Wood Science Research
Not Trendy, but Absolutely Necessary

Dr. Jim Bowyer

Dr. Jeff Howe
Kathryn Fernholz

May 19, 2006

Dovetail Partners, Inc.

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Introduction

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, dingys and ships, bridges and sidewalks, plows 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.

Wood use was not based on research, but rather on wood's abundance, range of inherent properties, ease of conversion to useful products, and long history of use in places of origin for Americas immigrant population.

As the colonies gave way to rapidly expanding cities, and as populations expanded, wood abundance in many areas turned to scarcity as unrestrained wood use, combined with land clearing for agriculture, resulted in greatly diminished forests. But as wooden wagon trains carried homesteaders steadily westward, new forests were encountered and clearing of forests continued. Wood for fencing of pastures alone required enormous volumes of timber (Figure 1), with some 3.2 million miles of such fencing estimated to have been in existence in the mid 1800s. Development of the steam engine led to the need for great quantities of additional wood – for steamboat fuel and for railroad ties and trestles, and it provided a means of moving large volumes of wood to population centers. As earlier, wood research did not provide an underpinning for wood use.

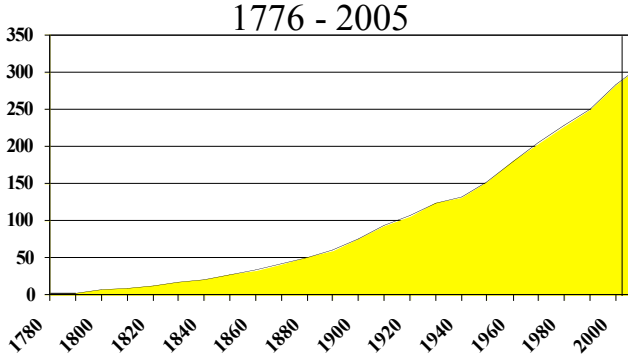
One of the early drivers of inquiry into whether things might be done to increase the efficiency of wood used was the tendency of wood to rot. The huge volumes used for fencing, ties, trestles, bridges, and telegraph line poles required replacement after only a few years of use due to natural deterioration. As noted by MacCleery, just replacing railroad ties on a sustained basis required from 15 to 20 million acres of forest land in 1900. Interest in finding a way to preserve wood to eliminate or slow decay processes provided an impetus to an early field of inquiry in what would later become known as the field of wood science.

Figure 1
Wooden Fencing Required the Use of Enormous Quantities of Wood

The Past as Prologue to the Future

As the population of the United States grew – from an estimated 3 million in 1785 to 77 million in 1900 (Figure 2) wood consumption grew rapidly (Figure 3); primary uses of wood were lumber and fuelwood. Rapid growth in wood use continued for about another decade but then, despite ongoing increases in population, a dramatic shift in wood use occurred.

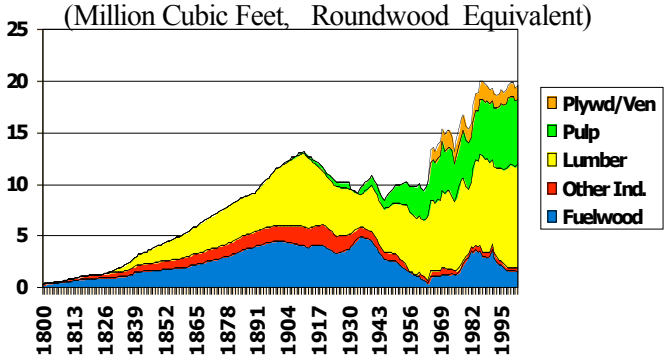
Figure 2
Growth of U.S. Population,
1776 - 2005



Source: U.S. Census Bureau, 2006.

First, lumber consumption declined almost as fast as it had increased. The causes of the decline were many, including substitution of non-wood materials for many applications, increased efficiency of wood use, and development of new technologies. 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. Another development – 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. 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.

Figure 3
U.S. Consumption of Wood and Wood Products,
1800 - 2002
(Million Cubic Feet, Roundwood Equivalent)



Source: Howard, J. 2004. U.S.D.A. - Forest Service, USFPL.

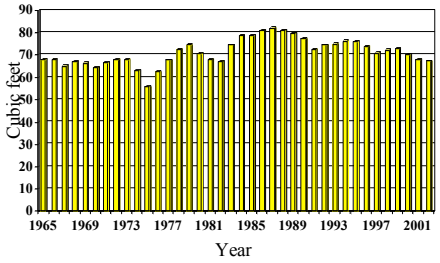
But then World War II ended, and the postwar boom that ensued is the stuff of legend. New homes were built at a stunning pace, and with them production of durable and non-durable goods of all kinds skyrocketed. Industries of all kinds grew at a breakneck pace, fueling growth of communication and with it demand for paper. 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 growth of wood use for energy rose rapidly through the 1980s, helping to push wood use to ever higher levels.

Technology, Process, and Product Development Lead Positive Change

Growth of wood use in the 1960s and '70s closely matched growth in population, meaning the 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. Subsequently, per capita consumption has fallen slowly, and is now about the same as in 1965 (Figure 4).

As rapidly as wood consumption rose in the post war years, the rise would have been far more spectacular were it not for innovation 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 particleboard, hardboard, and waferboard. Significant increases in paper making efficiency were also achieved during this period.

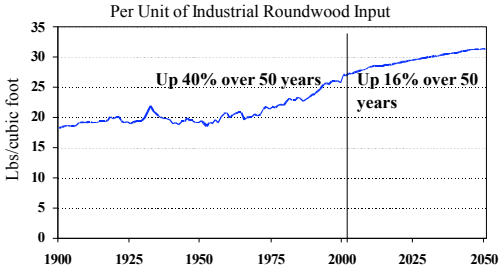
Figure 4
Annual Per Capita Consumption of Wood Products – U.S., 1965-2002
(Roundwood equivalent)



The new family of products that are 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 LVL, PSL, and wood composite I-beams allowed the use of less wood for a given application, thereby further stretching wood supplies. At the same time, improvements in recycling technology greatly increased waste paper recovery and reuse rates, with these numbers up by 50 to 65 percent in the last 15 years alone.

Overall, increased consumption efficiencies are reflected across all products (Figure 5). Interestingly, the 14.5 percent reduction in per capita consumption of wood that occurred between 1985 and 2002 resulted in a savings of 3.3 billion cubic feet of wood. This is remarkably similar to the 2.8 billion cubic feet of wood saved through the increase in wood conversion efficiency (17.6 percent) that occurred over the same time period. Thus, the slow reduction in per capita wood consumption that has occurred since the mid 1980s is mostly (84%+) due to technology improvements.

Figure 5
U.S. Industrial Wood Productivity – Industrial Wood Product Output
Per Unit of Industrial Roundwood Input



Source: Skog, K. USFPL 2002

An indication of the significance of technology gains is provided in a recent position statement of the Society of Wood Science and Technology. Included in this statement is the following summary:

> *Recent assessments of the state of the nation's forests have revealed a more-than-fifty-consecutive-year-record of net forest growth in excess of forest removals despite steadily increasing demand for fiber and chemicals supplied by these forests and corresponding increases in harvest levels. New technology developed by wood science and forest products research and development programs, coupled with successes in forest management, made it possible for the nation's forests to supply substantial quantities of critical raw materials while providing clean water, recreation, biodiversity, and a myriad of other forest values. To continue to maintain all of these values and also keep pace with the nation's growing need for wood and fiber will require proactive action on several fronts, including advancement of knowledge and technology to improve wood utilization, improved technologies for dealing with plantation-grown wood and other bio-fiber, ongoing improvement of environmental performance of manufacturing technologies, and increased use of recycled wood-based materials.*

Research and Development Takes a Hit

At the same time that pressures on forests and consumption of wood and wood products are growing funding for forestry and wood products research is declining. The 2002 National Research Council report *National Capacity in Forestry Research* documents the loss of research capacity in forestry and in forest products in particular. For instance, in the period 1985 to 1999 the U.S. Forest Service – the largest forestry research organization in the world – experienced a 46 percent decrease in the number of scientists – from 985 to 537.

The decrease in scientists within the Forest Service occurred over all areas of research, but the largest proportional loss of expertise was in the forest products technologist classification; here, the number of scientists declined from 64 in 1985 to just 13 in 1999, a 75 percent reduction. Reductions approaching this magnitude occurred in the ranks of chemical, industrial, mechanical, and civil engineers, as well as in numbers of scientists trained in chemistry, physics, and mathematics. The loss of funding for forest products research was only slightly less dramatic. In constant dollars, support for such research fell from $17.7 million in 1985 to $12.8 million in 2002, a 28 percent reduction. Within the past year, further reductions in both funding and personnel have been announced.

While the U.S. Forest Service is the largest player in forestry and forest products research, other organizations are also involved, including universities and the private sector. However, forestry and forest products research has declined in recent decades in both universities and the public sector. Within universities, the numbers of faculty working in forestry totaled 1,503 nationally in 1984/85, 1,459 in 1993/94, and 1,361 in 2001/2002; on a full-year equivalent basis, about one-half of this number is devoted to research. Forest products research within universities, involves roughly eight to ten percent of faculty in forestry oriented academic units, with additional scientists who work

on wood science related issues residing in colleges of engineering and similar units. Here again the trend appears to be downward, with three U.S. undergraduate forest products programs (of 26) having been eliminated in the past 15 years. Not only has the number of programs declined, but Forest Service funding for support of university research has declined as well. On a constant dollar basis the decline in annual support for extramural research was $7.3 million over the period 1992 to 2001. Given the reality of great pressure within universities for procuring research grants, it is possible that the Forest Service decision regarding external funding of research played a role in university forest products program decline.

Within the private sector, the number of scientists working in the area of forestry and forest products totaled one to two hundred during peak years in the 1980s. Since that time, investment in forest products R&D has declined significantly as a result of shareholder pressure for short-term profits and consolidation in the domestic forest products industry.

Wood science and forest products oriented research and development, it appears, is not trendy in today's society.

An Uncertain Future

Current and projected trends in petroleum availability are raising concerns about the nation's energy future. Concern about sources of industrial chemicals and feedstocks, almost all of which are today derived from petroleum, is also rising. As described in previous Dovetail articles (May 2005, *Bio-Energy: Momentum is Building for Large Scale Development*; March 2006, *Biomass Energy - From Farms to Forests an Emerging Opportunity for Rural America*) doubts about future petroleum supplies have triggered intense interest in the potential for bio-energy development, including biomass-fueled electric generation, and development of liquid transportation fuels from biomass. Biomass is also viewed as a likely source of as much as 50 percent of industrial chemicals by the middle of this century. In all of these developments, wood will play a significant role. New developments in nano-science are also likely to make possible the production of entirely new products for a variety of uses including a wide array of construction products. Again, wood is likely to be a key raw material in such development.

Energy and petrochemicals concerns gave rise to the issuance in 1999 of Executive Order 13134 (*Developing and Promoting Biobased Products and Bioenergy*) by President Clinton, which called for a tripling of U.S. use of bio-based products by 2010. This led, in turn, to passage of the Biomass Research Development Act of 2000, a measure that promoted research and development leading to the development of bio-based industrial products. A subsequently issued request for proposals (RFP) covered plant and animal derived materials, and included new (non-food) uses for underutilized co-products and residuals from agricultural, forest, and wood-food processing operations. The number of product areas targeted for investigation under the RFP was impressive, as noted in the narrative:

> *"Examples of research to be supported include: (a) development of chemicals and materials such as adhesives, adsorbents, coatings, detergents and surfactants, films, foams, lubricants, organic acids, polymers (biodegradable polymers, engineering plastics, copolymers, polymer blends and networks), specialty fibers, textiles (geotextiles and biomedical materials), and fiber-reinforced composites; (b) research on improved process technology such as raw material preparation, chemical and bioconversions, electrotechnologies, methods for processing forest and agricultural co-products (e.g. leather, wood, food processing and crop/forest residues, etc.), and conventional unit operations; and (c) utilization research including end-use development and biodegradation studies."*

Passage of the Biomass Research Development Act was good news. The news became even better in 2002 when the act was reauthorized, this time at three times the original funding level. The bad news is that enacted funding levels turned out to be only 6 percent of authorized levels ($12 million rather than $200 million).

In what direction will wood consumption go in the future? Will domestic consumption of wood increase in absolute terms? Almost certainly the answer to this question is yes, with consumption linked to a domestic population that is expected to more than double in this century. Will wood consumption increase on a per capita basis? Here the answer is less clear. On the one hand, new interest in wood as a source of electricity and transportation fuels will lead toward increased consumption levels. On the other hand, advancements wood science research and development could continue to drive productivity improvements such that efficiency of wood use increases over time. A key question is whether sufficient research funding will be made available to ensure success. The outlook currently is not good.

The Bottom Line

Wood is vitally important in today's society, and the global trend is an increasing interest in even greater use of this raw material. Supplies of wood can be increased by growing wood more quickly by finding ways to accelerate growth through application of more intensive silvicultural practices in forest management, by establishing fast-growth tree plantations, and/or by genetically modifying planting stock; all are controversial. Alternatively, wood supplies can be increased by using that wood which is harvested more efficiently and effectively – an approach about which there should be no controversy. It is essential that our society find a way to substantially increase funding for wood science and biomass research and associated technology development.

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DOVETAIL PARTNERS, INC.

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This Dovetail Report is made possible through the generous support of the Rockefeller Brothers Fund, Surdna Foundation, McKnight Foundation and individual donors.

DOVETAIL PARTNERS, INC.
4801 N. Highway 61, Suite 108
White Bear Lake, MN 55110
Phone: 651-762-4007
Fax: 651-762-9642
www.dovetailinc.org