicle was a cart, with two solid wooden wheels attached to wooden axles; the diameters of the wheels equaled the height of a man. The wheels were made very wide so that they would

not easily sink in mud. There was also a flat wagon, but this was improved on early in the 18th century. German settlers in the Conestoga Valley of Pennsylvania developed the Conestoga wagon, which was to assume a legendary role in the settlement of the American West.

The Conestoga was based on covered wagons of Europe, but was given an emphatic downward curve toward the middle so that the load would settle toward the center while traveling over the Pennsylvania hills. The front and rear panels were slanted downward and inward; wooden bows were arched above the wagon bed; over these a tentlike covering was drawn. The panels were often decoratively carved. The wagon, usually made of oak and poplar, weighed more than 3,000 pounds, and could carry 2 to 4 tons of goods. The largest wagons were drawn by eight horses. Conestoga wagons became the standard freight carriers in Pennsylvania. During Washington's winter at Valley Forge, Conestogas were used to carry army supplies.

Roads, Bridges, and Boats

The first American roads were trails marked by blazed trees. Most roads in 1776 were muddy trails cluttered with fallen trees, stumps, and rocks, which were rough going for vehicles. An improvement attempted over muddy and swampy passages was a pavement of small logs or saplings laid across the road; later this "pavement" was called corduroy roads. This expedient prevented coaches from sinking in the mud, but the logs were bumpy and slippery and had no solid foundation. The logs dipped or twisted loose and eventually split and rotted. When kept in good condition, these roads impressed European visitors who had seen nothing like them in their own countries, where roads were also generally bad. A French traveler wrote,

> Part of the road from New York to Newark runs through marshes. I found this section truly astounding . . . . Built wholly of wood, with so much toil and perserverance, in the midst of water and shifting ground, this road proves what can be accomplished by the patience of men determined to conquer nature.[9]

Even when roads were passable, a traveler was hindered by the general lack of bridges. Bridge building had just begun to advance beyond the use of a "raccoon bridge," a tree felled across a creek, or of a few logs tied together. Crude rafts were used for large streams. Most bridges were only

rough logs laid across beams, without any safeguards on the sides. On large rivers, there were usually flatboat ferries, sometimes drawn across by pulleys. Occasionally, however, permanent bridges were built across major streams. A timber crib filled with stone would be built in midstream, and stone packed around the crib to prevent undermining; planks would be extended from the crib to the banks. On large streams, the number of supports and sections was increased.

In 1761, Major Samuel Sewall achieved some technical advances in a wooden bridge he built across the York River in Maine. The bridge was 270 feet long and had 13 sections; each section was supported by four pilings of saplings driven into the river bottom by a pile-driving device. The piledriver was a large oak beam raised by pulleys, and released with sufficient force to drive the supports into the mud. The center section was arranged as a drawbridge. The next development was the introduction of the arch and truss, the principles of which were only beginning to be understood.

In 1764, a bridge, 120 feet long and 28 feet above the water, was built over the Shetucket River in Connecticut. It was probably the first use of trusses in American bridge building. The wooden trusswork formed triangular patterns that gave the structure its nickname, "geometry bridge."

Travel on rivers was usually easier than over them. The early settlers adopted the Indians' light birchbark canoe for streams with rapids; the canoe could shoot the rapids one direction and be carried around them in the other. Bark was lashed to a cedar frame with spruce roots and calked with balsam resin and pine pitch. The settlers also adopted the Indian practice of converting hollow sycamore trunks into dugout canoes, and for rocky streams they developed their own small, strong boat, the bateau.

The settlers eventually devised an improvement on the birchbark canoe by hollowing out white pine or tuliptree logs into canoes. These were still light enough to be portaged but stronger than the birchbark canoes, and, because the ends were sharpened, they were faster and easier to maneuver. Canoes of this type carried pioneers up the eastern streams into the wilderness, then westward down the rivers beyond the Appalachians.

About 1750, on a western river, Jacob Yoder launched a boxlike craft he called a flatboat. He built a low cabin onto a flat bottom of thick hardwood timbers and planking; it drew only a few feet of water. In addition to the flatboat, river cargo was carried by long keel boats with masts and sails, rafts, and barges.

On western rivers, the flatboat was the primary cargo vessel until the arrival of the steamboat. Flatboats were from 10 to 20 feet wide and 20 to 60 feet long, and required a crew of five or six. Driven by the current and guided by one or more long sweeps, flatboats carried grain, flour, furs, and settlers and their belongings. When the boats reached their destination downstream, they were broken up and sold for lumber.

Art of Shipbuilding

A French scholar who visited this country during the War of Independence wrote, "The art of constructing vessels has made more rapid progress in America than anywhere else."[10] In the 100 years prior to the Revolution, American shipbuilding had advanced from a small, scattered, part-time enterprise, which produced vessels mainly for fishing and coastal trade, to a major industry, which supplied a large domestic merchant fleet as well as foreign maritime interests. In 1775, one-third of the ships in the British merchant marine had been built in American shipyards.

Shipbuilding attracted skilled English and Dutch artisans, and at its best equaled the technical excellence of European shipwrights. With demand increasing both at home and abroad, American shipbuilders sold their ships as fast as they could make them. They had an advantage over their European rivals, a rich and steady supply of timber that made American ships the least expensive available.

Shipbuilding was originally concentrated in New England, where there were large fishing and merchant fleets, an excellent supply of ship timbers, and an advanced lumbering industry. Boston, Newport, Portsmouth, and other New England towns continued to dominate the industry and launched half of all American tonnage in the years before the Revolution. The rapid expansion of shipbuilding during these years was accompanied by geographical expansion of the industry. Philadelphia and Baltimore became important building centers; ships were even built in inland cities like Reading, Pennsylvania, and sent downstream to the sea. In the southern states, shipyards were well established by 1776; the ships they produced, although fewer in number than those of the North, surpassed them in design and quality.

The outbreak of war in 1776, by interfering with trade and closing off the English and other foreign markets, dealt a serious blow to the shipyards. But the losses were made up to some extent by producing privateers to prey on British trade, sometimes very profitably, and by being commissioned by Congress to build a Continental Navy. Frigates were built for the war effort throughout the states.

Before the War, American shipbuilders had been turning out ships of all kinds, although on the average they were smaller than European ships. The most prevalent kind was the schooner, an American innovation developed in New England early in the 18th century. A small ship with a narrow, sharp hull, it rode the surface of the water with speed and maneuverability.

Shipwrights, like other craftsmen, had to have a thorough knowledge of the properties and performance of different woods. Their range of choice was narrow; few species met the qualifications for the principal parts of ships. Of the more than 500 species of trees in North America, only about 20 were ever used extensively in shipbuilding.

The main qualifications for a species of wood for shipbuilding were great strength, hardness to withstand frequent blows or groundings, resistance to bending and warping to impart resistance to leaks, light weight to insure speed and carrying capacity, resistance to decay to insure durability, and tenacity to hold fastenings. Few species met all of these criteria. Some that did were inaccessible, too small, or of limited quantity. Only the largest, full-grown trees could be used for keels, sternposts, stems, frames, and spars. This meant virgin timber had to be used. Furthermore, naturally curved and bent timbers had to be found for certain parts of a hull. Shipbuilders usually stocked little of this timber. When orders arrived or a need arose, they went to a farmer's or a lumber company's woods and selected the required pieces. Sometimes a shipwright owned his own forest, and timber-cruised during the winter.

Decay, which occurs in warm, moist conditions, was the mortal enemy of wood ships. American shipbuilders had an advantage; they could use certain methods of cutting that reduced the risk of decay. The abundance of large trees allowed them to cut away the less resistant outer sapwood and to use only the durable heartwood. The timber they cut

was in close proximity and could be stored outdoors, whereas timber shipped over long distances in closed storage tended to deteriorate.

The primary species of woods used in frames of American ships were white oak and live oak. Locust, was also excellent, but it was not available in sufficient quantity and size. It was used mainly in top timbers and other small parts of a frame. White oak, the traditional wood for ship frames and the most abundant, was the usual choice. Tough and resilient, white oak could withstand very successfully the impact of grounding or of gunfire. Properly seasoned, it was resistant to decay, and the tannic acid it contained, although it might corrode ironwork, discouraged worms. Also, oak trees offered many large curved pieces for the shaped parts of the hull.

Live oak, a short, thick tree, is a fine-grained, heavy, durable wood. If seasoned, this wood made an almost indestructible ship frame. It was believed that live oak ships could last 100 years. Like white oak, it, too, offered many good curved pieces; its only disadvantages were it was relatively heavy and it was difficult to work. Its use was confined to southern shipyards; later, it was to become the principal frame timber of the United States Navy.

A timber, also, used extensively in frames, was the heartwood of chestnut. This tree grew large; the wood was extremely lightweight and sufficiently durable if well seasoned. Redcedar, also lightweight and durable, was sometimes employed, but a lack of size and strength and insufficient quantities prevented it from becoming a major ship timber. Ash, strong and elastic, was often chosen for top timbers. In New England, especially in Maine, maple, beech, birch, hackmatack (tamarack), and spruce were used for ship frames, but because all were inferior to white oak, they were confined to small ships.

Two kinds of planking were used in wooden ships: For bottom and sides of the hull and for decks. For the bottom and sides, builders required wood that was strong, easy to bend, resistant to decay, and able to withstand alternating heat, cold, water, and hot sun. These requirements were best met by white oak and southern pine. In this period, white oak was the dominant wood for planking, and also for the ceiling of the hold. For decks, white pine was most often chosen because of its light weight and its resistance to sun and weather. It was also commonly selected for deckhouses and cabins, although in the finest ships teak and mahogany might be used.

White pine was also one of the most satisfactory mast timbers in the world. It reached heights of 150 feet, diameters of 3 feet or more, and had the necessary qualities of strength, light weight, durability, and suppleness that enabled it to bend in squalls without breaking. For small spars, spruce timber was occasionally used instead of white pine.

As in Europe, American ships were sometimes built according to carefully drawn drafts and specifications; small ships might be put together by eye and rule of thumb. The most common procedure was to use a model skillfully and precisely carved out of white pine and dark redcedar at a scale of a 1/4 inch to a foot. Thus there would be a 25-inch scale model for a 100-foot vessel. The carving of the model was a delicate task. Few scientific principles were established; a builder relied on his own judgment and taste.

The first step for a ship's carpenter to put together a ship was to lay a huge keel at a proper slope on keel blocks. He then raised stem and sternpost in position onto the keel, and placed and bolted the floor timbers. Thus the bottom of the ship was outlined. The most difficult operation was raising the half-frames into position by a derrick, after which keelson, clamps, knees, and beams could be added. The final steps were planking, calking, and smoothing.

Treenails, of locust and hickory steeped in tar, were used throughout the ship; after they swelled in place with the aid of the tar, they held tight. Masts and spars were put in place after the ship was launched. Launching was always a festive occasion; the ship was christened by either a young lady or a carpenter riding the bowsprit.

Art Forms of Wood

Projecting from a bow of a ship would be a realistically carved, brightly painted wooden figurehead. For a crew, each ship had a particular personality expressed by her name and figurehead. The crew associated the figurehead with the luck of the ship; the gallant, steadfast human figure, enduring storms and long voyages, must have commanded loyalty and reverence. Some imposing American figureheads that fell into the hands of the South Sea Islanders were worshiped as idols.

Until the middle of the 18th century, English and Colonial ships featured carved lions, then seahorses and other animals. These were soon followed by allegorical and individual human figures. By 1776, American ships displayed carved portraits of Washington, John Hancock, and other patriots; portraits of a shipowner, his wife, or daughter; eagles; Indians; and personifications of liberty.

American shipcarvers favored soft pine for figureheads rather than the elm or oak customarily used in Europe. They worked from sketches and live models and carved from a single block. By 1776, American shipcarvers were developing their native style; it was spare and vigorous and emphasized the broad contours of a silhouette. American carvers preferred full-length, individualized portraits to the ornate three-quarter figures of European carvers. The figurehead leaned out from an elaborately carved scroll, and similar decoration was found throughout the ship; even cannon portholes were surrounded by carved wreathes.

Shipcarvers also produced wooden decorative sculpture for homes and gardens, including architectural ornamentation, weathervanes, and decorative carving in relief on mantlepieces. An outstanding shipcarver, William Rush, carved a wooden statue of Washington for Independence Hall. Woodcarvers turned out portraits, classical figures, busts of poets, and animal sculpture that are fine examples of American folk art. In the Southwest, Spanish-Indian woodcarvers were creating religious sculpture in a distinctive style that fused Spanish Baroque with Indian geometric simplicity.

Shop signs in 1776 were usually images carved in wood or painted on wooden slabs. Wooden Indians were appearing in front of tobacco stores. A carving of a sailor advertised the ship chandler's shop in seaport towns. Large wooden watches, boots, horseshoes, identified a shopkeeper's wares to passers-by. Even public buildings were often represented by appropriate figures--a female personification of justice in front of a courthouse, a manacled man in front of a jail. Names of taverns or inns might be illustrated by a wooden sign with a painting of a Turk's head, St. George and the dragon, or a Bacchus with grapes.

Several of the most famous early American painters, such as Benjamin West, Gilbert Stuart, Charles Willson Peale, and Matthew Pratt, began their careers by painting shop signs. Even when artists turned to more ambitious subjects, they might continue to paint on wood, often used instead of canvas. Many itinerant portrait painters carried stacks of wood panels with them instead of canvas and stretchers; they were connoisseurs of wood; they knew the woods least likely to warp, crack, or react to moisture.

Their many artifacts indicates professional woodcarvers must have been fairly numerous in 1776. Amateur woodcarvers, however, who worked with a jackknife, were to be found everywhere. The jackknife became a Yankee trademark. Sailors, lumberjacks, farmers, and small boys expressed their creative impluses by whittling carved ships, chains, animals, and all kinds of household woodenware. Children created their own toys--whistles from willow branches, bows and arrows from hemlock, popguns from alder, and wooden tops, hoops, and balls from white pine. John Adams remembered as a boy carving his own toy water wheels and windmills. Some professionals carved wooden dolls, blocks, rocking horses, billiard balls, and chess sets.

Amateur carving could reach a highly accomplished level of art, as in the exquisite butter molds, boxes, cooky boards, and other woodenware carved with flower and geometric designs by the Pennsylvania Germans. Carving of wooden decoys was another fine art and was adopted from the American Indians. A decoy had to be accurate in every detail. Not only ducks but all species of waterfowl sought by hunters were skillfully carved of wood.

Indian woodcarvings are also important examples of folk art, particularly the totem poles of the Northwest coastal tribes. The totem pole was a cedar column carved with boldly imaginative and intricate figures and designs, brightly painted. These poles ranged from 10 to 70 feet in height and from 1 to 3 feet in diameter and served as memorials or as decorative poles at the front of houses.

Appreciation of Wood

In retrospect, life in America 200 years ago was not only made possible but it was made beautiful by wood. It is fitting that Americans of that time should have chosen the tree as a symbol of their country and its newly won liberty. Americans, at first, may have felt hostility for the forest

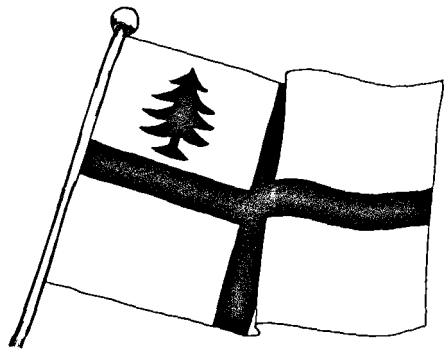
as an immediate obstacle to their plans and purposes. When they became settled, however, it did not take them long to realize how dependent they were on the forest. They became aware of the infinite variety of and indispensable uses of forest products in their daily lives. Their hostility then gave way to reverence for the tree as a symbol of the American way of life.

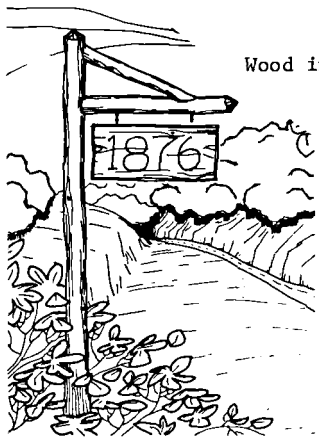
The first American coin was the pine tree shilling of Massachusetts. Later there were coins with depictions of willow and oak trees. Joseph Jenks, the designer of these coins, perceptively asked, "What better thing than a tree to portray the wealth of our country?"[11]

Many of the Colonies placed the emblem of a tree on their flags; later, a pine tree was portrayed on both the official seal and the flag of the State of Maine. American soldiers at the Battle of Bunker Hill fought under a flag that had a pine tree in one corner and the first American Naval cruisers flew a flag that bore a green pine tree in a field of white.

In many towns, the meetings at which Americans made the decisions that led to the Revolution were held under venerable trees that became known as Liberty Trees. For a Liberty Tree in Providence, Rhode Island, the following dedication was written:

> We do, therefore, dedicate and solemnly devote this tree to be a Tree of Liberty. May all our councils and deliberations under its branches be guided by wisdom and directed to the support and maintenance of that liberty which our renowned forefathers sought out and found under trees and in the wilderness.[12]





SECTION TWO

Wood in the Growing Nation

One hundred years after the Declaration of Independence, the United States had become a continental nation of 45 million people. It had survived a Civil War and was in the process of rapid industrial and urban expansion. The technological advances of the Industrial Revolution, which included the railroad, the telegraph, and the factory system, were transforming the material and social life of Americans. As a result, Americans were gradually moving from the country to the city. By the 1870's, more than 20 percent of the population lived in cities; the largest city, New York, had a population of 1 million. The major cities provided a crowded refuge for most of the new European immigrants, who were arriving in increasingly vast numbers. Almost 3 million arrived in the 1870's; more than 5 million in the next decade.

In the Centennial Year of 1876, Colorado was admitted to the Union as the 38th state; the remaining of the present states, except for Hawaii, were held as territories. The frontier was being pushed westward by the advances of cattlemen, miners, and the first farmers of the Great Plains. The last of the independent Indian tribes were retreating.

In 1876, the National League of baseball teams was founded, and Mark Twain published Tom Sawyer. It was a time of economic depression and political scandal. The effects of the Panic of 1873 were widespread: Business failures, high unemployment, and multiplying labor strikes. President Grant, in his last year of office, apologized to Congress for the scandals that had caused several members of his cabinet to resign. In the November presidential election, a small margin of victory won by the Democratic candidate Samuel Tilden was disputed; it was not until the next year that his Republican opponent, Rutherford B. Hayes, was declared winner. Despite these troubles, a Centennial Exposition in Philadelphia was successful. It was the first American World's Fair; among its displays of new inventions were the typewriter, the Corliss engine, and Alexander Graham Bell's first telephone.

Forest and Forestry

The technological revolution and the rapid growth of population were having a major impact on American forests. Railroads, telegraph lines, charcoal steel mills, and other industries were consuming immense quantities of wood. The settlers on the treeless plains needed lumber for houses, fences, and construction purposes, and they had no woodlots or local sawmills.

New cities of the Midwest, such as Chicago, Cleveland, and Indianapolis, were being built mostly of wood, while the expanding older cities in the East could not depend on their almost depleted local forests to meet their increasing requirements. The Civil War had made heavy demands on forest resources for fuel, fortifications, and supplies; one gun factory alone used 28,000 walnut trees for gunstocks. During the latter half of the 19th century, the value of forest products harvested each year rose from $60 million to almost $600 million. The lumber industry expanded on a comparable scale. By 1876 the largest operations had shifted from the East to the white pine forests of the Great Lakes region, close to the lucrative markets being opened by the railroads on the Great Plains.

Lumbering was a fiercely competitive and highly speculative business dependent on quick profits. This encouraged careless and extravagantly wasteful methods of lumbering. An observer writing in 1870 complained, "the waste of lumber in the United States is almost criminal."[1]

On the Pacific coast, where lumbering was just beginning, more than half of the timber felled was left to decay. The debris after lumbering operations was fuel for enormous forest fires that killed the young and secondary growth. Every summer major fires burned throughout the country. Some regions were burned over and over again, and reduced to desolate wasteland. Fires probably consumed as much of the virgin forests as lumbermen cut. The worst fire of the time was also the worst natural disaster in American history; 1,200 people were killed Peshtigo, Wisconsin, on the night of October 8, 1871, and 2 million acres of virgin white pine were reduced to ashes. This was also the night of the Great Chicago Fire.

Most of the forest fires were started by sparks from locomotives or by negligence. Some, however, were deliberately set by lumbermen or settlers to conceal their theft of timber from Government lands. Helping oneself to Government timber was an American tradition from colonial days. The Federal Government lacked the power and the necessary agents to prevent thefts. When Federal agents did try to enforce the law, they encountered local hositility and juries that refused to convict. The resistance was not due simply to economic interest or distrust of the Government in Washington, although these were factors.

Both lumbermen and settlers saw no reason for the Government to deny them the timber; to them it was obvious that the American forests were inexhaustible. For the Government to withhold acres of timber that might be put to good use made no sense to them. In 1852, Representative B. C. Eastman of Wisconsin had asserted that the lake country possessed "interminable forests of pine, sufficient to supply all the wants of the citizens in the country, from which this supply can be drawn for all time to come."[2]

In 1876, the belief of the inexhaustibility of forests still prevailed not only in the lake country, but also in Congress and the remainder of the Government. The unrestricted sale of public lands continued. The Homestead Acts were blatantly manipulated by private speculators, and vast tracts of timber were allowed to be exploited without regard for future needs.

A few voices in and out of the Government were raised in protest against exploitation of timberlands. Realization had begun to "sink in" that an accelerating rate of timber consumption and waste could not continue forever. In a report by the Commissioner of the General Land Office in 1876, citizens were warned, "A national calamity is being rapidly and surely brought upon the country by the useless destruction of the forests." Referring to the provisions of the Timber Culture Act, it continued,

> . . . it is an anomalous fact that the Government is giving away the rich alluvial soil of Iowa, Nebraska, Kansas, and Minnesota to any citizen who will plant a few acres of cottonwood or other inferior timber, while under the provisions of the preemption and homestead laws it is granting a license to destroy millions of acres of pine forests of almost incalculable value, which should be preserved as a nation's heritage[3]

Outside the Government, there had been warnings, but they were unheeded. In 1837, a writer in the North American Review noted the depletion of southern live oak and New England white pine and stressed the need to economize what yet remained of the rich national treasures and that what has been so carelessly wasted should be replaced. Local timber shortages already existed in the East, but only New England shipbuilders and fur companies had adopted practices that promoted conservation.

After the Civil War, with lumbering more extensive than ever, the concern for the forests increased, sometimes leading to overstatements of the situation. For instance, a series of letters in the Chicago Tribune prematurely warned of the exhaustion of marketable timber in the Great Lakes pine regions. In 1869, a writer in the Scientific American predicted that these pine forests would all be cut down, and the land would remain desolate. At the same time, theories were published that purported to prove that the fall of ancient empires, radical changes of climate, and the spread of epidemics could be attributed to deforestation. These theories gained considerable currency, but they were generalizations based on insufficient evidence. They did, however, bring to the attention of the public the real importance of the forests and their relationship to soil erosion, streamflow, and minor variations in weather conditions. The erosion of cleared land and the narrowing of stream beds by sedimentation had become common problems.

The theories also made familiar the European arguments that a nation's prosperity and civilization were essentially connected with its forests. These arguments lay behind European laws that provided for conservation, fire control, and reforestation. Once the theories gained acceptance in this country, they led to a movement for similar laws.

At first the conservation movement was largely confined to scientists, academics, and journalists, whose influence in Congress did not compare to that of the opposition. The acquisition of forest lands by the Government intended to preserve shipbuilding timbers had been authorized by Congress early in the 19th century. It failed, however, to provide funds and subsequent legislation to prevent the routine pillaging of the Government land by private interests. The best the Interior Department could do after it was created in 1850 was to send agents to collect payment from the lumber companies for the Government timber they had logged. At the same time, other forested public land meant for homesteaders, was allowed to fall into the hands of private speculators.

The conservation movement gained momentum, and by the 1870's influenced state legislatures, then the Federal Government. In the East, where forests were thought to be in danger of depletion from exploitation and destruction by fires, legislatures not only set up special commissions to study the forests but also created state forestry departments. On the western plains, a tree-planting movement developed, and societies were founded to promote it.

In 1872, Nebraska proclaimed Arbor Day, which became a national event. Throughout the plains, trees were planted for ornamental and protective purposes, and tree plantations were started by railroads and commercial enterprises. The interest in tree planting on the plains was reflected in the Timber Culture Act passed by Congress in 1873; this conferred title to 160 acres of public land if 40 acres were planted with trees. This Act, however, was also difficult to carry out.

While tree planting was becoming popular, the important concept of scientific forest management was being developed. In 1873, Franklin B. Hough of New York delivered an address on American forests and national welfare to the American Association for the Advancement of Science. He proposed the Government teach forestry to students and farmers, revise taxes to discourage careless lumbering, and establish forest reserves. A special committee, with Hough as Chairman, was created to promote the cultivation of timber and preserve the forests by informing legislatures of forestry methods.

The information the special committee sent to Congress and the President was a first step that led to the eventual creation of the U.S. Forest Service. Congress appropriated $2,000 for a study of forest and lumber production, and commissioned Hough to write the first of his influential Reports on Forestry, which appeared in 1876.

In 1877, Carl Schurz was appointed Secretary of the Interior by President Hayes, and began to take stronger measures against what he called the wicked and wanton waste of timber on public lands. Schurz set up a forestry agency in the Department of the Interior; this agency eventually became the Division of Forestry in the Department of Agriculture. He sent representatives to Europe to study forestry practices.

The first, short-lived national forestry association was organized in Philadelphia in 1876. In 1882, the American Forestry Congress, later called the American Forestry Association, was organized in Cincinnati, Ohio, with Dr. B. E. Fernow the first Secretary. Fernow became the Chief of the Forestry Division.

The policies Fernow instituted were based on the stated aims of the Forestry Congress for a business-like and conservative use and treatment of forest resources; Federal and state legislation and administration of forests; promotion of knowledge of conservation, and reforestation; and proper utilization of forest products. Within a few years forestry courses were inaugurated at a number of American colleges.

The Federal forestry agency in its early stages was only an information service. It had no power to interfere with timber theft on Government land, which Congress was not much interested in stopping. Although Congress had in 1872 made the first direct appropriation for the protection of public timberlands, in 1876 it turned down an attempt to create specifically defined national forests along major rivers.

Not until the early 20th century, in President Theodore Roosevelt's administration, was the present system of national forests established. The closest precedent was Yellowstone National Park, created in 1876; the principle, however, was the Federal preservation of a "scenic" rather than a "commercial" forest.

In 1885, a mixture of recreational and commercial interests led to the first major state forest, the Adirondack Forest Preserve in New York. Finally, in 1891, Congress empowered the President to declare Government-owned forest lands public reservations; this led directly to the national forests.

New Lumber Industry

The early conservation movement was a response to the dangers or potential dangers created by rapid and careless lumbering. But the positive contributions of the lumber industry at this time cannot be overlooked. Without the rapid expansion of lumbering, the prairies and the far West could not have been settled so rapidly. To meet the rising demand for inexpensive wood, the lumber industry had to move quickly, be bold and resourceful. Under the circumstances it was bound to be a financially risky, ruthless business. It shared all these characteristics with other frontier enterprises.

As lumbering moved westward, the industry ceased to be a collection of small operations and became a great industry that ranked with the railroad and the iron industries. Fortunes in lumbering were made and lost. The general tendency was toward consolidation--larger holdings and larger sawmills.

Early in the 19th century, New York surpassed Maine in lumbering; later Pennsylvania became the leading state. By 1876, Michigan was by far the most productive state, with more than 1,500 timber camps and sawmills that employed more than 20,000. Pennsylvania was second in production, followed by Wisconsin and New York. Michigan lumber was sent down the Erie Canal to the eastern seaports and Europe. As the plains were settled, sawmill towns and lumber depots sprang up along the Mississippi River. LaCrosse, Prairie du Chien, Dubuque, Rock Island, St. Louis, and Hannibal all prospered from the lumber trade.

The midwestern focal point for the trade was Chicago, which received lumber over the lakes from the north woods, and from there it was shipped by rail. Chicago itself required immense quantities of wood for rebuilding after the 1871 fire. In 1872, it was said, Chicago handled enough lumber to cover 3,000 acres 20 feet deep.[4]

The Lake States remained the center of the lumber industry until the early 20th century, when their magnificent stands of virgin white pine were finally exhausted. The major lumbering operations then shifted to the southern pine belt, but in 1876 these vast pine forests were just beginning to be opened by the railroads. Soon after the Civil War, about 50 sawmills were established near Augusta, Georgia, and a number of large mills were built in northern Florida. Mobile, Alabama, became a major lumber port. Southern lumber regions were exporting cypress and live oak as well as pine.

In the West, small lumbering operations were already cutting into the redwood forests of northern California. Cutting of sequoias had begun as early as the Gold Rush of 1849, and many San Francisco mansions were constructed of their wood.

In 1852, the California state legislature had turned down a bill to create redwood reserves. After the Civil War public forest lands were allowed to pass rapidly into private hands. As a result, many superb stands of sequoias were lost, despite the protests of John Muir and others who had discovered their beauty. There were sawmills along the California coast from Monterey to Eureka, and some of the lumber was shipped as far as Australia and the Pacific islands. Farther north, after 1860 there were lumbering operations in the dense forests around Puget Sound. As in earlier days, much timber continued to be taken illegally from Government land.

The lumber camps developed a life of their own, which Walt Whitman described in his "Song of the Broad-Axe":

> Lumbermen in their winter camp, daybreak in the woods, stripes of snow on the limbs of trees, the occasional snapping. The glad clear sound of one's own voice, the merry song, the natural life of the woods, the strong day's work. The blazing fire at night, the sweet taste of supper, the talk, the bed of hemlock-boughs and the bear-skin . . . .

The camps also had, in their tall stories about Paul Bunyan, a folklore of their own. These stories originated in the Northeast between 1850 and 1870, and grew taller and more numerous as they followed the camps to the Great Lakes region. They eventually spread and continued to flourish in southern and western forests.

Lumberjacks generally worked in winter in isolated camps. Timber cruisers explored and mapped the woods, noting species, quality, and logging conditions; lumberjacks used these maps, cut the timber, and dragged it to riverbanks. In spring logs were branded to identify the owner and floated downstream to sawmills.

About 1876, a number of inventions made logging faster and more efficient. The double-bitted "Yankee ax" was introduced after 1860; the spiked cant hook for handling logs was perfected about 1870. In 1876, lumberjacks were just beginning to use saws to fell trees. There were also new measuring devices and improved log wagons and rafts.

By the 1860's, sawmills, too, had been made more efficient by technical progress. Turbine wheels and steam engines had superseded water wheels in large midwestern and southern mills, although the smaller eastern mills continued to use waterpower. The old single-bladed upright saws were replaced by circular saws, which in turn were being replaced in the 70's by bandsaws. A long bandsaw and a combined jig-bandsaw for ornamental carving were exhibited at the Centennial Exhibition in Philadelphia. Gangsaws consisting of as many as 54 saws were in use by this time.

Numerous devices were developed for specialized cutting: Scroll saws, cylinder saws for stave making, planers, and sandpapering and shingle machines. Quartersawing, the cutting of logs on radial lines from the center, which reduced the tendency of boards to warp, also was begun in the 1870's. The many technical improvements resulted in reducing the price of lumber; this helped accelerate industrial and urban development of the Nation.

Forest Products in Industry

Most of the industrial uses of wood in 1776 were continued on a larger scale 100 years later. In the North especially, the tanning industry had begun to use hemlock bark extensively as well as oak bark. In the South, sumac leaves were sometimes used for tanning and dyeing. There were about 7,500 tanneries; most of them in Pennsylvania and New York.

The manufacture of naval stores continued to flourish in the South, and was especially important in North Carolina. The yellow pines were still the main source; 10,000 trees were needed to produce 50 barrels of turpentine and 200 barrels of rosin. Pyroligneous acid, or wood vinegar, was also being produced in some southern pine wood distilleries.

Coal, the concentrated remnant of prehistoric forests, was gradually replacing charcoal as an industrial fuel. The charcoal industry, however, while suffering from wood shortages and gradual decline, was still important. The industry had almost exhausted surrounding woodlands in the East; by 1876 it was concentrated in Michigan and the South, where supplies of wood were still adequate. Iron foundries followed this industry to these regions for charcoal iron was the best available. After 1869, however, charcoal iron's share of the market was increasingly surpassed by that of coal and coke iron.

Charcoal was still most commonly made in earth-covered pits in the woods amid its source of supply or in conical or oblong brick kilns. Oak made the best charcoal. An acre of black oak yielded 1,000 bushels of charcoal; about 50 bushels of charcoal were required to process 1 ton of iron ore. Chestnut, hickory, other hardwoods, and pine were also converted to charcoal.

Apart from fuel, charcoal had other industrial uses. It is produced with high heat, and is a fairly satisfactory conductor of electricity; thus, it was employed in electrical circuits. It was also used to absorb noxious gases and fumes, and as a filter to purify water and other liquids.

Wood was indispensable for structural purposes in many industries. The increasing number of coal, copper, and gold mines required millions of tunnel timbers, or mine props, and wooden rails. After oil was first drilled at Titusville, Pennsylvania, in 1859, derricks were made of hardwoods and storage tanks of cypress. The expanding telegraph system required great numbers of poles; about 300,000 were erected each year. Frames of many industrial machines were of wood.

In chemical industries, wooden vats held corrosive chemicals. Wooden barrels were still used for shipping liquids of all kinds. Many important chemicals were distilled from hardwoods; these included acetic acid, wood alcohol, acetone, creosote, formaldehyde, phenols, and tars. Wood charred at high temperatures yielded a gas suitable for illuminating purposes.

Paper from Wood

The most important of the new industrial uses of wood was in papermaking, where the introduction of woodpulp paper was beginning to have a revolutionary effect. Until this time, paper was made from rags, which were relatively expensive and their supply fell short of the growing needs of the papermaking industry. Since the end of the 18th century efforts had been made to provide a substitute for rags by using wood. In 1794, Matthew Lyon of Vermont made paper from a mixture of basswood bark and rags. In 1830, two Pennsylvanians made paper woodpulp by using aspen wood and lime. But these methods and others like them were too inefficient to be adopted on a large commercial scale.

About the middle of the 19th century, experiments led to three commercially feasible processes for making woodpulp. About 1855, Hugh Burgess of England and Morris Kean of Philadelphia developed the soda process. The wood was cut into chips, boiled in a caustic soda solution under high-pressure steam, washed, filtered, and bleached with chlorine; this produced a pulp that could be mixed with rags or straw to make paper. In 1864, Burgess and Kean established the American Wood Paper Company at Philadelphia, an event that received local attention. Using poplar from Pennsylvania, the mill turned out paper that was 80 percent wood. Other mills were soon built, and when a shortage of local poplar developed, the wood was imported from Maine. Later, mills began to follow the supply of wood to Maine, New Hampshire, and Michigan.

In Germany, also about 1855, Heinrich Voelter perfected the groundwood process, which became the chief method of producing woodpulp. Pieces of wood are forced against a grindstone, and a stream of water washes away the fibers for pulp. Machinery for this process was introduced to this country in 1866; by 1876 there were about 25 to 30 groundwood papermills. The preferred wood was again poplar, but spruce, pine, basswood, and birch were also used.

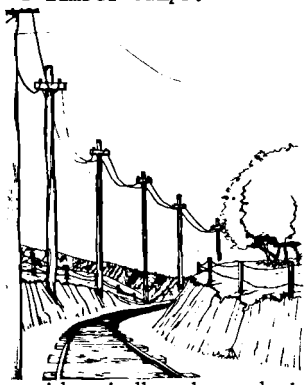
In the 1860's Benjamin Tilghman of Pennsylvania experimented with the sulfite process; in the 1870's, the process was perfected in Sweden. A solution of sulfurous acid and lime dissolves some of the cellular matter of the wood, and leaves the fiber to be turned into pulp. The first sulfite pulpmill was established in 1882 in Providence; by 1890 there were more than 12 successful mills.

At first, woodpulp paper met resistance as an unproved novelty, but once accepted, its inexpensiveness had a revolutionary effect on journalism and publishing. Newspapers that had been limited to four pages and sold for 5 or 10 cents a copy early in the 1870's were expanded to 10 pages or more and sold for 1 or 2 cents by the end of the decade. The papers increased their news coverage, advertising, and circulation; thus, the papers greatly increased their political and social influence. Book paper fell from 24 cents to 7 cents a pound. The greatly increased availability of printed matter encouraged the spread of literacy at a time when a large proportion of the population could not read.

The development of inexpensive woodpulp paper stimulated a wide range of paper manufactures: Cardboard and wallpaper were soon being made from wood-based paper, as were new products such as paper collars and bonnets, battery jars, and insulation. Paper and paste were compacted by hydraulic pressure into a hard, solid mass resembling ebony and made into doorframes and window frames, barrels, and even, with steel hubs and rims, into railroad wheels. The paper wheels were more elastic than iron wheels; thus, they reduced vibration. They made less noise, which made them especially suitable for sleeping cars. It was reported that they also lasted longer than iron wheels. By absorbing shocks better, they reduced wear on cars. The Allen Paper Carwheel Company, with large factories in Hudson, New York, and Pullman, Illinois, sold 13,000 of these wheels in a single year.

Wood in Travel

The railroads, of course, used wood for many purposes. Wood was fuel and kindling. Wood was used for tracks and ties, cars, bridges, trestles, tunnel linings, sheds, and stations. The first railroad tracks were wooden planks or rails, sometimes topped with spiked-down strap iron. In 1876, some of these old wooden roads were still being used in remote areas, and wooden railroads were still being built to serve mines and lumber camps.



Each year railroads required millions of new crossties. Locust ties lasted longest, 15 to 20 years; yellow pine, cypress, and cedar, sometimes used, lasted 8 to 10 years. The most common ties were of white oak and of chestnut, which, until preservatives were developed soon after 1876, had to be replaced every 7 years. Railroads began tree plantations at this time to insure a supply of wood for ties and for fuel; they also planted trees along tracks to provide windbreaks and shade and to encourage settlement.

Although by 1876, coal was becoming the standard railroad fuel locomotives still commonly burned wood, especially in the South and in the north woods where supply was plentiful. In the 1860's at its peak as a fuel, wood was burned by the railroads in prodigious amounts. In 1869, all American locomotives combined burned 19,000 cords of wood a day. On the Lake Shore and Michigan Southern Railroad, 1 cord of white oak, beech, or maple was required to cover 48 miles. Wood was used for kindling in coal-burning locomotives; wood was always used in stoves in passenger cars to provide heat during the winter.

Pullman day cars, light wooden passenger cars, were introduced in 1858; Pullman sleepers and dining cars, after the Civil War. By 1876, these cars had become as luxurious as the interior of a Victorian mansion, replete with mahogany paneling and elaborate decorative carving.

New types of public transportation in cities, horsecars, electric trolleys, and cable cars, were made mostly of wood, as were private carriages and buggies. In the 1870's, the old style of private carriage, with small front wheels and low axles, was giving way to a more streamlined model. Front wheels were almost as large as rear wheels, and allowed the carriage to run more smoothly. American buggies had a good reputation overseas as well as at home for being lightweight, inexpensive vehicles. The two-wheeled velocipede had "caught on" in the 1860's, and a school for training prospective riders was opened in New York.

Eastern coachmakers still had the reputation for producing the finest coaches and carriages in the country, but the manufacture of wagons as well as pleasure vehicles was also well established in the Midwest and West. Conestoga wagons, farm and freight wagons, and carts were turned out by large, mechanized factories, with specialized machines to produce every part of a vehicle.

Plank Roads

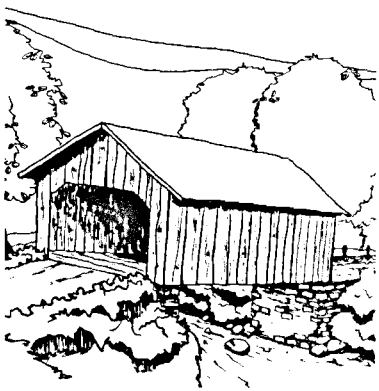
Roads were better than they had been 100 years earlier, but they needed to be improved. An improvement tried with only temporary success was the plank road; it had its brief heyday in the 1850's. The plank road came in with the railroads, first as a rival, then as a smoother way of reaching the railroad terminals. Plank roads were turnpikes with tollgates to provide revenue for upkeep. Companies were chartered to build these roads, and laws were passed in state legislatures to assist the companies.

The roads were built with planks 8 feet long and 3 or 4 inches thick laid across two or four parallel rows of timbers embedded in the earth. In the North, hemlock, oak, elm, and beech were the woods primarily used, and in the South, pine. In good condition, they were the smoothest of the American roads until the concrete roads of this century, and they were less expensive than any other pavements of that period. Horses or mules could draw two or three times the load on plank roads that they could on Macadam pavement or ordinary roads. There was less wear on vehicles. Therefore, plank roads were popular with farmers, and adjacent farmland increased in value. Unfortunately, backers had underestimated their rate of deterioration. Plank roads had been expected, with repairs, to last 10 years but they averaged about 5. When holes formed, the roads were dangerous or impassable; the companies found it difficult to keep them repaired. Consequently, few plank roads were built after 1857.

During the 10 years in which plank roads were popular, they were built throughout the country. Two thousand miles of wooden roads were built in New York. Michigan, Wisconsin, and other midwestern states had extensive systems. In some states, such as Alabama, plank roads delayed the coming of railroads, but the extension of railroads and the deterioration of the plank roads evenutually brought about their demise. A few wooden roads remained in 1876, however. Some of Chicago's streets were still paved with planks because stone pavement tended to sink into swampy ground, and several of the plank roads to the sourrounding prairie remained in use.

Covered and Uncovered Bridges

When a road reached a stream, a traveler of 1876, unlike a traveler of 1776, was likely to find a sound and sophisticated wooden bridge, open or covered. Iron bridges were just appearing; most bridges were still built of wood. The first known American covered bridge had been a 550-foot, three-span bridge built by Timothy Palmer at Philadelphia in 1805. The covered bridge soon thereafter became a familiar feature of the American landscape, an emblem of small-town life. The bridge was not covered to protect the user, to keep his horse from shying at the sight of water, or to keep snow off the floor. It was covered to protect the wooden framework of the bridge itself. If the supporting structural timbers or trusses were kept dry, the bridge would endure as evidenced by the condition of many of the covered bridges today. More than 1,500 covered bridges can still be found in the United States and Canada.



Covered bridges were commonly built by ordinary carpenters, who used only handtools and exerted much skill and ingenuity. Almost any kind of wood might be chosen: White oak, pine, fir, hemlock, or cedar. Many railroad bridges were covered. In small towns, the covered bridge served as play areas for children, a place for advertisements, public meetings, and courtship. It was not surprising they acquired the appellation, "Kissing bridges!"

Several important advances in bridge engineering were achieved during the early 19th century. Laminated structural members were introduced in 1805 in the Trenton Bridge spanning the Delaware River. Ithiel Town, in 1819, developed the Town Bridge, with latticework trusses, which allowed lighter than customary timbers to be used. In 1840, William Howe patented a parallel-chord truss that permitted a complete stress analysis by mathematical method. These valuable structural innovations were incorporated in the wooden bridges built during the 1870's. Concurrently, engineers developed methods of preserving timber by injecting creosote and other chemicals under pressure. This greatly increased the lifespan not only of bridges, but also of piers, docks, retaining walls, and other wooden structures exposed to water.

End of Shipbuilding Era

Advances had been made in shipbuilding in the 100 years since independence. The paddlewheel steamboat dominated the traffic on the Ohio, Mississippi, and other major rivers. This type of boat was built of oak, walnut, yellow-poplar, and other woods; it consumed wood for fuel in immense quantities. The boilers in the largest steamboats required a cord of hardwood each hour. These boats stopped frequently at river ports to replenish their supply of maple, oak, hickory, pecan, and other firewood. Barges and rafts were still on the rivers; canal boats, on numerous canals dug early in the century. Sailing yachts for recreation were appearing on coastal waters and lakes.

The advent of steam-powered oceangoing ships that used coal as fuel spelled an end to the era of wooden sailing ships, but especially in the United States, the end came slowly. Although by the 1880's, iron steamships had begun to dominate foreign fleets, the U.S. Navy wooden sailing ships prevailed until the turn of the century in American shipyards and merchant fleets. Until then, wooden sailing ships were still necessary for long trading voyages, such as those around South America and Africa, where there were no adequate coal stations for steamships.

American shipyards, which could not profitably compete with European shipyards in iron construction, continued to produce relatively cheap wooden ships. Consequently, as the number of sailing ships declined and were gradually replaced by steamships on even the longer trade routes, the number of American shipyards declined. The shipyards also produced wooden steamships, but since wooden hulls did not always hold up well against the vibrations of the larger engines, iron construction was increasingly favored for oceangoing steamers.

Wooden paddlewheel steamers continued to be produced, however, for trade on the coasts and on the Great Lakes. Even for iron ships, wood was still needed. Iron fouled badly with long exposure to seawater; iron hulls were often sheathed with layers of wood or wood was sandwiched between an iron hull and an outer copper sheathing.

In the last age of wooden sailing ships, the fastest and the most romantic, the clippers, appeared. Toward the end of the 19th century, the largest sailing ships in history, the merchant ships, were built in Maine. The American clipper flourished in the 1850's on the Atlantic crossing and particularly on the long trip to California around the Cape. It was designed for speed, with a long, sleek hull and a great expanse of sail. It could average 18 miles per hour, covering more than 400 miles in 24 hours; in full sail it was a graceful and an exhilarating sight.

In the 1870's the competition of steamships and the general economic conditions culminated in the virtual extinction of wooden shipbuilding south of Cape Cod. Norfolk, Baltimore, Philadelphia, New York, and the cities of southern New England ceased or almost ceased building oceangoing vessels. Many shipbuilders were bankrupt, yards closed, and shipwrights had moved on or were confined to repair work. Even in Massachusetts, the output of deep-sea ships in the 1870's was less than half of that of the 1850's.

Only in Maine, with its stable rural economy, its local supply of timber, and especially its relatively cheap labor costs, did shipbuilding remain prosperous. By 1875, Maine shipyards produced 80 percent of the square-rigged ships built in the United States, although even in Maine production had declined 50 percent since the 1850's. But the standard ships being built there, great wooden cargo ships for carrying grain, were three times as large as the typical freighters of the clipper ship era. In the 1870's, vessels of more than 2,000 tons were common; in the 1880's, a number

of 3,000-ton ships were built in the Bath, Thomaston, Rockport, and Kennebunkport yards. In 1892, the largest American wooden sailing ship ever built, the 3,539-ton Roanoke, was completed at Bath. The builders believed that it had the greatest size and efficiency attainable in a wooden ship.

The vessels built in the remaining eastern shipyards during the 1870's were of timbers assembled from throughout the United States. The necessity of transporting wood from distant virgin forests was a factor that not only made shipbuilding less profitable, but untenable. Except in Maine and a few isolated spots, the supply of ship timbers in the forests along the coast had been virtually exhausted.

In the construction of large ships for hauling grain, from 200 to 300 great white oaks were required; these trees had become rare in the Northeast. The heavy frame pieces, therefore, increasingly had to be brought from the remaining white oak stands in coastal and interior regions of Maryland and Virginia and from the oak woods of the Ohio Valley, the Great Lakes' States, and Ontario. Live oak was still occasionally used as a floor timber, and was obtained in Florida. Knees were made of hackmatack (tamarack) or spruce, softwoods from northern Maine or New Brunswick, Canada. Hardwoods, maple, beech, and birch, were used in top timbers and other parts of the ship. The planking was usually southern hard pine or white oak.

With the depletion of the great white pines in the East, mast timbers had to be obtained from the stands of virgin white pine in the Lake States or from the pine forests of the southern states and the State of Oregon. Shipbuilders usually were compelled to hire timber contractors who went into the woods with the ship specifications and supervised cutting. This, unfortunately, added time and expense to the increasing costs and dificulties that beset shipbuilders in the 1870's. Only in Maine did most shipyards survive the difficulties.

Household Objects of Wood

Iron was invading small manufactures, tools, and domestic ware as well as shipbuilding; yet in 1876 as in 1776 most of the implements, instruments, and utensils were still wholly or partly of wood. This was especially true in the country, where whittling woodenware continued to be a customary pastime.

In the country, trees remained a source of folk remedies and dyes; the lore was passed on from generation to generation. Maple sugar reached peak production in 1880, and was produced not only in the Northeast but as far south and west as Tennessee and Missouri. Trees were cultivated more than they had ever been for shade, windbreaks, and ornament. At Christmas, the custom of bringing an evergreen tree into the home and decorating it, introduced by German immigrants in the 1840's, had become an American tradition.

On the plains, where no local wood was available for fencing, the small, thorny osage-orange tree served as an efficient hedge. Barbed wire, invented in 1873, eventually replaced hedges but even then wood was needed for posts.

In a home, among much traditional woodenware, a number of items had appeared since 1776 and were at least partly made of wood: Sewing machines with walnut tables, ironing boards, washing machines, iceboxes, ice cream freezers, and coffee grinders. Metal tools and implements of all kinds, from icepicks to umbrellas, had wooden handles, as did brushes, dusters, and brooms. Clocks, whether a large grandfather clock or a mantel clock, still had wooden casing.

Many small wooden manufactures were new: Matchsticks, pencils, rulers, pipes, and, of course, baseball bats. Factories specializing in small wooden items were concentrated in New England. A single establishment in Burlington, Vermont, produced 4,000 bushels of shoe pegs a day. A small factory district in Maine produced two-thirds of the spools used in the United States.

Winchendon, Massachusetts, claimed it manufactured more woodenware than any other town in the world; the value of its products was more than $1 million annually. Remote New England hill villages turned out all varieties of woodenware. Many of these small establishments found toys a profitable sideline, and produced children's wheelbarrows, carts, sleds, and rocking horses.

Musical instruments had become an important manufacture from wood. American pianos, which won two gold medals and attracted much attention at the Paris Exhibition of 1867, were unexcelled by those of any other country. New York probably led the world in piano manufacturing. As early as 1865, some 70 establishments were producing between 250 and 300 instruments a week. In 1870, more than 24,000 pianos were manufactured in the United States; this volume probably exceeded that of any other country. In the same year an even larger number of small household organs were produced; of the 29,000 reported in the census, about half were produced in Massachusetts and 3,000 in Vermont. At about the same time, a 60-foot-high organ was made of black walnut for the Boston Music Hall; the wood was embellished with mythological figures and busts of composers.

Furnituremaking: Craft and Industry

In 1876, in remote small towns, furniture was still made by carpenters and joiners. Sometimes 18th century styles were still followed in the simple pine cupboards and chests; hickory and oak chairs and rockers; and maple four-poster beds, kitchen tables, and six-leg tables with tapered maple legs. No ornamentation was used except perhaps stenciled designs on surfaces. Pine, maple, and cherry were still the species most frequently chosen.

In general, early in the 19th century large furniture workshops, which resembled factories in which labor was distributed among skilled and unskilled workers, had begun to replace the individual craftsman's shop. After 1850, furniture factories with steam-driven machinery multiplied, particularly in areas close to the lumber industry. By 1836, furniture was being manufactured in Grand Rapids, Michigan, which soon became a center of the industry.

As demand increased, mass-produced, machinemade furniture completely dominated the market. By 1877 a writer in The American Cabinet Maker, a trade journal, stated with only slight exaggeration, "The days are gone, never to return, when an individual art workman could be employed on an individual piece of furniture to do what he liked with it."

Furniture ceased to have the esthetic distinction of the 18th century. Machinery could not equal the mastery and imagination of the individual craftsman. Furthermore, the advantage of a pure, universal style was lost. Virtually all styles that had ever been fashionable were revived during the Victorian period, and mixed and superimposed to the point of chaos. A typical Victorian room was cluttered and over-decorated. The taste was for lavish, ostentatious embellishment. Large furniture companies competed with each other to pile ornament upon ornament, which resulted in conglomerations of Greek, Turkish, Gothic, Renaissance, Empire, and Egyptian motifs.

Elaborately curved, intricately carved designs first became popular in the 1840's in the furniture of John Belter of New York City. Belter was a skillful carver. Because an ordinary board could not sustain the delicate, lacy carved patterns Belter preferred, he used laminated wood, like plywood. He glued together from 3 to 16 thin layers of rosewood, oak, black walnut, or ebonized hardwood, each about 1/16 inch thick, so that the grain of a given layer ran at a right angle to that on either surface. He then frequently steamed the laminated panels in molds to achieve the sinuous curves characteristic of his work.

The use of plywood in furniture was fairly new, although veneer had been used for furniture by the ancient Egyptians. In America, the first use of plywood was about 1830 by the piano industry. It was soon adopted for sewing machines, organs, desk tops, chairs, and other types of furniture. In 1840, the first veneer-cutting lathe was patented in America by John Dresser; by 1875, a veneer slicer had been developed.

By the middle of the 19th century, dozens of new woodworking machines were introduced, including steam-driven planers, mortisers, and wood-carving and fret-cutting machines. At this time, the circular saw came into general use. It could cut large sheets of thin lumber or veneer, which were used to cover soft secondary woods in large pieces of cabinet furniture. The bandsaw was widely adopted after 1870.

The advent of power-driven saws and carving machines completed the trend toward mechanization and mass production in the furniture industry. This made fashionable furniture available to the middle-income families as well as to the high-income. The new machines also completed the trend toward extravagant ornamentation and the revival of past styles.

After the massive, ornate Renaissance style was popularized by Grand Rapids furniture companies, other historical and new exotic styles became fashionable in rapid succession. Within these styles, there were notable artistic achievements, as in some Renaissance chairs and cabinets made in New York. In general, however, the styles were overwrought or combined in ponderous confusion, and furniture design declined.

In the 1870's, the latest fashion was the Gothic Eastlake style. Originally intended as a reform, it soon became encrusted with fussy ornament. The preferred primary woods were mahogany, rosewood, and walnut; pine and poplar were the most often used secondary woods.

In reaction to the stylistic deformities in machine-made furniture a crafts movement emerged in England; then, in the United States. Groups of artists and craftsmen, such as the Roycrafters at East Aurora, New York, and the Art Workers Guild of Providence, Rhode Island, produced the most attractive furniture of the time. Architects such as H. H. Richardson began to design furniture that was harmonious with the houses they designed. Although this furniture was too expensive and limited in quantity for general consumption, it eventually influenced the market.

Toward the end of the 19th century the vogue for oak furniture of plain, massive, rectilinear Mission style was an outgrowth of the crafts movement. Furthermore, amid the elaborate and heavy sideboards, bureaus, dropleaf tables, upholstered chairs, and lampstands that are thought of as typical Victorian furniture, there were some outstanding innovations. Among these that made use of wood were reclining chairs, chairs with metal backs and legs and wooden seats, and canvas folding chairs with x-shaped wooden legs.

Toward the end of the 19th century, an interest in 18th century furniture emerged, which in 1876 turned into a "Centennial mania" for colonial heirlooms. At the Philadelphia Centennial Exhibition, New England exhibits, displayed in wooden Georgian-style houses, included 100-year-old spinning wheels, mahogany furniture, and grandfather clocks with wooden works. The cult of antiques then began in earnest.

People who had not inherited colonial furniture went on antiquing expeditions throughout the countryside. Generally they found old Windsor chairs and Queen Anne tables had been consigned to an attic or a henhouse. The country people were undoubtedly astonished when city dwellers offered to buy their most dilapidated furniture. Despite the taste for 18th century antiques, however, Queen Anne and Chippendale were among the few styles that were not extensively revived in Victorian furniture, probably because they did not lend themselves to rich adornment. At the end of the century, however, the devotion to antiques finally did foster reproductions of colonial styles in machine-made furniture.

Old and New Architecture

The styles of architecture in 1876 bear a resemblance to those of the furniture: Very plain on the frontier and in the countryside and villages; extravagantly ornate in the cities and the fashionable suburbs and resorts. At the same time, interesting innovations were appearing.

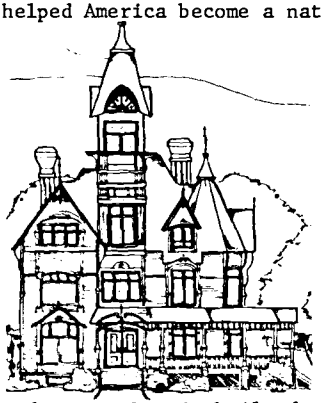
On the western frontier wherever timber was available and in the southern Appalachians and the Ozarks, the log cabin was still the standard dwelling. Western cattle and mining towns were typified by wooden commercial buildings, clapboard houses and churches, wooden sidewalks, hitching posts, and corrals.

On farms, in small towns, and in many city neighborhoods, plain wooden houses were the most common type of dwelling. The characteristic New England village, with shady streets lined with white-painted clapboard houses, was reproduced throughout the country.

Wood remained the principal domestic construction material. An important reason for its continuing success in meeting the housing needs of Americans was the use of the "balloon frame," invented in the 1830's. Prior to this, buildings had been supported by heavy walls or frameworks of heavy timbers; either type required time and skill to construct. Augustine Taylor of Chicago then discovered that a sound structure could be achieved with multiple thin pieces of lumber precisely spaced, braced, and fastened together with a generous number of nails. In fact, the introduction of cheap, machine-produced nails made this building innovation possible.

The first application by Taylor of the new frame theory was a wooden church, which was generally expected to collapse but disappointed skeptics by standing. A structure of this kind is, in fact, strong. The cubical framework of multiple vertical members with horizontal components and diagonal braces enabled 2 by 4's to perform similarly to heavy oak timbers 10 inches square in section in older buildings.

The multiple-member construction and nonweight-bearing walls anticipated the steel-framed skyscraper, the prototypes of which were built, also in Chicago, soon after 1876. The more flexible interior arrangement of Victorian houses was partly due to the introduction of balloon-frame construction. Because this method of construction was less expensive and because of an abundance of inexpensive lumber, this method helped America become a nation of homeowners.



Most of the fashionable styles of architecture in 1876, as in 1776, were imported from Europe. Again the chief difference was the American versions were frequently of wood. In Victorian architecture, as in furniture, elaborate ornamentation was preferred, and was facilitated by wood construction. This period, or gilded age, as it is called, is almost perfectly symbolized by the opulent wooden Gothic millionaire's mansions and resort hotels built during the period. A most extravagant and extraordinary example is the mansion built in 1885 by lumber magnate William McKendrie Carson in Eureka, California. Crowded with bizarre multicolored carved ornament outside and inside, it is said to contain every kind of wood then available on the world market.

About 1876 the Gothic style reached its greatest popularity in the United States. Its characteristic features are tall, often topheavy towers and pinnacles; spires; narrow, pointed windows; a profusion of dormers; and steep, sharply peaked gables. In its purest manifestations, the external carved woodwork of a Gothic house was not simply gingerbread ornament. It had, or apparently had, a structural function. The general effect was one of complex angularity, strong vertical lines, and pointed, narrow forms--a romantic medieval effect.

A style, the Queen Anne, also a romantic one, which featured steep roofs, towers, and turrets, "caught on" after it was displayed in the British exhibit at the Philadelphia Centennial Exposition. It was derived not from the 18th century when Queen Anne ruled, but from the late Medieval and Tudor periods. It is not known who gave it the misnomer. Queen Anne houses often had brick lower sections, with the upper sections in the Tudor half-timber style or else were entirely of wood with shingles or clapboard sheathing. The style, therefore, offered a variety of colors and textures. The carved wood embellishment was frequently massive and elaborate, and might consist of broad friezes with carved leaf decoration and ornate supports under the eaves.

The French Second Empire style was often realized in wood, as in the California Governor's former mansion in Sacramento. It is characterized by a high mansard roof with arched dormer windows, balconies, windows with ornamental framing, and in general, tall, bold forms, often including a tower.

The translation of the Italianate villa style into wood after it was introduced about the middle of the 19th century brought about some variations in the design. This was especially in the interior, where the great adaptibility of wood allowed an architect to suit the particular needs of a client. The exterior featured wide eaves, window-frame moldings, a prominent gable over the front door, a pillard loggia, or gallery, and a square tower.

One of the imported styles, the Swiss Chalet style, did not have to be imitated in wood. Swiss prototypes were built entirely of wood. About midcentury, this style appealed to those who favored the picturesque. Gables were wide, eaves broad; there were multiple balconies and exterior stairs and quaint carved decorations throughout.

Because all of the major European styles were reproduced in wood in this country, it is not surprising that the only two prominent domestic styles of the time that originated in America were styles of wooden construction. The "Stick" style, although it reflected the influence of the Gothic style and that of the Swiss Chalet, was an original native style introduced in 1850. In a stick style house, the large framing timbers were exposed on the upper stories in rectangular and diagonal patterns, as in the Tudor half-timber house, and the space between covered with clapboards. The projection of the beams was intended to reveal the wood structure and so evince "truthfulness" in architecture, a concern that

became a preoccupation of modern architecture. Other characteristics of the style were a high steep roof with projecting eaves and an extensive porch with carved posts. The plan of the house was complex and irregular.

The "Shingle" style originated in the 1870's in New England and derived much of its character from the earliest colonial houses in that area. This style with its horizontal forms and quiet, plain exterior was in marked contrast with the prevailing Victorian styles. Generally there was no carved ornamentation. The walls, the gambrel roof, and sometimes even the porch supports were covered with shingles. The most distinguished example is the Sherman residence in Newport, Rhode Island. The roof with dormers is steeply pitched and shingled, and the upper story is shingled with cross-timbered sections above a first story of stone. Completed in 1876, it is considered the finest domestic design by H. H. Richardson, one of the greatest and most influential American architects.

Woodcarving

The interiors of mansions and hotels of 1876, whether of masonry or wood construction, were decorated with rich paneling and intricate, florid carving. The carving in many Victorian buildings was by craftsmen who exercised their trade with considerable virtuosity and often achieved designs of high artistic quality.

Shipcarvers were still busy not only in the eastern seaports but on the Great Lakes and the Pacific coast, although their art necessarily was sharing the declining fortunes of wooden sailing ships. Shipcarving had flourished in the decades dominated by the clippers.

Masterpieces of figureheads were still being created for the sailing ships still being built. For instance the figurehead for the Belle of Bath by C.A.L. Sampson of Bath, Maine, is an elegant portrait of the captain's daughter with flowing drapery and scrollwork that expresses the motion of the waves of the sea. On steamships there was no projecting prow for a figurehead to embellish and complete. Although a few early steamships had sedate, upright figures at their bows, carving on them was generally limited to pilothouse eagles, paddlebox decorations, and frequently rich cabin decorations.

With the decline in commissions for figureheads, some shipcarvers turned to carving cigarstore Indians and similar advertising figures. This carving reached its greatest popularity in the 1870's and 1880's. Not only Indians, but Turks, sailors, baseball players, Uncle Sams, men and women of fashion, policemen, preachers, and famous individuals like Lord Byron and John L. Sullivan were carved to be placed in front of tobacco stores, all holding cigars or a leaf of tobacco. The carver usually worked with white pine, bought in logs at spar yards; he blocked the figure out with an ax, and used a chisel for detail. Hands and arms were attached, and the finished figure painted and set on a wheeled stand. Some of the wooden Indians are remarkably realistic.

Professional carvers continued to turn out a variety of appropriate symbols and signs for shops, plaques and portraits for public buildings, religious figures, weathervanes, and sculptural decoration for saloons and for gardens and homes. Samuel Robb, who became the most prolific carver of wooden Indians, opened shop in New York in 1876 and produced all varieties of wood carving, including circus carvings, which were for the new Ringling and Barnum traveling circuses in the 1870's. Circus wagons, designed to lure spectators were lavishly decorated with brightly painted, gilded carved fairytale and mythological figures and circus animals. Carrousels displayed herds of fanciful wooden horses and other animals. All of these circus sculptures were carved of pine wood and given all of the imaginative vitality that artists could summon.

Amateur carvers using jackknives produced notable specimens of American folk art. Wilhelm Schimmel, a German immigrant, was a well-known itinerant carver who wandered the Cumberland Valley in Pennsylvania during the late 19th century. The thousands of small, vigorously carved animals he traded for shelter, board, and rum are now eagerly sought and proudly displayed by collectors and museums. Statues and busts of Lincoln and other patriotic figures are typical creations of the amateur carvers as are religious sculptures, garden statues, flagpole ornaments, and mantlepieces.

Some of the most beautiful carvings were as in 1776 the bird decoys, an art adopted from the Indians. The bodies of the decoys were of cedar or pine, the heads of a harder wood; the finished carving was finely polished and realistically painted. All kinds of shorebirds--plovers, sandpipers, herons--were imitated as well as ducks; owl decoys were used to attract crows. Indian tribes throughout the country continued their traditional wood carving--totem poles, animal and human figures, and decorated woodenware.

Sailors on South Sea voyages picked up pieces of mahogany and other exotic woods and carved boxes, canes, pipes, watch holders, and model ships. Whittling continued to be a productive and creative activity on the farm.

Woodblock Engraving

In 1876, woodblock engraving was an indispensable art in publishing. It had become the essential medium for every kind of printed illustration, from encyclopedias to illustrated newspapers. Before the invention of photographic printing, only the wood engraver could provide illustrations with the detail and the accuracy needed for catalogs of mass-produced goods, advertisements, magazines, and books, including textbooks. Engravers masterfully copied the drawings of major artists, and made them available to a wide public. In 1876 colored engravings, printed by superimposing images from several indivually cut blocks, were just being introduced; they rivaled lithography in accuracy and brilliance.

Woodblock illustration dates back to the 15th century, but until the 19th century blocks of softwood were used. In this type of illustration, a wood block is cut away, leaving a design in relief.

By the 18th century, metal plates were used for most illustrations, and the woodcut had declined into a cheap and crudely executed method of illustration produced in small workshops for local printers.

Early in the 19th century, Thomas Berwick of England discovered that a block of boxwood, a very hard wood with close, even grain, would yield a very finely detailed engraving. This method was at least as accurate as intaglio printing from metal plates, and was cheaper and faster; it soon prevailed in the publishing business. Berwick also introduced the technique of working out the picture directly on the block instead of copying drawings. Wood engraving again became a fine art.

In America there were 400 professional engravers by 1870. Illustrated magazines enlisted major artists, such as Winslow Homer, Thomas LaFarge, and Thomas Nast, as well as established engravers, who produced masterpieces of the art. Toward the end of the century, mechanical and photographic methods of reproduction began to replace wood engraving, although they could not equal the capacity of the wood engraving to reproduce minute details. A few engraving establishments survived. The technique was taken up again by artists who worked directly on a woodblock and produced prints of highest artistic quality.

Age of Transition

The year 1876 belonged to an age of transition. It is not surprising that the importance of wood in American life should also have been in a state of transition. Some of the older uses of wood--fuel, pavement, sailing ships, charcoal iron--were diminishing or disappearing. It is perhaps surprising to discover that the many new uses of wood--for paper, plywood, telegraph and telephone poles, railroads, chemicals--more than made up the loss. Many of the uses in 1776--construction, furniture, tanning, vehicles, bridges, fencing, musical instruments, art--persisted in 1876, and had grown with the country. It is perhaps surprising to discover how much the new industrial age--the age of iron, steel, and coal--was still an age of wood.

Because wood was adaptable to changing conditions, the rich tradition of wood in American life was preserved, and the close and essential relationship of the American people to their forests continued. The conservation movement that emerged about 1876 reflected not only an awareness of this relationship, but an awareness that the close relationship could and must endure.

SECTION THREE

Wood in the Industrial Era

A Nation of 13 sparcely settled states, founded in 1776, has become, in its Bicentennial Year of 1976, a Nation of 50 states with a population of more than 212 million. Three-fourths of the population is urban or suburban. Each of the three largest cities, New York, Chicago, and Los Angeles, has a population larger than that of the entire country at the time of the Declaration of Independence.

The predominantly urban society of the United States of 1976 has been made possible by continuous technological development. During the last 100 years, innovations in transportation, agriculture, communications, and medical care have profoundly affected American life. Civilization now rests on a complex, interdependent industrial economy that requires vast and increasing amounts of energy and raw materials.

In this setting, it is not surprising that timber remains one of the raw materials basic to the U.S. economy. During the last four to five decades, annual consumption of wood products has increased 50 percent to a prodigious level of 13.7 billion cubic feet of wood, according to the U.S. Forest Service.

Forest products industries employ almost 1.8 million and have an annual payroll of 14 billion dollars, according to the U.S. Department of Commerce. Forest industries still retain a strong grass roots complexion. They are highly competitive and involve many enterprises throughout the Nation. The 1972 Census of Manufacturers reported 33,695 establishments dealing in lumber products.

Accelerated demand for sawed wood products a century ago resulted in rapid development of a large sawmilling industry. Production of lumber in 1876 totaled 18 billion board feet, sawed with the aid of the newly invented steam engine. As the Nation grew and demanded more and more wood products to build the railroads that crossed the continent and to house the population of the Plains States, so the sawmilling industry grew. At first the industry was based on the seemingly limitless timber supplies of the northern Lake States. By 1906 lumber production had reached a peak of 40 billion board feet. The industry was forced to look elsewhere for timber--to the South, then to the West Coast with its virgin stands of very large timber.

In a report by the President's Advisory Panel on Timber and the Environment, it was noted that with the depression in 1932, annual sawmill output dropped to a low level of 13.5 billion board feet but during World War II recovered to an annual level of about 40 billion board feet, where it remains. An estimated 50,000 sawmills were operating after World War II, but many of these were small and inefficient. At present about 12,000 sawmills, many of them new, large, and efficient are operating.

The source of most of today's supply of wood is the 500 million acres classified as commercial forest land; this is about 22 percent of the total U.S. land area. The increased yield from the shrinking forest land base reflects the results of reforestation, improved management and growth, and control of fires attained by American foresters.

The wildfire that consumed so much forest in the past has been greatly reduced by fire control programs. In some areas crowded and cluttered forest conditions have given way to scientifically cultivated stands. Direct seeding and planting of genetically improved stock have been introduced. Planting of forest trees rose sharply during the 1950's from one-half million acres to a peak of 2 million acres under the Soil Bank Program toward the end of the decade, and benefits are being realized from that farsighted effort today. As a result of these successful applications of forestry principles, the annual growth of softwood and hardwood trees combined has increased about 20 percent in recent decades.

In addition to a traditional concern over the adequacy of the Nation's timber for future needs, new concerns have been added. In recent years, the Nation has experienced an energy crisis and pollution alerts. The impact of industrialization on the natural environment has become a major concern of Government, of industry, of private organizations, and of each citizen. This broad concern has led to an increasing interest in American forests. The timber resource is renewable, whereas the recreational, esthetic, and ecological values of the forest are important factors in environmental quality. There is an increased interest in preserving some forest areas in a natural undeveloped state.

Wood has retained many of its traditional uses. Although new uses have developed to meet new needs and new and improved wood products have entered the market, the changes brought about by improved technology have been ushered in gradually. Only by careful retrospection can there be understanding of the scope and the significance of the dramatic changes in managing, harvesting, manufacturing, and using the U.S. forest resource.

Two significant and parallel developments are of special importance in understanding how change has come about. One is the industrialization of the forest products industries; the other, the growth of research on which industrialization depends.

Industrialization of Forest Products

During the last century, industrialization in the wood industries via the Industrial Revolution progressed slowly compared to that in the minerals and metals industries. Perhaps, because wood always had been so widely used, so well known, so readily available, and so easily worked, the continuance of simple conversion methods was encouraged. Even today many wood products are made in widely dispersed small factories reminiscent of cottage industries. The rapid development of a high and complex state of technology and the accompanying mechanization essential in converting iron to steel and usable consumer products were not as immediately essential to the continued widespread use of wood for buildings, vehicles, furniture, and the many other products.

A century ago the wood products used were either entire tree trunks or portions of the trunks. Whatever the final form of a wood product, whether a board or a violin, the internal structure of the product was always the same as that developed in the living tree. Only shape was changed. It is possible, but not necessarily economical, to produce boards or even the most intricate solid wood objects with only simple handtools.

Products of solid wood, in the form of timber and lumber and the objects made from them remain today the most important class of wood products. A certain degree of mechanization has been the key for producing better and more uniform wood products more efficiently than at any time in history. Thus, the products can meet the competition in today's marketplace.

The first, the slowest, and the most arduous task of the early wood craftsman was cutting logs into usable shapes and sizes. It is not surprising, then, that means for mechanizing this task were developed and adopted early in U.S. history.

The basic process of producing lumber by forcing wood against a toothed cutting tool or moving the tool through the wood is still in use. Many important improvements, however, have been made. Utilization of the large West Coast logs triggered a great change in sawing equipment. Existing circular saws were incapable of sawing logs in excess of 4 feet in diameter with a desired accuracy; therefore, double circular saws cutting simultaneously from top and bottom were developed. These saws, however, proved wasteful of material; because of their size, sawblades had to be excessively thick to prevent vibration while sawing. This led to the development of a bandsaw. The bandsaw provided not only a relatively narrow saw kerf but also more accurate sawing.

Increased demand for fiber products brought about hydraulic and mechanical debarkers at sawmills so that barkfree chips suitable for pulping could be made from slabs and other residues of the sawmilling process. In 1950 the invention of the rotating ring debarker vastly increased the availability to the pulpmills of wood that could be chipped.

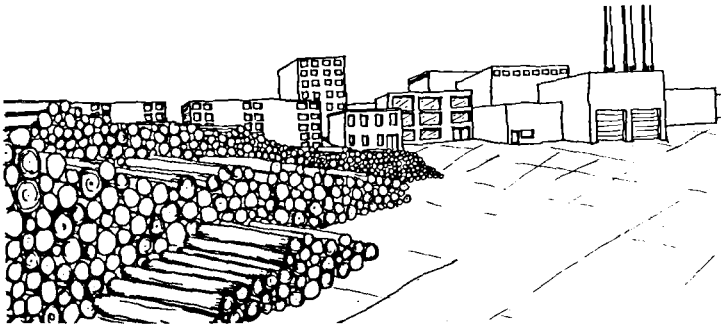
Between 1963 and 1966 a chipping headrig was introduced at sawmills. In squaring a log for sawing, this headrig removes the outer material as chips rather than as slabs. This machine boosts lumber production per man-hour, increases the percentage of log converted to chips, and reduces sawdust.

Today's sawmill results from continuous progress; this includes development of new power sources and improved production, new methods for handling materials, and new equipment for drying and stacking lumber. These kinds of improvements have been aimed at speed production of improved products with less waste. Similar progress has been made by the secondary wood industries that require lumber products as their source of raw material.

Forest operations of the lumbering industry are now largely mechanized. Efficient tractors have replaced teams of oxen and horses. Chain saws have replaced the backbreaking handsaws. Logs are moved to a mill by truck instead of by water or logging railroad. Mechanized handling and loading equipment has been developed; in some recent operations huge machines, like mammoth scissors, clip the tree at the base and remove the entire tree for further processing.

Within the last century a new family of wood-based products has been developed that has profoundly affected wood utilization. These new products differ greatly from each other but have in common the principle of their manufacture. Wood is reduced into pieces or fibers, then reassembled into products, the properties of which differ from those of the original material. Paper, building boards of wood fibers or particles, and plywood are examples. All are important in the U.S. economy and are now of particular interest because they make possible more efficient use of the wood resource.

Composite wood-based products cannot be made commercially with simple tools and equipment. Large capital investments are needed to supply the necessary equipment for handling materials, manufacturing, and quality control. These products and, in a sense, the industries that develop them are, in turn, the results of research. Research has been and continues to provide the pivotal base for both growth and product improvement.



A new trend has appeared recently in the industrialization of the forest products industries. Large industrial firms, sometimes called integrated industries, have developed that are equipped to manufacture and market all types of wood products such as lumber, paper, plywood, and fiberboard. In log yards of these firms, each log can be channeled for its best and most efficient use. Waste from one product can be used as the raw material for another. This development also makes possible the pooling of technical skills for efficient operation.

Paralleling but contrasting the slow industrialization and technological improvements in the sawmilling industry during the early part of the last century has been a spectacular development of a pulp and paper industry based on wood fiber.

About the middle of the 19th century, the demand for paper surpassed the available supplies of rags then used almost universally. The long fibers of spruce wood, obtained by grinding this wood, were found to serve well in producing paper. At first a cylinder method was used, then a high-speed, continuous, Fourdrinier screen process.

The manufacture of paper from woodpulp appeared as a new industry that required new equipment with heavy power demand and, for that time, large capital investments. From the beginning, survival of the industry depended on aggressive industrialization to meet a steadily increasing demand. In "Making paper from trees," the Forest Service notes the consumption of pulpwood for paper and paperboard has risen from 6 million cords in 1925 to more than 77 million cords in 1974. U.S. per capita consumption of paper and paper products in 1974 was 614 pounds, the highest in the world. More than nine-tenths of today's paper comes from wood pulp. Paper, an indispensable commodity of today's life, has re-emphasized American's dependence on forests.

Of three major commercially feasible methods of converting wood into paper pulp, the first was the mechanical, or groundwood, process by which wood is mechanically ground into a fibrous slurry. This process has the advantage of converting almost 100 percent of wood into pulp. Two processes were introduced early in the 20th century. The sulfate, or kraft, process was invented in Germany in 1884 and first applied commercially in this country in 1909 at a mill in Roanoke Rapids, South Carolina. The most recently introduced major pulping process, the semichemical, that combines the mechanical and the chemical fiber-separating forces, was developed at the U.S. Forest Products Laboratory, Madison, Wisconsin, in 1922. It was first used commercially in 1925 at Knoxville, Tennessee.

During the last 50 years, technical advances have been achieved in all phases of pulpmill and papermill operations that include the following:

Improved harvesting equipment and, recently, whole-tree harvesting;

Outside storage and pneumatic handling of chips;

Adoption of the kraft pulping process (now 70 percent of all pulping) with chemical recovery, odor suppression, continuous digesters, and computer control;

Multistage bleaching with newly developed chemicals;

New pulp cleaning equipment;

Disk refiners for increased pulp strength;

Wider paper machines with twin-wire sheet formers that produce products of greater uniformity faster; and

Reduction of stream and air pollution.

A change in the paper industry over the past 50 years that has also required new equipment and new processes is the increasing use of hardwoods along with the softwoods, spruces, pines, and hemlocks, which had been preferred. Today, hardwoods furnish about a fourth of the pulpwood cut in the United States, and the proportion is expected to increase to 40 percent by the end of this century. Hardwoods have become an indispensable source of fiber for many grades of paper.

The expansion of pulpwood materials to include almost all of the U.S. wood species has brought a geographical expansion of the pulp industry. Large mills using the most advanced techniques have been established near old hardwood forests and in areas where cutover softwood forests have been replaced by hardwoods. The center of the industry remains in the South, where it moved in the 1930's when development of the kraft process allowed the use of the resinous southern pines. Southern pines supply half of the total volume of pulpwood.

Research in Forest Products

The industrialization of the wood industry has brought the consumer wood products that not only perform better but are more serviceable than ever before. Throughout U.S. history, change, in the form of improved efficiency in manufacturing methods, has been adopted by industry to remain competitive; in the process, the consumer has not only obtained improved products, but frequently has obtained them at lower prices.

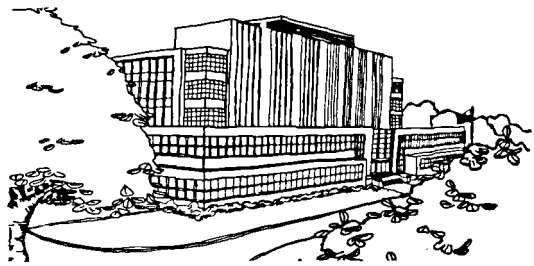
All of the technical improvements have been based on application of various research findings. Some innovations have resulted from simple ideas quickly adopted. A few have been adaptations of unrelated discoveries. The most significant technical improvements, however, have resulted increasingly from concentrated research aimed at solving specific problems.

In the United States, the origins of organized forestry as well as forest products research lie in the early conservation movement and the subsequent Federal forestry activity. As early as 1887, the U.S. Division of Forestry sponsored research on forest products. At first the research was conducted at a number of small Government laboratories and at some universities throughout the country. These efforts, however, proved relatively ineffectual and difficult to correlate and manage.

On November 16, 1906, representatives of the Forest Service and many national woodworking associations met in Washington, D.C., to discuss the desirability and feasibility of having one central research laboratory. They concluded with a resolution that is still meaningful:

> Wood is an essential material in every industry. Nearly all forms of wood are rapidly rising in price, on account of the diminished supply and the great demand. This laboratory [for forest products research] would lead the way on one hand to making available a greater supply, and on the other, to increasing the duration of timber in service. It would, therefore, affect favorably both supply and demand and, in consequence, be an institution for the benefit of the entire public.[1]

As a result of the meeting, the Forest Products Laboratory, a part of the Forest Service of the U.S. Department of Agriculture, was formally opened June 4, 1910, in Madison, Wisconsin, where it functions in cooperation with the University of Wisconsin. Thus, it was the concern and the support of both industry and the early conservationists that actually brought the Laboratory into existence. The central location of Wisconsin and the fact that the Lake States were then the center of the logging industry were significant factors in the selection of the site.



From its inception the Laboratory was staffed and equipped to conduct research in all phases of forest products research--from production to final use. The research has necessarily changed with changing needs. For instance, during World Wars I and II the entire research program was directed toward aiding the war effort.

In addition to the Forest Products Laboratory, forest products research is also conducted at industry, association, private, state, and university laboratories. The research is frequently coordinated between laboratories working on specific problems. Important findings have led to improved wood utilization. Assigning credit for specific achievements to an individual or a single laboratory is almost impossible. Alexander Graham Bell observed that great discoveries and improvements invariably involve the cooperation of many minds.

The potential of today's wood research that makes use of the newest developments in unrelated fields and adapts them to solve a specific lumber-production problem can be illustrated by the following example.

Lumber mills have the problem of producing rectangular lumber items of specified sizes from cylindrical logs. Lumber yield is therefore complicated by the need to fit rectangles into a circle. Slight variations in location of a saw line can result in substantial differences in lumber yield. The crucial step is the first, or opening, cut, because the resulting face, or saw line, fixes the position of subsequent cuts in the same plane.

To solve the problem of the first cut, the Best Opening Face sawing system, utilizing computerized, automatic equipment, was developed at the U.S. Forest Products Laboratory in the early 1970's. An automatic diameter-measuring device, accurate to 0.1 inch, relays information to a minicomputer, programed to handle various options and variables. The computer selects the best opening face and sawing pattern for the log and directs the precision-built saw, carriage, and setworks to cut the log in the selected pattern. The system, which is rapidly being adopted, has introduced an era of sophistication not heretofore experienced by the industry. In addition, improvement in volume yields can range as high as 90 percent depending on the log diameters being sawed. The system is a first step beyond mechanization to provide automation capabilities to the sawmilling industry.

Shortly after the founding of the Forest Products Laboratory, a monumental task was begun of determining strength and other physical properties of commercial woods from trees grown in the United States. Because trees are products of nature, no two trees in a forest, although of the same species, are exactly alike. Wood properties vary from tree to tree and even from board to adjacent board. The infinite variety of wood material nature provides is a pleasant challenge to a fine craftsman but is a hindrance to a designer who must be concerned for the safety of a structure.

At the Laboratory, scientific sampling and test methods were developed first; then a qualitative evaluation of the forest resource was begun. This information made it possible to segregate wood material into a number of visual grades and to assign design values to the grades. Designers can now design with confidence and greater efficiency of materials and can choose a species of wood that best meets their needs. The scientific information on wood now available has also been of great value in developing modern standards for the production and the use of wood products.

As distance between wood supplier and user increased and as transportation improved, the old person-to-person arrangement no longer sufficed for purchasing wood materials. Instructions and requirements became more detailed. With time they have been developed into standardized rules and regulations.

Today wood and wood products are marketed nationally and internationally. This was made possible by the development of realistic and universally accepted product codes and standards that govern product sizes, tolerances, appearance, strength properties, and often performance. The development of workable standards for wood products from a diverse product of nature is of major significance in the more efficient use of the U.S. timber resource.

Research has been the impetus for bringing many new wood products into existence. Exterior plywoods, laminated beams, and structural building boards depend on adhesive bonding as an essential to their functional performance. These types of products, or at least some applications of them, would not have been possible without the significant advancements in adhesive technology in recent years.

Early glues were developed from materials of natural origin; the earliest were animal-and-hide glues. Casein, also an animal product, and vegetable proteins later formed the base for adhesives, and are still used to some extent. All of these types, however, lack resistance to moisture and to fungi; thus products that incorporate them are limited in use.

The greatest advances in adhesives have come since the midthirties with various coal tar- or petroleum-based synthetic resin adhesive systems developed to meet specific needs. Some of these adhesive systems have been shown to produce bonds stronger and more durable than the bond of the wood cells.

Polyvinyl resin emulsion adhesives, the commonly used white glues, have largely replaced animal glues in the furniture industry for edge-bonding and assembly operations. Some of the initial limitations of this type of adhesive are now being overcome.

Another crucial advance in wood use brought about by research is the development of effective preservative treatments. Early pioneers soon learned that some of the native species resisted decay much better than did others. Whenever possible they selected cedar, baldcypress, chestnut, locust, white oak, or other decay-tolerant species for use in fenceposts or in other situations in which the wood would be in contact with the ground. Some of the early settlers in the Midwest brought locust saplings with them from the East to assure themselves of a future supply of durable fenceposts.

Research, through the application of various preservative chemicals, has made possible extended service life of all wood species used in unfavorable conditions. Preservation treatment is essentially an impregnation of a wood with a water- or an oil-borne toxic, which prevents or retards wood attack by biological organisms. The effectiveness of a treatment depends on wood penetration and retention of a particular chemical. Improved methods for assuring proper retention have recently been developed.

Among the great variety of products customarily treated with preservatives are utility poles, marine piling, fenceposts, railroad ties, lumber, timber, and plywood. Treatment imparts a service life 10 to 20 times that of these wood products with no treatment. The prolonged endurance of treated wood results in annual savings of about 2.3 billion cubic feet of wood, one-sixth that of present consumption.

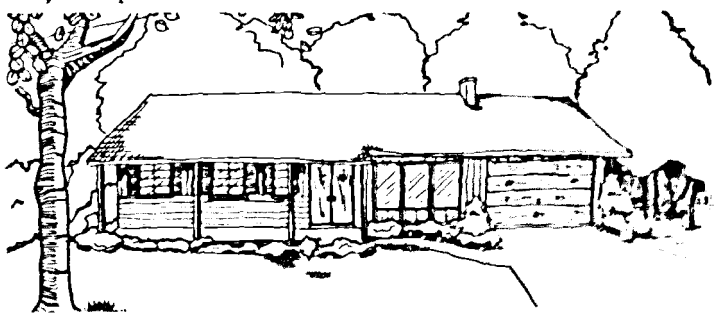
New Uses of Wood

Users of the U.S. wood resource today consume about 13.7 billion cubic feet yearly. Some of the early wood uses, such as for masts, ships, plank roads, wagons, and even for fuel, are of little or no importance today. Wood, however, has retained many of its traditional uses--for housing, industrial buildings, furniture, and utility poles. A great many new uses have been added. Wood today is sometimes so greatly modified in the manufacturing process that even an expert cannot identify a product as having a wood base.

Wood for Housing

Wood has retained its essential role in housing and provides the largest single market for lumber, for plywood, and for a wide variety of other wood products.

About a third of U.S. softwood lumber and plywood is used to produce new housing, as well as substantial volumes of other timber products, such as hardwood, plywood, particleboard, and insulation board, according to the U.S. Forest Service. Also according to the Service, the 1.9 million living units constructed in 1970 required a staggering 12.3 billion board feet of lumber, 6.3 billion square feet of plywood, and 2 billion square feet of hardboard, insulation board, and particleboard.



Despite technological developments, the first half of the 20th century brought few changes in residential architecture. The two-story house with its white clapboard siding remained the most popular style until the arrival, after World War II, of the low-profile ranchhouse. A native new wood architecture that emphasized use of the natural appearance of wood began on the West Coast. In a few years it became the widespread new image of the American home. Wood now is the favored material for low-rise residential apartments.

The basic light-frame construction system widely employed today is a native development; it has had relatively little change in basic concept since it was introduced in the mid-1830's in Chicago.

In recent years, the housing industry has introduced new products, prefabricated components, and new construction techniques. Although outwardly houses have changed little in the last few years, important advances can be attributed to the use of improved materials and construction methods. The use of prefabricated components such as entire wall and roof sections for quick erection on a building site is rapidly expanding. Virtually all buildings are now insulated to conserve energy. Panel materials, such as plywood, fiberboard, and particleboard for sheathing, subflooring, and exterior siding, are used extensively.

Builders quickly recognized the advantages of the new panel materials. Sheets, usually 4 feet by 8 feet, are relatively lightweight and easy to handle, easy to apply, and provide strength and rigidity not formerly attainable in light-frame construction. Thus, a structure can be enclosed against the elements in record time.

During the early part of this century, veneer and plywood--panels with adjacent veneers bonded together with their grains at right angles--were made chiefly in the East from hardwoods such as yellow-poplar, sweetgum, birch, and walnut. These panels were used for sewing machine cabinets, desk tops, doors, and furniture, but were little used for construction. The animal and the vegetable glues employed in the early 1900's restricted plywood use to interiors that were free from excessive moisture. The development in the 1930's of water-resistant adhesives from synthetic resins removed the restriction. Today large quantities of plywood are used for exterior housing as well as for other construction.

Douglas-fir plywood was introduced at the Lewis and Clark Exposition of 1905. Until about 1960, Douglas-fir was the primary species for construction plywood. Since that time there has been a gradual increase in the use of other western softwoods such as western hemlock, the true firs, western larch, and Engelmann spruce. Southern pine plywood came on the market in 1963, and today, according to the Forest Service, accounts for about 30 percent of the total production of construction plywood.

Prior to 1950 most decorative plywood, used primarily for prefinished interior wall paneling, was from native hardwoods. A change in tariffs stimulated imports, and today half of the decorative plywood used in the United States is imported.

Housing provides the major outlet for panels of reconstituted wood. These panels include insulation boards, hardboards, and particleboards. Building fiberboards, hardboards and insulation boards, are made of interfelted wood fibers. Particleboards, also called chipcore, chipboard, or flakeboard, are made from small chips or flakes of wood--planer shavings, sawdust, or specially made flakes--bonded with an adhesive. Leftovers from wood-using industries supply about 60 percent of the raw material for these reconstituted wood products.

Although U.S. patents for different types of reconstituted wood date back more than 100 years, this type of panel is really a product of the 20th century. Insulation board is the oldest type. Insulation boards are lightweight and have effective thermal and sound-insulating properties that usually dictate their use in construction. In recent years, almost two-thirds of the houses in the United States with exterior sheathing have insulation board sheathing. Other uses of reconstituted wood panels include acoustical ceiling tile, roof insulation and decking, and sound-deadening board in walls.

Hardboard is a fiberboard that is hot-pressed, sometimes a binder is added; the board generally is less than 1/2-inch thick. The largest market for hardboard is house siding, either as large vertical panels or as horizontal lap siding. Hardboard is also used for floor underlayment, for prefinished wall paneling, and for storage walls in a form known as pegboard.

Particleboard, the newest of the reconstituted wood products, was first manufactured commercially in the United States about 1945. The industry has grown rapidly in the last 20 years. According to the U.S. Forest Service, production in 1955 was less than 200 million square feet, on a 3/8-inch thickness basis. Now annual production is about 6 billion square feet.

The first use for particleboard in this country was as corestock in furniture; this is still one of its leading markets. Another leading market is for floor underlayment; about one-third of all particleboard is made for this use. Also, more than 90 percent of the single-width mobile homes have particleboard floor decking. Some exterior grades of particleboard are being promoted for use as house siding and sheathing.

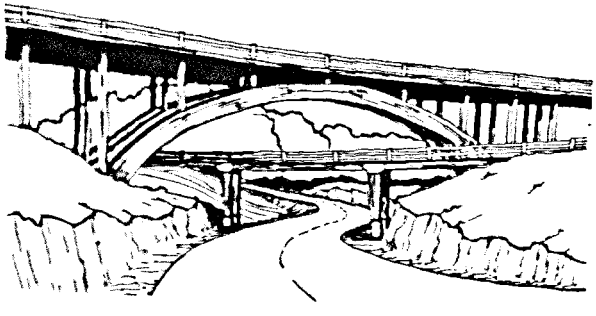
The increasing use of these reconstituted wood materials in the vast housing construction market is of great current interest because the U.S. wood resource can thus be used efficiently.

Wood for Nonresidential Construction

Almost 10 percent of the lumber and plywood used in the United States in 1970 and large quantities of building boards were used in constructing large structures such as offices, stores, warehouses, schools, hospitals, and highway bridges, according to the Forest Service. Many are of conventional design, but new materials and standardized wood products with known design properties have resulted in better than conventional structures and in new architectural opportunities.

Laminated structural lumber--the result of gluing together layers of lumber with all grains essentially parallel into large shapes to meet specific design requirements--has gained wide acceptance. Because of their attractiveness, wood structural members are usually left exposed; thus their natural esthetic qualities are lent to the design. The development of waterproof adhesives makes possible the use of laminated beams in outdoor exposures.

The graceful esthetic effects of laminated arches have won them a place in many churches and public buildings. The large clear spans that can be achieved, many over 250 feet, are also ideal for aircraft hangars and sports arenas. A dramatic example of the use of laminated and solid wood is the Keystone Wye interchange on U.S. Highway 16 near Mount Rushmore, South Dakota. Wood was chosen to blend its natural beauty with the surrounding landscape. This trilevel interchange has a 290-foot-long upper bridge supported by three 155-foot-long arches over a lower bridge.



Wood in Transportation and Communications

Throughout most of American history, travel, if not by foot or horseback, was by a wooden conveyance--canoe, ship, coach, or railroad passenger car. The drastic changes in transportation during the last 100 years have led to wood for specialized uses rather than as a customary basic material for modern conveyances.

In the 20th century, wartime steel shortages and strategic requirements brought about several wooden shipbuilding revivals. During World War I, on both coasts, wooden ships were constructed for commercial firms and for the Navy. World War II brought another revival. In 1944, for instance, the Navy required 9 million tons of steel and 3 million tons of wood for its construction program.[2]

In railroading, wood has lost little of its traditional importance. Wood is still used for tracks, cars, bridges, stations, fences, snowsheds, tunnel linings, docks, wharves, bulkheads, crossing planks, dams, and for maintenance. Treating ties with preservatives was begun early in the 1900's. Today, ties must be replaced only one-third as often as they were at the turn of the century. Indicative of the declining importance of railroads, however, is a drop in annual production of railroad ties--from 96 million in the 1920's to 21 million in 1970.

Largely forgotten is the fact that early aircraft, including those used in World War I, were made of wood. Wooden wing spars and ribs were used to support fabric covering. This type of construction continued through and after World War II for lightweight, inexpensive private planes and civilian trainers. Between the two Wars, plywood was introduced as a covering for spars and framing on wings and fuselages of military trainers and in the faster, more expensive private planes.

At the beginning of World War II, American military and commercial planes were almost entirely of metal, but primary and advanced trainers and gliders made use of wood and plywood. Shortages of metals early in the War brought about an increased use of wood in aircraft, and led to the development of molded plywood construction in varying thicknesses and complex shapes. Production of wood trainers and gliders accelerated rapidly, and new designs in wood construction were realized. The most publicized wood aircraft, flown just once in 1947, was a "flying boat" by Howard Hughes. It was built mainly from birch plywood and molded by methods that were engineering breakthroughs.

Exactly 100 years ago, Alexander Graham Bell exhibited his newly invented telephone at the Philadelphia Centennial Exhibition. By the 1920's almost 2 million wood poles were required annually for U.S. communications systems. Some authorities predicted the supply would run out. But, according to the Forest Service, for the last 25 years, the United States has produced and used 5 or 6 million wooden poles annually.

Chestnut was originally the predominant species for utility poles; 50 years ago it was cedar, primarily northern cedar. Today, 85 percent of the poles are of southern pine (small poles); the remaining, of western redcedar and Douglas-fir (large poles). Since 1930, virtually all utility poles have been treated with preservatives. In the last few decades some large transmission structures have been fabricated with glued-laminated members.

Wood in Shipping and Handling

Wood is not only a major source of industrial products. Wood in the form of the familiar corrugated fiberboard container is the means by which most industrial and agricultural products are now shipped. During the last 50 years, fiberboard from wood fiber has replaced solid wood as the predominant shipping container material. Corrugated fiberboard containers are remarkably versatile, lightweight, and adaptable for all kinds of products. This material not only provides ample protection, but also lends itself to automatic setup, filling, closing, sealing, handling, and inventory control. Its impact on the environment is minimal, for it is reusable, biodegradable, and easily recycled. More than 200 billion square feet of fiberboard were used for containers in the United States in 1972, according to the Fibre Box Association.

Many of the fiberboard containers are shipped in groups on wood pallets, which reduce individual handling and allow forklift trucks to be used. This results in increased efficiency and decreased product damage. The pallet industry, only 30 years old, has grown rapidly, and in 1974 produced 205 million shipping pallets according to the National Wooden Pallet and Container Association.

Wood for Furniture

Wood has retained its traditional preeminence for furniture. The furniture industry guided by dealers and consumers continues a strong preference for wood. The industry is a major consumer of lumber, and uses annually between 2 and 2-1/2 billion board feet of the hardwoods produced and almost 1 billion board feet of the softwoods, as well as large quantities of the reconstituted wood products, hardboard and particleboard. Most of the wood used is from domestic species. No single species dominates the furniture market. The major part of the market is shared by 8 to 10 woods that include oak, pine, maple, pecan, walnut, cherry, and birch.

Preferences in style change rapidly, and are dependent on regional preferences. In general, however, the present trend is a rejection of exotic and elaborate designs in favor of natural or simplified modern forms. Interest is growing in "country look" furniture of thick lumber, and all-wood furniture devoid of plastic decoration is preferred.

Chemicals from Wood

Production of chemicals from wood is not new. The chemicals grouped under the general name "naval stores" are still by far the most important chemicals derived from wood. The southern pines are the main source of these stores. The old methods of tree tapping for gum rosin and turpentine and extracting wood rosin and turpentine from dead logs and stumps are still practiced. However, their share in the production of naval stores has been steadily declining. This is giving way to extracting naval stores as a byproduct (tall oil) of the kraft production of paper pulp.

According to the Pulp Chemicals Association, about 1.2 billion pounds of crude tall oil are now produced annually in the United States. By distillation, tall oil yields rosin and fatty acids. These chemicals are used in manufacturing many useful products that include adhesives, asphalt tile, carbon paper, detergents, gasoline additives, lubricants, varnishes, pine oil disinfectants, printing inks, soaps, vinyl plasticizers, and waterproofing agents.

Naval stores are among the extractives, the nonwood substances that occur in wood; extractives range to up to 10 percent of wood weight. Smaller amounts of chemicals are derived from chemical decomposition of the three basic constitutents of wood substance: Cellulose, hemicellulose, and lignin. For instance, pulping processes, which obtain a cellulose-rich substance suitable for papermaking, leave as byproducts the so-called spent liquors, which contain carbohydrate and lignate decomposition products. These, by fermentation, may be converted to industrial ethyl alcohol, and, by various other processes, to yeast suitable for animal and poultry feed and to vanillin flavoring. The spent liquors from kraft pulping are mostly concentrated and used as fuel. A portion, however, is converted to dimethyl sulfide, which is a valuable intermediate for production of dimethyl sulfoxide, a very useful solvent.

Since petroleum, the source of many industrial chemicals, increases in price, there is renewed interest to derive still more organic chemicals from wood, available and renewable. Important engineering and economic assessments of the problems involved await investigation.

Wood as Fuel

Wood for fuel, one of the oldest uses of wood, continues in the United States although the proportion of roundwood harvested for use as fuel is less than 5 percent of the total. In other parts of the world wood retains its importance as fuel; 50 percent of wood harvested throughout the world is used for fuel.

In 1970, according to Forest Service estimates, U.S. fuelwood consumption was 1.4 billion cubic feet. This included about 314 million cubic feet of roundwood from growing trees, 225 million cubic feet from other sources such as dead and discarded timber, and 723 million cubic feet from residues of wood-processing plants.

Charcoal briquets fuel barbecue ovens in millions of backyards across the country. They are made from sawmill residue such as slabs, sawdust, bark, and some low-quality roundwood. The charcoal industry produces 600,000 tons of charcoal briquets annually from about 1.8 million tons of wood, the equivalent of 120 million additional cubic feet of fuelwood.

In addition to ordinary logs, fireplace-size logs produced from sawdust, shavings, and other finely divided residue have become popular. More than 40 million of these logs are produced annually.

Most of the remaining wood residue used as fuel is burned for heat and for steampower in mills and wood-processing plants. The pulp and paper industry, the fourth largest energy consumer in the United States, consumes the largest amount of wood residue for fuel. It derives 10 percent of its energy from wood residues and an additional 32 percent from combustion of wood-derived materials in spent pulping liquors.

Miscellaneous Uses of Wood

Wood is no longer the universally used material of 200 years ago. Much of the woodenware described in the section on 1776 has no modern descendants or has been replaced by metal, glass, or plastic. Yet a great many wooden items are still familiar objects in every household. There are rolling pins, mashers, chopping boards, bowls, utensil holders, trays, boxes, clothespins, and baskets. Kitchen knives and axes, rakes, shovels, and other tools still commonly have wood handles, as do brooms, hairbrushes, paintbrushes, and artist's brushes. Wooden cribs and chests are still customary, and wood is still used in ladders, shingles, fencing, and in many farm structures.

Most of the small wooden manufactures that flourished 100 years ago flourish today, including wooden spools, matchsticks, pencils, pipes, rulers, baseball bats, toys, picture and mirror frames, models, musical instruments, caskets, and clockcases. Wooden barrels are still required for wine and whiskey and are being revived for some dry goods. Although this may be considered a minor use of wood, 215 million board feet of lumber were used for barrels in 1970.[3]

Other uses of wood are being restored by a growing crafts' renaissance in the United States. Thirty years ago woodworkers and individual furnituremakers, survivers of a great tradition, were few in number. There was no place to study crafts and no apprentice system, as in Europe. After World War II, however, there was an influx of European craftsmen. Many became teachers. Schools and universities began to adopt crafts programs. Most of today's young craftsmen are university trained. They grow in number as more people discover the satisfaction of hand-working natural, organic materials. Many imaginative amateur architects are building their own houses; the material chosen most often is wood.

Communities of craftsmen have emerged throughout the country, and handmade wooden furniture, boats, baskets, toys, and utensils are appearing. The products are not only useful and of high quality but can be beautiful works of art as well.

Wood, as an artistic material, has never lost its vitality. Wood sculpture--religious objects, portraiture, and animal carvings--is still a major folk art. Wood engravings and woodcuts have continued to grow in popularity among professional artists; the prints are in effect multiple original works of art.

Wood engravings have begun to appear again as illustrations in serious novels and other types of books. Americans are becoming increasingly aware of the need to use the renewable resource of wood and to adapt it to a modern technology. With this awareness, craftsmen and artists, undoubtedly, will insure the preservation of the intimate knowledge and high standards of workmanship of wood, a part of the oldest heritage of this Nation.

Timber Demand and Supply

Wood is so essential in the economy of the United States and is so universally used that it is important that reliable information on timber supplies be available as well as information on present and predicted demands for timber. Yet a comparison of the periodic major reports of the U.S. timber situation is likely to cause only confusion for anyone unfamiliar with the methods by which timber is measured, inventoried, and used. Only one area will be found consistent throughout the various inventory documents of the 20th century: A concern that the much dreaded and oft-predicted timber famine is likely to arrive in the near future.

For the greater part of the two centuries of this Nation's existence, timber was considered an inexhaustible resource. This attitude was applied to the superb virgin timber stands. These stands plus the fertile soil, rich supplies of minerals, and the hard-working people made America into a rich and prosperous land. Today there is no supply of virgin timber to exploit. The virgin hardwoods and the virgin spruce and pine of the Northeast as well as the virgin pine and oak timber of the South have been depleted. The magnificent white pine stands of the northern Lake States were harvested in a relatively short period about the turn of this century. More recently, the large industrial timber establishments, propelled by World War II and the booming economy that followed, have almost depleted the virgin timber of the West. Most forested land has experienced the logger's ax for a second and even a third time. The timber famine would indeed be here if wood, like minerals, could be utterly depleted.

Over the decades, industry has found many substitutes for wood. Large buildings are constructed of metal, concrete, and stone. Transport systems are heavy users of steel and aluminum. The average consumer is accustomed to the increasing use of metal and plastics to replace wood for household gadgets and even for furniture. Despite these substitutions, growing demands for wood have continued and timber supply problems, although acute, are likely to be solved.

How then with the depletion of the Nation's virgin timber supplies, is it possible that wood products can continue to increase to unprecedented heights?

The miracle of wood is that nature has made it renewable. The miracle is so astounding even America's early foresters failed to appreciate the potential of the forest land to reproduce timber crops. The early foresters consistently predicted imminent shortages. Only in recent years, because the backlog of virgin timber has essentially been consumed, has the forester as a husbander of timber crops begun to be appreciated.

Further advances in utilization must be anticipated as species, sizes, qualities, and geographical distributions of available timber supplies continue to change. It is the major role of wood utilization research to make these advances possible. Foresters now confidently predict that U.S. forests have potential to provide a reasonable quantity of forest products for consumption by more than 400 million people.

Progress in avoiding the long-predicted timber famine cannot be attributed solely to nature and to foresters manipulating the forces of nature. The most important element for progress is improving the utilization habits of wood processors. Early loggers were highly selective in their harvesting methods; they chose only quality trees for the sawmill. The remaining trees were left in the forest: Small trees, trees of undesirable form, partially decayed trees, dead trees, and a whole group of "less desirable species." The harvesting process itself was very wasteful even of the highest quality trees. Large portions of each tree were left in the form of high stumps, limby wood, and broken logs.

Early foresters accepted industry's evaluation of what was usable at a mill. That evaluation, in turn, was influenced by traditions of limitless supplies of inexpensive timber. Even inventories of the Nation's timber supplies were traditionally based not on volume but on industry's conversion practices; witness the "board foot" as a measure of standing timber instead of cubic volume used elsewhere in the world.

Perhaps one of the most dramatic illustrations of the changes in recent years that improve timber utilization efficiency comes from one of the largest of the Nation's timber firms. In 1948, a typical acre of Douglas-fir timberland harvested by that company produced logs that were sawed into 3,640 cubic feet of lumber; 14,280 cubic feet of wood were left as waste or were used as fuel. A quarter of a century later, in 1972, a typical acre of Douglas-fir timberland harvested by that company produced 3,248 cubic feet of lumber. In addition, from that same acre the company produced 1,272 cubic feet of plywood, 1,026 cubic feet of particleboard, 2,234 cubic feet of linerboard (a heavy paper product for containers), and 6,341 cubic feet of saleable chips and logs. The total yield of products was 14,121 cubic feet! Only 3,247 cubic feet of wood were left at the mill for fuel or were wasted.[4] This is a magnificent achievement in utilization efficiency and yet is may be assumed that improvement is not yet at an end!

To arrive at production statistics to predict future timber demand and supply, it is understandable that customarily a conservative position has been adopted. Perhaps this has been influenced by the early "low technology" image of the timber industries. Thus, Forest Service predictions assumed that technological improvements in the lumber industry would lead to increases of 2 to 4 percent per decade in product output from a given volume of roundwood.

A most recent estimate of utilization improvements from technological change, based on a study of timber input and product output from World War II to the present, indicates an average advance of 1.75 percent per year--almost 20 percent in a decade.[5] The 20 percent deals only with utilization efficiency at the processing plant, and does not include harvesting gains similar to that of the Douglas-fir timberland.

In 1970, the U.S. Forest Service estimated the Nation used approximately 45 billion board feet of softwood sawtimber and 11 billion board feet of hardwood sawtimber from U.S. forests. By the year 2000, demands for domestic softwood supplies are expected to increase to 54 billion board feet; those for hardwood, to 21 billion. If these figures prove correct, assuming little or no progress in forestry improvement, U.S. would indeed "be mined" by the year 2000. Timber would be cut faster than grown.

Much can occur to upset predictions. Prices will inevitably rise, and demand and supply will reach a new balance. Continuing research and its implementation can be expected to bring about great improvements in growing timber and in developing more efficient methods for its use. Because of the growing shortages of nonrenewable resources on which the U.S. high standard of living depends, the challenge of attaining improvements in the availability and the use of wood becomes daily more urgent.

Much more could be said about the status of the Nation's timber inventory. For example, the bulk of the Nation's softwood, now the mainstay of the industry, is in the West. The inventories are being reduced at rates that overshadow the gains being made in the East, where there is an increasing overabundance of hardwoods. For the Nation as a whole, the present balance between growth and removal, regardless of species, is favorable. Furthermore, the net annual growth of timber is rising, but is still only about one-half the potential of fully stocked stands.

More timber is harvested for sawing into lumber than for all other products combined. Pulpwood accounts for about one-third of all roundwood products from U.S. forests. Within a relatively few years the problem is likely to be a shortage of softwood sawtimber and will require a major readjustment in wood-use habits.

Within the United States, there are still a number of sources of wood fiber. Recycling wood fiber products, mostly in the form of paperboard containers and to a lesser extent newspapers, although encouraging, is still at a relatively low level. Only about 20 percent of once-used paper products is recycled. In some parts of Europe and Japan, 50 percent is recycled. Economic incentives to greater recycling may be lacking at present, but the technology exists. It is assumed that inevitably a high rate of recycling of once-used wood products will become reality.

A source of wood fiber, although not used, is the urban renewal waste from the demolition of old buildings. The reuse of once-used ties, timbers, pallets, and other large volume items could considerably relieve demands for additional timber from U.S. forests. Obviously the great variety in shapes, sizes, and qualities of wood products entering the recycling stream will be suitable mainly for recovery of wood fiber.

Some pulp experts predict the U.S. pulp industry will be able to exist entirely on wood residues from other wood-using industries, such as sawmills and plywood plants, from recycled wood fiber, and from solid wood objects. Added to all these sources will be ornamental and shade trees from urban parks and streets, a source of wood fiber not used that adds to the disposal problems of urban solid-waste handlers.

Utilization practices have obviously undergone great changes to adapt to the changes in timber qualities and quantities available for utilization. A great need exists to exploit to the fullest the forestry opportunities for growing timber as a crop in an ever-increasing quantity. Already this has been accomplished for annual agricultural crops. Because of the long timespan required for growing trees, the problem is complex, and governmental agencies will have to assume responsibility for long-range planning.

Only a fraction of the Nation's commercial timberland is operated as cropland with efficient husbandry. Industrial firms own about 14 percent of the country's most productive forest land and have taken aggressive forestry action to grow timber in increasing quantity and of improved quality.

Twenty-seven percent of the commercial timberland is in government ownership--Federal, state, county, and municipal--and this includes some of the less productive areas. Often care is purely custodial. Well over 50 percent of the most productive commercial land is owned by farmers and by a miscellaney of small private ownerships. The quality of forest management practiced on this large segment of land varies greatly with each owner's interests and capabilities. Great opportunities exist for improvement of this segment.

The task of extending U.S. timber supplies and products to accommodate the next century's needs has hardly begun. The need is great to put the 500 million acres of America's commercial forest land to work growing wood as a crop. The growing will require all of the innovations, the ingenuity, and the new developments from research that American scientists and professional foresters are capable of applying.

Looking Ahead

In this Bicentennial year of 1976, Americans have cause to be concerned about their future. America has completed a full cycle of the rich resources so abundant and important in making this Nation a world power. Material resources and energy for industry are no longer readily available, and future supplies of both are expected to be critical. Of the major materials available for industry and for construction, only renewable wood is capable of serving man's needs in perpetuity.

Evidence grows that significant changes lie ahead. Recently and suddenly, concern for new energy sources, elimination of pollution, and the wiser use of natural resources has brought historic transformation in the thinking of concerned Americans.

Plans are under way to approach the problems of this Nation's renewable forest resources in a forthright and comprehensive manner. Federal legislation has initiated the Forest and Rangeland Renewable Resources Planning Act of 1974.

For the first time, an act proposes to attack the overall problems of assessing the Nation's renewable natural resources and of developing long-range policies and programs to make use of these resources on a continuing basis. The Act directs the Forest Service to develop long-range plans to ensure the United States of having an adequate supply of renewable resources from the Nation's 1.6 billion acres of public and private forests and rangelands while maintaining the integrity and the quality of the environment.

Major opportunities proposed in the Act for improving utilization of the renewable resource wood include the following:

Extend raw material sources by using material now left as logging or mill residues, by expanding recycling of wood products, and by increasing the use of domestic hardwoods;

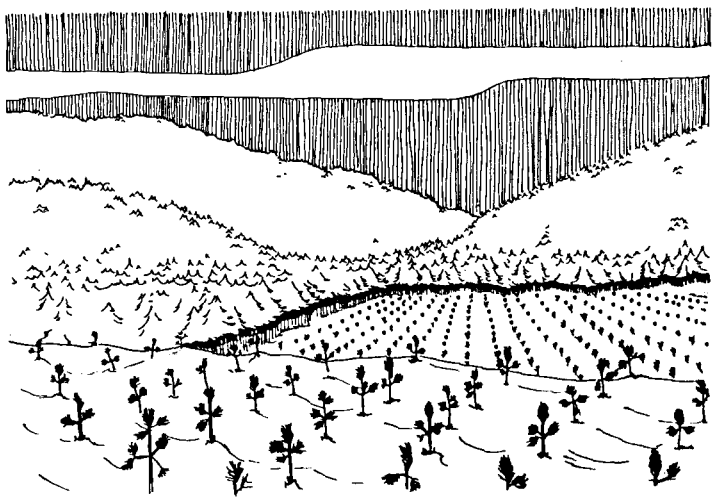
Increase recovery of primary products through process improvements;

Develop new products that can be produced efficiently or can meet specific product performance more efficiently than present products;

Improve engineering structures designed to meet performance requirements at reduced expense; and

Improve techniques to protect wood from fire, weathering, and decay.

Implementation of this farsighted Act would, indeed, be a fitting prelude to the third century of the United States of America.



SECTION FOUR

Wood in the Nation's Future

PROLOG

Prediction of the future economic importance of wood in the United States must, of course, be conjecture. However, it need not be pure guesswork. The lessons of the past and of the present can be helpful. It can be assumed that future generations will find solutions to problems that can now be readily identified but not solved. It can be assumed, too, that men and women of the future will aggressively seek solutions because the present-day stewardship of U.S. natural resources will have greatly restricted the options.

It is logical to predict that by 2076 industry will need more raw materials than ever before to manufacture goods to satisfy the needs of an as yet undetermined but presumably larger population.

Needs will have to be met within worldwide restraints--shortages and rising raw material prices and stricter environmental controls. It is illogical to assume that by 2076 some magical and inexhaustible substitute for wood will have been developed. It is, however, logical to predict that forests will be growing in 2076, and that the wood harvest from those forests, whatever the nature and amount, will be in great demand and be quickly put to use.

An assumption has been made: An advance copy of a talk on wood utilization for presentation July 4, 2076, is available for review.

WOOD UTILIZATION--A TRICENTENNIAL REVIEW[1]

By

Dr. A. Caroline Smith[2]

To be the first speaker at this important conference is, indeed, a great honor. I recognize, however, that this is not a personal tribute but rather a recognition of our Nation's great dependence on the important material I will be discussing--wood.

To comply with the objectives of this conference and the explicit instructions I received, my remarks will be confined to progress in wood utilization in the last 100 years. On this significant day in our Nation's history, however, I cannot refrain from harkening back a bit.

Three hundred years ago, in 1776, our economy was heavily based on wood--for fuel, for housing, for transportation, and for a myriad of other uses. In 1876, wood continued its indispensable role and contributed to another successful revolution--the Industrial Revolution--from which this Nation emerged as a great world power. In 1976 wood was still one of the most important raw materials; the annual tonnage of wood produced in the United States in 1976 was greater than the tonnage of steel, cement, plastics, aluminum, and all other metals combined. Each of these three eras might well be characterized as an "Age of Wood." But, now in 2076, I feel our claim to that designation is the greatest.

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[1] To be presented at National Conference on Material Resources and Environment, Philadelphia, Pa., July 4, 2076.

[2] Scientist, Historian, and Director of Resources Institute, U.S. Department of Materials and Energy, Washington, D.C.

In my studies I find that throughout our history a few of our people have raised concern over the management and use of our timber resources. For the most part they have not been heeded. Changes have come but few measures were taken to slow the rapid exhaustion of our natural resources. Strangely, about 100 years ago, the realization that an era of abundance was at an end came abruptly. Our people recognized the growing scarcity of both materials and energy and their increasing dependence on uncertain foreign imports. For the first time the oft-repeated predictions of timber shortages were well documented. There were no virgin forests in the West to exploit. From this complex and manmade dilemma came the great changes that we live with today.

My purpose here is to discuss some of the changes that have led to our Nation's present self-sufficiency in wood. I have organized my talk in four sections. In the first section I shall compare how we used wood in 1976 with how we use it today. In the second I describe changes in the technology of processing and using wood that have extended our timber supply and enabled our wood to be used more wisely. In the third I discuss research breakthoroughs during the last 100 years that have made wood the predominant material for the chemical industries of 2076.

In the fourth and concluding section I tell how our forests, nature's bounty, can continue to provide our Nation this unique and seemingly limitless material through research.

Use of Wood--Now and Then

In the early years of this Nation we were fortunate for we had always sufficient supplies of wood to enable us to use wood liberally. Yet a century ago, in 1976, the annual consumption of wood per capita had declined to barely one metric ton. It had been largely replaced for fuel by gas and petroleum; for other uses, by metals, plastics, and masonry. Our citizens then became worried about the rapidly declining supplies of our nonrenewable materials, and rightly so!

Environmental concerns also forced a reassessment of our thoughtless and bad habits in using material resources. For example, a report issued in 1973 by the national Commission on Materials Policy classified the major construction materials for "social costs," the added cost in percent of total cost to avoid environmental damage in producing a material, as shown in the following: Lumber, 2; steel, 9; aluminum, 28 and concrete block, 48.

A century ago was, indeed, a time of critical study and introspection! Fortunately for future generations, plans were initiated to exercise some control over the availability and the use of material resources. Thus in 1975, for example, the U.S. Forest Service, in response to new Federal legislation, presented to Congress its first draft of a program and assessment for the Nation's renewable resources. But for the development and the partial implementation of these farsighted plans, we could not maintain our standard of living today.

As petroleum supplies "dried up" during the last century and as the price of metals increased because of increasing extraction, shipping, and environmental costs, the total volume of wood used began to rise. To meet the growing demands, some major readjustments and changes were necessary.

It is interesting that a century ago even after a long history of ruthless exploitation and primitive forestry practices, timber was still growing faster than it was being removed. The timber removals in 1970 were estimated at about 400 million cubic meters as compared to 525 million cubic meters annual growth. Those figures were based on what, in those days, was considered "commercial"--that is, usable by the somewhat wasteful practices of that day. By today's method of measuring total growth, the volumes would, of course, be much higher. The annual removals, however, were mostly (about 70 percent) in large softwood timber, where shortages were said to be imminent. However, there was an oversupply of hardwood timber, much of which was considered low quality and sizes and types considered undesirable by the industrial users of that day.

A century ago a relatively small part of the Nation's timber harvest, less than 5 percent, largely in the form of raw material suitable for pulping, was exported. At the time, more than twice that amount of wood was imported by our country; some of it was highly selected tropical woods for fine paneling and cabinetry; some was lumber and some, pulp.

The wood-using industries of a century ago were not yet fully integrated. Hence, by today's standards, sawtimber was overemphasized. Sawtimber was timber-yielding logs of a type and size suitable for sawing into lumber. Fully one-half of the nation's timber went through the sawmill as its primary step for conversion into consumer products. About one-third of the timber cut went to pulpmills, although these mills had progressed to a point at which 35 percent of their supplies were in the form of chipped residues from other manufacturing processes. About 10 percent of the timber cut was made into veneer and plywood products. The remainder was converted into miscellaneous industrial products or burned as fuel.

The entire system of growing, selling, and using timber had been set up to accommodate the unintegrated industry as it had developed during the century preceding 1976. Sawmillers harvested or purchased sawlogs measured in a lumber unit known as the board foot, which could not readily be converted into measurement units for other products. Pulpmills sought their supplies in roundwood measured by the cord or purchased as chips in tons or cubic feet. Veneer mills were satisfied to select their material from the sawlog supply. Other products, such as poles or ties, were sold by the piece.

Only a few large progressive firms had adopted complete systems of measuring and using their timber supplies in a fully integrated system. By these systems they greatly minimized their inventory and materials control problems, and reduced waste in conversion.

A century ago, as in previous centuries, many still looked on wood as a fuel, a direct source of energy. Most homes and many manufacturing plants generated their heat and energy by direct combustion on the site. Petroleum, a major source of energy a century ago, has now, of course, been replaced by solar and thermal sources; coal, too, is now burned only in central generating plants with pollution controls. Wood, today has so many other important uses that it is much too expensive to use as fuel!

Coincident with the change to metric units of measure came a shift from measurement of only the volume of "merchantable" timber to that of the volume of the "complete" tree. This provided a better estimate of the total wood resource, and emphasized the portion of the resource previously wasted. The net result was a gradual improvement in utilization. There are, of course, different grades of wood that come from the forest; the grades are dependent on whether a wood is suitable only for fuel, fiber, or for some more discriminating use. The economically wasteful practices of processing good sawlogs into pulp or of burning wood residues from the sawmilling process have long since been abandoned. Wood formerly suitable only for fuel is today converted into chemicals and into fiber products, and I shall speak more about that.

By 1976 the trend to convert timber into panel products for specific uses--engineering applications, furniture--was well established. Plywood production had grown at a phenomenal rate, and had replaced lumber for many purposes such as house sheathing for walls, roofs, and subflooring. Structural particleboards, enabling the use of wood otherwise suitable only for fiber or fuel, had already been laboratory tested and was being marketed. Research was exploring the potential of composite panels or shaped products produced from wood fibers or particles combined with other materials such as fiberglass and synthetic rubber or produced from combinations of wood products in forms such as veneer, particles, and paper. These products are common today; each is designed to perform functions specified for that particular product.

Most wood-base fiber products of today are no longer of virgin roundwood. Following the trend of a century ago, they are made of wood formerly wasted or from recycled, once-used wood or wood-fiber products. Bark and the poorest grades of wood are now used for producing chemicals.

Concurrent with all these changes, the forest products industries, to remain competitive, have made some drastic changes in their practices and products. For many former uses, lumber has been replaced by panels, molded products, and composites. Countless products now being mass-produced in factories--boxes, boats, houses--require well standardized raw materials designed to the particular specifications needed. Lumber, once marketed as a commodity, has largely disappeared. It has been replaced by more sophisticated fabricated and graded products--solid wood, fiber products, and glued composites.

Manufacturers of furniture now use large quantities of particleboard and wood-fiber molded products. Furniture of solid wood is a rare luxury, and not often mass produced. Manufacturers who do produce this type of furniture and similar items obtain their wood supplies not as lumber but as squares or other discrete pieces; each is prepared on order. Only craftsmen--who still produce heirloom products by hand--hobbyists, wood-carvers, and other specialists still prefer to purchase their lumber supplies directly from a primary lumber processor.

In reviewing the timber situation in 1976, I noted a preference for large, softwood sawtimber of "good quality," and an overabundance of hardwood timber. Meanwhile, softwoods were being rapidly depleted. This situation has, of course, been remedied.

For most wood products in use today, conversion entails chipping, cutting, grinding, tearing, or chemically decomposing wood into small bits or fibers, then reconstituting the material into well designed products. Today's conversion processes were developed through research. The objectives were the following:

To free the timber user from a need to have timber of great size to get reasonably sized products;

To eliminate or reduce weakening effects of knots or areas of irregular grain or other nonuniformities;

To improve dimensional stability of wood in use;

To reduce waste in processing; and

To develop more efficient processes of drying wood, treating wood with chemicals, and getting wood into the most efficient shape for an intended use.

The relative oversupply of hardwoods versus softwoods has been equalized through research. Use of some hardwoods for lumber often presented problems in drying, in fastening, in other areas and--especially the irregular pieces of denser woods so common in hardwood timber stands a century ago. These problems, however, were eliminated through adopting various conversion processes. Already in use for paper a century ago, hardwoods are now commonly used for fiber and particle products for the construction and other industries. The concern about converting hardwood timber stands to softwood stands is no longer valid. All wood supplies regardless of preconceived preferences about species, size, or quality are provided useful and profitable outlets.

Technical Changes--A Boon to Wood Products

Technical improvements through research and industrial development came about rapidly when we Americans fully appreciated the importance of wood in our economy. This was enhanced by the realization that wood would have to be used more wisely or we would be going without the many products we had long been accustomed to having.

First of all, processing methods were developed that produced wood in shapes and sizes needed by an architect and an engineer. These products included large panels, glued of veneer or of wood particles, often combined with other materials as was specified and extruded or molded shapes, such as beams, columns, tubes, and curved members. All were made possible by taking wood apart and putting it together again with adhesives in a manner needed for an intended use.

A century ago a builder accepted wood for construction largely in the form it was developed in the tree, its fibrillar orientation designed by nature to serve as a column in a tree trunk. Obviously, this often did not fit an architect's design. Rearrangement of fibrillar elements in reconstituted wood products gave products stability, freedom from shrinkage, swelling, and warping, and the needed combination of strength properties.

The new processing methods made possible imparting fire resistance to wood by adding minute quantities of chemicals to dampen the combustion process. The methods made wood resistant to attack by insects and decaying organisms, without adding toxics, by removing the elements essential to the growth of the organisms that caused deterioration. The new methods also made wood resistant to penetration by atmospheric or liquid moisture by including chemicals that were unknown a century ago.

Long before 1976, we already knew how to "explode" the cellulose fiber to produce hardboard panels without the addition of adhesives. More recently, as we learned to manipulate the behavior of wood, we also learned how to modify wood nondestructively. Thus we could make "softwoods" out of "hardwoods," low-density products of great strength and even fiber products comparable to plastic foams. The major end-accomplishment has been the ability to make, within limits, wood materials of any desired strength or density. Thus, we are freed from certain disadvantages that hampered the utilization of our dense hardwoods a century ago!

A development related to our understanding of lignin, which had long been a mystery, was a partial and temporary treatment of wood that dissolves surface structure. Thus we can bond pieces of wood together without adding expensive synthetic adhesives. This new process enabled us, for the first time, to join pieces of wood together by a process comparable to that of welding metals! This is truly a breakthrough! At last, we are freed from limitations of size and shape, and can develop limitless shapes of wood at will!

WOOD--THE BASE FOR TWENTY-FIRST CENTURY CHEMICAL INDUSTRY

Nature has designed a remarkable method to create organic materials from carbon, oxygen, and hydrogen, with the aid of solar energy. Plants carry on this process, known as photosynthesis, every day, and, in turn, all other living matter is dependent on this basic process. The forest, growing at a very moderate rate of 2 metric tons of organic material per hectare per year, produces three times as much cellulose fiber per year as does a good crop of cotton.

In the early days of the wood chemical industry, wood was not used directly for chemical production. More than a century ago, some pyroligneous acid that yielded acetic acid and methanol was recovered from the charcoal process. Naval stores yielded turpentine and pitch; tall oil was extracted from waste sulphate pulping liquor left from the pulping of southern pines. Research, at that time, showed how to regulate the production of these chemicals by treating the living tree. There are other minor constitutents of wood that can be extracted for direct chemical use.

A true wood chemical industry, however, awaited the advent of processes to use the major constituents of wood, cellulose and lignin, for chemical products.

The cellulose fiber is composed of giant molecular chains, or polymers, just like cotton cellulose, although not so long. Cellulose is a highly useful chemical material. The highest polymer fractions can be dissolved and reconstituted into fibers such as rayon or converted into cellulose acetate, esters, and ethers, and these in turn into explosives, plastics, and lacquers.

Cellulose is converted chemically into sugar and alcohol, then into heavy chemicals. The process is started by treating cellulose with sulfuric acid or with other hydrolytic agents. Nonedible as well as some edible sugars are produced, which are, in turn, the basis for manufacturing protein yeasts or alcohol. Although these processes have long been known, they were never fully exploited. Now there are methods to convert trees quickly and directly into oil through the cyclic application of heat and pressure in the presence of a catalyst. Thus, we can now duplicate the process of making oil similar to that made through the long ages by nature itself. Limited quantities of plastics, motor fuel, and many other chemicals formerly produced from petroleum are now produced from wood that was long wasted.

As I mentioned, the important wood component lignin was the least understood. Lignin, the binding material between the cellulose fibers, makes up 25 to 30 percent of wood. As a result of a major research breakthrough, this plastic binding material between wood fibers can now be dissolved from wood for use or modified in place. As a byproduct of the cellulose pulping industry, lignin provides the basic material for plastics and for the post-petroleum chemical industry. By modifying lignin within wood structure, then by bending or by otherwise shaping, by stretching, or by compressing the cellulose structure, followed by fixing the lignin, wood can now be molded like a plastic or bent, stamped, or drawn like a metal.

NEW ERA OF WOOD UTILIZATION

A century ago grave doubt was expressed--Would America with its ever-decreasing forest land be able to continue to meet its needs for timber, this country's major renewable material resource? In fact, much of the 20th century has now gone down in history as the most splendid and also the most wasteful period in mankind's sojourn on this planet. Much speculation was given to the imminent doom sure to follow the ultimate depletion of the world's nonrenewable resources. Only very late in the century did we actually turn from speculation to an attack on material and energy problems.

We are still here in 2076 and bear witness that we have learned to live within our materials budget. We have learned to "make do" with what we have, in the quantities available. And, fortunately, we have learned to appreciate, to husband, and to enlarge our major renewable resource, wood. We no longer have "fat" in the system: Wasteful processing methods and wasteful habits of artificially created obsolescence. The wood junkyards of the previous century have disappeared!

A century ago we had made a good start on improving the efficiency of our processing methods to produce higher yields of wood products. Sawmill efficiency was improved through many steps. From the circular saw we went to thin bandsaws; from manual control of the sawing process, to computerized control. More precise and dependable equipment resulted in greater accuracy and increased yields. In lumber-drying, we developed methods of rapidly removing water without creating shrinkage flaws.

In the chemical-pulping processes that came into use in the 20th century, pulp yields were as low as 45 to 50 percent. Major components of wood, lignin and degraded cellulose, were lost or converted into process fuel in the chemical recovery process. Changes in these processes saved the portion of cellulose that had been degraded; yields soared to 65 or even 70 percent. Of course the solution of the "lignin mystery"--which I have already mentioned--provided us with a new material for industrial conversion that accounted for almost one-third of all pulped wood.

Great increases in wood supply were brought about by using species that had not been used. Many American woods considered "refractory" or "weed species" in 1876 had already been proved economically valuable by 1976, such as aspen and cottonwood, sweetgum and tupelo, and hemlock and the true firs. Equipment changes enabled small stems formerly left in the woods to rot to be used for sawmilling, for veneer and plywood, and for pulp manufacture. Economic changes in the value of raw materials generally made it profitable to bring from the woods kinds and qualities of wood not formerly used, such as insect-killed or partially decayed wood, limbs, broken and irregular pieces, and even bark. Although these irregular materials were at first not sought, changes made their use feasible.

The pulp industry had learned to receive much of its raw material in the form of chips rather than roundwood. Soon the industry avidly sought chips from wastewood generated in other primary processing industries such as sawmilling and veneer and plywood manufacture. As the industries in turn improved their efficiencies and generated less waste, the pulp, paper, and fiberboard industries expanded the recycling of once-used wood gathered in the form of old paperboard containers, newspapers, and even once-used timber, poles, ties, and demolition waste from urban trash.

Recycled wood fiber, used at a level of about 20 percent a century ago, readily rose to the present level, about 50 percent. Today recycling all types of used materials is considered essential. Structural fiberboards--fine materials for construction because of their strength, stiffness, insulating properties--are the long term resting place of much wood fiber material first used in paper or as solid wood.

Throughout our history the largest single use of wood has been in the construction of houses and other buildings. This still holds today although remarkable changes have occurred in both construction practices and in materials used. We Americans do not have to visit a museum to see the homes of our ancestors. They are still here and being used--a great tribute to the durability of wood. No doubt some in this audience live in houses dating from our Bicentennial or, perhaps, from our Centennial period. The Centennial period homes and even these built in Colonial days are beautiful and functional. Perhaps our most severe criticism of them would relate to the lavishly extravagant use of wood!

Because of the large volume of wood used in construction, a great amount of research has been directed toward improving wood utilization in this field. The growing practice of designing wood-base products for specific uses has resulted in great improvements in utilization. For example, high-grade lumber was almost universally used for sheathing buildings a century and a half ago. The panel industry changed that, and made the use of thinner panel materials possible--half the thickness of the lumber then used--to sheath buildings. Actually, these materials improved the strength and rigidity of a structure.

Our typical single-family house of today uses less than half of the material required for a house of similar size built 100 years ago. Today's house has greater fire safety and in all other respects is as livable, safe, and durable as the house of a century ago. Contributing significantly to this achievement was a new concept of evaluating structural adequacy. Tests of completed structures, rather than smaller building components, revealed areas for which savings in materials could be made. The savings achieved also extend to our larger structures--but to a lesser degree.

A century ago much research on the use of adhesives was concentrated on procedures to make wood members larger and more functional than nature could supply them. In 1976, a thriving laminating industry supplied large timbers as needed, either straight or curved, each designed and assembled of moderate-size pieces of lumber, to meet specific stress requirements.

Our modern adhesives have made possible advancements far beyond the 1976 level in producing required or specified shapes and sizes of wood from a great variety of species and qualities of wood. All this has been via fiber or particle processes. The development of structural particleboard a century ago was just a prelude to a major industry that today supplies large members that are glued, shaped, or molded to meet architects' and engineers' requirements.

The multifold changes in wood-material demands have been reflected in forest operations. Two centuries ago the magnificent white pine stands of the Lake States were cut down; only the large sawlogs were harvested for lumber. Years later the same land was recut, but by that time pulpwood--roundwood of very moderate size down to a 3-inch or 4-inch top diameter--was extracted. An even greater change has come within the last century, timber harvesting has become mechanized.

As fiber and particle products began to predominate, wood was more and more dismembered in the forests; entire trees could be chipped for delivery to processing plants. Only a small percentage of a tree--twigs, leaves, roots--was left in a forest to provide ground protection and to recycle the essential mineral nutrients needed for the next crop of timber. Now, of course, in areas of high-intensity forestry, it is profitable to replace the mineral nutrients through fertilization when a new crop is established.

This brings me to the function of the forester, whose responsibility is the management of our Nation's woodlands. By this management he supplies us with continuing crops of timber as well as providing for the many other uses of the forest, such as watershed, wildlife, recreation, and esthetic values.

A century ago wood grew essentially as a wild plant in the forest, just as the grains and the fruits grew before agriculture as we know it was developed. Just as we succeeded in multiplying many times over the yields of grains per hectare by applying scientific developments to agriculture, so we have succeeded in increasing the growth of wood crops by employing scientific and intensive forestry practices.

A century ago, forestry researchers had demonstrated that the growth rate of trees, in terms of wood laid down in the stem, could be doubled through particular genetic selection and breeding practices. It was shown that by using genetic strains of trees that produced particular characteristics desired, the amount of wood grown during the first generation could be doubled. Since then we have progressed further. On selected hectares designated especially for growing timber crops for harvest, application of practices such as fertilizing and irrigation produces another doubling of growth rate.

At one time the question, how large should timber be grown for harvest, was hotly debated among foresters. For some uses it is still desirable to grow trees to an age that will permit harvesting large logs. By applying intensive and expensive forestry practices, it is even possible to speed this process greatly.

Economic considerations usually predominate in determining rotation periods for forests. Added to initial investment cost is interest on a particular investment over the many years of a tree's life. Therefore, high-intensity forests managed for the single wood crop are usually short-rotation forests. These intensely managed lands, often with periodically repeated investments in fertilizer, irrigation, and highly selected expensive planting stock, are usually not grown to great size over many years. Wood for conversion to fiber or chemicals now requires from 3 to 7 years under the best growth conditions. This trend toward high-intensity forests began a century ago.

Let me emphasize again that for utilization there is no longer any advantage to grow trees of great size. The development of durable and economical wood-bonding processes has freed us from the need to use wood as nature provides it; we can now supply improved products regardless of size!

On most of our commercial forest lands, management, while striving for high timber yields, is modified to secure the many other essential benefits forests provide--watershed, wildlife, recreation, and esthetic values. All areas are carefully considered and each area is handled to secure an optimum mix of these "products" in addition to the wood that can be produced.

The very careful management of "production" forests, coupled with high standards of wood utilization, has enabled us to meet our raw material needs. We are not sacrificing the other equally important values we associate with forests. In addition, this management has given us the unique opportunity of preserving large and widely distributed areas in an undeveloped state much as they were when first viewed by our ancestors. The cultural and the scientific contributions of these wilderness areas have been immense; they are admired by other countries.

I mentioned that wood fiber material is salvaged from urban trash. It should not be overlooked that trees grown for shade and beautification in urban parks and residential areas also form an important new source of material for industry. These trees eventually die or must be removed for some other reason. Then they are chipped, and the material, formerly burned, is fed into our industrial production system for conversion into particleboards, fiber products, and chemicals. Thus, land that may originally have been part of the Nation's base of about 200-million hectares of commercial timberland, but subsequently preempted for other developments, continues to contribute in perpetuity to the Nation's wood material supplies.

An area in which improvement has not depended primarily on the forester has been the attitude of the landowner and of the general public toward land use. As our country grew, some of its best timber-growing land was converted into farmland. On farms, a wooded area was often reserved to provide fuelwood and occasional logs for market. About one-fourth of the Nation's best timber-growing land was in these small farm woodlots. Another even larger segment, 33 percent, was held in small tracts by a variety of owners who had little knowledge of or interest in forestry. The problem of the appalling losses to our economy from the former neglect of these productive hectares has, of course, been remedied. The production from this timberland has been effectively doubled during the last century!

PAST, PRESENT, AND FUTURE

Now let me attempt to recapitulate our Nation's timber situation, past, present, and future. I would call your attention to the quantitative data on our Nation's renewable resources that is regularly reported to Congress at 10-year intervals. In my opinion, the beginning of the modern forestry-planning era in this Nation began with the passage by Congress of the Forest and Rangeland Renewable Resources Planning Act of 1974. Our population of about 210-million people was then enjoying the use of about 1 metric ton of wood per person per year; this tonnage was extracted mostly from natural stands of timber by rather primitive methods and processed and used without much thought to full utilization. In fact, one of the period's chief forest industrialists referred to his colleagues as "wastrels."

Since 1974, we can roughly state that our population has doubled, the land area available for commercially growing timber has shrunk, and wood has filled the gap left by our depleted nonrenewable resources. Roughly 800 million metric tons of wood are now used annually in consumer products. On an average, again roughly, we grow 5 metric tons per year of wood per hectare of commercial timberland on which we claim we practice high-intensity forestry. This is not a miraculous achievement for in 1976 foresters readily agreed that this type of goal was realistic even with their limited knowledge and tools!

We still have much to do to accomplish even the very limited goals that scientists in 1976 predicted were attainable! Let me list 10 methods available even then, any one of which if pursued aggressively by research and application might have brought about as much as a doubling of wood products for the consumer.

Intensify forestry practices in natural stands through cultural operations to bring about full stocking; improve cuttings and thinnings; provide full fire protection; protect against insects and disease.

Grow wood more rapidly and of better quality by selecting superior species and fast-growing trees and incorporating genetic improvements.

Improve harvesting practices to bring all or most of a tree out of a forest, instead of only sawlogs and roundwood for pulping.

Adopt sound forestry practices on the 60 percent of our Nation's commerical timberland privately held in farms and small tracts.

Use mature, injured, or dying nonforest trees, such as shade trees from parks and urban areas and trees removed in land-clearing operations.

Recycle previously used wood fiber products.

Eliminate waste from primary wood conversion processes.

Improve product performance so that wood products last longer through improved design, treat wood with preservatives, with fire retardants, with stabilizing chemicals, and with finishes.

Design products--especially engineering structures so that structures can be efficiently constructed with less wood.

Expand practice of rehabilitating existing structures to meet new needs.

Even with our advanced state of knowledge we have scarcely kept abreast of growing consumer demands. Furthermore, I do not wish to imply that each of the 10 methods is mutually exclusive of any of the others. If that were true, we could expect a thousand-fold increase in wood products from the 1976 levels!

I wish to share with you a historic assessment of what is attainable for wood as predicted in 1949 by Dr. Egon Glesinger, then Head of the Forestry Division of the Food and Agriculture Organization of the United Nations. At that time, Dr. Glesinger published an imaginative book "The Coming Age of Wood," in which he predicted many of the developments that we see today. Speaking of forestry on a global basis, he concluded: "Forests can be made to produce about fifty times their present volume of end products and still remain a permanently self-renewing source for our raw material supplies."

We have progressed, but we still have much to accomplish before attaining that objective!

If I were asked, what is the greatest single achievement in the last century for wiser use of our wood resource, I would have to pass over the many brilliant scientific achievements. Instead I would state, it is the remarkable change in the attitude of our citizens! We have become intolerant of waste! We have willingly paid the social and the economic costs of the improvements needed to use our wood resource more wisely. It is this progressive attitude that gives all of us great expectations for the future.

Epilog

The foregoing presentation on wood utilization in the year 2076 was based on predictions made in 1976. Obviously, change will come, and only change for the better is in keeping with our Nation's tradition.

SECTION ONE

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