

RESEARCH PAPERS

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THE U.S. FOREST PRODUCTS INDUSTRY – PAST, PRESENT, AND FUTURE

Long the dominant producer and consumer of wood products globally, the U.S. has nonetheless gone through several cycles of forest sector decline and renewal. Now, as the sector begins to emerge from an historic economic reversal, it is clear that the forest products industry of the future will look different from the industry of the past. New product lines and entirely new markets will increasingly bolster the financial bottom lines of forest sector companies that will also continue to serve long- established markets.

Keywords: forest history, forest trends, forest products, industrial productivity, globalization

Introduction

The United States has long been both the largest volume producer and consumer of wood globally. Wood has played a prominent role in the nation's basic materials picture since the beginning of European settlement, with its use more than doubling over the last half of the 20th century. However, a significant downward shift in domestic wood consumption that began around the beginning of the 21st century, and that was accentuated by a pronounced economic recession, has created major challenges for the U.S. forest sector. In what ways and how significantly the sector is likely to change over the long term in response to these factors is an open question, though current developments provide clues to the future.

This article is intended to provide an historical context for understanding the recent dynamics of the U.S. forest industry and how the industry is changing to adapt to new realities. Forest trends from the time of European settlement to the present are reviewed, as is the history of wood use and the influences of

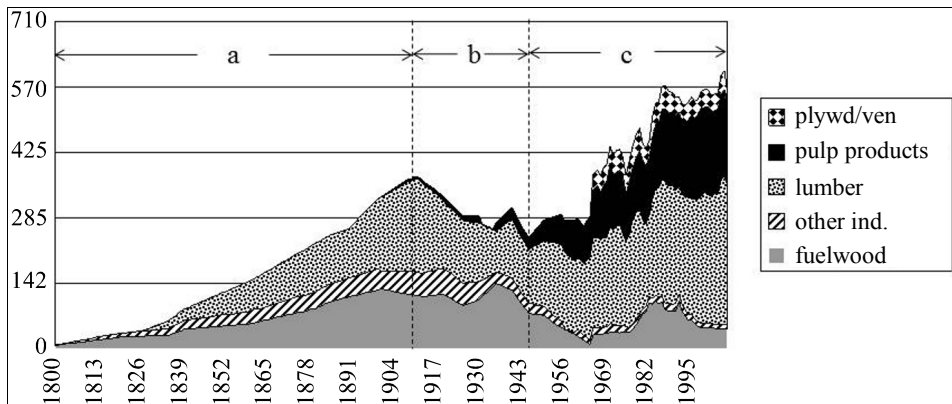
industrialization, competing materials development, economic disruption and social upheaval, and prolonged economic growth. Recent technological advances are also examined in the context of opportunities for wood-based industrial expansion.

Research Methodology

This article is based on a review of literature regarding historical forest trends and wood uses and consumption in the United States, and contemporary articles, reports, and data sources related to the U.S. forest sector. Information as to relatively recent developments is supplemented by the personal experience and knowledge of the author.

Forests and Wood in U.S. History

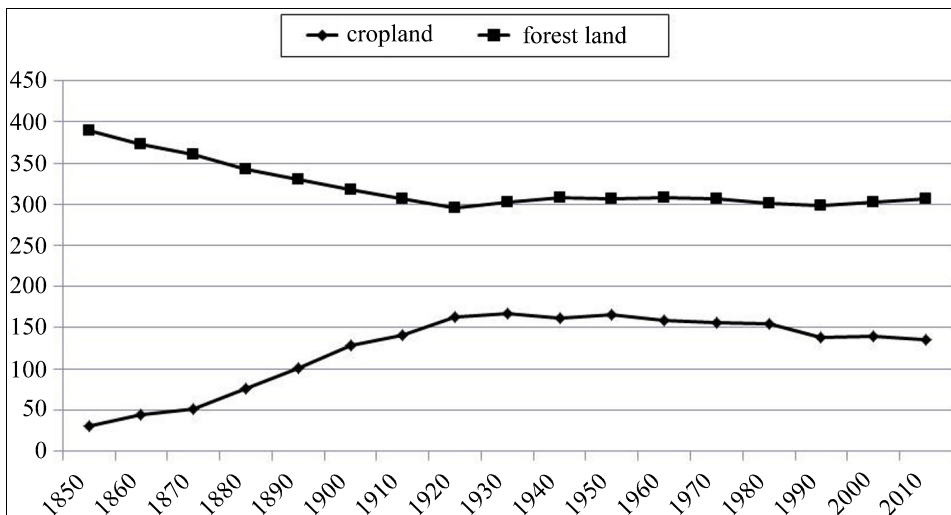
Heavy reliance on wood traces back to the beginnings of U.S. history. Confronted with vast forests, early settlers who arrived on wooden ships began clearing land and used wood for virtually everything. In colonial America wood was the foundation on which society was built. Buildings and furniture, spinning wheels and looms, dishes and pails, wagons and carriages, boats and ships, bridges and sidewalks, ploughs and hay rakes, milling machinery and sawmills, and products of every kind and shape were made of wood. Wood was also a major fuel source, used for heating and cooking and as the principal fuel of industry [Youngquist 1977]. It all added up to substantial growth in wood consumption (fig. 1a).



Source: Frederick and Sedjo [1991]; Howard and Westby [2013].

Fig. 1. U.S. consumption of wood and wood products, 1800-2006 (thousand cubic meters, roundwood equivalent)

Clearing of land for agriculture to feed a growing population and to provide wood for building of towns and cities and the rail lines that carried people westward took a toll on the new nation's forests. In just 50 years, from 1800 to 1850, the area of cropland grew from about eight million hectares to thirty-one million not counting pasture land, estimated to be as much as double the area of cropland; much of this expansion was at the expense of forests. The clearing of forests, primarily to agricultural conversion, accelerated following 1850 with another seventy-seven million ha of forests cleared in the succeeding sixty years (fig. 2). This brought the area of forest lost since the initial year of settlement (1607) to about 117 million hectares, a development that paralleled growth in the population from a few thousand in 1607 to about seventy-six million in 1900 [Fedkiw 1989]. Agricultural practices used at the time required the establishment of 1.2-1.6 ha of farm and pasture land for every new resident [MacCleary 1992].



Source: Fedkiw [1989]; US Census Bureau [1975, 1990, 2010, 2012]; USDA – Forest Service [2001]; Oswalt et al. [2014].

Fig. 2. U.S. crop and forest land area, 1850-2013 (million ha)

Then, in the early 20th century, five developments fundamentally changed the relationship between those living in the U.S. and their forests:

1. Mechanized farming equipment largely replaced horses and mules used as draft animals, which in turn greatly reduced the need for pasture land.
2. Modern agricultural practices were adopted that led to far greater crop yields per hectare.
3. A new conservation ethic led to the establishment of the U.S. Forest Service, and soon thereafter to the Park Service.
4. Forestry was introduced as a profession, with several forestry colleges established.
5. Research led to the development of effective wood preservatives.

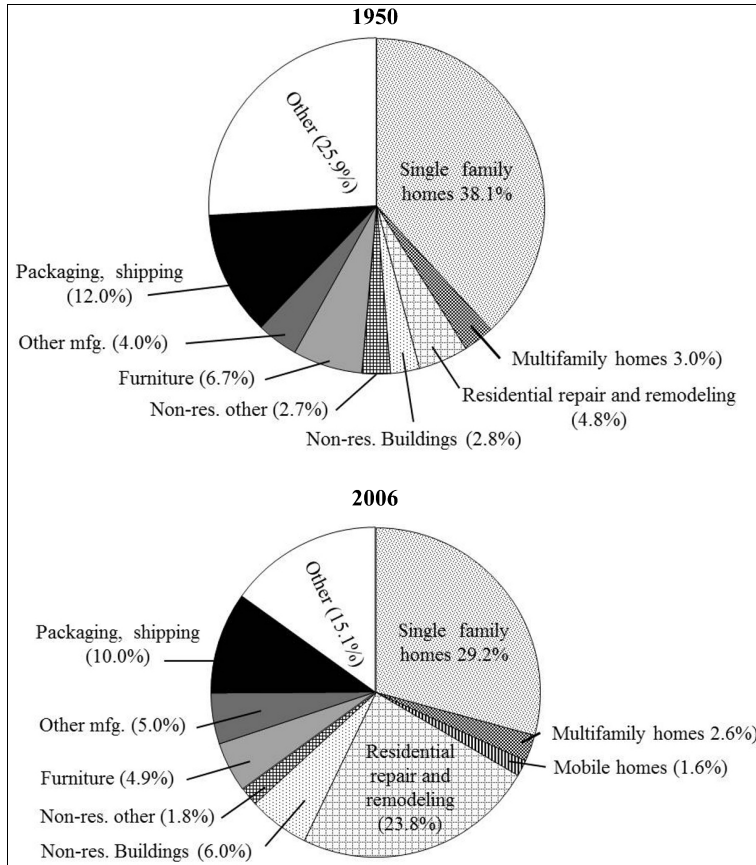
The combined effect of these changes was dramatic. Despite further growth of the population, from seventy-six million in 1900 to 317 million in 2012, the area of agricultural land remained nearly constant. So too did the area of forest land [Fedkiw 1989; MacCleery 1992]. The need for replacement of wood due to decay was also substantially reduced.

The reversal, from a period of rapid forest loss to forest stabilization is consistent with the experience of a number of other developed countries. Described by the term “forest transition”, stemming of forest losses followed by reforestation of at least a portion of previously converted land areas has been extensively documented [Rudel et al. 2010].

Wood consumption continued to grow through the early 20th century, after which the great economic depression combined with a number of other factors dramatically reduced wood use. First, lumber consumption declined almost as fast as it had increased. There were many causes of the decline, including substitution of non-wood materials for many applications, increased efficiency of wood use, and development of new technologies. The development of wood preservatives and preservative treatments alone resulted in a substantial reduction in the quantity of wood needed for replacement of ties, poles, fencing, and similar products. The invention of barbed wire meant that as the 3.2 million miles of wooden fencing estimated to have existed in the mid-1800s began to deteriorate, far smaller quantities of wood were needed for replacement [MacCleery 1992]. In addition to declining lumber consumption, growth in the use of wood as a source of energy leveled off at the turn of the century and then began to decline as fossil fuels became increasingly more important. Wood energy rebounded during the great depression of the 1930s, but then began a steep decline that continued through the early 1970s. By 1945, overall consumption of wood in the United States had fallen to a level similar to that of 1880 despite an almost 3-fold increase in population during that period (fig. 1b). At the beginning of the mid-20th century, however, the U.S. forest sector experienced a major resurgence, driven by an extended period of economic prosperity. New homes were built at a rapid pace. More than thirty-one million housing units were constructed between 1940 and 1970 [US Census Bureau 2011], resulting in a near doubling of the nation's housing stock. The production of durable and non-durable goods of all kinds, including wood furniture and cabinets, grew rapidly as well, as did production of a wide range of paper and paperboard products. As the economy grew, wood use rebounded, reaching record levels by the late 1960s and with new records set almost every year thereafter. The oil shocks of the 1970s triggered new interest in wood as a fuel, and wood use for energy rose rapidly through the 1980s, helping to push wood use to ever higher levels (fig. 1c).

The dominant uses of wood in the U.S. are as building materials, production of paper and paperboard, and energy. More than half of solid wood products are used for building construction and remodeling. In 1950, forty-nine percent of

wood was used for this purpose, a figure that increased to over sixty-three percent in 2006 (fig. 3). Other uses include furniture and packaging (fig. 3).

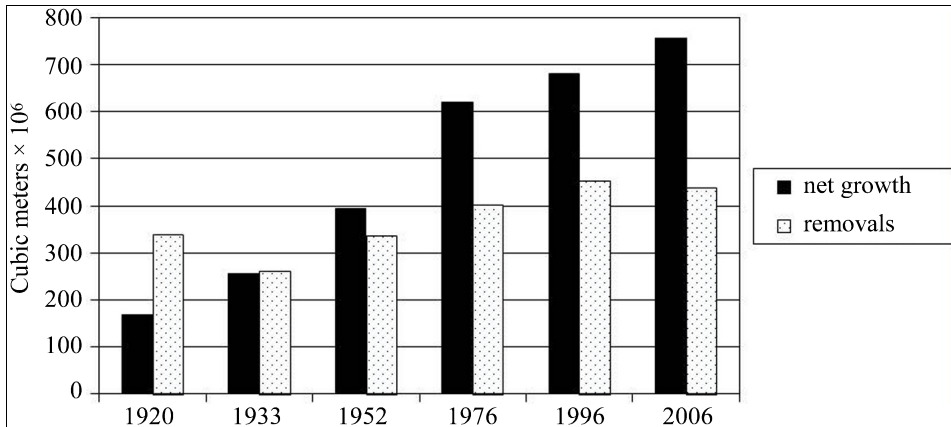


Source: McKeever [2009].

Fig. 3. Primary uses of wood in the United States, 1950 and 2006

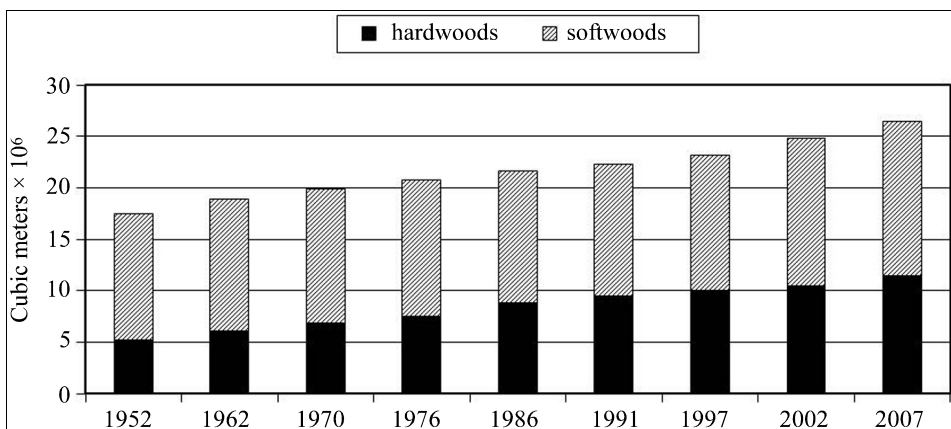
The growth of wood use in the 1960s and '70s closely matched growth in population, meaning that wood use per capita remained relatively constant during this period. However, in the economic boom years from the late 1970s through the mid-1980s wood use grew more quickly than population numbers, and wood use on a per capita basis rose substantially [Howard and Westby 2013].

The unprecedented expansion of wood use did not bring about further loss of forests as many feared. Not only were increasing harvest levels more than matched by rising forest growth rates (fig. 4) – leading to steady increases in standing timber volume (fig. 5) – but, as noted earlier, the forested area remained stable (fig. 2).



Source: Oswalt et al. [2014].

Fig. 4. U.S. timber net growth and removals, 1920-2006



Source: Oswalt et al. [2014].

Fig. 5. U.S. standing timber inventory, 1952-2007

Now there are concerns about the possibility of a new period of forest loss. A recent assessment of the future of forest and rangelands projected losses of 6-14 million ha of forest land by 2060 due to urban expansion and low density housing development in forested areas [USDA – Forest Service 2012].

The U.S. Forest Industry

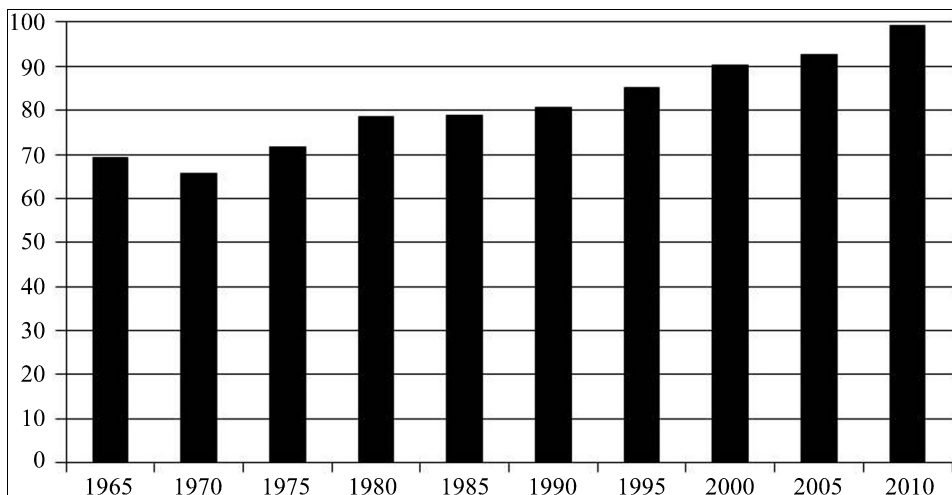
19th and 20th Century

The early 19th and 20th century forest industry was largely dedicated to production of lumber, timbers, and railroad ties; and poles and ship masts. Products such as pitch and tar were also produced. Fuel-wood was commercially harvested for distribution in many cities. Wood-based paper came into the

picture in the early 1900s. These products defined the U.S. forest products industry through the first half of the 20th century.

Mid-century not only marked the beginning of wood industry resurgence, but, (not coincidentally) a period of process and product innovation as well. As rapidly as wood consumption rose in the post war years, the rise would have been far more spectacular were it not for innovations relative to both process and new products. For instance, in the twenty-five years between 1948 and 1973 the yield of lumber from a given quantity of logs doubled, while the quantity of useful products obtained quadrupled. New products brought into production during this period include softwood plywood, particleboard (using technology developed in Germany), hardboard, and waferboard. Significant increases in paper making efficiency were also achieved during this period.

The new family of products made of fibers, particles, and flakes served to greatly expand the options of wood products manufacturing and to increase the yield of final products. Subsequently, innovation brought to the market more new composite products. Structural composites such as oriented strand board, laminated veneer lumber, parallel strand lumber, and wood composite I-beams allowed the use of less wood for a given application. At the same time, improvements in recycling technology greatly increased waste paper recovery and reuse rates, with these numbers up from fifty to sixty-five percent in the last fifteen years alone [American Forest and Paper Association 2015b]. These developments are reflected in a long history of rising wood productivity (fig. 6).



Source: Howard and Westby [2013].

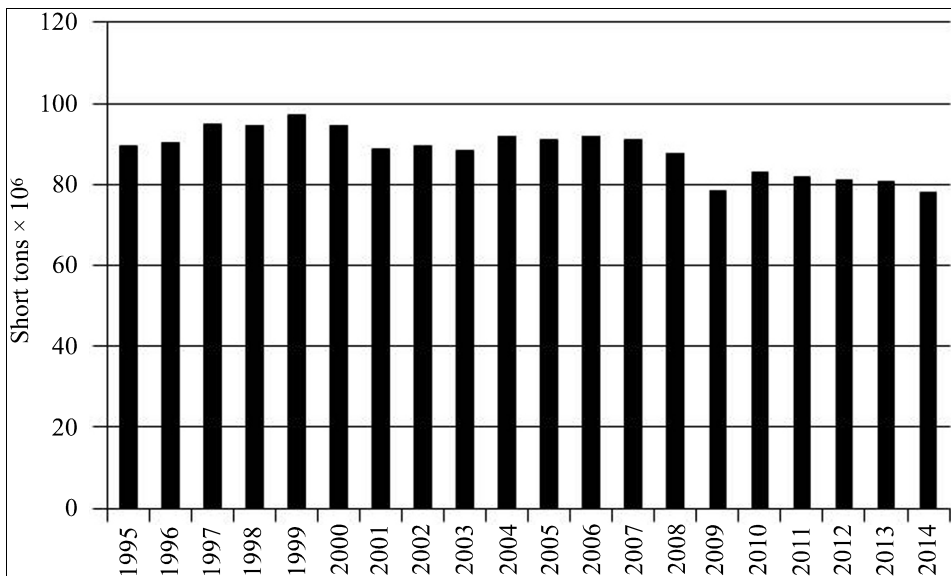
Fig. 6. U.S. industrial wood productivity, 1965-2010 (industrial wood product output per unit of roundwood input (tons/ton), expressed in percent)

By the end of the century the U.S. forest products industry served largely the same markets as fifty years earlier, but with a wider array of products. Although markets were strong, however, and manufacturing performance at unprecedented levels, there were several areas of concern.

A troubling trend that first appeared in the 1970s and significantly accelerated in the 1980s was loss of domestic wood furniture markets to imported goods – largely from China. By 2000 what had begun as a small increase in imports turned into a forty percent capture of domestic markets, a number that would continue to climb in subsequent years with devastating effects on the nation’s furniture manufacturers [Schuler and Lawser 2007; Luppold and Bumgardner 2011]. Then, in the late 1990s, domestic newsprint and printing and writing paper markets began to show signs of weakness.

Early 21st Century

The decline in domestic paper production that began in the late ‘90s has continued into the new millennium, with production in 2014 down about thirteen percent from 1995 (fig. 7). The decline has not been uniform across industry sectors, however. While the production of pulp, and printing and writing papers declined sharply from 2000 to 2014, due to a combination of increasing reliance on electronic communication and competition from overseas paper producers, domestic production of paperboard, packaging, tissue, towels, and specialty papers expanded during this period. Nonetheless, capital spending in the U.S. paper and paperboard industry in recent years has been less than a third of that in the mid-1990s, suggesting further contraction in the coming years.



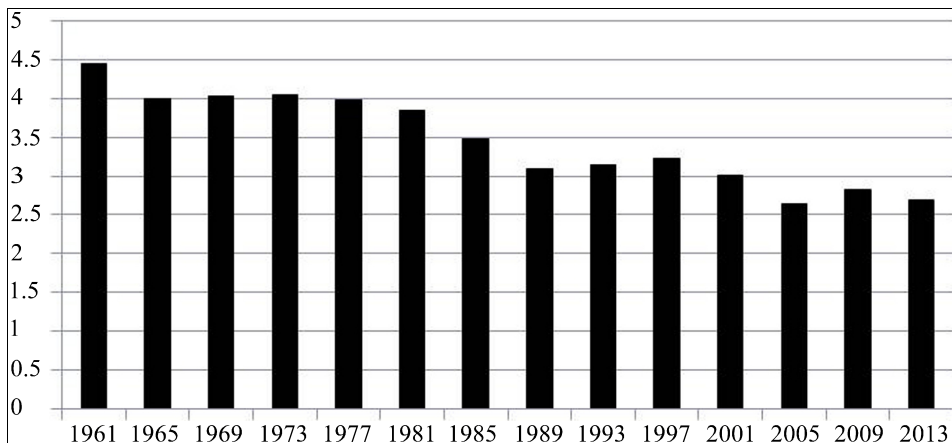
Source: 1995-2011 Howard and Westby [2013], table 43; 2012-2014 various sources.

Fig. 7. U.S. paper and paperboard production, 1995-2014

Meanwhile, imports of wood furniture continued to grow following 2000, and by 2011 imports accounted for seventy percent of the U.S. market [Koenig 2013]. Over a forty year period, a major portion of the U.S. wood furniture industry was shuttered, as foreign competitors and offshore subsidiaries of U.S. companies increased the volume of exports to the U.S. (Luppold and Bumgardner 2011). Office furniture manufacturers are now experiencing similar pressures.

The forest products industry overall shed 220,000 jobs (fifteen percent) from 1997-2006. The vast majority of the job losses during this period were in the non-upholstered wood products and pulp and paper sectors [USDA – Forest Service 2014]. Caution is in order when interpreting the causes and significance of reductions in employment. As in many industries, investments aimed at improving manufacturing efficiency have been ongoing in the forest products industry throughout its history, and particularly in the 1980s. The result has been a steady reduction in employment per unit of wood products output (fig. 8). Consequently, the majority of the reduction in forest products industry employment up through 2006 was attributable to gains in labor efficiency.

Then came 2007 and the onset of what is known in the United States as the Great Recession (2007-2009).



Source: Prestemon et al. [2015].

Fig. 8. Labor intensity in the U.S. Forest Products Industry, 1961-2013 (persons employed per 1,000 m³ of product output*

*Expressed in industrial roundwood equivalent.

An indication of the effect of the 2007-2009 economic recession on the U.S. forest products industry is indicated by the fact that housing construction – the primary market for wood products – literally collapsed, falling by more than seventy-five percent between 2005 and 2010. Predictably, the impact on most sectors of the industry was severe. Particularly hard hit was the southern U.S., a region that contains only two percent of global forests, but which annually provides nineteen percent of the world harvest of pulpwood and twelve percent

of the global production of industrial timber and over half of U.S. wood products production. This region experienced a reduction of softwood and hardwood lumber production of thirty-six percent and fifty-five percent, respectively, and of plywood and engineered wood by more than forty-eight percent. Job losses in the non-upholstered wood furniture industry, already substantial prior to the recession, declined by another sixty-two percent. The paper industry lost an additional eighteen percent of its workforce, and non-furniture wood products manufacturing employment, fell by more than thirty-six percent [Hodges et al. 2012]. In short, it was a devastating period for the U.S. forest products industry.

Now, as the U.S. economy rebounds from recession, there are early signs of a rebound in the forest sector as well. As of late 2015 annual housing starts were more than double those of 2009 and construction activity in most categories of commercial buildings was up sharply [Gavin 2015; Trading Economics 2015]. Currently, production and consumption of lumber and other building products is increasing, and paper and paperboard production and consumption is now above the 2006 low point. In addition, a wood pellet export industry that emerged through the course of the recession continues to grow, providing a market for some of the wood that had previously been used in paper and paperboard manufacturing.

Results and Discussion

U.S. forest sector recovery from recent events depends in large part on the extent to which the residential housing market recovers. Though increasing, housing starts for 2015 are forecast at only about one-half of pre-recession highs, and there is some concern that the next generation may be less interested in, or able to afford, home ownership than previous generations [Gavin 2015]. Thus there is uncertainty as to the likelihood of fully regaining previous housing-related markets [Hodges et al. 2012; Prestemon et al. 2015]. There is similar uncertainty regarding future paper markets. Continued decline in demand for newsprint and printing and writing papers is viewed as likely, and the future of a currently strong sector – containers and containerboard – is seen as closely linked to domestic manufacturing activity overall, which has been declining for some time [Prestemon et al. 2015]. Current low pulpwood prices provide some optimism for improved competitiveness in export markets [Hodges et al. 2012].

With regard to hardwood markets, there is some indication that domestic manufacturers that shifted manufacturing to offshore locations in the past, may be reconsidering location decisions. Hidden costs of offshoring, such as shipping and inventory costs, long lead times, delayed returns, negative impacts on innovation caused by reduced interaction between engineers and factory workers, and rising labor costs in current producing regions are cited as factors driving re-examination of mill location [North Carolina in the Global Economy

2014, Neil 2013]. This is creating optimism in some quarters that at least a portion of lost domestic furniture production may be restored.

In view of these challenges and trends it would be easy to conclude that the U.S. forest products industry is on brink of extinction. The reality is, however, that the U.S. still consumes and produces more forest products than any other country [Prestemon et al. 2015], employs three-quarters of a million people [US Department of Labor 2015a, b], and accounts for about four percent of US manufacturing GDP – US\$210 billion [American Forest and Paper Association 2015a].

A key question is how the industry will adapt going forward to changing global realities. Another is what the impact on the nation's forests would be if the industry were to substantially down-size over the long-term.

Among the areas viewed as presenting opportunity for the U.S. forest sector are the following:

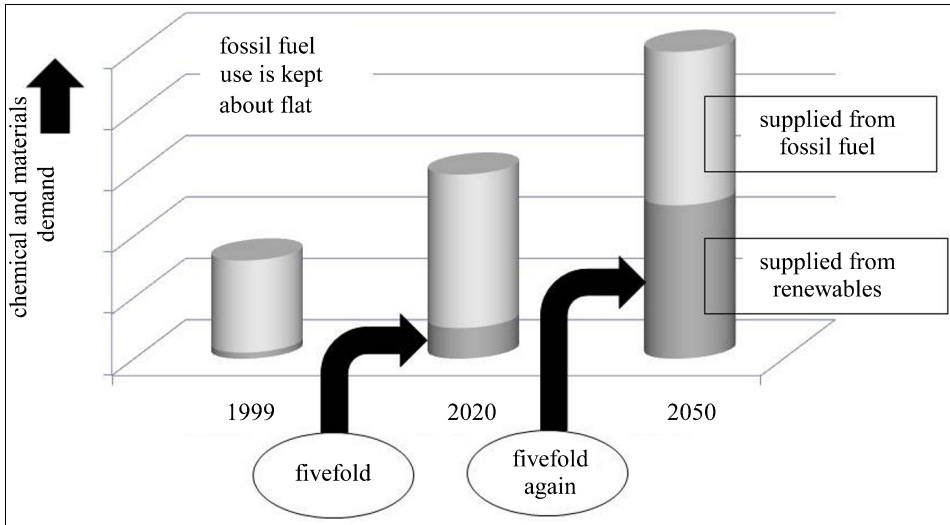
- New, innovative uses of wood in creating commercial structures, including tall buildings.
- Use of wood as a feedstock in industrial chemicals production.
- Involvement in the emerging nanotechnology industry.
- Wood energy, including wood pellets for export and domestic use, and wood-derived biofuels.

The development of engineered wood products over the past three decades, coupled with the recent development of cross-laminated timber in Austria, has created new opportunities for use of wood in construction. Based on European experience, interest in tall wood buildings is growing in the United States, assisted by initial adoption in western Canada and the potential for reducing the carbon footprint of buildings through greater wood use. Current regulations limit the use of wood as a structural material in buildings to no more than five to six stories. Extending that limit to ten to twelve stories or more would significantly expand opportunities for wood use.

The Department of Energy forecast in 1999 that some ten percent of industrial chemicals and materials would be produced from renewable resources (including wood and agricultural fiber) by as early as 2020, with this number approaching fifty percent by 2050 (fig. 9). Even at a ten percent share for wood, such chemicals would have an annual value of about \$400 billion (1999 dollars), or about twice the value of all forest products currently produced in the U.S. In addition to this, great potential is seen in nanocellulose for applications in paper and packaging, construction, automotive manufacture, textiles, and personal care products; a recent estimate found that if nanocellulose were to account for just three percent of U.S. nanotechnology potential in 2020, it would amount to a US\$100 billion industry [Goergen et al. 2013]. The opportunities would appear to be substantial.

U.S. production of wood fuel pellets has increased substantially in recent years. Production grew from near zero in 2003 to an estimated six to seven

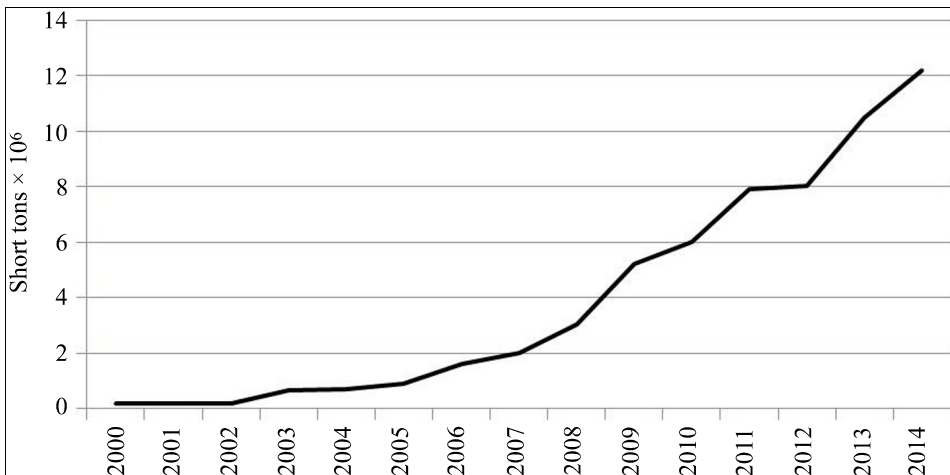
million dry tons in 2014 (fig. 10), about half of which was exported to the E.U. Significant growth is expected in the future, with the magnitude of growth highly dependent upon government policies in the U.S. and E.U.



Chemical and material demand 10% from renewable resources by 2020 ~\$400 billion/year in products (2 times late 1990s forest products)

Source: US Department of Energy [1999].

Fig. 9. An estimate of U.S. biochemicals potential



Source: Abt et al. [2014]; Mendell [2015].

Fig. 10. Growth in U.S. fuel pellet production capacity, 2000-2014

In addition to fuel pellets, there is considerable research activity directed toward the development of liquid fuels from biomass, including woody biomass, motivated in large part by government mandates that call for biofuels production of 61×10^9 liters in 2015, an amount that increases to 133×10^9 liters in 2022. With a focus on advanced biofuels, this represents a potential new market for wood.

Successful development in all of these areas will require ongoing research and development as well as attention to government policies regarding forests and their management. Global trends and competition will continue to shape the industry.

With respect to forests, in view of the fact that over eighty-eight percent of commercial timber harvests in the U.S. occur on privately owned forest land [Oswalt et al. 2014 – table 35], the long-term fate of much of this land is somewhat dependent upon the health and vitality of the domestic forest products industry. There are growing concerns that a loss of markets over an extended period could lead to the conversion of forest land to urban development, agricultural energy crops, or traditional agriculture.

Surveys of non-industrial private forest owners across the United States have found that they are primarily interested in such amenities as aesthetics and privacy that their forests provide. Although timber production is not a primary objective of most such owners, timber harvesting is, however, a common activity [Butler 2008], and financial considerations have been found to be an important factor in land management decisions. A survey of private forest landowners in the southern and dominant timber producing region in the U.S. found that owners primarily interested in timber production controlled over one-third of forestland in the region, whereas those who indicated that they would never harvest timber from their land controlled only twelve percent of the total private timberland acreage [Wicker 2002].

Consequently, forest land is under constant pressure from agricultural interests – often in the form of current owners who own both farm and forest land [McCraw 2014]. In addition there is also considerable and mounting interest in forest conversion to urban development or for subdivision to vacation homes. In fact, the U.S. Forest Service has forecast forest losses of seven to thirteen percent of forested area in the southern region by 2060, primarily due to urbanization trends. The greatest losses are projected in an environment of high economic growth and low timber prices. Conversely, increasing timber prices (i.e. strong timber markets) and low economic growth lead to the lowest extent of forest loss. Other assessments of drivers of forest retention have similarly found that increased wood demand can slow the loss of forest or even lead to expansion of forest area [Miner et al. 2014].

Conclusions

The forest products industry of the United States is the world's largest, having grown substantially since the mid-1960s. Wood is dominant in residential housing, engineered wood products are increasingly specified, and wood use in commercial/industrial construction is growing. Moreover, annual net forest growth on land available for periodic harvest is more than double removals, the standing timber inventory is increasing, and wood that is harvested is converted to products with essentially zero waste.

Despite all these positive indicators, the U.S. industry has suffered severe losses over the past two decades, with substantial loss of markets in the printing and writing papers and wooden household furniture sectors. The severe U.S. economic recession of 2007-2009 hit the forest products industry particularly hard because of the impact on home-building and remodeling, the primary domestic markets for wood products.

Nonetheless, emerging from the trials of recent decades, the industry is highly efficient, diverse, and still large by any measure. A number of new potential markets also offer significant opportunities in the relatively near term.

An ongoing challenge will be the retention of forest land in an era of increasing urbanization and pressures from other competing land uses. Success will depend in part on the existence of a stable, robust, and profitable forest sector.

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