A NEW MODEL FOR FOREST SECTOR RESEARCH AND DEVELOPMENT IN THE UNITED STATES

Executive Summary[1]

Structural changes in the United States (U.S.) forest industry have undercut support of the science and technology required to maintain a competitive position. Forest products companies' spending on research and development (R&D) has fallen. The research arms of forest industry trade associations have struggled. Half of the South's university forestry research cooperatives, whose work enabled the productivity gains of the 20th century, have been terminated. Public sector R&D investments are also declining.

Foreign competitors in the global marketplace, meanwhile, are continuing to invest in R&D, to the detriment of the U.S. Finland is developing higher-value products from wood waste. The Confederation of European Paper Industries is focused on reducing manufacturers' energy costs. And Canada has consolidated public and private sector research efforts into a national, coordinated nonprofit, FPInnovations. These and other competitors are likely to innovate and grow their market share and profitability faster than the U.S. sector, with its uncoordinated, underfunded efforts.

This report explores the state of forestry and forest products R&D in the U.S. and proposes a new model in which private and public sectors partner to leverage funding and coordinate research efforts. It recommends the establishment of jointly funded and directed public-private partnerships. Sustained, dependable funding could come from the industry, via commodity check-offs, with matching federal dollars. These partnerships would have transparent, balanced governance, in which all participants helped set research priorities and benefited from the results.

The partnerships could be patterned on the Healthy Forests Initiative, a public-private partnership of the U.S. Endowment for Forestry and Communities (the Endowment) with the USDA Forest Service (USFS) and Duke Energy. This partnership has pioneered a governance structure that operates with transparency and accountability. Encouraged by its success in addressing a forest health challenge, the Endowment and the USFS recently launched another initiative, to advance woody cellulosic nanotechnology. Similar partnerships could address green building, wood-to-energy, advanced pulping technology, forest restoration, forest inventory and analysis, and other areas of national importance to the forest sector and associated industries.

Without a commitment to R&D, America's once-robust forest sector will continue to decline, with unfortunate consequences for forest health and condition. A new, sector-wide, coordinated approach is needed to ensure a brighter future—a resilient model that picks up where 20th-century ideas left off and works for the 21st century.

[1] By Robert Kellison, Professor Emeritus, NC State University, January 2014 for the U.S. Endowment for Forestry and Communities as follow-up to "The State and Future of U.S. Forestry and the Forest Industry" convening.

A NEW MODEL FOR FOREST SECTOR RESEARCH AND DEVELOPMENT IN THE UNITED STATES

The U.S. was the leader in forestry and forest products research and development for decades. In pulping technology, engineered wood manufacturing, genetic improvement of forest trees, plant nutrition, and many other fields, U.S. research has made the forest sector profitable, efficient, and sustainable. As a result, the U.S. has had the world's largest forest products industry and a stable forest base. Figure 1 conceptualizes the relationship between intensity of R&D, measured as a percentage of gross sales, and competitive advantages.

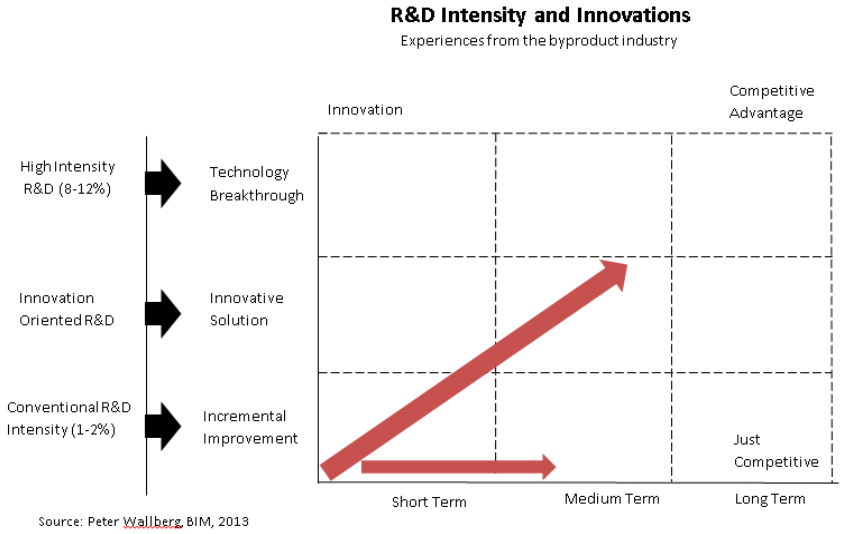

Figure 1. R&D intensity and innovation, a theoretical model from the bioproducts industry

R&D enjoyed strong support when integrated companies managed the value chain from tree to end-user. Today, however, because of tax law changes and the globalization of markets, manufacturing is typically separate from landownership. Divesture of timberlands by fully integrated forest products companies has brought fundament changes. The new owners of large private forests are timber investment management organizations (TIMOs) and real estate investment trusts (REITs). Their obligations to shareholders, combined with the consolidation of forest products companies through mergers and acquisitions, have meant the dismantling of research budgets and greatly reduced investment in forestry and forest products development.

The most recent data available, from before the 2008 recession, show that the wood products industry invests 0.6 percent of total sales in R&D, and the pulp and paper segment invests 0.5 percent (of which one company accounts for half). By comparison, the textile industry, which largely moved offshore more than two decades ago, still invests 0.7 percent of total sales in R&D in the U.S. And the average for the entire U.S. manufacturing sector is 3.4 percent of sales. Public funding for R&D in the forest sector is also dropping.

At the same time, foreign competitors, such as Finland and the European Confederation of Paper Industries, are expanding their R&D in forest products. That double-edged sword begs the question: What are the implications for the U.S. forest sector 10 to 20 years from now?

The next section of this report summarizes the reasons for the drop in research funding and surveys current investments in R&D by the U.S. forest sector: research cooperatives, companies, trade associations, and the federal government. The report then describes examples of forest sector research abroad. Finally, it proposes a new model, a public-private partnership with a sustained source of funding, to revive forest sector R&D in the U.S.

Decline in R&D and its causes

The decline in forestry and forest products R&D began in the early 1980s, when arbitragers, such as Sir James Goldsmith, T. Boone Pickens, and Al "Chainsaw" Dunlap, began buying undervalued pulp and paper companies—Diamond International Corporation in the Northeast, Crown Zellerbach Corporation in California, and Scott Paper Company in the South—inclusive of land, timber, manufacturing plants, and distribution centers, and then dismantled the organizations, selling the parts for a sum greater than the whole. When St. Regis Paper Company was targeted by arbitragers, it ended up being bought by Champion International to avoid being dismantled. Champion's debt, following the purchase of St. Regis, was enough to discourage the arbitragers, and loading themselves with debt became a defensive strategy of other pulp and paper companies. International Paper (IP), for example, bought Hammermill Paper Company, Georgia-Pacific bought Brunswick Pulp & Land Company, and Weyerhaeuser purchased the fluff pulp mills of Buckeye Cellulose.

With few exceptions, the R&D of the purchased company was folded into that of the buyer, typically resulting in a net loss of activity. For example, in 1998, IP had 250 employees in its R&D division, Union Camp Corporation had 120, and Champion International, 100, but soon after IP had acquired the other two companies, the total number of R&D employees had shrunk back to 250. By 2005 when IP sold five million acres of their timberlands the division had been reduced to 100 employees. Since that time the number has been reduced to fewer than a dozen.

A decline in R&D funding has also accompanied the formation of TIMOs and REITs. By 2000, about 25 TIMOs in the South had purchased some 26 million acres of timberland from pulp and paper companies. These new landowners focus on value and returns to investors; investments in research are low priorities. The four REITs—Plum Creek Timber Company, Weyerhaeuser Company, Rayonier Corporation, and Potlatch Corporation, which together have amassed about 16 million acres—manage their designated timberlands in accordance with current technology but are more cautious about sharing research results and application than when they were stand-alone companies.

University cooperatives

Forestry, a long-term venture, requires long-term investments. A single company might identify the performance standards of a selected species on a particular site, but the task becomes increasingly complicated and costly with multiple tree species on multiple sites. At Texas A&M University in 1951, Bruce Zobel, a forest geneticist, sought to address that challenge by involving both public and private entities in a cooperative program for the genetic improvement of loblolly and slash pines. The cooperative worked so well that the concept was copied by the University of Florida in 1953 and by North Carolina State (NC State) in 1956 and was subsequently used by other forestry disciplines—hardwood silviculture, tree nutrition, nursery management, plant propagation, biotechnology, weed control, pest control, growth-and-yield, wood science, and gene conservation—both here and abroad. Today, active forestry cooperatives exist in Canada, Australia, New Zealand, Argentina, Brazil, Chile, Mexico, South Africa, Scandinavia, and elsewhere.

In Zobel's model, forest product companies were both the major contributors and the beneficiaries. Each member of the cooperative paid a fee to participate but also conducted research on its own lands, following work plans developed by the co-op administrators, generally university scientists. With corporate mergers and acquisitions and the rise of TIMOs and REITs, however, many forestry cooperatives ceased to function (Table 1). Furthermore, many of the surviving cooperatives have fewer members, and thus less funding and reduced research.

Table 1. Status of university-sponsored forestry cooperatives in South

Cooperative	*Sponsor*	*Founding*	*Status*
Tree improvement	Texas A&M University	1951	Ongoing
Tree improvement	University of Florida	1953	Ongoing
Tree improvement	North Carolina State	1956	Ongoing
Hardwood research	North Carolina State	1963	Terminated 2001
Forest fertilization	University of Florida	1967	Terminated 1991
Forest fertilization	North Carolina State	1969	Ongoing
Nursery management	Auburn University	1972	Ongoing
Industrial development	Virginia Tech	1973	Ongoing
Growth-and-yield	University of Georgia	1975	Ongoing
Forest equipment	North Carolina State	1975	Terminated 1984
Growth-and-yield	Virginia Tech	1979	Ongoing
Gene conservation	North Carolina State	1980	Ongoing
Silvicultural herbicide	Auburn University	1981	Terminated 2001
Forest pest management	University of Florida	1981	Terminated 1995
Rooted cuttings	North Carolina State	1984	Terminated 2009
Forest biotechnology	North Carolina State	1986	Terminated 2012
Accelerated productivity	University of Georgia	1991	Terminated 1996
Maintaining site productivity	Louisiana State University	1993	Terminated 2010
Tip moth control	University of Georgia	1995	Terminated 2000
Forest biology	University of Florida	1995	Ongoing
Fusiform rust	North Carolina State	1995	Terminated 2007
Forest pest management	Texas A&M University	1996	Ongoing
Wood properties	University of Georgia	1996	Ongoing

Some organizations remain viable. For example, the growth-and-yield cooperatives at the University of Georgia and Virginia Tech and the gene conservation and forest fertilization cooperatives at NC State have expanded their regional focus nationally and internationally.

The tree improvement program at NC State has adopted a new approach to remain viable. Although members' fees had increased several-fold over the years, the decline in membership since the 1980s left insufficient funding to support groundbreaking research in forest tree improvement. The co-op therefore opened its membership to a second tier of organizations, consisting of TIMOs, sawmill owners, foundations, and consultants (Figure 2). These associate members are interested in genetically improved planting stock for short-term investment. Over the past decade, that approach has helped the co-op obtain more than $5 million from grants and contracts.

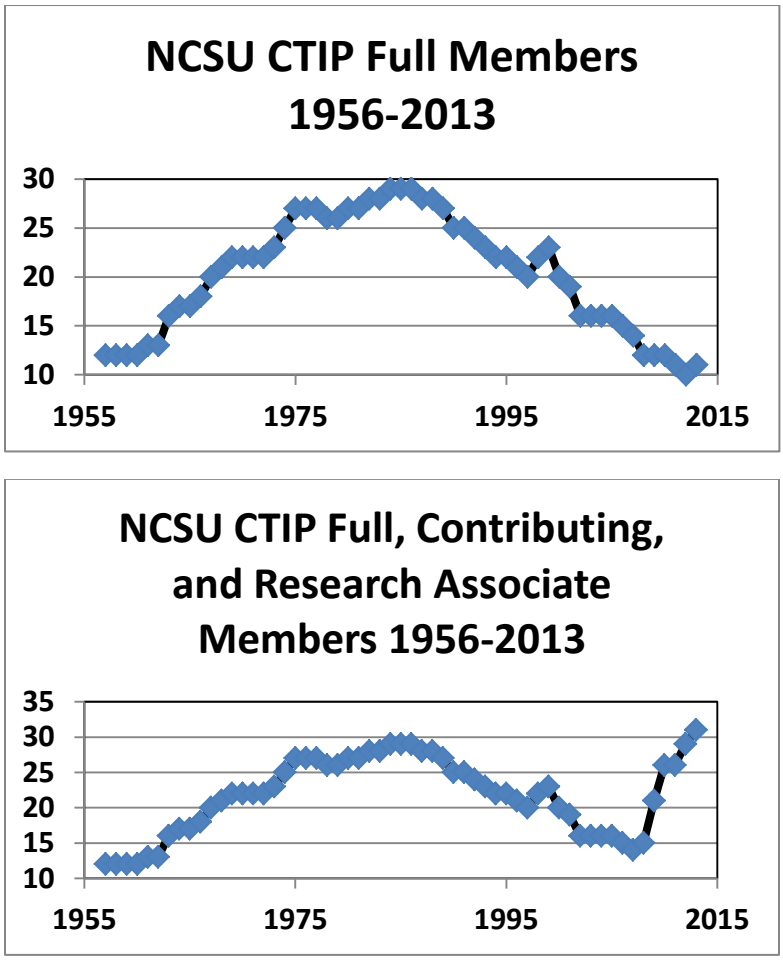

Figure 2. North Carolina State Cooperative Tree Improvement Program (CTIP) (A) full members, and (B) full plus associate members, 1956–2013

The tree improvement cooperatives at Texas A&M and the University of Florida have also faced financial challenges because of declining membership; they have maintained their programs in forest genetics through grants, contracts, and university support.

American Forest & Paper Association

The American Forest & Paper Association (AF&PA) has been the major national trade association of the forest products industry since 1993, when the National Forest Product Association and the American Paper Institute merged. AF&PA's Agenda 2020 Technology Alliance (A2020), whose goal was to improve forest productivity and manufacturing capabilities by 20 percent by 2020, had six components: sustainable forestry, environmental performance, energy performance, improved capital effectiveness, recycling, and sensors and controls. A2020 sought to encourage public agency scientists to develop research projects whose results would pass stern scientific review; forest industry would fund 20 percent of direct and indirect costs, with the Department of Energy (DOE) and the USFS picking up the rest.

By 1999, however, the DOE had begun channeling research funds to energy crops, primarily agricultural residue and annual crops. That left only the USFS working with AF&PA to fund research in the six areas. Funding was further constrained in the first decade of the 21st century, when industrial land holdings were sold to TIMOs and REITs, reducing AF&PA membership. Nevertheless, 94 research proposals had been funded and completed by FY 2010, mostly with funding from USFS R&D.

In 2010, A2020 was converted into a 501(c)3 foundation because of lack of membership and funding. It now collaborates with the Forest Products Laboratory of the Forest Service, with the following goals:

- to emphasize the potential of wood-based nanotechnology for the economy and the environment;
- to overcome technical barriers to commercialization of wood-based nanotechnology;
- to demonstrate commitment to creating high-paying jobs in rural America through value-added manufacturing and high-value products; and
- to showcase the commitment of the Department of Agriculture and the Forest Service for conducting research and creating products and jobs for the future.

Institute of Paper Science and Technology

The Institute of Paper Chemistry was formed in 1929 in Appleton, Wisconsin, to address the release of untreated pulp mill waste into U.S. waters. The mission soon expanded into pulping and papermaking and then into forestry research and development, inclusive of forest genetics and biotechnology. In 1989 the institute broadened its research objectives, changed its name to the Institute of Paper Science and Technology (IPST), moved to Atlanta, and became a nonprofit 501(c)3 associated with Georgia Technology University (Georgia Tech).

The new research objectives initially inspired enthusiastic participation and funding by members of the pulp and paper industry and attracted grants from the DOE, USDA, the

National Science Foundation, and the USFS; IPST also benefited from legislative mandates for funding by the State of Georgia. However, the continued sales and mergers in the forest industry have reduced its membership and thus its financial support. And in 1999, IP, Westvaco Corporation (today MeadWestvaco), and two New Zealand firms, Fletcher Challenge Forests and Genesis, formed an independent company, ArborGen, to conduct forest biotechnology research. Since forest biotechnology was also a mainstay of the university-based research program, IPST has struggled to maintain its ongoing research and curtailed future initiatives.

National Council for Air and Stream Improvement

Formed in 1943 by the forest products industry, the National Council for Air and Stream Improvement (NCASI) is an independent, nonprofit research institute that focuses on environmental and sustainability topics relevant to forest management and the manufacture of forest products. An important part of NCASI's mission is improving pollution control measures employed by forest products manufacturing facilities. The wastewater treatment practices it developed to treat mill effluents are now widely used for treatment of municipal and other wastewaters. NCASI's technical expertise in environmental topics extends from wood products manufacturing to timber production and includes soil sedimentation, noxious pollutants, carbon sequestration, invasive species, and wildlife conservation.

In recent years, NCASI has given additional emphasis to research in forest sustainability to help members attain forest management certification under the Sustainable Forestry Initiative and the Forest Stewardship Council programs. Despite the vagaries of the economy, NCASI has maintained a relatively strong base of financial support from its members, and its research results continue to support the forest products industry.

USDA Forest Service Research Stations

The USFS began organized forestry research in 1908 with formation of the Forest Products Laboratory at Madison, Wisconsin. That initiative was supplemented in 1921 with formation of the Southern Forest Research Station in New Orleans and the Appalachian Forest Research Station in Asheville, North Carolina. The Appalachian Station was renamed the Southeastern Research Station in 1946. In 1995 the two stations were merged into one, the Southern Forest Research Station, with headquarters at Asheville. Similarly, the research centers in other regions of the country were consolidated into the Northern, Rocky Mountain, Pacific Northwest, and Pacific Southwest stations. The USFS also operates the Institute of Tropical Forestry in Puerto Rico. The Forest Products Laboratory, operated independently for decades, but is now administered jointly with the Northern Forest Experiment Station (see below).

Federal funding for the research stations has waxed and waned over the decades but in recent years it began a steady decline. Federal funding for all R&D—not just for forestry—as a percentage of gross domestic product (GDP) was 1.27 percent in 1976 but 0.92 percent in 2012 (Figure 3); in the natural resources and environment category, environment is receiving more, and natural resources, less.

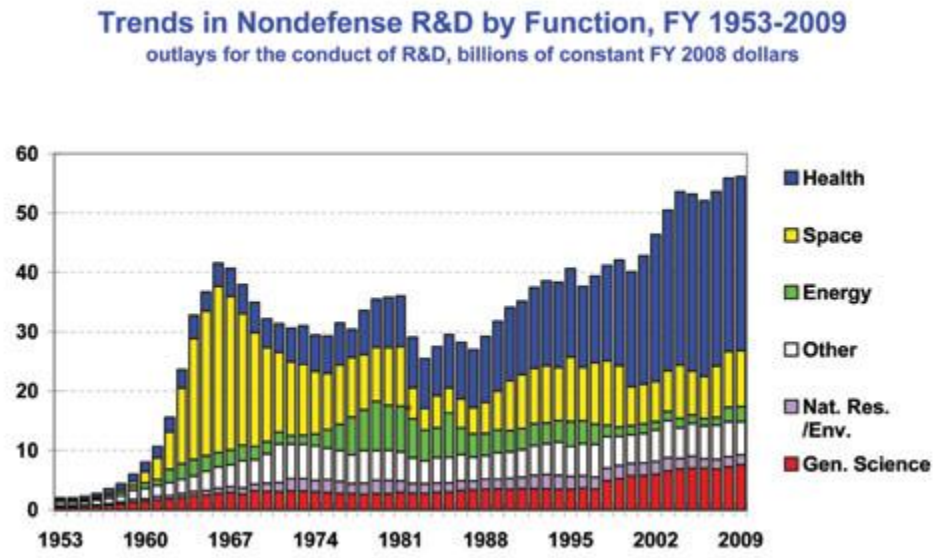

Figure 3. Federal nondefense R&D, 1953–2009, in billions of 2008 dollars

Forest Products Laboratory

The Forest Products Laboratory (FPL), in Madison, Wisconsin, was established to conduct research on wood, wood products, and their commercial uses; its researchers partner with universities, industry, tribes, and government agencies. Almost every manufactured wood product of commercial value—oriented-strand board, laminated veneer lumber, cross-laminated veneer, glulam, parallam, and many other engineered wood products used in modern construction—had its origin from research conducted by the scientists who have rotated through its halls and laboratories. The most recent area of research is nanotechnology.

Although the FPL budget has not changed significantly since 1965, staffing has fallen from 475 to 164 employees (many of whom are support personnel rather than researchers), reducing the amount of research the lab can conduct (Figure 4). Moreover, a recent Congressional Budget Office report suggests eliminating forestry and rangeland R&D and State and Private Forestry to help reduce the federal deficit by $5.1 billion by 2023.

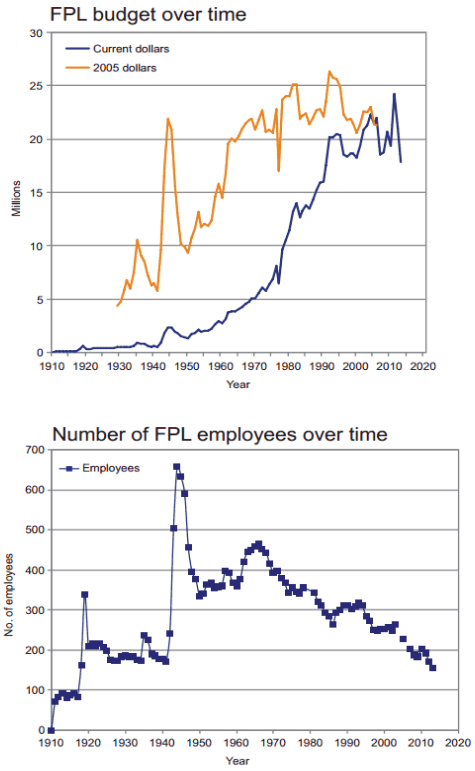

Figure 4. Forest Products Laboratory budget and staffing, 1910–2012

Foreign Examples of Forest Sector R&D

Other countries with wood resources and manufacturing capabilities comparable to those of the U.S. are making inroads into American market share. The approaches taken by Finland, the Confederation of European Paper Industries, and Canada are described here as examples.

Finland

Finland is seeking to create cellulosic products that feature the best qualities of cotton, polyester, and other materials. Annually, an estimated 5 million to 6 million tons of fiber could be manufactured from Finland's current logging residue (900 million to 1,050 million cubic feet per year). This could replace more than 20 percent of the world's cotton production while reducing carbon dioxide emissions by 120 million to 150 million tons and releasing enough farmland to grow food for 18 million to 25 million people.

The new products will be manufactured from wood cellulose through nanotechnology. The Finnish effort is spearheaded by the VTT Technical Research Centre of Finland, an applied research consortium that is funded by the Finnish government.

Confederation of European Paper Industries

The Confederation of European Paper Industries (CEPI) represents companies in 17 countries of the European Union plus Norway. CEPI has committed to major reductions in the global warming gases emitted from pulping and papermaking operations. A new focus is the use of deep eutectic solvents to dissolve the wood and extract the lignin. Compared with pulping by conventional means—grinding or cooking the wood—this would reduce primary energy use by 40 percent and recover the lignin for commercial purposes.

Another novel approach being explored by CEPI relates to sheet formation of paper and paperboard. The conventional means flows a wet pulp furnish over the forming fabrics of the paper machine. Large quantities of energy are then required to remove the water from the formed sheet. One energy-efficient alternative involves separating the pulp fibers with steam, using reduced amounts of water; in another, the pulp fibers are suspended in a viscous fluid, which is then expelled by modifying the viscosity around them.

Canada and FPInnovations

Forestland ownership in Canada is 96 percent Crown, versus 28 percent public ownership of all U.S. forests. The forest products industry contributes about 12 percent of the country's GDP, and the Canadian government and forest sector have long demonstrated a commitment to forestry and forest products R&D. With a forest base equivalent to that of the U.S. but with a population and economy only one-tenth as large, the country had the Canadian Wood Fibre Center of the Canadian Forest Service, plus three major research institutes supported directly by industry with provincial and federal aid: Forintek (manufacturing and solid-wood products), Feric (forests), and Paprican (paper). In 2007 all four research efforts were combined into FPInnovations, with a $100 million annual budget and more than 660 employees.

FPInnovations calls itself one of the world's largest private, nonprofit centers for forest research. Its business model allows it to respond efficiently to the needs of its members in the private sector and its research partners in universities and federal and provincial governments. With FPInnovations, Canada has made a strong commitment to continued investment to ensure that its forests and forest products industry will have the science necessary to compete in a global economy.

Proposed model for the U.S.: Public-private R&D partnerships

The U.S. has literally scores of independent trade groups and associations for solid wood (further divided into softwoods and hardwoods), engineered wood, and pulp and paper. These entities compete for scarce R&D dollars from the same public and private agencies. We believe that a more concerted innovation effort is needed.

The USFS's Forest Products Laboratory, with its deep roots and history of success, most resembles Canada's FPInnovations, but it is subject to whims of federal funding. What is needed is a semi-autonomous entity that wins strong private sector support and operates with joint governance. A public-private partnership with an independent steering committee could move rapidly, make investment decisions efficiently, operate transparently, and obtain and leverage public funding for R&D.

Example public-private partnerships

The public-private model being proposed here is relatively new but not untested. The Forest Health Initiative is a successful example of a public-private partnership involving the USFS, Duke Energy, and the U.S. Endowment for Forestry and Communities (the Endowment). Its aim is to apply modern biotechnology to forest health challenges—the initial focus being the American chestnut (*Castanea dentata*).

In 1904, a fungal disease *(Endothia parasitica)* that attacks *chestnut* was introduced from Asia. Attempts to control the disease failed, and by the early 1940s the American chestnut had been

largely eliminated from eastern deciduous forests. After 40 years of collaborative research, a hybrid of American chestnut and a related, nonsusceptible species (15/16th American chestnut) has been developed and tested by traditional tree improvement. The American Chestnut Foundation is now seeking to recolonize eastern forests with the improved tree. The Forest Health Initiative has initiated a different approach, modern gene-splicing biotechnology, to advance a blight/disease resistant American chestnut. Collaborating scientists at university and USFS laboratories have manipulated American chestnut genetic material to produce individuals resistant to both chestnut blight and a lethal root rot *(Phytophtoria cinnamoni).* This initiative has made rapid progress since it began in 2009.

The Forest Health Initiative demonstrates the power of a public-private partnership model. In just three years and with about $6 million, it advanced the use of biotechnology as a tool to improve forest health. The project's biotech research has been conducted transparently and has been sensitive to social, environmental, and regulatory concerns. Such research can obtain public support and operate with a "braided" – all concerns concurrently -- approach.

In December 2013, the USFS and the Endowment announced another initiative to address a major forest sector need: a public-private partnership to conduct research in advanced woody biomaterials, or P^3Nano. The two founding partners have each committed $2 million and engaged a full-time project director to help guide and support the work. Whereas the Forest Health Initiative intentionally eschewed investments from forest industry, P^3Nano is intended to involve industry, and in fact, its success depends on industry support.

The public-private partnership model can be extended to other research needs of the forest products industry, such as wood-to-energy and green building materials, all of them housed within a single coordinating structure.

Funding for research partnerships

Regardless of their focus, public-private partnerships need sustained, reliable funding. For decades, producers of agricultural commodities—beef, milk, potatoes, corn, soybeans, cotton—have voluntarily assessed themselves to support research and promotion under USDA Agricultural Marketing Service rules. These are the so-called check-off programs (e.g., the "Got milk?" dairy campaign). In 2012, the Forest Service and the Endowment released a report, "State and Future of U.S. Forestry and the Forest Industry," which recommends broader adoption of check-off programs to support forest sector research and promotion. In 2011, with leadership from the Endowment and a cross-section of forest industry leaders, the softwood lumber industry adopted a check-off program.

In November 2013 the paper and paper-based packaging sector followed suit again with the Endowment sharing funding support. The Chemical Pulp Action Team (part of the capital effectiveness component of AF&PA's A2020) set priorities for research. The top agenda item of

the 25 conferees was an alternative to kraft pulping, the energy- and capital-intensive method used by the pulp and paper industry for the past 50 years. The criteria for new technology include a 25 percent reduction in pulp mill energy input, a 5 percent increase in pulp yield, a 25 percent reduction in biological oxygen demand and chemical oxygen demand, and significantly reduced capital requirements. How these ambitious research-based goals will be funded is the first critical question.

Producers in the hardwood lumber and hardwood plywood sectors will vote on their own check-off programs in early 2014. Significant gains are anticipated if the segments of the forest products industry use check-off programs to invest in consumer research and promotion and set up public-private partnerships to help fund product research.

Conclusion

The changes in the U.S. forest sector have had a devastating effect on support for in-house research, cooperative research, and industry trade organization research. The problem has been compounded by the decline in public funding for forest sector R&D. For what little funding remains, there is no entity to help set research priorities, and the result is a shotgun approach to addressing forestry and forest industry issues.

Meanwhile, international competitors—Finland, with its biotechnology research on manufacturing synthetic fibers from wood waste; the Confederation of European Paper Industries, focusing on efficiencies in pulping and papermaking; and Canada, with FPInnovations, its national research institute—are centralizing and coordinating research. To be competitive, the U.S. forest sector can likewise funnel industry and federal funding into a single coordinating structure, where all participants help set the research priorities and share research results. Collaboration under one umbrella organization focused on innovation in forest products would supersede underfunded, disjointed efforts, while the federal government continues doing supportive basic research of public interest.

The success of the Forest Health Initiative and the promise of P^3Nano exemplify one approach. Both initiatives involve collaboration with USFS researchers. Building on the public-private partnership model, with its shared funding and governance, forestry and forest products companies could benefit from research that would at least keep the U.S. sector in the game if not give it a competitive edge.