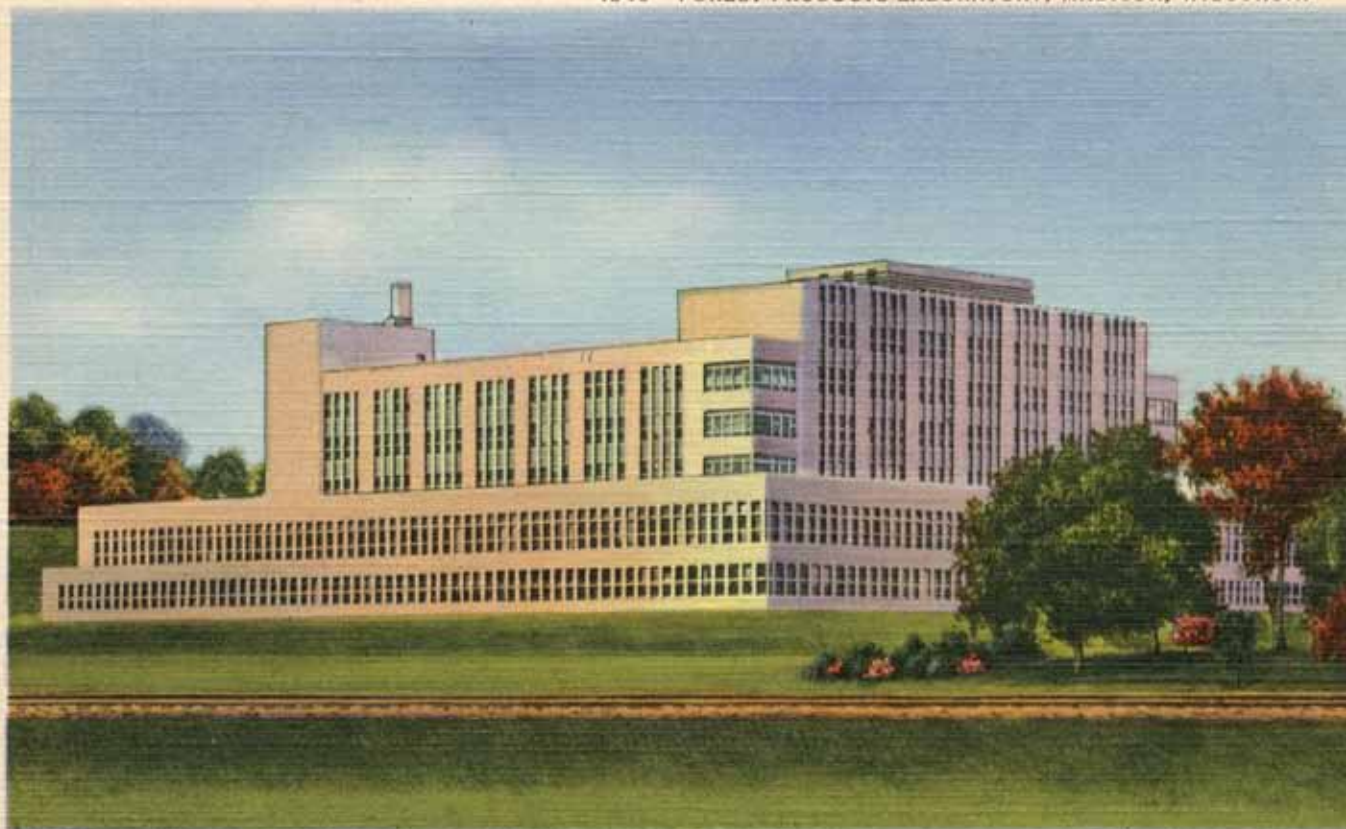


JOURNAL FOREST PRODUCTS

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A Century of Research Working for You

*The Centennial Year of the
USDA Forest Service's Forest Products
Laboratory offers a time to reflect on
significant breakthroughs and look to a
future of unprecedented innovation.*

1910-2010

The U.S. Forest Service Forest Products Laboratory: 1910–2010



A Century of Research Working for You



By James T. Spartz

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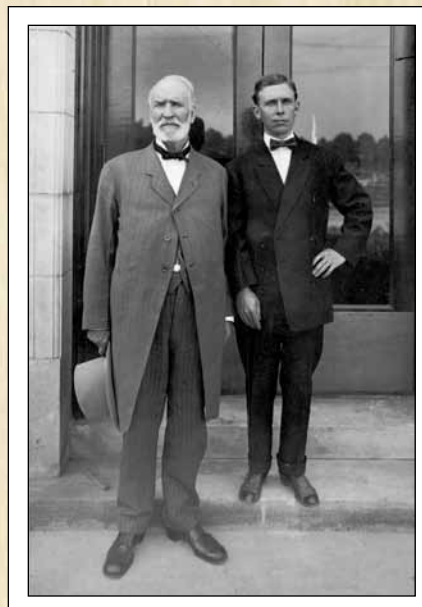
Introduction to the Past

Since 1910, the Forest Products Laboratory (FPL) has promoted healthy forests and forest-based economies through the efficient, sustainable use of American wood resources. These past 100 years have produced an extraordinary amount of research. From propellers and paper to construction materials and fire safety, the Forest Products Laboratory has helped make life easier, more comfortable, and infinitely more rewarding for almost every American.

The early years of the 20th century were brimming with industrial promise and ingenuity. The American frontier spirit of lumberjacking and self-reliance was still held in high regard. In 1910, James McGillivray's first story about the giant lumberman Paul Bunyan was published in the *Detroit News*, locomotives steamed coast to coast and the professional class took to motoring through the countryside in pursuit of recreation and leisure. Cultural advances coincided with pursuits in the biological sciences and environmental conservation resulting in efforts to maximize America's wood resources through a more efficient stream of production.

In 1907, McGarvey Cline, Chief of the Office of Wood Utilization in the U.S. Forest Service, proposed to colleagues that, in order to improve coordination among disparate centers of research, one main Forest Service research laboratory be established. By January 1909, Gifford Pinchot, head of the Forest Service, made an offer to the University of Wisconsin (UW) in Madison to be home to this new central research laboratory. The offer was accepted with much acclaim by UW President Charles Van Hise. Forester Pinchot then, surprisingly, retracted the offer in light of objections by Congressman James McLaughlin of Michigan and a separate offer from the University of Minnesota. Heated deliberation ensued. Eventually, a February meeting between Pinchot, Van Hise, and Wisconsin Senator Robert M. "Fighting Bob" La Follette, among others, at the exclusive Cosmos Club in

U.S. Secretary of Agriculture James Wilson (left) with Director McGarvey Cline during FPL's first inspection in 1912.



Washington, D.C., turned the tide. On March 5, 1909, the day after President Taft's inauguration, the announcement was made by Secretary of Agriculture James Wilson that Madison, Wisconsin, would indeed be home to the Nation's first central wood research laboratory.

Architectural planning proceeded quickly. By December 1909, the assembly of laboratory equipment began, and by spring of 1910, administrative offices opened. McGarvey Cline was named director prior to the official opening on June 4, 1910. The Forest Products Laboratory made its home on the UW-Madison campus in what today functions as the Materials Science and Engineering Building.

Early research priorities at the FPL focused on timber testing, wood preservation, wood-based distillates, wood technology (timber physics), pulp and paper, and wood chemistry.

A Note on References -

In his definitive dissertation on early FPL history, Charles A. Nelson wrote that researchers were engaged in "a scientific crusade against waste and inefficiency in the use of America's forest resources" (Nelson, 1971; p. 46). This description remains appropriate for today's state-of-the-art research and cooperative efforts at the FPL. To that end, this article focuses on modern advancements in forest products research in light of accomplishments made over the past 100 years. Much of the historical information for this article was drawn from Dr. Nelson's dissertation, published in 1971 as the *History of the U.S. Forest Products Laboratory (1910–1963)*. We are deeply indebted to this document as a reference to the Lab's first half-century of service.

In 2008, the University of Wisconsin's Digital Collections Library compiled an oral history of the FPL. Fifty-two current and former FPL employee interviews were recorded and transcribed for the public. With permission from the Oral History Program at UW-Madison, this article draws from those transcripts. Some quotes have been edited for length. Verbatim transcripts and original digital audio recordings can be accessed through UW-Madison's Digital Collections Library at <http://digicoll.library.wisc.edu/FPL-Hist/>.

Former FPL Assistant Director John Koning was also an invaluable resource in the reporting of this article. Mr. Koning provided generous feedback in weaving together 100 years of scientific progress at the FPL.



From propellers and paper to construction materials and fire safety, the Forest Products Laboratory has helped make life easier, more comfortable, and infinitely more rewarding for almost every American.

Fourteen scientists and six assistants were initially supported by a total of \$28,000 per year. Dr. L.F. Hawley moved to Madison to continue his experiments in refining crude turpentine; Harry Tiemann, discoverer of the fiber-saturation point of wood, came to

direct the timber physics section, while Rolf Thelen and John Newlin supervised engineering and testing, respectively. F.M. Bond became section chief for wood preservation, and Howard Weiss, a preservation expert, took a role as assistant director. The new laboratory did not have a mycology section at the time but C.J. Humphrey, under the Federal Bureau of Plant Industry, was given laboratory space for his team to investigate wood-destroying fungi (Nelson 1971, p. 38).

Under Cline's oversight, the FPL focused on characterizing the fundamental properties of wood and on wood products utilization. Cline also strengthened ties to industry. The development of low-cost residential construction standards through World War I and the Great Depression provided shelter for thousands of citizens shifting from rural to urban areas. National defense initiatives were also an early priority for the FPL. Research into highly absorbent charcoal for gas masks, aircraft engineering, the effects of humidity and temperature change on wooden and laminate propellers, and wood drying processes began by early

1917. FPL research also made significant contributions to World War II and the Korean Conflict. Support of military efforts continued through the 1960s to the modern era of Desert Storm.

Wartime efforts were multifaceted and produced two influential publications: *A Wood Aircraft Fabrication Manual* and the *ANC Handbook on the Design of Wood Aircraft Structures*. Packaging experts at the FPL also engineered remarkable savings in cargo space by redesigning boxes and packing material for wartime equipment. Chemicals derived from wood enhanced the understanding of wood chemistry and provided the basis for information on naval stores, chemical intermediates, extractions, explosives, rayon, flavorings, alcohol, and fuel. These and other FPL accomplishments in times of war are highlighted in a review published as *Forest Products Laboratory: Supporting the Nation's Armed Forces with Valuable Wood Research for 90 years* (Risbrudt et al. 2007).

Throughout its 100-year history, the Forest Products Laboratory has stated approximately 264 broad research and project goals. These goals, which incorporate many past and current research efforts at the FPL, have been synthesized into the following eight general categories:

- Develop basic knowledge of wood and its use
- Improve wood processing to increase yield and quality while reducing costs and waste
- Extend the service life of wood products
- Utilize various wood species and changing quality of wood
- Improve the quality and usefulness of wood products
- Develop new products from wood
- Develop basic knowledge of the biological aspects of wood
- Transfer research findings nationally and internationally

Develop basic knowledge of wood and its use

Characterization and strength testing of wood formed much of the basic research at the FPL. Determining mechanical properties of North American woods and wood products led to practical applications for under-valued species found on National Forest and private lands. Lodgepole pine and Engelmann spruce, for example, were found to be suitable substitutes for redcedar as telephone poles and in light construction. These early categorizations resulted in specifications and guidelines for the use of wood in structural applications that are still used today.

Wood preservation, another focus of early FPL research, often aimed to educate industrial wood consumers such as architects and railroad and mining engineers in the ways of efficient utilization. Early research sought to extend the useful life of railroad crossties and structural timbers used in transportation structures. These efforts also strived to improve the economic conditions of wood-using industries in light of a period of market overproduction, cutthroat competition, and considerable waste from the forest to the factory (Nelson 1971, pp. 52–53).

Fundamentals regarding the basic knowledge of wood have more recently entered a 21st century level of analysis: the nanoscale. Nanotechnology is the study and manipulation of materials

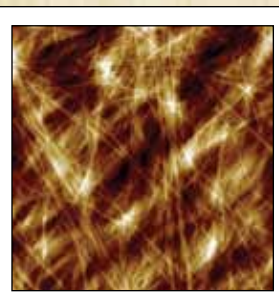


Research on the effects of humidity and temperature change on wooden and laminate airplane propellers supported the war effort during World War I.





Students in an early Wood Properties and Uses course observe a static bending test to measure strength properties of wood.



Wood is naturally composed of very small but extremely strong cellulose nanofibrils. Nanotechnology enables scientists and engineers to create products with unique functions and improved performance.

ranging from 1 to 100 nanometers in at least one dimension (one nanometer is about 50,000 times thinner than a human hair). It is an enabling technology used by scientists and engineers to create products with unique functions and improved performance. Innovative nano-related advancements will help replace non-sustainable plastic and metal products with lighter and stronger renewable bio-based materials. Advances in lignocellulosic (wood-based) nanotechnology could lead to new techniques for modifying wood growth characteristics and improving strength, durability, and performance aspects of many paper, packaging, and structural products.

Advancement at the nanoscale is only one of many high-tech applications at the FPL. As a leader in the development and use of ultrasound technologies to locate defects in wood, the Engineering Properties of Wood, Wood-Based Materials and Structures unit at the FPL has helped pioneer methods of nondestructive evaluation (NDE). According to Project Leader Robert Ross, NDE is the science of identifying the physical and mechanical properties of materials, products, and structures without altering their end-use capabilities. This evaluation includes testing of standing trees as well as logs, timbers, and lumber. Basic research on wood physics, particularly vibration and sound propagation properties of various wood species, says Ross, have served as the foundation for many modern lumber-grading and automated assessment technologies.

Improve wood processing to increase yield and quality while reducing costs and waste

Improving efficiencies in the processing of wood has been a focal point of the FPL mission since the days of McGarvey Cline. Kent McDonald, former FPL researcher in the Wood Quality Research unit, was concerned with sawmill inefficiencies in the early 1970s when sawmilling research was considered all but obsolete. McDonald and fellow scientists Erv Bulgrin and Hiram Hallock conjured up a novel solution to waste in the mill: the use of computers to determine appropriate sawing dimensions per log. This approach, known as Best Opening Face technology, vastly improved efficiency and helped avert an industry collapse by saving an estimated one billion board feet of lumber annually through improved sawing techniques (see FPL Greatest Hits, p. 6).

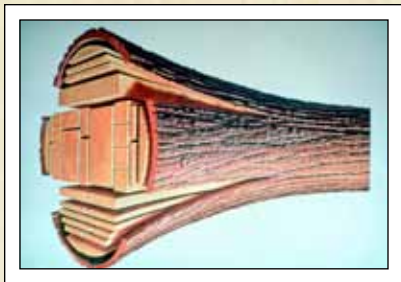
Wood-based distillates were another early focus of FPL efficiency research. Better grades of wood turpentine were developed, as was production of methyl alcohol, in the 1920s. More recently, in 2005, scientists from the FPL Institute for Microbial and Biochemical Technology patented a process for converting xylose (wood sugar) to ethanol and xylitol (wood sugar alcohol). This fermentation process uses specialized yeast strains to metabolize xylose more quickly. The development of modern biorefineries to process and convert wood into an array of usable fibers, fuels, and chemicals is getting a fresh look as fossil-fuel prices rise and environmental sustainability becomes a bigger part of the bottom line.

Kenneth Skog and Peter Ince of the FPL Economics and Statistics Research unit believe that biorefineries using sequential, integrated processing approaches could have economic advantages over standalone cellulosic biofuels plants. Integrated facilities would take advantage of existing infrastructure for biofuel and pulp production as well as support rural economies in forestry-dependent areas. Skog and Ince (2008) estimate that wood-based biofuels production could provide 102,000 to 220,000 new American jobs by 2022 with estimates reaching higher if economic conditions become more favorable than currently projected.

Economics and statistics research are critical components to the success of broader scientific investigations at the FPL. Economists provide information about how and why markets and technologies for wood products change over time, implications for natural resources management, and broad environmental and social impacts. Statisticians apply modern statistical methods to enhance the integrity of utilization research. This unit supports other research projects by developing innovations to conserve resources and expand the competitive use



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In the 1970s, Best Opening Face technology revolutionized the sawmill industry. Using computers to determine sawing dimensions per log save an estimated one billion board feet of lumber annually.

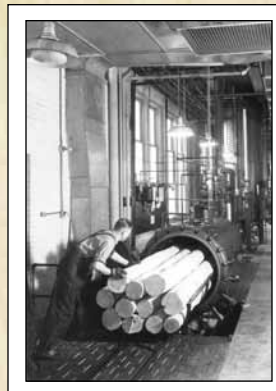
of wood; evaluate the role of market trends and competitiveness of U.S. firms in the global marketplace; and evaluate the impacts on forests of forest management policies and forest industry initiatives.

Extend the service life of wood products

Some of the most important early work in timber preservation was in cooperation with the Nation's railroads. In 1900, America's growing railroad industry was using 110,000,000 crossties annually, yet only about one percent of these were treated with preservatives (Nelson 1971, p. 16). By the turn of the century, decreasing supplies of large-diameter timber suitable for crossties made preservation research paramount to the economic concerns of railroads and the industries they supported. This supply crunch also raised the ecological concerns of America's leading foresters in what was then the U.S. Bureau of Forestry. In 1905, the average number of crossties used by the primary railroads was 237 per mile, per year. By 1925, using a wider variety of wood species and more effective preservation techniques, the annual average dropped to 194 crossties per mile of track. These statistics, as Charles Nelson noted in 1971 (p. 89), "dramatically demonstrated the practical value of the FPL's continuing research in wood preservation."

Wood preservation has come in many forms. Common practices used today benefit from decades of research but, unfortunately, many wood preservation techniques have historically used undesirable broad-spectrum toxicants. With nearly 400 million cubic feet of preservative-treated wood now produced and consumed in the United States annually, more environmentally compatible preservatives are needed to replace broad-spectrum conventional biocides. The voluntary withdrawal of chromated copper arsenate from applications such as play structures and picnic tables in 2004, for example, was a significant change in wood preservation use and safety. Other preservative regimens may soon face similar environmental scrutiny.

FPL researchers in the Durability & Wood Protection unit are developing new, environmentally preferable wood preservation technologies, including formulations free of toxic metals. Although changes in wood preservation are needed, it is difficult for researchers to respond quickly to societal pressure for environmentally sensitive preservatives. It can take years to evaluate the long-term effectiveness of new preservatives. FPL researchers are actively developing improved methods to rapidly assess



Developing preservatives for wood helped sustain the Nation's railroads and forest resources in the early 20th century. Lengthening the service life of railroad crossties eased the demand on forests being harvested for replacement ties.

the potential for environmentally preferable wood preservatives in providing safe and reliable long-term protection.

Durability & Wood Protection researchers also evaluate the performance of wood products from a fire safety perspective. By studying the fundamentals of fire behavior, FPL researchers have developed treatments for wood products that help reduce the flammability of structural and wood paneling, among many other products. These evaluations have influenced the development of building codes and increased the fire safety performance of residential and commercial structures worldwide.

Utilize various wood species and changing quality of wood

The Rattlesnake Creek pedestrian bridge near Missoula, Montana, was built using 6-inch-diameter lodgepole pine from a beetle-killed forest near Elk City, Idaho. This unique bridge was designed and built to demonstrate the potential use of lodgepole pine in the Pacific Northwest that have been killed by the pine bark beetle. FPL engineers worked with the University of Idaho and Timber Products Inspection of Vancouver, Washington, to develop the technical basis for mechanical grading of these whole round timbers. Research has shown that structures such as log homes and bridges provide a high-value use for logs cut from standing dead trees and is a source for local production and employment.

Retooling sawmills to process small-diameter logs and a wider variety of species, including invasive and non-native woods, has helped reinvigorate rural economies and maintain healthier forests. Finding new uses for overcrowded small-diameter



Corrugated fiberboard and other fiber-based containers revolutionized the shipping industry during the 1920s. Its status as the packaging material of choice today is due in no small part to FPL research.



The Rattlesnake Creek bridge near Missoula, Montana, was built using 6-inch-diameter lodgepole pine from a forest in Idaho to demonstrate the effective use of trees killed by the pine bark beetle.

Testing box materials and construction for durability helped revolutionize the shipping industry during and after World War I.

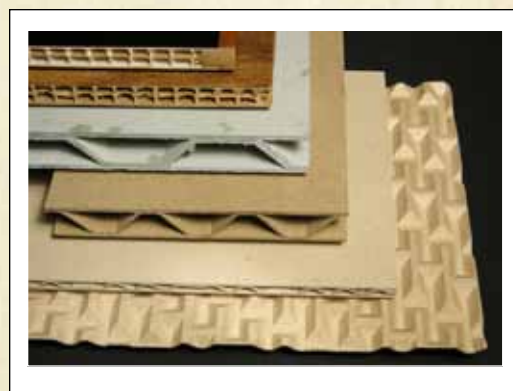


trees on millions of fire-suppressed acres of National Forest land is essential to minimizing potential damage from catastrophic wildfires. One key to this more efficient utilization is the development of composite products using small-diameter trees and plantation-raised short-rotation woody crops as source materials.

Engineered wood products, including wood-based composites, represent over 40 percent of the total materials used in North American residential construction. They are light, strong, easily worked, readily available, and cost-effective. FPL researchers from the Advanced Housing Research Center, Engineered Composite Sciences unit, and the Engineering Mechanics and Remote Sensing Laboratory are working to develop engineered biocomposites to meet the diverse needs of users for high-performance and commodity products with enhanced performance, serviceability, and durability.

Improve the quality and usefulness of wood products

In looking to increase packaging performance and efficiency, early FPL research in the design and durability of wooden boxes was a direct response to demand by manufacturers and shippers. As American involvement in World War I increased, the War Department turned to the FPL to help create better shipping crates as well as substitutes for wooden boxes. Corrugated fiberboard and other fiber-based containers revolutionized the shipping industry during the 1920s. Its status as the packaging material of choice today is due in no small part to FPL research.



Biocomposite materials are light, strong, readily available, and cost effective.



Glued-laminated (glulam) beams and arches use multiple layers of lower-grade wood to create large durable beams.

As was the case with packaging, most research at FPL is done in partnership with industry, academia, and other government agencies. Charles Frihart of the Performance Enhanced Biopolymers unit at the FPL, in cooperation with Heartland Resource Technologies and Ashland Hercules, recently helped develop an improvement in the field of soy-based adhesives, which combines the low cost of soy-based raw materials with the exterior durability characteristics of petrochemicals. When cured, these adhesives exhibit excellent water resistance, which makes them ideal for plywood, panels, and wood composite products. Importantly, these adhesives also meet the stringent California Air Resources Board standards on formaldehyde emissions from wood products.

Develop new products from wood

Changes in forest resources have often spurred innovation in the development of new wood products. In the 1930s, as the supply of large-diameter select commercial species dwindled and industry became impatient with the long rotation period required to grow large merchantable timbers, the FPL capitalized on advancements in glues and gluing practices to construct glued-laminated (glulam) beams and arches for structural and transportation applications. Multiple layers of shorter length, narrow-width stock are used to create large, durable beams. The end result combines the economy of lower grade stock for core laminate layers with a low fire risk due to large size members. These sturdy and attractive structural supports can often be seen in sports arenas, auditoriums, churches, and warehouses. They have also been employed in transportation structures such as bridges and span walkways throughout the Nation.

(continued on p. 8)

U.S. Forest Service Forest Products Laboratory Greatest Hits: 1910–2010



Since 1910, the USDA Forest Service Forest Products Laboratory (FPL) has been helping Americans meet their demand for wood in the most efficient, sustainable manner possible. With state-of-the-art technology, FPL scientists continue to research methods for promoting clean water, better homes, improved recycling processes, and healthier forests. Below are just a few of the breakthrough technologies and applications that got their start at the FPL.

Engineered Wood Products

Engineered wood products help extend our forest resources by putting previously underutilized materials to use. Much of the technology needed for the manufacture and design properties of glued-laminated (glulam) timber was developed at the FPL in the 1930s. Glulam beams, often seen in churches, sporting arenas, and other large structures, have high structural value but can be made of lower-grade material.

Wooden I-joists are another highly efficient structural component developed by the FPL. Spurred by military needs of the aircraft industry, wooden I-joist research and production evolved in the late 1960s. These products, made by combining wood with plywood or other panel products, are a significant structural material in both residential and non-residential construction.

The FPL also played a role in the development of oriented strandboard (OSB), a composition board meant for structural purposes and made with moisture-resistant adhesives. The development of OSB and other similar products provided a use for logging residues that were previously considered waste.



Neutral Sulfite Semichemical (NSSC) Pulping

The FPL was influential in developing the semichemical pulping process as a higher yield offshoot for the kraft process in papermaking. For decades, semichemical pulping has been the dominant process used for producing corrugating medium in the United States. Corrugating medium, the wavy fluting material in corrugated boxes, is one of 12 major grades of paper and paperboard products. Corrugated boxes revolutionized the shipping industry and are used to ship over 90% of all goods in the U.S. economy.

Packaging

Some of the FPL's earliest research developed standardized methods for testing package performance. Research on efficient packaging design saved an estimated \$50 million during World Wars I and II. These advances greatly reduced packaging volumes and product damage. FPL research allowed the packaging industry to broaden the range of wood species and quality of wood used in packaging; minimize the amount of fiber used, thus extending the timber supply; and optimize fiber use in providing product protection, thereby making fiber the packing material of choice. The current industry standard for performance testing for shipping containers and systems is based on FPL research.





Recycling

FPL research has led to great progress in recycling materials, from paper to wood and other solids. Fiber-loading technology developed at the FPL produces more paper from less fiber and reduces the amount of sludge produced during recycling. This and other research on recycling, in cooperation with the U.S. Postal Service, has resulted in the development of self-adhesive stamps that do not cause problems with recycling operations. As these adhesives are implemented, an additional 20 million tons of mixed wastepaper can be recycled.

Lumber Grading and Assignment of Design Values

One of the Forest Products Laboratory's early achievements was developing procedures for structural lumber grading. This was the first system based on observations from lumber strength tests and justified a 20% increase in design value for major species. A broader array of species was also identified as suitable for structural use.

In the 1980s, a changing resource base and demands for more precise design values resulted in another comprehensive study of lumber properties. This FPL-led "in-grade" program changed the historic basis for property assignments. As a result, design values assigned to 2 by 4's increased significantly, which is of particular importance for the utilization of lumber from small-diameter trees in engineered wood products.

Current grading research at the FPL is bringing the use of recycled lumber and timber closer to commercial reality. FPL researchers are developing a new grading system to ensure that this lumber and timber will meet performance requirements in many applications. Research on lumber re-grading will allow wood from old buildings to be reused safely while reducing disposal costs and saving landfill space.



Sawing

Computer-aided sawmill technology developed in the 1970s helped sawmills maximize lumber production from small log sources. Called Best Opening Face (BOF), this technology aided in the automation of softwood dimension sawmills and helped prevent an industry collapse when sawmills shifted from old-growth to second-growth timber resources. Today, most softwood lumber used for construction purposes in the United States and around the world is processed using BOF technology. An estimated one billion board feet of lumber has been conserved annually through the use of this optimization technology.

Drying

In the 1950s, Robert L. Youngs began working on an FPL team to develop dry kiln schedules for all native North American wood species. These parameters, still the industry standard, detailed the most efficient methods for drying lumber by minimizing loss due to drying defects. The schedules in the Dry Kiln Operators Manual, revised most recently in 1990, minimize time, cost, and energy used in the kiln drying process. Youngs eventually served as FPL Director from 1975 to 1985.



(continued from p. 5)

The development of new products from wood often stems from market forces pushing industry and associated research in new directions. FPL economist Henry Spelter and economics assistant Daniel Toth have recently found that rising fossil fuel prices since 2000, among other factors, has led to growing interest in renewable fuel alternatives, specifically the wood pellet sector (Spelter and Toth 2009). Energy market disruptions caused by Hurricane Katrina in 2005 spurred a demand surge and elevated wood pellets as a serious alternative-energy contender. The European Union's "20 by 20" goal to supply 20 percent of its energy needs from renewable sources by 2020 will be difficult to achieve from indigenous European sources alone and has amplified interest in North American wood pellet exports.

Develop basic knowledge of the biological aspects of wood

Investigations into the biochemistry of wood and its structure are still yielding new insights to the complex nature of wood. Researchers in the FPL Institute for Microbial and Biochemical Technology are studying how selected white-rot, brown-rot, and soft-rot fungi degrade wood. Knowledge of how forest fungi attack wood helps researchers find better ways to protect wood in use. Because of their unique capabilities, wood-decay fungi and the chemicals they produce show promise as versatile and environmentally preferable bioprocessing agents. Management of old and unusable treated wood through the use of decay fungi for myco-remediation and degradation is an attractive alternative to incineration or landfilling.

The use of enzymes is another option in meeting popular demand for sustainable bioprocessing. Enzymes catalyze reactions under less environmentally severe conditions than alternative chemical processes. Research in enzymatic and microbial modifications of wood and fiber surfaces has found great potential for the removal or modification of specific wood components. These processes may be useful in developing new products such as chemicals, fuels, toxic metal and nutrient adsorbents, or for the replacement of harsh industrial chemicals.

FPL research focusing on the discovery and use of microorganisms, enzymes, and biomimetics to treat virgin fibers, recycled fibers, and wood residues seeks processes to release complex cellular compounds, such as lignin, from pulps. Enzymes that might increase the strength of paper made from lower grade wood residuals and pulp are also sought. The pulp and paper industry already uses enzymes for pulp bleaching and removing inks and contaminants from recycled fibers. Enzyme pretreatment of biomass will be indispensable for forest biorefineries and holds promise for value-prior-to-pulping processes. An important consideration in this research is ensuring that the use of enzymes fits with existing industry technologies to increase their acceptance and use.



The use of small-diameter and other residues from forest thinning projects helps create employment in rural areas and promotes forest health while reducing the threat of catastrophic wildfires and insect infestation.

Transfer research findings nationally and internationally

Technology transfer—the sharing of research and results across the spectrum of industry, academia, and government agencies—addresses the need to get technical information into the hands of those who can put it to use. The State and Private Forestry Technology Marketing Unit at the FPL, headed by Susan LeVan-Green, is one example of where the timber hits the blade in utilizing FPL expertise for the benefit of struggling, often rural, wood industry communities and businesses. Similar to extension services offered by many universities, the State and Private Forestry branch of the U.S. Forest Service reaches across the boundaries of National Forests to states, municipalities, tribal communities, and nonindustrial private landowners.

In her UW Oral History Project interview, LeVan-Green recalls one particular technology transfer success story from the town of Hayfork, California. The community was struggling, she says. "They were losing their schools [and] losing their health facilities. They knew they needed to create employment." The townsfolk were aware of forest thinning work to be done and started consulting with FPL specialists in the early 1990s. The main sawmill started with two employees, says LeVan-Green, but is now up to about 35 people. The company uses wood material taken from forest thinning operations to make flooring, furniture, and specialty products for national distributors. The best part, says LeVan-Green, was seeing the community benefit from the revival of this mill.

Each of these eight research goals exemplifies a persistence in promoting healthy forests and forest-based economies through the efficient, sustainable use of forest resources. The prescient vision of McGarvey Cline to establish a central Federal research laboratory for the accumulation of scientific knowledge about forest products has come to pass as one of the best values American taxpayers have received in affecting the stability and comfort of everyday life. With each passing year, the FPL compounds on its history to provide even greater return on investment for the future of wood research and utilization.



The FPL's classic Art Deco lobby circa 1940s.

The "New" FPL

Between 1931 and 1932, a new building for the Forest Products Laboratory was designed and built less than a mile west of the original FPL building on the University of Wisconsin campus. The Chicago architectural firm of Holabird and Root designed the building. Both Holabird and Root were graduates of the École des Beaux Arts in Paris, and the firm's architectural accomplishments include, among many others, the Palmolive Building in Chicago and the Chrysler Building in New York City.

According to *A History of the Architecture of the USDA Forest Service*, the new FPL building typifies the American Perpendicular or Modernistic Phase of the Art Deco style as applied to commercial design. With a U-shaped layout, the main FPL building has a steel and concrete frame with an exterior face of smooth white Indiana limestone. Windows are massed in groupings of four, one-over-one, with double-hung sashes and flat surrounds. Cypress-wood fins run the height of the vertical faces flanking each window and add a decorative and functional detail by partially shading the windows during the day. The flat roof has a plain parapet with no cornice decoration (Forest Service Engineering Staff 1999, pp. 154–155).

Walking through the tall hallways of the FPL today feels a bit like strolling through a sparsely decorated museum. Art meets science in the classic Art Deco lobby and main elevator. Throughout the building heavy wooden doors, filing cabinets, and desks speak to a past filled with the muffled sounds of research and filing performed by seven decades of scientists and their secretaries.

The fourth floor's north wing has a string of offices with beautiful hardwood floors. These are not government extravagance, however. Several combinations of wood species and design applications were laid out as test flooring to measure changes due to temperature, humidity, and general use. At the end of this long hallway is the Center for Wood Anatomy Research. Through its heavy wood

You're Invited

Attendees of the Forest Products Society's 64th International Convention are invited to a centennial celebration at the Forest Products Laboratory (FPL) on Wednesday, June 23rd, 2010. To commemorate 100 years of innovation, invited guests and employees will gather outside FPL's new Centennial Research Facility for a ribbon cutting ceremony. The official program will begin at 9:00 a.m. with FPL Director Chris Risbrudt hosting the event. Invited speakers include: USDA Secretary of Agriculture Tom Vilsack, U.S. Senators Herb Kohl and Russ Feingold, Congresswoman Tammy Baldwin, Governor James Doyle, Forest Service Chief Tom Tidwell and Deputy Chief of Research Ann Bartuska. A reception will follow with entertainment by the Fiddlin' Foresters, the official "old-time string band of the U.S. Forest Service." Guests will be welcome to tour the 87,000 square foot research facility where displays, exhibits, and ongoing research will be highlighted.



Several combinations of wood species were designed and laid out as test flooring on the FPL's fourth floor to measure effects of humidity, temperature change, and general use.



Because forests help mitigate climate change by cleaning the air and acting as large carbon storage units, the use of wood as a structural material extends carbon sequestration beyond the life of the tree throughout the life of the product.

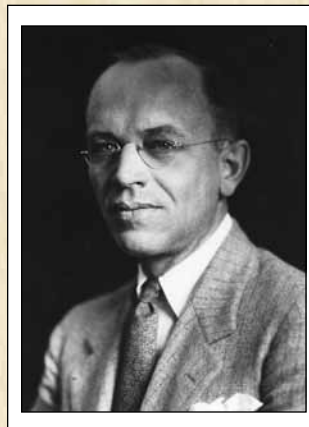
door sits over 100,000 wood specimens representing about 18,000 tree species from every corner of the globe—the largest collection of its kind. A piece of white oak recovered from a shipwreck near San Julian, Argentina, is believed to be from one of Magellan's ships, which sank during a storm in 1520. A

specimen taken from what has been called a boat-like structure 13,000 feet up Mt. Ararat in Eastern Turkey is believed by some to be from Noah's Ark. These samples and many others sit near a bit of Thor Heyerdahl's Kon Tiki; chunks from the USS Constitution—branded "Old Ironsides" during the War of 1812; samples from King Tut's tomb; and a 40 million year old piece of unfossilized hickory discovered in the western United States and now only found in China. A vast range of human and pre-human history is represented in this one small corner of the FPL.

The wood anatomy unit essentially began the day Eloise Gerry walked through FPL doors in June 1910. Though the Forest Service wasn't interested in hiring a woman at the time, as Gerry recalled, "there wasn't any man willing to come and do the work" (McBeath 1978, p. 129). She became the first woman appointed to a professional staff position at the FPL and the first woman in the United States to specialize in forest products research. Gerry authored more than 120 technical and trade journal articles; edited the Naval Stores Handbook of 1935; and was project leader from 1914 to 1924 for the wood anatomy research unit. The first recorded wood identification was made on January 16, 1914.

The year Gerry stepped down as project leader, 1924, was the same year Aldo Leopold became assistant director at the FPL under Carlisle P. "Cap" Winslow. Leopold's organizational abilities and talent for writing proved a boon for the FPL though, as a forester amid an orchard of scientists, he seemed a "fish out of water" within the confines of a laboratory (Meine 1988, p. 234). Despite what may have been tenuous comfort working within the confines of a research laboratory, Leopold's articles, published for professionals and lay people alike, established him as the Nation's foremost spokesman for the preservation of wild country (Meine 1988, p. 243) and the wise utilization of forest resources. Leopold, among other duties, supervised the FPL's effort to reduce wood industry waste at the mill—by some estimates 66 percent—and encouraged the use of "inferior" species of trees until his departure from the FPL in June 1928.

In 1910, Eloise Gerry was the first woman appointed to a professional staff position at the FPL and the first woman in the United States to specialize in forest products research.



Aldo Leopold was Assistant Director at the FPL from 1924–1928. His organizational abilities and talent for writing proved a benefit to both the Forest Service and the Forest Products Laboratory.

Daniel Caufield, in his UW Oral History Project interview, noted that Leopold maintained a philosophy of wise utilization as "the best form of conservation." Caufield spent 40 years working in wood chemistry and in the Pulp and Paper division at the FPL. The argument could always be made, says Caufield, that the FPL wasn't interested in making paper better so much as making paper more efficiently.

Thomas Hamilton, FPL director from 1994 to 2001, stated in his UW Oral History Project interview that a variety of unique characteristics makes the FPL a special kind of place. Hamilton recalls somebody once saying, "When you walk down the hall of the Forest Products Lab, you are probably going to pass the world expert in a particular field." This was different, Hamilton says, than other research labs where there might be very strong expertise in a few areas but not the ability to look at a particular problem from such an all-encompassing, group perspective.

An early synthesis of this combined expertise in wood and forest products research came in the form of the *Wood Handbook—Wood as an Engineering Material*, first published in 1935. The chief basis for this handbook has been the accumulation of information from engineering and allied investigations of wood and wood products. It also provides basic knowledge for everyday construction practices. The *Wood Handbook* remains the most popular FPL publication. Over 1,600 digital downloads of all or part of this book are procured by the public weekly. A centennial version of the *Wood Handbook*, its seventh edition, will be published in 2010 by the current team of FPL experts.

Current Areas of Focus

In moving toward improved efficiencies in the use of our Nation's forest resources, the FPL has identified five current areas of research focus: Advanced Structures, Advanced Composites, Forest Biorefinery and Biomass Utilization, and Nanotechnology.

Modern structures are complex systems of integrated components. Advancements in construction technology and the exploration of alternative building methods by FPL researchers in the Advanced Structures Research unit have greatly enhanced the value and durability of wood in residential, nonresidential, and transportation structures. Life-cycle assessment studies have shown that because forests help mitigate climate change by cleaning the air and acting as large carbon storage units, the use of wood as a structural material extends carbon sequestration beyond the life of the tree throughout the life of the product. Wood-frame buildings, consequently, represent a significantly lower environmental burden than buildings made exclusively of steel, concrete, or bricks.

Wood transportation structures such as railroad trestles and wood bridges, including many historic covered bridges, are getting a closer look through a cooperative effort by the National Center for Wood Transportation Structures (NCWTS). This center, at the Institute for Transportation at Iowa State University, is maintained in partnership with the FPL, the Federal Highway Administration, and the National Park Service. The NCWTS brings together allied interests to complete research, demonstration, and education regarding durable, cost-effective wood transportation structures and to improve the transportation infrastructure of America and the world (NCWTS 2009).

Part of developing a sustainable infrastructure includes nurturing the practices of sustainable resource management. In the future, lumber used for housing will increasingly be sourced from plantation-grown trees and small-diameter secondary species. Composite products from bio-based materials will help promote the long-term sustainability of our Nation's forests. The Advanced Composites group at FPL has developed methods for using a variety of undervalued materials including fibers, wood particles, flakes from small trees, post-industrial and post-consumer wood wastes, and other natural bio-fibers such as wheat straw, corn straw, and even chicken feathers. Wood composite technologies have been used for decades to create building and home furnishing products and for a number of structural and nonstructural applications including interior paneling, sheathing, furniture, and support structures in many different types of buildings.

Research suggests that roughly 73 million acres of national forest land needs thinning to improve forest health and resiliency. In 2008 and 2009, the U.S. Department of Agriculture awarded \$4.1 and \$4.2 million, respectively, in grants to help small businesses and community groups develop innovative uses of woody biomass harvested from National Forest land. The grants,

administered by FPL's State and Private Forestry Technology Marketing Unit, help create markets for new Forest Biorefinery and Biomass Utilization projects, including renewable energy production from forest biomass. These investments help move America toward energy independence and contribute to the mitigation of global climate change while supporting rural economies and promoting sustainable natural resources utilization.

Underutilized Woody Biomass Research has shown the growth of many trees is suppressed in overcrowded forests. Small-diameter (suppressed-growth) trees have narrower annual rings, more uniform fiber cell structure within the rings, and a higher volume of mature wood. Ironically, due to a number of economic factors, availability of pulpwood from public and private lands in the western United States is diminishing. The pulp and paper industry has become increasingly reliant on the availability of residuals from sawmill operations. Pulping trials undertaken by FPL show that the characteristics of suppressed-growth trees improve pulp properties in the production of paper. Furthermore, less refining energy is required to produce pulp from forest thinnings than from conventional wood supplies. These pulping trials also show that lumber produced from forest thinnings meets or exceeds sawmill specifications.

As environmental and ecological problems related to the incursion of invasive species into native ecosystems become more prevalent, economic concerns about removing or limiting invasives become more pressing. One method to help offset forest harvesting and restoration costs is to develop value-added bio-composite products that can incorporate these invasive species. FPL researchers in the Engineered Composites Sciences unit have investigated two problematic invasive species, salt cedar (*Tamarisk ramosissima*) and Utah juniper (*Juniperus osteosperma*), for use as fillers in biofiber-polymer composites. A separate FPL study investigating the use of small-diameter ponderosa pine lumber in glulam members found an effective combination utilizing small-diameter ponderosa pine for all laminations. Compared with the current single-grade combination standard, glulam combinations using two separate lamination grades were found to be generally higher in performance value.

The FPL has also led a project to produce a Web tool, the Fuel Treatment Evaluator 3.0. This innovative tool uses data from the Forest Service's Forest Inventory and Analysis program to identify locations in Western states where localized utilization of woody biomass could cover costs of forest thinning treatments.



An estimated 73 million acres of national forest land needs thinning to reduce risk of fire hazard, insect infestation, and disease.

Nanotechnology Research presents great potential for improved wood product performance and serviceability. As such, the FPL is poised to be the preeminent Federal facility for the application of nano-science in forest products research. Potential nanotech applications include wood composite materials with embedded nanosensors to measure and react to structural forces, loads, moisture, and temperatures. Nano-enabled antimicrobial and water resistant coatings on lumber for use in flood-prone areas and hurricane zones could improve health, safety, and wood resiliency in these areas. "Smart" paper and paperboard packaging will likely replace many plastics for commercial and food products sensitive to heat, contamination, odor, or tampering. The development of high-value products from undervalued wood resources using cellulose nanocrystals and nanofibrillated cellulose components will also improve the performance and durability of fiberboard, particleboard, and glued structural products for use in a wide array of structural applications.

FPL research units have developed advanced science, technology, and economic information needed for the efficient use of small-diameter trees and forest thinnings as raw material feedstock in the high-volume commodities of dimensional lumber; composites; pulp, paper, and paperboard; and engineered wood. This research assesses the potential use of these materials to provide unique product features such as nanotech applications and converting forest biomass to energy. These innovative research and development activities reduce the amount of potential material to fuel wildfires, expand markets for forest products, and provide sustainable benefits to the American public while restoring and enhancing the Nation's forests.

Welcome to the Future

The Centennial Research Facility

The most advanced large-scale addition to the FPL in over 70 years is the Centennial Research Facility (CRF), a 87,000-square-foot multi-use laboratory. The CRF is qualified for Silver certification by the Leadership in Energy & Environmental Design (LEED) rating system developed by the U.S. Green Building Council. As such, the CRF was designed to improve performance across the most important efficiency metrics: energy savings, water usage, CO₂ emissions reduction, improved indoor environmental quality, and stewardship of resources including sensitivity to their impacts.

Researchers in engineering mechanics can assess the strength of full-scale structures while durability researchers test wood products in a rather punishing weather simulation chamber. Modern preservation testing equipment will replace the older vessels previously used, while an efficient and manufacturing-friendly floor plan will help advance wood- and bio-based composites research.

As a combination wood, steel, and concrete structure; the CRF has composite wood fins highlighting each column of tall tinted windows facing west and south. A white rubber-membrane roof system blankets two stories rising in the west, while a single-story high-bay space overlooks interior laboratory functions. Equipment and laboratories are housed in four main areas of research: Composites, Durability, Engineering Mechanics, and Preservation. The CRF will be commemorated with an official ribbon-cutting ceremony on June 23, 2010.

Composites: The Engineered Composite Sciences unit investigates relationships between materials, process, and performance to engineer biocomposites that benefit users while promoting sustainability of both virgin and recycled forest products. Biocomposites can be manufactured into highly engineered building products using low-value natural resources, which helps offset costs of forest thinning operations needed to improve forest health. Research focuses on enhancing traditional composites and developing the next generation of biocomposites to provide high-performance industrial products while opening new markets and reducing detrimental environmental effects. With the help of FPL's Technology Marketing Unit, high-value wood-plastic composites that are noncorrosive, insect and mold resistant, nontoxic, and stable in all weather conditions are being used in many applications, including signage, decking, fencing, picnic tables, park benches, tool handles, and landscape timbers.



FPL's new 87,000-square-foot Centennial Research Facility (CRF) allows scientists to perform full-scale testing of wood-framed buildings, formulate new environmentally-friendly preservatives, and develop composite products in a manufacturing-friendly space. The CRF also houses a one-of-a-kind weathering chamber that simulates temperature, humidity, sunlight, wind and rain to test the durability of wood products.



"Science is the accumulation of basic and applied knowledge. We stand on the shoulders of giants here at FPL; and our tradition of passing our knowledge continues to benefit not only the Forest Service but the broader community of science."
- FPL Director, Chris Risbrudt

used to protect wood from deterioration by fungi and insects have been broad-spectrum biocides. These harsh chemicals now face increased environmental regulatory pressure. FPL wood protection research focuses on developing selective biocides that protect against specific threats to wood. These systems offer a way to control wood-degrading organisms in an environmentally responsible manner. With this approach, researchers study the mechanisms by which a particular fungus or insect is able to degrade wood, enabling the development of an inhibitor based on that particular mechanism. Researchers also study how specific organisms tolerate various wood preservatives and use that knowledge to design durable systems to neutralize, block, prevent, or counteract that tolerance.

Engineering Mechanics: The Engineering Mechanics and Remote Sensing Laboratory (EMRSL) conducts physical and mechanical testing on a wide range of materials, from housing to transportation structures. Results are used to develop building codes and inform structural design. Testing of products and structures can involve samples ranging from toothpick-sized to structural beams 50 feet long. Materials are solid wood or combinations of wood fibers, plastics, adhesives, and metal. Tests can be static, as in simulated snow loads or dead loads, or dynamic, simulating seismic, fatigue, and wind loads. The new the EMRSL has testing machines ranging from desktop-size, rated from 1 to 10,000 pounds of force, to stand-alone machines rated from 60,000 to 1 million pounds. A strong floor and wall system provides the ability to apply loads from multiple directions and allows for full-scale testing of three-dimensional structures, such as wood-framed building mock-ups, up to 20 feet tall.

Wood Preservation: Wood Preservation and Durability laboratories will provide the widest variety of FPL testing capabilities available to date. Emulsification, pumping, and ventilation equipment allows for cutting-edge research in penetration and retention testing of new preservative formulations on commercially available and underutilized wood species. Five pilot-scale pressure treatment cylinders are available for a wide variety of both water- and oil-based chemical

Durability: One of the surest ways to extend the available timber supply is by improving the durability of wood in use. Vulnerability to moisture, fire, and biodeterioration are significant limitations to the expected long service life of wood and can result in economic and resource loss. Traditionally, chemicals

treatment tests. Dedicated environmental control chambers allow research on termites and mold and decay fungi while separate air-handling systems avoid cross-contamination between research projects. A fungal cellar allows accelerated durability tests on treated wood across a range of simulated environmental exposure conditions. Durability researchers can also conduct accelerated lab tests of preservative releases when exposed to water submersion, simulated rainfall, and a range of weathering scenarios. Chemistry, biochemistry, and bacteriology laboratories are also included in this area. The CRF houses a custom-designed stainless steel moisture testing chamber unlike any other of its size in North America. Capabilities include simulating rainfall of up to five inches per hour; temperature settings of 30–110 °F; dew point temperatures of 25–80 °F; and 25-mile-per-hour wind speeds with faster gusts lasting up to five seconds.

Advanced Housing Research Center

In response to America's need for durable, affordable, and energy-efficient housing, the Advanced Housing Research Center (AHRC) was established at the FPL in 2001. Research at the AHRC evaluates technology for both new and existing housing and encompasses all types of residential structures in which wood or wood-based products are used as primary or secondary building components. Emphasizing the improved use of traditional wood products, recycled and engineered wood composite materials, durability, moisture control, natural disaster resistance, and an improved living environment, the Center's research focuses primarily on the housing structure and practical technologies that can be readily adopted by homebuilders, industry, and consumers.

In 2001 the AHRC Research Demonstration House was built as a cooperative project with APA-The Engineered Wood Association and the Southern Pine Council, among others. The house and its associated "Carriage House" garage structure were designed to supply the energy needs and potable

The Research Demonstration House, built in 2001, provides real-life conditions for housing studies on moisture and air flow. The associated Carriage House demonstrates small-diameter timber construction and was designed to efficiently supply the energy needs and potable water requirements for an average cold-climate residential home through the use of energy from wood waste, solar power, and a rainwater harvesting system.



water requirements for an average cold-climate residential home. Several types of wood were used as flooring material throughout the house, including Southern Pine, western larch, birdseye maple and even exterior wood (siding) recycled from a 60-year-old Army barracks in Ft. Ord, California. Composite material formed from recycled milk jugs were used to create a faux cedar-shake roof. Small-scale integrated gasification systems have the ability to convert biomass to energy, while external photovoltaic solar collectors supplement the electrical needs of the house. Rainwater harvesting and filtration systems provide potable water for the laundry and toilets, while sensors measure air pressure, temperature, and relative humidity in the wall cavities.

The AHRC cooperates with universities, industry, consumers, and other government agencies, including the Coalition for Advanced Wood Structures, to bring together diverse groups interested in improving the economy and performance of wood structures. The Partnership for Advancing Technology in Housing, a joint government-industry partnership run by the U.S. Department of Housing and Urban Development, also works with the FPL to accelerate development and implementation of new housing technologies.

Conclusion

While the Centennial Research Facility and the AHRC provide glimpses of technological advances at the FPL, social changes are also afoot. Retirements in the next decade will create turnover as baby-boomers move out and younger scientists move in to replace them. FPL director Chris Risbrudt looks forward to this sea-change as an opportunity for FPL veterans to pass on the valuable skills and knowledge accrued over many years of service to a new generation of researchers.

"Science is the accumulation of basic and applied knowledge," says Risbrudt. "We stand on the shoulders of giants here at the FPL. Our tradition of passing on knowledge continues to benefit not only the Forest Service but the broader community of science. This institution is one of the best values the American taxpayer has in service to the forests of our country and the consumers and industry people who help provide insight and motivation to use these resources in the most efficient and sustainable ways possible."

Even though some research has been slowed or eliminated by budget cuts in recent decades, Risbrudt is optimistic of the progress ahead. "Before the Centennial Research Facility, and aside from the Research Demonstration House, our most recent addition had been in 1967," Risbrudt explains. "With our new facilities, we will be able to maintain cutting-edge research efforts and attract a new generation of researchers."

In addressing questions of any change to the FPL's core mission, Risbrudt says that the FPL has gone through changes in the past but "fundamentally, we travel in the same direction set forth in 1910. Since then, we've fostered some of the best scientists in the world. We will continue to focus on the advancement of forest health and forest products ingenuity while staying well-grounded in the realities of good science and sound economics."



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