HAMILTON RODDIS
MEMORIAL LECTURE SERIES
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Wood:
The Foundation of Civilization

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A Forest Journey: The Story of Wood and Civilization

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HAMILTON RODDIS
MEMORIAL LECTURE SERIES

This Memorial Lecture Series honors the late Hamilton Roddis who served as Secretary, President and Chairman of the Board of Directors of the Roddis Plywood Corporation for more than sixty years.

Hamilton Roddis was born in 1875 in Milwaukee, Wisconsin, and moved to Marshfield with his family in 1894 when his father invested in and assumed the direction of the Hatteberg Veneer Company. Mr. Roddis enrolled in the University of Wisconsin-Madison Law School in 1896 intending to proceed through a normal course of study. A fire destroyed the Hatteberg Veneer plant in 1897 and Hamilton Roddis remained in Marshfield to help get the new plant running smoothly -- simultaneously, by independent study, he pursued his second-year law program by studying at night. He later rejoined his class in Madison and graduated on schedule. His capacity to operate on many functional levels served him well during the ensuing years in meeting the many challenges of the business world and at the same time maintaining an active involvement in civic, church and cultural affairs. Originally intending to enter the law profession, he was instead persuaded to join his father's firm (then known as the Roddis Veneer Company); he became president in 1920 and headed the company until his death in 1960. His character and intellect combined with his imaginative and progressive leadership spurred a business success through what we would today tout as Quality Management.

The Roddis enterprise spearheaded many innovations in forest products. It was the first to recognize the potential of the flush door and manufacture it on a large scale. During WWII it produced materials for the war effort by fabricating interior woodwork for the Liberty ships and aircraft plywood for the British Mosquito bomber and reconnaissance plane. In August of 1960 the Roddis Plywood Corporation, with holdings throughout the U.S. and Canada, was merged with the Weyerhaeuser Corporation.

Mr. Roddis' family, friends and university beneficiaries are pleased to honor the man and his extraordinary accomplishments in the Hamilton Roddis Memorial Lecture Series.

WOOD:
THE FOUNDATION OF CIVILIZATION

By John Perlin

The Tree that Changed the World

Astronomers for the longest time have regarded Venus as the planet most resembling Earth. Having almost the exact size as Earth and being almost as close to the sun led many even to call it Earth's twin. Clouds covering the Venusian landscape provided another compelling reason to believe in Venus' affinity to Earth. Pioneering astronomer Svante Arrhenius hypothesized great rains pouring from these clouds nurtured lush rain forests below.

When various space probes finally penetrated the Venusian atmosphere, astronomers found an inferno rather than a tropical paradise. Here they discovered the ultimate greenhouse effect: Although the carbon-dioxide laden atmosphere allows sunlight to pass through, when solar rays hit the surface of Venus and change into heat waves, they cannot escape the carbon-dioxide cover. Thus, the heat has nowhere to go and accumulates at the surface where temperatures exceed eight hundred degrees Fahrenheit. Interestingly, our planet has about as much carbon dioxide in the atmosphere as Venus, but instead of the gas blanketing the sky as it does on Venus, much of the carbon dioxide has been locked up on the surface of the Earth. This has made an enormous difference in the story of the two planets - one, a heaven bountiful with life, the other a hellish place where nothing animate can survive.

Beginning when simple forms of vegetation first clothed the Earth, but commencing rapidly during Late Devonian times, atmospheric carbon dioxide declined and oxygen increased to near present levels. Among the consequences identified by geochemists, temperatures on earth fell markedly and the ozone layer thirty miles up probably increased. Land formerly composed of thin soils and rocky plains with patches of moss-like plants was transformed over time to fertile soil. Conditions necessary for yet more land plants and animals blossomed.

Credit for most of these changes may lie with the rapid worldwide spread during the Devonian period of the first true trees known as *Archaeopteris*[1] . Their dense canopies of leaves would have absorbed carbon dioxide and discharged oxygen via photosynthesis. As plant parts were shed, the captured carbon dioxide accumulated on and in the surface of the earth. The tree's deep and powerful root

[1] R. Berner, 2004, The Phanerzoic Carbon Cycle, Oxford University Press, New York, New York

system broke down the rocky soils through which it dug where chemical reactions entombed the carbon dioxide in newly formed clays. Much of the remaining dead leaves, branches and twigs, trunks, and roots ended their lives buried by muds and sands through successive flooding. Over millions of years and under great pressure deep in the bowels of the earth, this organic debris became rich beds of fossils and coal. Once again, natural forces denied to the atmosphere the carbon dioxide *Archaeopteris* had transformed.

Initially, large vertebrates of the Devonian period only lived in rivers and seas. As more and more debris from the growing number of plants entered waterways, certain fish that had developed limbs rather than fins could better propel themselves through lake, river or sea bottoms strewn with branches, leaves and logs. The accumulation of plant debris in aquatic areas promoted algae growth that robbed many of the shallow watercourses of oxygen, necessary for any water animals' survival. Those equipped to escape, fish-like creatures capable of walking, and breathing air, would find a home on land made ready by the greening of the planet. The land now teemed with trees and plants that could provide food, shade and habitat for animals of all sizes. Thus began the chain of events that has permitted vertebrates to flourish on land so 400 million years later I can write the contents of my presentation and you can read it.

The Importance of Wood Fuel in Human Evolution and Civilization

It may seem bold to assert wood's crucial place in human evolution, but please consider one central fact: wood provided our ancestors with fuel for fire. The discovery of fire allowed *Homo erectus*, from which *Homo sapiens* evolved, to migrate from the warmth of their original equatorial habitat in Africa to lands throughout the Old World where heat from fire made these colder climates habitable. Fire released *Homo erectus* from restraints of climate, allowing the species to create its own environment. Increasing the range of habitat gave our genus better odds for survival. Light from wood fires liberated early man from the fears and confines of night. Wood fires also diversified Homo erectus' diet. Armed with torches, Homo erectus hunted at night with more effective fire-hardened wooden spears. Meat, tubers and other food sources, when cooked over fire became edible – even palatable - as well. Fire also provided our ancestors with greater security since they could sleep at night knowing that its flames warded off predators. Fire also gave early societies a reason to gather. While many animals like the chimpanzee and otter have used tools to aid in their pursuit of food, no other animal except for those in our genus from Homo erectus to *Homo sapiens* has ever built fires.

Wood fuel, in fact, is the unsung hero of the technological developments that brought us from a bone and stone culture to the Industrial Revolution. Without

access to vast supplies of wood, the great civilizations of Sumer, Assyria, Egypt, China, Knossos, ancient Greece and Rome, Western Europe, and the Western Hemisphere after European settlement would have never emerged.

Wood - Our Ancestor's Principal Fuel and Building Material

Wood, as humanity's principal fuel for fire, has allowed our species to reshape the earth for its use. With heat from wood fires,

- humanity has settled throughout the globe, making even very cold regions habitable;
- grains became edible when cooked over wood fires. Agriculture could now spread, resulting in settlements that grew from isolated rural houses to great cities;
- charcoal fueled kilns where temperatures rose above 900 degrees centigrade, allowed potters to change earth into durable ceramics to store and ship goods;
- metallurgists stoked charcoal fires to extract metal from stone. They revolutionized tools and weaponry to such a degree that historians categorize the various ages of civilization according to the dominant metal in use at the time;
- transportation, and by extension, trade, the accumulation of wealth, exploration and colonization would have been unthinkable without wood.

From the Bronze Age until two ironclads clashed by Hampton Roads, Virginia in 1862, most every ship, whether involved in commerce or war, was built with timber. Carts and chariots were also composed primarily of wood. Early steamboats and railroad locomotives in the United States ran on wood fuel. Wooden ships tied up to wooden piers and wharves. Wooden wagons crossed wooden bridges and, in the United States during the nineteenth century, traveled on wooden roads. Railroad ties, of course, were wooden. Wood was also used for the beams that propped up mine shafts and supported almost every type of building. Water wheels and windmills - the major means of mechanical power before steam was harnessed - were usually built of wood. The peasant could not farm without wooden tool handles or wood plows; the soldier could not throw his spear or shoot his arrows without their wooden shafts, or hold his gun without its wooden stock. What would archers have done lacking wood for bows; the brewer and vintner, without wood for their barrels and casks; or the woolen industry, without wood for its looms?

Recognizing the Importance of Wood

Great thinkers in times past recognized the importance of wood. Plato, according

to Diogenes Laertius, wrote that all technology was derived from mining and forestry. Lucretius, one of the foremost Roman philosophers, argued that wood made mining possible, thereby leading to great civilizations. Huge fires, according to Lucretius, "devoured the high forests and thoroughly heated the earth," to melt metal from ore. When people came to observe the burned forest, they saw solidified metal lying on the ground and "the thought came to them," Lucretius continued, "that these pieces could be made liquid again by fire and cast into the form and shape of anything, and then by hammering, could be drawn into the form of blades as sharp and thin as one pleased so they might equip themselves with tools..." Tools, in turn, Lucretius concluded, made forestry and carpentry possible, enabling humans "to cut forests, hew timber, smooth, and even fashion it with auger, chisel and gouge" (Lucretius 5.1255-1268). In this way, Lucretius surmised, civilization emerged.

Pliny, the great Roman natural historian, concurred with Lucretius' judgment that wood was "indispensable for carrying on life" (Pliny 12.5). The well-known Roman statesman Cicero explained the importance of wood to Roman civilization when he wrote, "We cut up trees to cook our food...for building...to keep out heat and cold...and also to build ships, which sail in all directions to bring us all the needs of life" (Cicero 2.150-151).

A fifteenth-century woodcut depicts three people carrying pieces of wood home from the forest with which to cook and heat their houses.

The English of the sixteenth and seventeenth centuries also recognized the crucial role wood played in their lives. Gabriel Plattes, who wrote on technological matters in the seventeenth century, observed that all "tools and instruments" used in Europe at that time "are made of wood and iron." But of the two materials, Plattes chose wood as more crucial because without wood fuel "no iron," the principal metal of that time, "can be provided"[2] . Likewise, the English of this period realized their dependence on wood for trade and navigation that gave the nation preeminence

[2] G. Plattes. 1639, 9

both commercially and economically. As one naval official declared, "As the Navy hath no being without ships, so no ships without timber"[3] .

Leaders of the new American nation quickly realized the importance of forests to the development of the country. Alexander Hamilton, in his Report on Manufactures, informed the American people of their good fortune to have iron "in great abundance" and cheap and plentiful supplies of charcoal, "the chief instrument in manufacturing it"[4] . Tench Coxe, a close friend of Thomas Jefferson and James Madison as well as an economic writer in his own right, made a similar observation in the 1790s that the new nation's great forests would provide the young country with an "immense and unequalled" store of "wooden raw materials and fuel for invaluable and numerous manufactures"[5] .

John Evelyn, a leading figure in seventeenth-century England, summed up the significance of wood to past societies with the observation that "all arts and artisans" - technology itself - "must fail and cease if there were no timber and wood..." Evelyn did not resort to hyperbole when he stated that England of his day would be better off "without gold than without timber"[6] . Wood was our ancestors' fuel and building material and therefore, its primary resource.

Examples of Wood Used for Fuel

Bronze Age Greece and Cyprus

Mycenaean Greece, the world Homer describes, attained an unprecedented level of material growth during the late Bronze Age. Yet it did not have much copper to make sufficient quantities of bronze, the essential metal of the time. To sustain the booming economy of the Mycenaean states, abundant and reliable sources of copper had to be found. Fortunately, there was one area close by - Cyprus - that had abundant copper ore and plenty of wood with which to smelt and refine it. In response to this need, the Cypriots smelted as much copper ore as they possibly could for the overseas market. But the growing demand put a great burden on the island's forests, as charcoal was the fuel for smelting and refining copper. One hundred and twenty pine trees were required to prepare six tons of charcoal needed to produce one ingot of copper, deforesting almost four acres. Archaeologists found on board a Bronze Age shipwreck two hundred ingots of copper that had been mined and smelted in Cyprus. The production of just this shipload cost the island almost 24,000 pine trees. The lively commerce in ingots during the fourteenth and thirteenth centuries B.C. surely consisted of many such shipments and the concomitant deforestation of large expanses of woodlands.

[3] J. Holland, 1896, Discourses on the Navy, 205
[4] Hamilton, 10.314
[5] T. Coxe 1794, 450-451
[6] J. Evelyn 1786, 2.216

Industry's consumption of wood deforested about four to five square miles of Cyprus' woods each year. Another four or five square miles of forest were cut to supply fuel for heating and cooking and for other industries such as pottery works and lime kilns The cumulative effect of deforestation on such a scale must have been felt quite soon on an island of only 3,600 square miles.

With wood becoming so difficult to come by, interest heightened in the search for ways to stretch limited supplies, resulting in technological advances and recycling. The adoption of hydrometallurgy to prepare copper ore for smelting appears to be one of the strategies chosen by Late Bronze Age Cypriot metalworkers to conserve fuel. The process required the exposure of mined ore to the elements so that the ambient moisture would leach impurities. The leached ore could be directly smelted, circumventing an initial roast and reducing the number of smelts needed to process the ore. Hence, the amount of fuel expended in this phase was decreased by a third. In another move to save fuel, metallurgists collected old and broken tools in order to reprocess them. Recycling bronze developed into a major source of the metal during the period of wood depletion on Cyprus.

Despite such highly innovative ways to save energy, metallurgists could not find enough wood to sustain the high productivity of the previous two centuries. Copper production peaked around 1200 b.c.e.[7] and the last copper furnaces were shut down in 1050 b.c.e. The depressed state of the Cypriot copper industry apparently affected the entire eastern Mediterranean region. Bronze was in such short supply that the smiths throughout the area bought up whatever pieces they could find, whether virgin ingots, ingots composed of recycled bronze, or scrap.

Many times, smiths in southern Europe could obtain only minute quantities of bronze because of copper shortages. Such was the case in Greek Messenia around 1200 b.c.e. With so little bronze available everyone suffered. Without metal hoes, plowshares and scythes, farmers were far less productive. Without axes, adzes, and saws, few ships could be built for commerce or war. And without enough arrowheads, spearheads and blades for swords, soldiers were no match for a well-armed foe.

Taking advantage of Messenia's vulnerability, a group of insurgents overpowered local forces and destroyed the palace at its capital, Pylos. After the catastrophe, the populace did not attempt to rebuild. Events at Messenia presaged trouble other societies in the eastern Mediterranean would soon face. Just as bronze gave these civilizations the material to expand to heights never before attained, the lack of bronze played a major role in their demise.

[7] before common era; BC and BCE are also identical in value

In this sea of troubles, new hope for future generations arose. The fuel crisis that had caused copper production to decline served as the incentive for metallurgists to begin working with iron. Because Bronze Age Cypriots smelted copper ore that contained ten times more iron than copper, metallurgists could obtain more useable iron than copper with the same investment of fuel. Hence, common sense dictated switching to iron smelting when fuel was at a premium. Furthermore, the refuse from Cypriot copper smelting contained significant amounts of iron. As long as there had been plenty of fuel, metallurgists smelted virgin ore and ignored the slag that had accumulated. When fuel became hard to come by and forced production cuts, metallurgists began to mine their industrial garbage. They discovered that the slag contained a great amount of iron, which could be removed simply by hammering. Taking iron out of the slag manually permitted metallurgists to bypass any processes requiring fuel and still obtain usable metal. The labor-intensive nature of working in this manner, however, drastically reduced the overall output of metal on Cyprus and yielded relatively small amounts of iron. But the success metallurgists had in working with iron at this early stage laid the foundation for the coming of the Iron Age in the Mediterranean as well as the rest of Europe.

Classical Greece

In classical Greece, the silver smelted at Laurion, near the sea southeast of Athens, paid for the Athenian fleet that defeated the Persians at Salamis. This turned the tide in the war against the Persians, who most likely would have conquered all of Europe if not vanquished in this battle. Coins minted with Laurion's silver were accepted as the currency of the Greek world. With its treasury full of bullion, the Athenian economy could well afford to spend as lavishly as it did in its heyday. Miners did not recover pure silver at Laurion, but galena ore. Once mined, metallurgists had to heat the ore to very high temperatures to extract the silver. Charcoal was the fuel metallurgists at Laurion used in the smelting process and trees, or course, had to be cut down to produce this charcoal To extract the silver from ore at Laurion required the burning of more than 24 million pines or more than 52 million oaks. The largest outlays of fuel occurred during the two most active periods of mining, from 482 b.c.e to 404 b.c.e., and from the second decade of the fourth century b.c.e. to its end. The surrounding areas could supply only a fraction of Laurion's fuel, forcing metallurgists to locate their furnaces right on the coast so they could easily receive fuel imported from Thrace by ship.

Classical Rome

Rome financed its growth largely with silver extracted from Spanish ore. Production increased considerably during the end of the Republic and the first years of the Empire. But this was accomplished only at great expense to the Iberian woodlands since silver smelting consumed more than 500 million trees

during the four hundred years of operation. Woodsmen had to deforest a little over seven thousand square miles to provide fuel for the furnaces. Near the end of the period of peak production, the need to sustain high output so strained the area's fuel supplies that it merited intervention by the Roman state. Under the reign of the emperor Vespasian, the Roman government directed all mining areas of southwestern Spain to prohibit the sale of burnable wood to those who ran bathhouses in the region.

To produce enough silver to support the habits of a succession of rulers who spent as extravagantly as Caligula and Nero, a time had to come when the forests in Spain would dwindle and production in silver would decline accordingly. Conservation laws could only temporarily stave off wood shortages when silver was spent so wastefully. Around the end of the second century a.c.e.[8], the inevitable occurred; silver production declined. Further output was limited not by the supply of ore, which remained abundant, but by the limited accessibility of fuel.

The decline in silver production offered later emperors two choices; either cut expenditures or find alternative financing. They unanimously chose the latter but each approached it differently. The emperor Commodus "stretched" silver coinage by adding base metal to comprise 30 percent of the coin. He also went on a killing spree, enraged that the Empire's revenues could not meet his expenditures. Ultimately, he auctioned off whatever he could, offering provincial and administrative offices to the highest bidder.

Septimius Severus, who ruled a few years after Commodus, added 20 percent more alloy to the silver coinage, thus reducing the silver content to a mere fifty percent. Because Roman money was now so badly debased, Severus instituted

Roman legionnaires felling trees to build a stockade in hostile territory.

[8] after common era; AD and ACE are also identical in value

the requisitioning of commodities rather than collecting worthless currency through taxation. Further debasements forced the government to search for "creative" ways of staying in power. Most of the methods chosen circumscribed the freedom of Rome's citizens. Providing the government with the provisions it needed became compulsory. The government also established guilds, expecting them to produce according to obligations it set but rewarding members with monopolies in their respective trades.

By the end of the third century a.c.e, Rome's currency had lost 98 percent of its silver content, and the public placed as little value on it as did the government. People increasingly took to trading in commodities and services so that by the first part of the fourth century a.c.e. barter had become widespread, replacing transactions with coins.

To keep those in Rome from becoming too anxious over the declining economy, the rulers of Rome constantly had to find ways to keep the population placated. The later emperors were well aware of the Romans' love of bathing and added many new baths to the city, eventually bringing the total to over nine hundred. The largest held as many as two thousand bathers at a time. Because keeping the Roman populace satisfied was paramount in the minds of those in power, the authorities were willing to go to great lengths to assure a constant flow of fuel to heat water for the bathing establishments.

In the third century a.c.e, the emperor Severus Alexander saw to it that entire forests were cut to keep the baths in Rome well heated. When these forests gave out a century later, the authorities founded a guild with sixty ships at its disposal for the sole purpose of supplying the baths with wood. Sometimes wood could be obtained as close to home as the Campania region. Usually, though, the guild had to find its wood in the forests of North Africa. That Romans would travel such great distances for fuel indicates just how little accessible wood was left near Rome and how dependent the Romans had become on foreign supplies.

England 1500s -1700s

At the opening of the sixteenth century, England depended on the Continent for its shot and artillery, but Henry VIII's apostasy resulted in an arms' embargo and a threat of invasion. Self-sufficiency seemed the only recourse. Henry therefore saw to the development of a local arms industry in Sussex where rich veins of high-phosphorous iron were particularly advantageous for the casting of guns, and where oak and beech would provide ample fuel for the foundries. They chose the blast furnace and forge over the simpler hearth because the former could produce about twenty times more iron than the latter. The blast furnace and forge also consumed much more charcoal. By the late 1540s the new English arms' industry annually consumed about 117,000 cords of wood, causing great

Woodcutters brought wood to where the charcoal was prepared. Charcoal producers stacked the wood to form a cone. The outside of the cone was coated with a claylike mixture of earth and charcoal dust. the coating kept temperatures inside the wood cone at a minimum so that the wood was converted to charcoal and not ash. Once the wood stack was coated, a workman lit the cone (left foreground). Moving counterclockwise, the wood is slowly reduced in size to charcoal. (University of California, Santa Barbara, Library Special Collections)

destruction of nearby forests. People living in the vicinity saw these blast furnaces and forges as menacing since the wood they consumed was essential to the locals' survival for heating their homes, cooking their meals, making their tools and fishing boats, and building and repairing their houses. By the 1700s the iron industry had deforested such a large area of southeast England that the iron masters had to ration the amount of iron ore they could smelt. To increase iron production required learning to smelt ore with coal without its impurities contaminating the finished metal. By discovering how to make coal as close to charcoal as possible, the English freed themselves from the constraints of its dwindling forests and began the Industrial Revolution - an Age that has qualitatively separated people living since the middle of the nineteenth century from the rest of history.

Madeira, West Indies & Brazil, 1400s - 1600s
Sugar brought great wealth to those who raised sugar cane. Hence, when the Portuguese landed on the warm, forested, fertile and well-watered island of Madeira in 1419, they almost immediately started to plant cane. Once the juice was crushed out of the stalks, workers poured the extracted liquid into kettles. A fire, rarely extinguished, burned beneath each pot. The wood from linden trees furnished much of the fuel. No doubt cedar was also used, being the most common wood on Madeira Sugar workers aptly called the room in which the cane juice was boiled, "the sweet inferno." The juice continued boiling until judged ready for removal to an area where it would solidify into sugar. By the end of the fifteenth century the island's sugar industry needed about sixty thousand tons of wood just for boiling the cane syrup. Four of the sixteen mills operating on Madeira consumed eighty thousand pack animal loads of wood per year.

Almost immediately after the discovery of the West Indies and South America, Europeans recognized that the land offered the same or better conditions for growing and processing sugar as existed on Madeira. The Spanish planted sugarcane on Espanola soon after Columbus's first journey to the New World. As expected the cane flourished, and by the end of the sixteenth century forty sugar mills were operating on the island. It was no different in other parts of the Indies as sugarcane proliferated and became the area's chief source of revenue. Nor did the Portuguese, after their success on Madeira, wait long to establish sugar plantations after colonizing Brazil. Before the close of the sixteenth century, a visitor reported seventy sugar mills at work in the Pernambuco region and forty in the area of Bahia. Experts in sugar production in the New World estimated that from six to eight slaves had to be constantly employed in cutting fuel in the forest and transporting it to each of the mills for optimum efficiency. To provide fuel for one mill stripped about ninety acres of forestland each year.

Such large-scale consumption of wood took its toll on the forests of the New World. Two hundred and forty years after the Portuguese had found Madeira, it had become the island of wood in name only, so deforested that those passing it by ship could find absolutely no forest in view. Likewise, the very thickly forested island of Espanola had become an open land. The pace of deforestation on Barbados exceeded that on Espanola or Madeira. In little more than twenty years, the representatives of the planters admitted to having used and destroyed all the timber formerly growing on the island.

The development of the sugar industry had other huge effects, some of which remain to this day. The European rid the Indies of their native population with the same violence that they employed to clear the forests. Needing huge numbers to work the sugar plantations, settlers initiated and came to rely upon the most

Sugar-mill workers, center background, pour the extracted cane juice into kettles. A fire, rarely extinguished, burns beneath each pot. (Burndy Library)

ruthless trafficking of humans ever known - the African slave trade. Wealth earned from the sugar trade also financed the industrial revolution. Sugar stimulated coffee consumption, which brought about the ubiquitous coffee house where intellectuals could meet.

American Colonies

America's great forests offered the pilgrims a higher standard of living than their peers in England since they had upon arrival more wood fuel to heat with than most noblemen in England. Families also used the enormous fireplace around which they huddled for lighting as well. Some fireplaces were so huge as to require logs of dimensions that could only be dragged into the house by a horse or oxen.

America's plethora of wood gave rise to a large and prosperous iron industry. American ironmasters could manufacture pig iron in the Colonies and export it to England, underselling English iron despite the fact that American woodcutters earned three times more than their counterparts in England. Americans who coaled the wood made about twice as much as those who did the same work in England. Despite this wage differential, the cost of fuel - a cord of wood cost fourteen times more in England than America – was even more important in the rise of an American industry. Iron furnaces and forges first began operating in

the backwoods of Virginia and Maryland and then spread to Pennsylvania and New Jersey. These furnaces not only produced iron for the English market but began producing cast iron goods for local use as well. The proliferation of home-produced iron goods frightened the English whose mercantile economy was based on buying raw materials from the Colonies at bargain prices and selling back finished products at a much higher price. The English therefore passed the Iron Act in 1749 that encouraged the importation of pig iron from the American Colonies, as wood shortages had hindered England's iron production, while forbidding the Americans from developing forges to turn out finished iron products.

It seemed unfair to Americans that they had to send to England the iron they produced in order to buy it back again as manufactured items, costing them almost twice as much as had they done the entire process at home. The intent of the Act reminded many of the servile conditions forced upon the Children of Israel by the Philistines when the Jews were not allowed any smiths of their own. The prohibitory nature of the new Act aroused revolutionary rhetoric among the more radical Americans like James Otis, credited by John Adams as being the father of the idea of Independence, and John Dickinson, who later authored revolutionary America's "Declaration of the Causes of Taking Up Arms." Both feared that by prohibiting the manufacture of iron goods was the first step in stopping the construction of any machinery that would further develop the Colonies' economy.

Despite the anger the new Act aroused in America, it did increase American exports of pig iron to England. By 1769 almost half of the prig iron worked in English forges came from America. By 1776, as much iron was produced in the Colonies as in Britain. Even more encouraging to those favoring revolution, and frightening to those wishing to hold onto the American Colonies, America's innumerable iron mines and endless forests give America the very sinews of power. A certain type of iron produced in America, called "Best Principio," was judged as good as any in the world for making shot and cannon.

America after Independence

Alexander Hamilton, probably the great advocate of industry during the early Republic, predicted that America was very fortunate to have vast supplies of iron ore and wood with which to develop an iron industry. Trench Coxe, a close colleague of Thomas Jefferson and James Madison, predicted that America's rich store of wood fuel would prove invaluable to the rise of industry and turn America into the most powerful country in the world. Breweries, distilleries, salt and potash works, casting and steel furnaces all needed heat to produce finished products. Francois Michaux, a French botanist who came to study America's forests at the turn of the eighteenth century, found that the bakers and brick

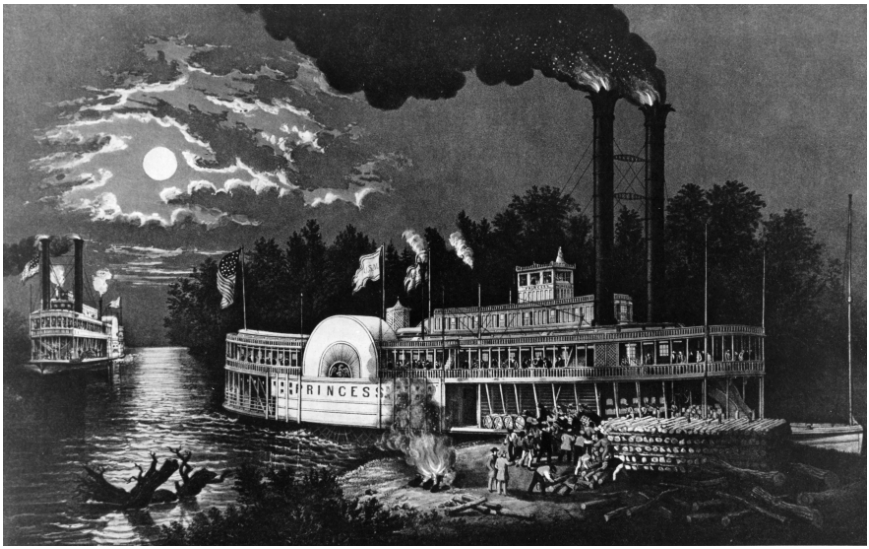
makers of New York, Philadelphia, and Baltimore commonly consumed prodigious quantities of pitch pine. Hatters of Pittsburgh, on the other hand, preferred charcoal made from sugar maple. Boats traveled along the Erie Canal picking up wood to fuel the nation's largest salt works, located in upstate New York. Boiling rooms, in which the salt water was evaporated over charcoal fires, produced two million bushels of salt per year. The salt went to Canada, Michigan, Chicago, and all points west. Farmers were the largest purchasers, using the salt for preserving meat they marketed. Steam engines, which in the 1830s began to replace factories run on waterpower, usually burned wood as their fuel.

Americans could see the Hand of Providence at work in providing great amounts of wood and iron next to each other. Wood and iron rich Western Pennsylvania, Northern Michigan, and Southeast Ohio became the principal producers of iron in nineteenth-century America. Throughout the nation charcoal burning iron mills produced nineteen million tons of iron between 1830 and 1890. To truly appreciate the magnitude of the output of America's wood-fueled iron furnaces, comparison to the amount of iron produced during the heyday of the British charcoal-burning iron industry, which dated from the 1640s to the 1780s, is in order. In its most productive years, England's charcoal-run ironworks produced around one million tons of iron over sixty years.

The steamboat opened the old American west -(lands east of the Mississippi River, north of the Ohio River, and west of the Allegheny Mountains) to settlement. How else could farmers in places like Ohio, Indiana, and Illinois expect to move their goods to distant markets except by navigation? Had farmers had to rely on land transport instead, they would have needed five thousand miles of good road, which did not exist at the time, and 250,000 wagons to transport the same amount of goods annually carried by steamboat! Mid-nineteenth-century pundits lauded steamboats as the most important technological development to have occurred in the United States because they contributed more than any other single cause to advance the prosperity of those living in the Mississippi and Ohio River basins.

Great quantities of wood were needed for fuel. The large steamboat Eclipse's fifteen boilers consumed wood by the carload. Thousands of wood yards went up along the banks of every navigable river simply to provide steamers with fuel. Backwoodsmen brought the timber they had cut to these depots and hacked them into proper size for the ships' furnaces. At night, the owners of these wood lots kept gigantic fires blazing so those onboard could see the yards and fuel up.

Railroads liberated American from their dependence on waterways for shipping freight, and personal travel. They slashed the cost and time it took to travel. With plenty of timber growing along the right-of-way of most railroads in America,



At night, the owners of wood lots along the Mississippi and many other rivers kept fires blazing so those on board the steamboats could find the yards and "wood-up." (The Travelers Companies)

locomotives used wood as their only fuel from when the first tracks were laid in 1830 to the beginning of the Civil War. Fuel needs of engines belonging to the New York Central Line required the railroad to put up 115 woodsheds along its track. If the woodshed were stacked side-by-side, they would have covered almost five miles. A wood yard for trains at Columbus, Nebraska, measured a half-mile in length!

Between 1810 and 1867 almost 5 billion cords had been consumed for fuel in fireplaces, industrial furnaces, steamboats, and railroads. To obtain such a quantity of wood meant the destruction of about two hundred thousand square miles of forestland, an area nearly equal to all the land that comprises the states of Illinois, Michigan, Ohio, and Wisconsin!

Current Use of Wood for Fuel

Today, still half of the wood cut throughout the world goes for fuel. Eighty percent of all wood consumed for fuel occurs in the developing world. In fact, the majority of people in the developing world depend on wood as its primary energy source. Charcoal and firewood in the Cameroons, for example, accounts for 80% of all energy consumption in that country. The demand for firewood and charcoal is also increasing as the population climbs. In Africa, the amount of wood consumed for energy rose from 250 million cubic meters in 1970 to 502 million cubic meters in 1994. In Latin America, too, the vast majority of the rural

population uses wood as its primary fuel. The true danger to the forests of the developing world is that growing numbers exploit local forests, threatening their viability and forcing people to travel greater distances for wood fuel. Demand for wood and charcoal in growing urban areas of the developing world has introduced a new and growing problem - the industrialization of acquiring firewood and charcoal. Instead of individuals fanning neighboring woods to cut down trees for fuel, well capitalized charcoal dealers search throughout the countryside for supplies. Bangkok's five million citizens obtain a large amount of their charcoal in this fashion from forests throughout Thailand. There seems no question that as the population in the developing world grows, so too will the demand for firewood and charcoal and deforestation will continue to accelerate.

The Importance of Timber for Construction in the Development of civilization

From antiquity to the present, economic power has depended on possessing fleets of cargo ships and, for their security, naval vessels. Until the two ironclads, the Merrimack and the Monitor, faced off near the Virginia coast in 1862, almost every ship that had ever sailed was built from wood. Hence, over the millennia, societies regarded wood as vital and access to forests essential. Timber playing such a major role in societal survival and prosperity gave rise to large-scale logging at a very early date.

Bronze Age Egypt, Mesopotamia & Crete

Records show a major forest industry emerging in the early third millennium b.c.e. With wood native to Egypt never growing large enough to build ships of sufficient size capable of carrying on international commerce or doing battle, Egyptian pharaohs early on realized that their power depended on finding and controlling accessible forested regions in foreign lands. They therefore looked to the cedars of Lebanon as their primary source. Rulers of Phoenicia controlled these forests. The exchange of gold and silver for this natural resource soon enriched the Phoenicians, making them a power to reckon with in the Bronze Age Mediterranean.

Farther east, in what is known as the Fertile Crescent, rulers of various city-states and dynasties raised expeditions to conquer the "cedar mountain" for its timber. The cedar mountain had no fixed location. The only certainty to its whereabouts was that the cedar mountain always existed somewhere in the hills and mountains of the Euphrates, Tigris, and Karun watersheds. For Enannatum, an early ruler of Lagash - a major city-state in Mesopotamia, the cedar mountain existed in the hills just east of the lower Tigris. He overthrew the ruler of this area to acquire its timberlands. After nearby forests such as this one became depleted of large trees, later rulers in the region such as Sargon and Naram-Sin placed the cedar

mountain northwest of the Fertile Crescent in present-day Turkey. Their troops conquered the indigenous people who lived in these mountains for access to timber growing there. To secure a continual flow of large wood, Naram-Sin slew the king of Ebla, who ruled over the routes to this well-timbered area. Timber-felling parties rafted the fallen logs down the river courses that passed through the various city-states adjacent to the Persian Gulf. Mesopotamian rulers also traded for timber as far east as the west coast of India. They used much of the wood to build cargo ships on whose decks a variety of imports enriched the Fertile Crescent.

By the end of the third millennium b.c.e., near Eastern kingdoms seemed to have focused their attention on Crete for timber. A Cretan hieroglyphic seal dated to the beginning of the second millennium b.c.e., showing a ship with five tree signs, one tree singled out and four in a cluster, suggests commerce in timber between Crete and the outside world at this time. The inclusion of a boat could refer to the use of wood for its construction or to the means of exporting the wood. Trade between the Mediterranean island and the Near East apparently injected enough new wealth into the local economy to transform fairly swiftly a minor island into one of the most powerful states in the Mediterranean.

Classical Greece

As the Athenians and the Persians fought for hegemony over the Greek peninsula in the fifth century b.c.e., both sides realized the importance of controlling accessible timber resources for outfitting their own navy, as well as denying the other the same capability. For this reason, the timber-rich and very accessible Strymon valley bordering Thrace and Macedonia became the focal point of Persian and Athenian interest. The Persians, for example, expelled the indigenous Greek population from the area and kept it off limits to even their most loyal Greeks allies. Athens's wooden warships defeated the Persians at Salamis and drove the Persians from the Greek peninsula. Over the next century, Athenian control of the seas made the Greek city-state preeminent in the Mediterranean. To secure their hold required a large and reliable source of timber. The Athenians therefore colonized Amphipolis, which controlled access to the Strymon. When the Athenian forces lost Amphipolis in the Peloponnesian Wars, they tried attacking Sicily to wrest control of Italy and Sicily's immense forests. With the failure of that military venture, the desperate Athenians established a monopoly on timber supplies from Macedonia, eventually constructing ship hulls there and then towing them to Athens. Other Greek city-states envying Athenian wealth and power schemed to wrest control of Macedonian timberlands from Athens. Eventually, under a strong monarch, Philip, father of Alexander, the Macedonians took control of its own timberlands and soon became the most powerful state in Greece.

Classical Rome
The Romans, too, recognized the importance of wood for shipbuilding. Cicero explained, "We cut trees to build ships, which sail in all directions to bring all the needs of life." In earlier times, the Romans built most of their ships around Pisa and then exploited the Ligurian woods. In later days they found supplies in France and North Africa.

Medieval & Renaissance Venice
Wood remained plentiful in one Italian region: the territory that later became the Venetian Republic. The great need for wood by Venice's Muslim neighbors in the southern Mediterranean and their willingness to pay dearly for it stimulated the growth of Venice's shipping industry. Venice came to rule the eastern Mediterranean, and provided the Venetian Republic with large amounts of gold to buy luxury goods from the East and sell them to European markets. The profits from this trade made Venice the richest European state of the Renaissance. To maintain supremacy at sea from generation to generation, the Venetians consolidated their production of warships in one location they called the Arsenal (Arabic for "house of construction") and began, in the thirteenth century a.c.e., to restrict the commerce and felling of oak near riverbanks to guarantee a secure supply of timber for the Republic. But no sanctions proved strong enough to stop competing interests-farmers who wished the land cleared for crops versus industrialists who needed the oak for fuel-from deforesting the timber on which the shipbuilders depended.

Early Modern Northern Europe
By the 1600s, lack of wood in nearby forests sent the local Venetian shipbuilding industry into decline. In contrast, Holland had easy access to huge tracts of timber along the Rhine, Meuse, and Moselle rivers as well as the Baltic, allowing the treeless nation to build great fleets for the lucrative Far East and transatlantic trade. France and Great Britain likewise took advantage of their proximity to forests and also built large fleets to profit from the mercantile opportunities offered by the opening of these great oceanic highways. The general scarcity of timber in the southern Mediterranean restricted the Venetians from building ships of great size and entering these lucrative overseas markets. Unfettered access to the Baltic demonstrates the significance the timber trade played in the fate of nations. A member of the British Parliament remarked that if the Dutch fleet closed the sea to the British, "We can neither defend ourselves nor employ ourselves."

American Colonies
Fortunately, timber growing in the British colonies in America provided the English with an alternative. Especially valued were the large trees that could mast the Royal Navy. Just how valued these became to England can be seen in

the diaries of Samuel Pepys, whose job it was to outfit the English Navy. In the midst of the Second Dutch War, ships carrying masting timber from America were long overdue. When they finally arrived, Pepys regarded it as "a blessing, mighty unexpected and without which, we must have failed." Although England tried through various acts of Parliament to preserve old-growth white pines in New England for masting its huge battleships, American settlers saw turning large trees, including those the English wished to conserve, into lumber and selling them on the international market as a profitable way to obtain the necessary startup capital for farming. Traders using ships built from American timber and usually sailing from Boston traded staves in the Canary Islands and Madeira for wine, then exchanged the wine in England for finished goods, which they then transported back to the colonies and sold.

American traders also used lumber to initiate what became known as the "Evil Triangle." The wood went down to the "Sugar Islands" - those in the West Indies - to build and maintain sugar mills. There the traders exchanged the timber for rum, which they took to Africa to trade for slaves, bringing back to the West Indies more African slaves and trading the human cargo for molasses, which in Boston they distilled into rum to trade with the Native Americans for pelts, which brought great profit on the world market. Through the timber trade, New England became the most dynamic part of America. The New England timber trade also forced the colonists into conflict with the Native Americans, who correctly saw the destruction of the woods as the end to their way of life, as well as with the British, who viewed the cutting down of timber preserved for the Royal Navy as a threat to its power throughout the world.

America after Independence

Independence gave the Americans control over the vast forestlands that spread from the East all the way to the Mississippi. The abundance of waterways and trees in the newly acquired lands west of the Allegheny Mountains proved a boon to the new American Republic. Pine logs from the great timber regions of Minnesota and Wisconsin were floated from tributaries of the Mississippi into the main river. Timber rafts headed for sale in New Orleans filled the Mississippi. Wooden boats and ships opened the old American west to settlement. How else could farmers in places like Ohio, Indiana, and Illinois expect to move their goods to distant markets except by navigation? At first, western farmers floated their products down the Ohio and Mississippi rivers by wooden flatboats. The flatboat suffered a major and insurmountable flaw: it could only sail with the current. Steamboats, though, built from the timber growing near the rivers on which they navigated, revolutionized water transport. A round-trip voyage from Pittsburgh to New Orleans by flatboat took more than a year as the flatboat men had to make the return trip by foot, while the steamboat made the journey in a little more than three weeks. Steamboats were lauded by mid-nineteenth-century

pundits as the most important technological development to have occurred in the United States because they "contributed more than any other single cause to advance the prosperity of the west," opening up markets for the millions settling in the region and feeding the entire nation.

Post-Civil War World

The clash in 1862 between the two ironclad ships the Merrimack and the Monitor immediately made wooden warships obsolete, and wood lost its geopolitical significance. Likewise, around the same time period, railroads diminished the importance of riverboats. Ironically, when wood declined from a vital resource to a mere consumer product, the demand for wood, and the timber industry's ability to provide, skyrocketed. The steam engine followed by the internal combustion engine revolutionized access to the forest and transport of forest products to consumers. Until the late nineteenth century, the timber industry depended on man or animal power for transport. Except under special circumstances where wood could be skidded over snowy terrain, the economics of physically hauling timber overland kept lumberjacks confined to working no more than 20 miles from a navigable waterway where the timber could be cheaply and easily floated or carried by ship. Trees growing beyond remained untouched. But the railroad and later tractors or trucks opened up the most remote woodlands to the logging industry. Axes and saws, used to fell trees from earliest times until the nineteenth century, gave way in the twentieth century to mechanical devices ranging from the chain saw to mobile machinery that can fell and process logs on site, changing logging from a labor-intensive to a capital-intensive industry as well as radically stepping up the tempo of tree cutting. The ever-growing demand for construction material and pulp for paper products has provided timber and logging concerns with the means for financing the industrialization of forestry.

Conclusions

Throughout history we see a process repeated time and time again. Blessed by easy access to forests, a society develops materially and people grow confident that nature will always provide. Prosperity and population invariably increase for a time. The faster an area develops demographically and economically, the greater are its demands on the remaining local forests. To ensure the continued flow of adequate amounts of wood, societies have relied on migration, colonization, diplomacy, and military ventures. Ultimately, however, the attempt to maintain high economic and population growth over time, in the face of a dwindling primary resource, results in decline. Substitute oil for wood in today's world and the parallel becomes sobering.

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