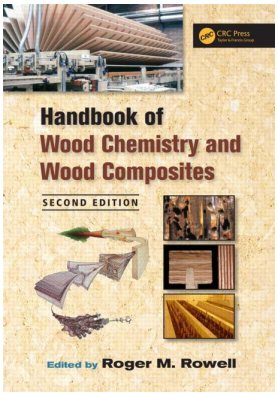

Handbook of Wood Chemistry and Wood Composites

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Wood and Society

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1 Wood and Society

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CONTENT

Forests, and the wood they produce, have played an important role in human activity since before recorded history. Indeed, one of the first major innovations was utilizing fire, fueled by wood, for cooking and heating. It is very likely that early hominids used wood fires for cooking, as long as 1.5 million years ago (Clark and Harris 1985). Clear evidence of this use of wood exists from sites 400,000 years old (Sauer 1962). Since this ancient beginning, the uses of wood, and the value of the forest, have expanded dramatically, as the populations of humans and their economies grew. Wood was used in myriad products, such as agricultural implements and tools, shelters and houses, bridges, road surfaces, ships and boats, arrows and bows, spears, shoes, wheelbarrows, wagons, ladders, and thousands of others. Other important products that forests provided were food, in the form of berries, nuts, fruits, and wild animals, and of course, fuel. Wood was the most important material in early human economies, and though other materials have grown in importance, wood used for solid products, fiber, composites, and chemicals is still the largest single type of raw material input by weight—with the one exception of crushed stone, sand, and gravel—into today's economy (Haynes 2003).

Wood is still the major source of cooking and heating fuel for most of the world. In 2010, world production of fuelwood and charcoal totaled 1,860,403,792 cubic meters. This represents over 58% of the world's consumption of wood. About 43% of this fuelwood consumption occurs in Asia, while Africa consumes 31%. The United States consumes only 4% of the world's total of fuelwood and charcoal (Food and Agriculture Organization [FAO] of the United Nations 2011). Total world consumption of roundwood, which includes fuelwood, charcoal, and industrial wood, amounted to 3275 million m^3 in 2010 (FAO of the UN 2011).

Owing to the large volumes of wood consumed around the world, and wood's critical role in heating and cooking, the sustainability of this valuable material is of special concern. As noted earlier, more than half of the wood consumed in the world is used for fuel. Although the majority of wood is used for this purpose, the economics of transportation limits the distances fuelwood can be moved. Hence, very little fuelwood is traded internationally (Steierer 2011). This means the sustainability of wood, and fuelwood in particular, must be evaluated and protected through management, locally.

Besides producing fuelwood and wood for construction and other uses, forests have always been an important part of the American cultural landscape, playing a key role in the social, economic, and spiritual life of the country. However, as the American population and economy grew, forests were removed to make way for farms, cities, and roadways. After the first European settlements in North America, forests were often viewed as an obstacle to farming and travel. Huge acreages were cleared in the nineteenth century to make way for field, pastures, cities, and industry. In 1800, total cropland area in the United States extended across 20 million acres. By 1850, this had grown to 76 million acres, with pasture and hayland at perhaps twice that amount. Most of this farmland expansion was at the expense of forests (MacCleery 1996). The amount of cropland in the United States peaked in 1932, at about 361 million acres (USDA National Agricultural Statistical Service 2003). However,

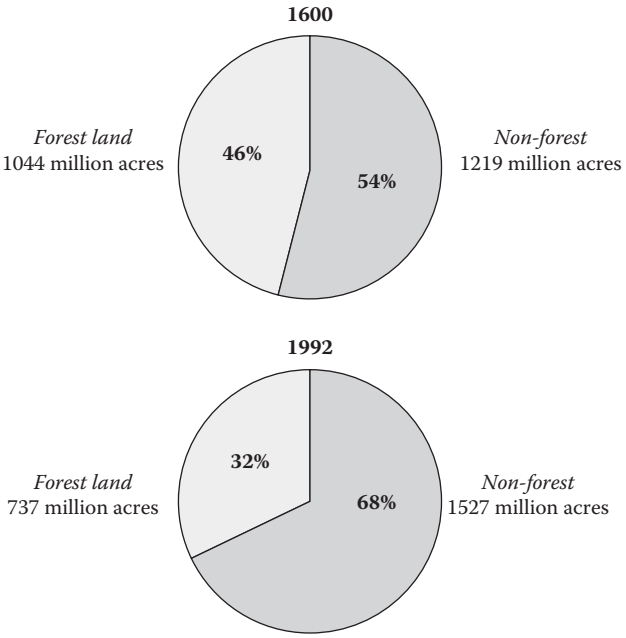

FIGURE 1.1 U.S. forest area. Forests as a percent of total U.S. land area, 1600–1992.

while much forest land has been converted to other uses, the net area of forest land has remained relatively stable since the 1920s (Alig et al. 2003). As shown in Figure 1.1, about 70% of the original amount of forested land still remains as forest, although much of it is likely modified from its structure and composition in 1600. Since 1932, however, as farmed land acreage decreased, forest area in the United States has been increasing. Forests have been the beneficiary of the conversion from animal power to mechanical power in farming. An estimated 20 million acres of grain fields and pastures were no longer needed when gasoline tractors replaced horses and mules. As agricultural productivity per acre increased, as a result of plant breeding, fertilizers, and pesticides, forests have reclaimed many acres back from farm fields.

Wood has remained an important substance throughout history because of its unique and useful properties. Wood is recyclable, renewable, and biodegradable. Many species are shock resistant, bendable, and stable (although all wood changes dimensions as it loses or gains moisture). Density among species varies greatly; the balsa popular with model-airplane builders can weigh as little as 6 lb/ft^3, while some tropical hardwoods weigh more than 70 lb. Wood and lignin can be converted to many useful industrial chemicals, such as ethanol and plastics. Wood can be treated to resist decay, and with proper construction techniques, and stains or paint, wood buildings can last hundreds of years. The oldest surviving wood structure is an Asian temple, built in the seventh century. Today, wood is used in tools, paper, buildings, bridges, guardrails, railroad ties, posts, poles, mulches, furniture, packaging, and thousands of other products.

Wood's versatility makes many wood products recyclable. Perhaps the earliest and simplest recycling was the burning of used wood for heat, whether in a wood stove, fireplace, or furnace. New technologies are improving the efficiency with which used or scrap wood can generate electricity and heat. The paper and paperboard industry has recycled paper to augment virgin wood pulp for decades. At first, recycled paper generally found its way into newsprint and other low-grade products, but recent advances in recycling technology permit used paper to go into the manufacture of higher quality papers, where appearance, texture, and consistency are important. Other products, whether railroad ties or structural timbers from 60-year-old buildings, find second lives as lumber. Affluent consumers, especially in the United States, have long been willing to pay a premium for

the aesthetics of using 100-year-old barn siding as interior paneling. More recently, entrepreneurs have recognized the availability and potential value of millions of board feet of high-quality lumber in World War II-era buildings sitting on closed (or soon-to-be-closed) military bases.

Other recycling opportunities for wood include the manufacture of wood fiber and plastic composite materials, where wood fibers improve the strength-to-weight ratio over that of plastic alone—a performance characteristic that has strong appeal in the automotive industry among others.

The ability of forests to regenerate on abandoned farmland—or after a destructive forest fire—testifies to the renewable nature of the wood resource. Though consumption of wood outpaces growth in some parts of the world, in the United States, trees have been growing and producing wood faster than they have been harvested since the early 1950s. By 1970, U.S. forestlands produced more than 20 billion ft^3 of wood, some 5 billion more than the harvest (MacCleery 1996). Much wood for U.S. home construction and the nation's paper industry comes from plantations—mostly southern pine—in the southeastern United States. Those plantations depend on the resource's renewability, with trees harvested and new ones planted and then harvested 15–30 years later. The major inputs are abundant: rain, sun, airborne carbon, and soil nutrients.

Wood's chemical makeup is largely carbon, hydrogen, and oxygen, arranged as cellulose, hemicellulose, and lignin. As such, wood presents an appetizing feast for a variety of fungi species that can metabolize either the sugar-like celluloses or the more complex lignin. With the help of these fungi in the presence of air and water, wood rots, or in environmental terms, is biologically degraded.

Wood is renewable, recyclable, and biodegradable—characteristics generally accepted as good for the environment. At the beginning of the twenty-first century, however, the most environmentally friendly aspect of wood may be its role in carbon sequestration. Growing trees soak up great quantities of carbon from atmospheric carbon dioxide (CO_2), widely regarded as a greenhouse gas that traps heat and affects global climates. Indeed, dry wood is roughly half carbon by weight. Each cubic foot of wood can contain between 11 and 20 lb of carbon. A single tree can easily contain a ton or more of carbon. In addition to the carbon in the tree above ground, significant carbon is locked in the roots and soil. With roughly one-third of the U.S. land area, or some 747 million acres, in forestland, the nation's forests hold more than 50 billion tons of carbon out of the atmosphere (U.S. Environmental Protection Agency 2002).

Forests hold unique significance in the environments that Americans value (see Table 1.1). While the United States is the world's largest importer *and* exporter of wood products, the forests of America are also highly regarded for their recreational, aesthetic, spiritual, and natural values. Forests are valued for providing wildlife and fish habitat, clean water, and clean air. Forests are further shown to be important sinks of carbon, slowing and ameliorating global warming. These concerns are all melded into the concept of sustainability. This concept, expressed through worldwide concern in the 1992 Rio de Janeiro agreement, has resulted in a multinational effort to measure forest sustainability. The Montreal Process, resulting from the Rio agreement, lists seven criteria and 67 indicators of factors and conditions that can help in the judgment of sustainability. The criteria are:

1. Conservation of biological diversity
2. Maintenance of productive capacity
3. Maintenance of forest ecosystem health and vitality
4. Maintenance of soil and water resources
5. Maintenance of forest contribution to global carbon cycles
6. Maintenance and enhancement of long-term multiple socioeconomic benefits to meet the needs of societies
7. Legal, institutional, and economic framework; capacity to measure and monitor changes; and capacity to conduct and apply research and development for forest conservation and sustainable management

TABLE 1.1
Indicator Variables for Outputs from FS- and BLM-Administered Lands Suitable for an Ecosystem Market Basket

Indicator Variable
Carbon storage
Ecosystem health
Fire risk to life and property
Fish
Game
Minerals
Passive-use values
Existence of salmon
Existence of other threatened and endangered species
Existence of unroaded areas
Range
Recreation
Access (roads)
Access to riparian areas
Science integrity
Soil productivity
Special forest and range products
Timber
Visibility
Water quality

Source: Haynes, R.W. An analysis of the timber situation in the United States: 1952–2050. General Technical Report PNW-GTR-560. USDA Forest Service, Portland, OR, 2003.

The United States has just completed its first assessment of these criteria and indicators (USDA Forest Service 2004).

Not surprisingly, the assessment produces mixed results in almost every category. While the total area of forest in the United States has remained stable for the past 80 years, the location of forests is changing and the nature of forests and how they are used is changing. Though much forest habitat has remained stable over recent decades, some forest plants, birds, and other animals are at risk of extinction. Net growth on timberland continues to exceed harvest removals.

The downside is that the net gain can represent overcrowding, which increases risk of wildfire and of susceptibility to insects and disease, thus being serious threats to the forest ecosystems.

Healthy forests function well as sources of water for towns and cities, especially in the western United States. The first sustainability assessment indicates however that at least 10% of the forested counties in each region have areas where forest conditions have deteriorated and water and soil quality have been compromised through reduced oxygen levels or higher sediment, dissolved salts, or acidity.

The assessment of long-term socioeconomic benefits to society reveals the interrelatedness and interdependence of many indicators. Recreational use of the nation's forests is increasing. At the same time, the increased demand for wood and wood products has not led to increased harvest of U.S. trees. It appears that increased wood imports and increased recovery of paper for recycling have enabled Americans to use more wood and paper without cutting more trees from America's forests. The global implications—economic, social, political, and environmental—can only be guessed at.

Since the Rio agreement, governmental and consumer concerns over the sustainability—the "greenness"—of products manufactured and consumed has only increased. In this regard, the

renewability, recyclability, and biodegradability of wood products are receiving renewed appreciation. For example, wood-framed homes contain 16–17% less embodied energy (resulting from manufacturing and transportation), and a 26–31% lower carbon footprint than steel or concrete buildings (Bowyer et al. 2005).

In spite of being one of the oldest materials used by man, we are still discovering new properties and uses for wood. Nanotechnology—the study and control of the properties of materials at the billionth of a meter scale—represent the latest advance in wood materials science. Wood has a significant amount of material that can be reduced to nano size, with highly desirable properties. Wood fibers 4–6 nm in diameter and 200–300 nm long are extremely strong, can be made into clear products, and can be combined with other materials into composites. Significant research is underway to determine if the promise of this material can be captured economically (Moon et al. 2011).

The United States, through government agencies, nongovernmental organizations, and institutions, industry, and academia, conducts extensive research regarding forests, wood, recycling, and related topics. Nonetheless, the national debate about the proper care and nurture of forests appears in many cases to be rooted in emotion and politics rather than science. The debate can be shrill at times, which reflects perhaps the intensity with which our culture regards forests. Perhaps the greatest challenge to ensuring the long-term sustainability of healthy forests that provide our society with valued resources, recreation, and aesthetic opportunities as well as environmentally vital carbon sequestration lies not in science but in finding a way to sit down at the table together, agree on some goals, and the continued need to explore alternative ways to achieve those goals.

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