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FINAL REPORT

The Blue Ribbon Commission on Forest and Forest Products Research & Development in the 21st Century

U.S. Endowment for Forestry and Communities

FINAL REPORT

The Blue Ribbon Commission on Forest and Forest Products Research & Development in the 21st Century

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The U.S. Endowment for Forestry & Communities, Inc. (Endowment) is a not-for-profit public charity established at the request of the governments of the United States and Canada in accordance with the terms of the Softwood Lumber Agreement 2006 (SLA) between the two countries. The Endowment is one of three entities designated to share in a one-time infusion of funds to support "meritorious initiatives" in the U.S. The Endowment received $200 million, to be managed as a perpetual fund, under the terms of the SLA.

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/AKNOWLEDGMENTS

As the largest public charity in North America focused on forests, the U.S. Endowment for Forestry and Communities is committed to doing all we can to keep working forests as forests and to advance family-wage jobs in forest-rich rural communities.

We believe that encouraging diverse, robust markets for forest products and services are key to achieving both aspects of our mission—markets that will give private landowners incentive to retain and steward their forests; and, markets that will help land managers keep America's public forests healthy and sustainable. Vibrant markets are themselves founded on innovation. If the forest sector and broader society choose to invest in innovation, then we can expect to see our nation's forests remain bountiful and productive for their full range of social, ecological, and economic benefits.

This report would not have been possible without the hard work of our independent commissioners—Robin Jolley, Tim Punk, Rich Ringeisen, Larry Selzer, and John Williams. Our lead consultant to the commission, Rich Guldin, devoted many hours of research and expertise to developing background materials for the commissioners and then aided the team in articulating ideas in the final report.

We also want to extend our thanks to all those in the various research institutions, both public and private, who helped amass the background information necessary to establish context as well as opportunity. Sally Atwater assisted with reviews and edits, ensuring that messages were clear and concise. Finally, we express appreciation to four anonymous reviewers from the academic and governmental sectors who provided rigorous, insightful, and comprehensive reviews.

It is our hope that this report will play a role in ensuring that America's forestry and forest products sector will come together to create a fresh approach to research that leads to a brighter future.

Carlton N. Owen
President & CEO
U.S. Endowment
for Forestry and Communities

/ WHY THIS REPORT

THE U.S. MARKET FOR BOTH TRADITIONAL FOREST PRODUCTS AND ECOSYSTEM SERVICES IS SUFFERING FROM A LACK OF INNOVATION

Forests are under increasing threat from catastrophic wildfires, pests, diseases, and conversion to nonforest uses. If we are to realize the full benefit of America's forests, society must work to retain them and keep them healthy and productive.

Markets help ensure the sustainability of forests by giving landowners incentive to keep and manage their tracts. But the U.S. market for both traditional forest products and ecosystem services is suffering from a lack of innovation. Concerns about declines in forestry and forest products research led the U.S. Endowment for Forestry and Communities in May 2016 to invite a panel of experts to study the issues and develop recommendations. The Blue Ribbon Commission on Forest and Forest Products Research & Development in the 21st Century had five members:

Following a year of examining the challenges facing the forest sector and the potential for its future growth, the Blue Ribbon Commission has prepared its report, intended for both public and private stakeholders.

Data sources and additional information are available in the report appendices: ***http://usendowment.org/publications.html***

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/CENTRAL MESSAGE

MAJOR CHANGES IN FOREST SECTOR RESEARCH AND DEVELOPMENT ARE NEEDED TO SECURE FOR THE FUTURE THE BENEFITS THAT AMERICA'S FORESTS PROVIDE.

/ America's forests deliver multiple economic, environmental, and social benefits.

Forests are a pillar of our country's prosperity, providing a renewable source of raw materials for thousands of products. Good jobs in the forest sector—forest management, harvesting, wood products manufacturing, outdoor recreation, and much more—are vital for rural prosperity and community stability.

Forests deliver ecosystem services that are irreplaceable—clean drinking water, oxygen, carbon sequestration, erosion control, biodiversity—and valued in the tens of billions of dollars annually.

Forests are preferred places for people to enjoy outdoor activities, relax in a natural environment, and find personal and spiritual renewal.

/ Innovation in forest management, forest products, and conservation has slowed, jeopardizing both U.S. competitiveness and forest stewardship.

Many traditional forest products markets have matured or declined. Yet the sector's research and development (R&D) funding—essential to innovation—has fallen and its R&D capacity has withered. Meanwhile, other countries are stepping up their efforts to capitalize on next-generation forest products.

A wide range of new forest goods and services are being recognized, and many nascent efforts to capitalize on them through new markets are being developed. But additional R&D is needed to remove barriers and remedy imperfections in the emerging markets before benefits will flow to all stakeholders.

Thriving, competitive forest products markets for commodities and services, characterized by leading-edge innovations, are essential because they create value that encourages private landowners to keep and manage their forests, rather than convert them for development or agricultural use. Markets also support management and restoration of a large portion of public forests.

/ Investment in and coordination of university, industry, and government research programs and a sharp focus on innovation are vital to forest retention and will maintain U.S. leadership in sustainable forest management and production.

If forests are to remain as forests and not be converted to other land uses, all of society, but especially forest landowners, must value and find value in forests. Creating more value will take focus, persistence, and determination by forest sector leaders—elected officials and heads of corporations, public agencies, private organizations, and research institutions—to ensure the long-term security of all the benefits that forests provide.

The forest sector must now look to innovation in existing markets and develop new markets. Renewed private support for R&D and a federal research agenda that reflects the needs of society as well as industry are two fundamental starting points.

After a brief discussion of the issues, this report offers recommendations for policymakers, private stakeholders, and research program managers and other leaders at federal agencies.

/ BACKGROUND:
Value of America's Forests

/ Extent and ownership

Fully one-third of the United States is forested—some 766 million acres in 2010. The majority of U.S. forestland area, 56 percent of the total, is privately owned. Urban forests account for roughly another 28 million acres with 4 billion trees.

/ Economic values

- The sector supports 1 million direct-impact jobs and 1.7 million indirect jobs, with a total payroll of $112.7 billion. Privately owned forests create the vast majority of the jobs and value.
- The forestry, pulp and paper, and wood products industries account for approximately 6 percent of the total U.S. manufacturing GDP—on par with the automotive and chemical industries—and make products worth more than $282 billion annually. The industry is among the top 10 manufacturing sector employers in 45 states. Economic multipliers usually increase these benefits by a factor of 2.
- Spending by visitors to federal forests and grasslands contributes about $10.3 billion to the U.S. economy and sustains more than 140,000 full- and part-time jobs. Global tourism is part of this value, with outdoor recreationists from around the world coming to enjoy our National Forests. Visits to state forests and private lands create additional economic value.
- The forest industry pays $5 billion annually in state and local taxes, supporting local services that people depend on, like education and health care.

RESEARCH & DEVELOPMENT INVESTMENT AS PERCENTAGE OF SALES

WOOD PRODUCTS SECTOR: ***0.6%***

PULP AND PAPER SECTOR: ***0.5%***

AVERAGE U.S. MANUFACTURING ***3.4%***

Source: R. Kellison, "A new model for forest sector research and development in the United States" (Greenville, SC: U.S. Endowment for Forestry and Communities, 2014).

/ Environmental values

- Forests are the source of 33 trillion cubic feet (53 percent) of the nation's annual water supply, valued at $38.4 billion. Forests provide clean drinking water for two of every three Americans, in communities ranging from small towns to New York City.
- Water flowing from forests generates clean hydroelectric power and provides water to irrigate crops.
- Forests and forest streams and lakes provide essential habitat for wildlife and fish, sustaining biological diversity.

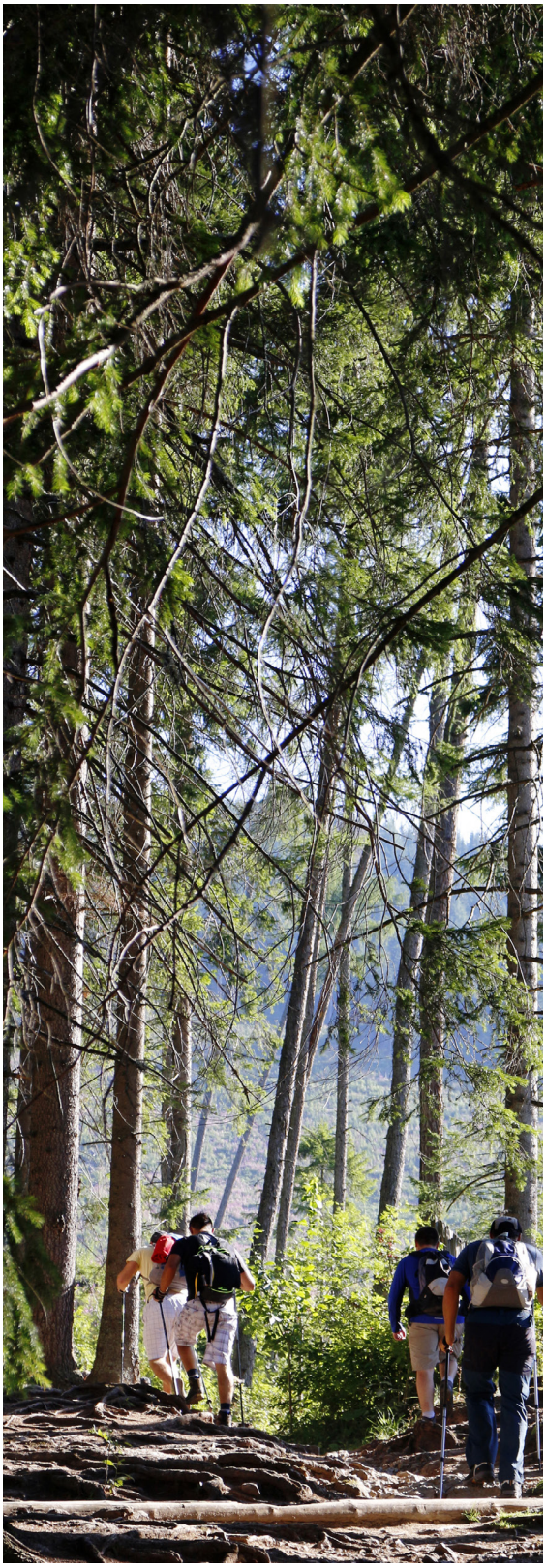
/ BACKGROUND:
Value of America's Forests

/ Environmental Values

- In an urban environment, forests lower ambient air temperatures, moderating heat island effects and reducing electricity consumption. Just like rural forests, urban forests reduce stormwater runoff and remove carbon dioxide from the air.
- As trees grow and are used in long-lived wood products, they store carbon.
- In addition to their value as raw material for wood products, trees generate billions of dollars in economic value from oxygen, reduced air pollution, protection against soil erosion, and scenic beauty.

/ Social Values

- Forests are favored places for people to "get away from it all" and participate in activities that strengthen family and community ties. These very real values are beyond financial estimation but figure strongly in public perceptions about forests and support for forest conservation.
- In rural areas, forests create family-wage jobs that underpin local economies, strengthening community vitality, well-being, and cohesion.
- In developed areas, trees dampen noise pollution, boost residential and commercial property values, and even aid in reducing crime.



/ FOREST SECTOR CHALLENGES

This important part of the U.S. economy is cyclical. For instance, declining housing starts are usually a leading indicator of an economic slowdown, whereas increases in housing starts are often among the first signs of an economic recovery. The Great Recession of 2007–2009 and the exceptionally slow recovery of housing and the entire economy are atypical of that historical pattern. Today, multiple global, structural, environmental, and societal factors are complicating the sector's recovery.

/ Shifts in core market segments

The U.S. forest sector was bruised by the recession. Its two largest primary manufacturing categories—solid wood products for construction, and pulp and paper for tissue, printing, packaging, and shipping—suffered, as did associated secondary manufacturing categories, including wood furniture and cabinetry.

- / **Collapse of the housing market**. When housing starts fell by 78 percent over 2007–2009, the markets for lumber, panels, millwork, cabinetry, and furniture were all hit hard. More than a thousand mills and factories closed. Associated businesses—trucking, equipment servicing—followed suit. The ripple effects hurt many rural businesses, strained local social services, and damaged community well-being and cohesion.

- / **Downward trend in manufacturing.** Although the tissue subsector has increased production, total paper and paperboard production has fallen 12 percent since 1996. The rise of digital media has significantly depressed newsprint and sheet paper production. Some pulp and paper mills have shifted to other product lines, but more than half have been permanently shuttered in the past 25 years.

/ Mixed long-term forecast for traditional wood products

Demand for traditional solid wood products is growing, but very slowly. Housing starts in 2016 were barely half the January 2006 level. In many areas, timber markets alone are not strong enough to provide the markets and income certainty that private landowners need to maintain working forests. Although growth in global manufacturing should augur well for packaging and tissue products, many traditional paper and paperboard markets continue to decline.

/ Conversion of forests to developed land uses

Residential, commercial, and infrastructure development in rural areas permanently changes land-use patterns, fragmenting forests and foreclosing or severely limiting their future contributions. Private forestland owners may be induced to sell when property taxes on their woodlots exceed income opportunities, or when land values for development exceed the value of land retained as working forest.

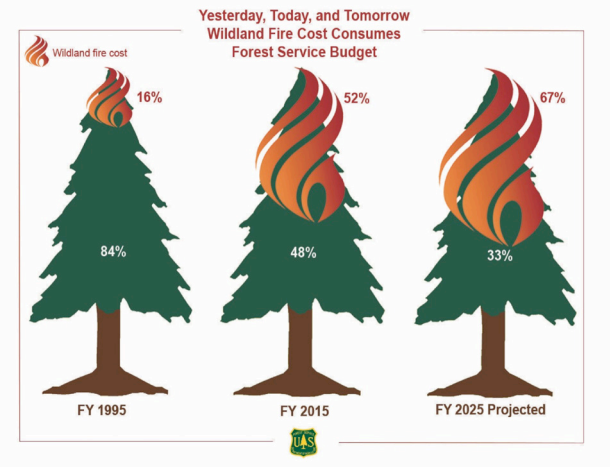
/ Exit of skilled workers and experienced managers

During the recession, foresters and other service providers lost clients, and skilled forest sector machine operators sought other opportunities. Mill owners who stayed afloat reduced working hours, leading some employees and experienced managers to search for work elsewhere. Further, the plummeting demand for products meant that mills lacked money for capital reinvestment to help them compete with imported products.

/ FOREST SECTOR CHALLENGES

/ Threats from forest pests and wildland fire

Responsible management activities, such as thinning the dense growth of small trees that regenerate naturally, restore forests and enhance their resilience to insects, diseases, and wildfire. The backlog of active management on public lands, however, has made adjoining private forests more susceptible to damage. One growing problem is infestations of alien species, introduced through international trade; examples include the emerald ash borer, Asian long-horned beetle, and Asian gypsy moth. With an enhanced focus on restoration management and biotechnology research and development, the risks and potential losses in both rural and urban forests could be reduced.



Wildland fire costs as percentage of U.S. Forest Service budget, 1995–2025 (projected). From 1995 to 2015, R&D's share fell 25 percent.

Source: "The rising cost of wildfire operations: Effects on the Forest Service's non-fire work" (Washington, DC: U.S. Department of Agriculture, 2015).

/ Changing weather patterns

Temperature and rainfall patterns are becoming more erratic. Droughts are more intense and longer-lasting, resulting in changed forest composition that makes trees more susceptible to pests and fires. Winters are warmer in some areas, reducing snowpack and water not just for forests but also for public water supplies and agricultural and industrial use. Midwinter warmups affect tree dormancy and lead to frost damage and stunted growth.

/ Societal factors

American's love of nature is sometimes in conflict with today's consumer culture

- **Demand for nontimber forest goods and services**. Clean water, quality habitat for wildlife and fish, and outdoor recreation are among the services that Americans want from their forests. That presents a challenge: how to set priorities and manage forests for ecosystem services that may generate no income for landowners, versus managing for merchantable wood and fiber. Innovations are needed in markets for currently unpriced, nonmarket goods and services, and landowners want new resource management tools to help them integrate commercial and societal needs.

- **New recreation preferences.** Families are taking shorter vacations closer to home. Recreation demand is shifting from distant federal lands—National Forests and National Parks—to state and county forests and parks, pressuring the budgets of state and local agencies that must address crowding and heavy use. However, any engagement with the forest is an opportunity to show the benefits these lands offer.

- **Public mistrust.** A common misapprehension is that forestry means logging and that logging equals deforestation. Many people who cherish living trees discount the value of forest products in their daily lives and the importance of markets for maintaining forests that revitalize and sustain rural communities.

/ OPPORTUNITES
for Forest Sector Research and Development

In the past, new products have helped drive business investment, create jobs, support forest landowners, and strengthen the forest sector. With markets for many traditional products now stagnant, the sector must innovate. Creating new products and services, developing new manufacturing processes, and marketing the new goods and ideas require not just basic research but, more importantly, applied research and development.

/ New forest products

Examples of recent product innovations that are creating well-paying manufacturing jobs, many of them in rural regions, include the following:

/ **High-performance fibers and natural chemicals.** Basic and applied researchers have developed nanofibers and nanocrystals produced from woody cellulose. These materials measure just 6 to 500 nanometers (1 nanometer is 1 millionth of 1 meter) but can enhance the properties of many substances, from plastics to paints to concrete (a remaining challenge to widespread commercialization is clearer understanding of the fate of nanoparticles in the environment after use). Woody cellulose can also be transformed into chemical feedstocks that could replace many petroleum-based feedstocks. Wood-based plastics have promise in the electronics and optics fields, including flexible and printable electronics. The next steps are improving awareness and scaling up production from bench to pilot and then to commercialization, with payoffs in jobs, demand for wood, and returns for private forest landowners.

/ **Engineered solid-wood products and midrise buildings.** New developments in construction materials are an extension of the research that made possible southern pine plywood and oriented-strand board. The latest innovation is mass timber, which pound for pound is stronger than steel. It can be manufactured in many sizes and shapes, enabling architects to design sanctuaries, sports facilities, and public buildings with soaring arches that span 500 feet. Mass timber also supports tall wood-framed buildings (six to 20 stories) that have superior safety in earthquakes and fires compared with steel-framed or concrete construction. Two challenges to wider deployment of this new technology are changing local building codes for multistory structures to enable the use of mass timber and educating architects, builders, and developers about uses and design specifications.

USING SMALL TREES TO MAKE BIG PRODUCTS

Cross-laminated timber (CLT), nail-laminated timber (NLT), dowel-laminated timber (DLT), and glue-laminated timber (glulam) are all mass timber products. They are cost competitive, carbon efficient, sustainable, and a reliable complement to existing light frame and heavy timber options. The CLT global market alone is projected to be $2 billion by 2025.

Source: "Cross laminated timber market analysis" (San Francisco: Grand View Research, 2017), http://www.grandviewresearch.com/industry-analysis/cross-laminated-timber-market

/ **Specialty wood products.** Entrepreneurs in urban and suburban areas are using wood from local forests for wood products manufacturing. Products are generally high-value items: millwork, trim, flooring, fireplace mantels, and short boards and blocks for custom cabinetry and hobby woodworking. Although most of these businesses have only a few employees, in aggregate they create meaningful numbers of good jobs and often take advantage of urban trees bound for the landfill.

/ OPPORTUNITES
for Forest Sector Research and Development

/ **Microcrystalline cellulose for pharmaceuticals and food.** Microcrystalline cellulose (MCC), manufactured from wood pulp, has many uses. In foods, it is a fat substitute with many desirable properties for enhancing baked goods, dairy products, frozen foods, and desserts. Because it is chemically inert, has no taste or odor, and has special attributes when compressed into pills, tablets, capsules, and sachets, it is used widely in manufacturing oral medications. Increasingly, it also is being used in cosmetics and personal care products. MCC has experienced an annual growth rate of 5.8 percent in recent years and is on track to become a $1 billion industry by 2020. Growth in demand for low-fat foods, easy-to-swallow oral medications, and bio-based cosmetics and personal care products will drive increased MCC demand.

/ Nontraditional forest product markets

Income for private landowners helps them maintain their working forests. Emerging environmental services and other new commodity markets include the following:

/ **Carbon credits.** Both states and nongovernmental organizations have developed programs in which a forestland owner who maintains a forest to sequester carbon from the atmosphere receives payments from carbon emitters. These programs are in their infancy and their future is uncertain, depending largely on whether federal and state governments enact policies to offset climate change. Another potential new market involves payments to forest landowners to help control air pollutants.

/ **Public water supply.** In some regions, the water yield from forest conservation and management is creating market opportunities that link payments from urban water consumers to rural water producers—that is, forest landowners—who manage their forests to conserve water quality.

COMPENSATING FOREST OWNERS FOR CLEAN WATER

Raleigh, North Carolina, is among a small but growing number of communities that are paying forest landowners to keep their forests as forests. Under a program developed in concert with the Endowment, the Natural Resources Conservation Service, and local land trusts, the City instituted a watershed protection fee—the average homeowner pays 60 cents a month—that yields $2.2 million a year for purchasing conservation easements.

/ **Forested buffer zones.** In areas surrounding military reservations, working forests are providing new value by buffering residential and commercial developments from training grounds for our armed forces. Conservation easements secure these lands and protect them from conversion to uses incompatible with military exercises.

/ **Renewable energy production.** Renewable energy demands are creating new markets for raw materials that provide incentives for private landowners to manage their forests. Forest thinning operations are often essential to enhance forest health and produce high-

/ OPPORTUNITES
for Forest Sector Research and Development

value sawtimber 10 to 20 years in the future, but they are often prohibitively expensive if they don't generate any income to offset the costs. Small-diameter wood that was once sought by pulp and paper mills now has little value in some areas because of mill closures. The income from selling this raw material for bioenergy creates an incentive for private landowners to manage their forests.

/ Easing or altering of development pressure

Millennials' preference for urban living is reducing—at least temporarily—land-use conversion pressures in rural areas, creating an opportunity to rethink forest conservation and management programs at the wildland-urban interface. Local governments are searching for ways to guide future development or redevelopment to meet residents' needs while sustaining forests and their benefits.

/ STATUS
of Forest Sector Research and Development

The promise of new markets and new products may not be realized if old approaches to R&D persist. Evidence that the system is in decline comes from many quarters.

/ Changing research landscape

/ **Loss of federal research capacity.** The number of researchers in federal land management agencies has plummeted. Staffing in fields essential for product innovation—forest products technology, chemistry, and general engineering—is only 25 percent of the level of three decades ago. In plant pathology and entomology, critical for protecting and maintaining forest health, staffing has been cut by 40 percent. The U.S. Forest Service's Forest Products Laboratory—the nation's only national laboratory for wood and wood fiber–based products—tells an even grimmer story: during World War II, the lab had 725 employees; today, it has just 141, only 50 of whom are researchers. FPL successes and innovations from the 1950s to 1980s are still yielding benefits sustaining today's lifestyles. Overall, federal research capacity in the forest sector has fallen by half in 30 years, substantially reducing the flow of R&D through the innovation pipeline and imperiling future gains.

/ **Loss of corporate research programs.** As the business model for forest sector industry transitioned away from vertical integration—the strategy of owning and managing woodlands to supply a corporation's wood raw material—in-house research programs were largely disbanded or spun off to independent entities. Research continues at an industry membership association, the National Council on Air and Stream Improvement, and at the Renewable Bioproducts Institute at Georgia Tech, a cooperative formerly known as the Institute for Paper Chemistry. A few commercial firms continue funding limited internal R&D programs or modest collaborations with universities, with most efforts directed at technical support and mill optimization.

/ STATUS
of Forest Sector Research and Development

/ **Loss of university research capacity.** Research capacity at land-grant universities has been redirected as state funding has declined and federal competitive grant program funding priorities have shifted to emphasize basic research. Rather than maintaining capacity to consider a broad range of both applied and basic research problems, university forestry research narrowed in response to the Obama administration's priorities, focusing on bioenergy, genomics, and climate change. The shifts in competitive grant programs toward basic research have squeezed out university capacity to pursue applied R&D on products and markets issues as well as sustainable forest management. The shifts have hit universities hardest because they rely most heavily on winning competitive grants to fund faculty and graduate student research.

FOREST PRODUCTS LABORATORY (FPL) ACHIEVEMENTS

FPL's successful innovations, beginning in 1910, are still yielding benefits for Americans today.

Early 20th century:

- wood preservation techniques that extended railroad tie lifespans from seven to 40 years
- wooden airplane bodies, wings, and propellers for WWI
- charcoal filters for gas masks
- wood treatments to protect homes, utility poles, and pilings against termites, fungi, and other pests

During WWII:

- ethyl alcohol production from wood; a vital ingredient for making synthetic rubber.
- processes to turn wood into nitrocellulose for gunpowder
- adhesives and resin treatments for wooden ships and for better aircraft carrier decks and wooden boats
- papermaking processes that could use southern pine, to meet a 40 percent jump in paper demand during the war

Postwar:

- skin material for jet fighters and missiles
- wood-plastic composites with great strength
- oriented-strand board to better utilize small-diameter logs unsuitable for plywood
- home construction techniques to better resist hurricanes
- postage stamp adhesive compatible with processes for recycling paper

21st century:

- structural designs that are energy efficient and resist wind and fire damage
- wood-based semiconductor chips for portable electronics that use no toxic metals and are biodegradable, with potential to ease disposal of the 50 million metric tons of electronics discarded each year.
- improved wooden propellers for military drones, remedying performance issues

*For more information on the Forest Products Laboratory, see Appendix 5, **http://usendowment.org/publications.html**.*

/ STATUS
of Forest Sector Research and Development

/ **New research entities.** Certification programs—Sustainable Forestry Initiative, Forest Stewardship Council—are funding modest research activities through competitive grant programs. Nongovernmental organizations like The Nature Conservancy also conduct research. But in aggregate, this work compensates for less than one-fifth of the capacity lost in federal and corporate research.

/ **New sources.** The U.S. Endowment for Forestry and Communities, the sponsor of this review, has funded applied research targeted at growing new markets. It has also promoted other new funding sources, such as the Softwood Lumber Board and the Paper & Paper-based Packaging Board, two USDA Research & Promotion Programs (a.k.a. "checkoffs") that provide some research support and have the potential to do more.

/ **New opportunites for environmental service markets.** Current markets for environmental services include federal and state payments to farmers and ranchers for land conservation activities (e.g., the Conservation Reserve Program and similar state programs); California Air Resources Board payments for carbon storage, available to landowners in many states; state or federal payments to protect endangered species habitats; and private individuals who pay forest landowners for leases to hunt game or collect nontimber forest products (e.g., mushrooms, ferns, ginseng). The research that undergirds such markets has just begun to explore how these markets attract both capital and landowners, how well they achieve their conservation objectives, and how the successful elements might be applied in other circumstances.

/ Inadequate funding

Scarce funding forces productive scientists to spend time chasing shrinking pots of grant money. By at least three measures, funding has fallen significantly.

/ **Comparison over time.** The total funding available for research in the U.S. forest sector is about $700 million per year, consisting of $500 million from four federal agencies, $150 million to $175 million from universities (largely state legislature appropriations to land-grant colleges and universities), and perhaps $10 million to $15 million annually from nongovernmental sources. In 1962, the total for all research in the forest sector was about $95 million per year, equivalent to $1.1 billion in 2015.

/ **Comparison with other sectors.** The decline in R&D funding is not unique to the forest sector: nearly all scientific funding has fallen in this century. But in total, corporate research in the forest sector is far below the level of corporate investment in R&D in other sectors. Current funding from all sources for forest sector R&D amounts to about 0.5 percent of the total annual revenues for all businesses in the forest sector. That percentage is much less than R&D spending in biomedicine and health care (almost 12 percent of revenue), computers and electronics (9 percent), software (more than 16 percent), or automobiles (3.5 percent).

/ STATUS
of Forest Sector Research and Development

/ **Comparison with other countries.** Countries whose forest sectors are major global competitors to the U.S. forest sector have taken more of a partnership approach with higher levels of funding relative to their economies.

// ***Canada*** *is investing nearly six times as much per year (as a percent of sales) as the United States in forest products innovation, even though its forest sector's value of shipments is only 18 percent that of America's. Canadian firms are strong funding partners in most of their government's initiatives. In 2015, Canadians invested CDN$95 million in FPInnovations, its forest products innovation center; 48 percent was provided by Canadian industries. The Canadian government funds two other programs—Investments in Forest Industry Transformation (IFIT) and Expanding Market Opportunities (EMO)—focused on translating research findings into commercial products. In 2017, it announced CDN$55 million in new funding over three years for IFIT to help firms implement first-of-kind technologies and get new products to market, including biochemicals, biomaterials, bioenergy, and next-generation building products. EMO is currently funded at CDN$45 million over three years.*

// ***Finland's*** *forest sector aims to be a world leader in new technologies and new products. In its R&D programs, Finland is emphasizing the importance of the entire value chain and encouraging researchers to focus on the needs of small- to medium-sized businesses in creating innovative, high-value products for global markets. Between the Finnish government and industry, €450 million is invested annually in forest sector R&D; one-third is contributed by forest industries. Two-thirds of the R&D funding is spent within Finland and the rest with research partners in other countries. Forest sector R&D amounts to 2.2 percent of the annual value of forest sector revenues. If the American forest sector invested that same percentage of its $282 billion in annual revenues, U.S. forest sector R&D funding would be $6.1 billion—nearly nine times the current U.S. investment level—and $2 billion of that total would be contributed by American industry.*

// ***The European Union*** *has launched Horizon 2020, a program to support research and innovation across a range of sectors. In 2016, €140 million was awarded for forest sector research and innovation, an increase of more than 10 percent from 2015. During 2007–2013, under the predecessor program to Horizon 2020, a total of €500 million was awarded for 180 projects in the forest sector.*

Those comparisons illustrate that other U.S. sectors and other countries have taken a different approach to innovation funding. As forest R&D in other countries grows stronger, the risk to U.S. forest sector jobs worsens, further endangering rural communities' economic stability and well-being. Other countries appear more willing to fund forest products research because their leaders see how the advances translate into returns throughout the product value chain, all the way back to private forest landowners.

/ Uncoordinated, unfocused system

Many links in the R&D chain—from basic research to applied research, development, and implementation—are weak. Funding agencies and organizations do not cooperate strategically on national priorities. The majority of product value in the forest sector comes from small- and medium-sized manufacturers, which collectively employ more Americans than do large manufacturers. But the small scale of individual firms precludes them from building their own research, development, and innovation capacity, and no mechanism exists to aggregate resources for R&D that would benefit all.

/ STATUS
of Forest Sector Research and Development

/ Thin pipeline of researchers

The scarcity of funding discourages graduate students across the breadth of forestry disciplines—students who will ensure a healthy supply of future scientists. Further, many of today's students, particularly in the forest products disciplines, are foreign-born and return home after graduating, taking their cutting-edge research skills with them. Their home countries' gain is America's loss.

/ Insufficient technology transfer

Many states' forestry agency budgets have been reduced by half. Extension agents' travel to professional and scientific meetings has been curtailed. The 200 extension specialists nationwide amount to one agent for every 3.1 million acres of private forest land or one agent per 55,000 private forest landowners.

Scientific journals' charges for downloading published papers—often $30 to $40 per article—are another obstacle. As a result, too few professionals are available to help private landowners improve their forest management, and research findings are less available to those charged with transferring knowledge.

/ Stranded search

Because potential users of research results are rarely involved in setting research priorities, the science often does not lead to innovation. Programs that fund basic research often do not support syntheses of prior studies, and research results may not be published. The consequences—duplication of effort, lost science, lack of return on investment—are broken links in the chain from basic research to development to innovation.

/ RECOMMENDATIONS

INNOVATION, PARTICULARLY IN FOREST PRODUCTS AND ENVIRONMENTAL SERVICES, IS THE FOREST SECTOR'S WAY FORWARD. IT REQUIRES PUBLIC AND PRIVATE ACTORS TO ABANDON OLD APPROACHES AND ADOPT MORE EFFECTIVE, COLLABORATIVE STRATEGIES.

/ For leaders and policy makers

/ **Restructure federal R&D for enhanced relevance, global competitiveness, and effective coordination.** Ensure that the forest research programs in four agencies (Forest Service, National Institute of Food and Agriculture, Department of Energy, and National Science Foundation) have a central vetting or oversight structure to avoid the duplication that often proceeds from working in agency silos. Alternatively, pull all program priority-setting for federally funded forest-related research under a single entity—a standing committee of agency leaders or a new Forest Research subcommittee of the National Research Council's Board on Agriculture and Natural Resources—that focuses on setting high-level strategies, priorities, coordination, efficiency, and results.

/ **Restructure and rebuild partnerships inside the Forest Service Forest Products Laboratory.** FPL is the nation's only federal forest products research center and has a national scope. Currently, it is grafted onto one of the regional research stations, whose director must also oversee FPL from a remote location. This creates a conflict between the national scope of FPL and the regional territory of the other station, and it divides leadership attention—to the detriment of both FPL and the regional station. The unusual arrangement emerged as a temporary

/ RECOMMENDATIONS

solution within the past decade; continuing it on a permanent basis is inappropriate for a true national laboratory. Reconstitute FPL with a full-time, on-site director who reports directly to the Deputy Chief for R&D. Reorient programs—including solid wood, pulp and paper, and biochemical—as national centers of excellence that have direct links with the best university and private research entities in the nation to ensure coordinated, results-oriented programs that emphasize applied research.

/ **Assume leadership in developing environmental services and nontimber forest products markets.** Payments for environmental services and nontimber forest products offer expanding opportunity to generate income for forest landowners while protecting working forests. Although research on forests' environmental benefits has grown, an innovative program that focuses on developing market instruments to monetize and capture these values is needed. This could help draw together today's disparate research and practice and spur federal and private research funding.

/ **Restore the "use" criterion.** Basic and applied research program managers need to propose research and choose topics with a high-value end use in mind. Applied R&D activities that target end users are more likely to spur innovation and create new jobs and markets.

/ **Focus on applied R&D.** Direct a greater portion of the federal funding for competitive grants to applied R&D. Rebuild capacity for intramural federal applied R&D. Develop mechanisms and incentives, or take better advantage of existing tools, to boost partnerships and private investment in research programs. Expand product development research through partnerships co-funded with private sector producers.

/ **Maintain basic forest inventory and forest health research.** Information about forest status and recent trends is essential for evaluating results. Forest health and productivity research is vital for addressing insect and disease outbreaks, restoring forests, and increasing forest resilience. Establish pilot projects to test innovative ways for private sector experts to more cost-effectively help collect, analyze, and deliver forest inventory and forest health information. The recent collaboration between Forest Service R&D's Forest Inventory and Analysis program and Esri to deliver inventory information in easy-to-use geospatial form is a good start. Further opportunities exist to partner with private firms for everything from collecting inventory data to analyzing results. Collaboration and partnerships might lead to lower program costs, shorter remeasurement cycles, and more timely release of fresh information after fieldwork is completed.

/ **Refocus university funding.** Refocus current formula funding from individual universities to multi-university consortia that respond to the priorities established in the national forest research strategic plan or the proposed federal forest research center. Some increased percentage of formula funds should target applied R&D and the infrastructure needed to further that work.

/ For research program managers at the Forest Service, National Institute of Food and Agriculture, Department of Energy, and National Science Foundation

/ **Convene stakeholders to set priorities.** Meet with forest sector stakeholders on a regular basis—at least annually—to discuss research needs and program direction.

/ RECOMMENDATIONS

/ **Develop a national research plan for the forest sector.** Create a strategic plan for forestry and forest products research funded by the four federal agencies. Because the Forest Service has the largest appropriated budget for forestry and forest products research, its R&D mission area should lead this endeavor. The Secretary of Agriculture should convene and champion the strategic planning process within the Executive Branch to ensure full participation by all funders and stakeholders.

/ **Coordinate efforts to achieve synergies.** Conduct periodic meetings of program leaders to foster better coordination of research, promote collaboration among the agencies, and avoid duplication.

/ **Increase the proportion of competitive grants awarded to applied R&D.** Shift the emphasis from basic research to development that promotes innovation.

/ **Identify cross-sectoral research opportunities.** Expertise from materials science, medicine, chemistry, and physics disciplines can add value to traditional wood technology research by identifying characteristics of wood useful in other sectors. Novel health and plastic products may emerge. Similarly, linking fish, wildlife, and environmental research with economics and social science can help develop new markets for conservation benefits.

/ **Develop public-private partnerships with businesses and research organizations.** The Stevenson-Wydler Technology Innovation Act of 1980 and the Federal Technology Transfer Act of 1986 allow firms in public-private partnership research endeavors to hold intellectual property rights and realize commercialization opportunities; the mechanism is called a cooperative research and development agreement (CRADA). Use these tools and pathways to engage private sector investment partners.

/ **Create a new governance structure.** Allow those who invest in applied R&D and innovation to participate in overseeing the research activities. Research conducted with some industry oversight will attract more private dollars and be more responsive to private investors' needs.

/ **Leverage federal dollars.** For some grants, require a 50-50 match of private funding from the industry. Funding could come from individual companies, trade associations, and certification or checkoff programs.

/ For federal land management agency leaders

/ **Rebuild the federal forest research cadre.** Create emeritus positions and retain recently retired scientists as part-time advisers, mentors, and reviewers. Replace some retiring senior scientists with midcareer researchers, rather than bringing in entry-level people who need time to develop leadership skills. Align the scientific strengths of new hires with national needs.

/ **Assign top agency scientists to lead research teams.** Rather than exclusively hiring researchers with narrow experience and interests, contract more of the actual research to university scientists. By assuming a coordinating, leadership role, senior agency scientists could employ the best minds from a range of disciplines and a broader context to address changing needs.

/ **Assign senior scientists to synthesize research.** Synthesis of the findings from basic research across many studies and scientific disciplines would identify promising approaches for future applied research, development, and innovation; it would also capture more value from the studies funded.

/ RECOMMENDATIONS

/ **Realign reporting relationships within Forest Service R&D.** To better serve the broader forest sector, the Forest Service needs to be more visible, persuasive, and influential in working with other federal agencies and nonfederal partners to develop and implement a national research agenda for the forest sector. Two changes are recommended. First, the Deputy Chief for R&D should be made the leading line officer—in the agency and the federal government—for forest sector R&D. Second, to support this leadership role, all the Forest Service's regional research station directors should report directly to the Deputy Chief; that is, regional line officers would report to the national line officer responsible for research.

/ For private sector and innovation stakeholders

/ **Promote R&D through existing mechanisms.** Channel a portion of funding from certification and checkoff programs into product R&D. Support industry groups, cooperatives, and NGOs that invest in research.

/ **Advocate for private forestland owners.** Incentives are needed both for corporate investment in R&D and for private landowners' forest management and conservation. Creating more certainty about the tax treatment of private investment and the reliability of environmental services markets in the future will help drive innovation and promote forest stewardship.

/ **Support third-party innovation to develop new products and services.** The pharmaceutical sector, among others, deploys third-party experts to envision marketable new products and services that could be produced from a firm's existing value chain. This business model requires (1) ways to protect new intellectual property, both new products and new manufacturing processes; (2) capital for the third party to move from concept to product to licensing; and (3) legal authorities that promote product development partnerships with potential licensees. Federal authorities for public-private partnerships and protection of intellectual property already exist (e.g., Cooperative Research and Development Agreement, CRADA). The limiting factor appears to be third-party access to capital, particularly for potential federal research partners. Focusing more money on innovation would help third-party developers accelerate innovation, particularly for segments of the forest sector that are susceptible to market displacement.

/CLOSING THOUGHTS

REBUILDING THE R&D CAPACITY OF THE U.S. FOREST SECTOR REQUIRES FUNDATMENTAL CHANGE.

Forests deliver ecosystem services and provide family-wage jobs in forest management, forest products, and recreation in rural America. Today, however, investments in research, development, and innovation in our nation's forest sector are weak, and forests are losing value as a source of wealth.

A thriving, competitive forest products market and new conservation markets can give private landowners incentives to keep and manage their forests, rather than convert them to other uses. The same forces affect public lands: markets provide opportunities for managers to protect and restore forest health on a large scale without overburdening taxpayers.

Markets are always changing and evolving. But as some traditional forest products markets have declined, the sector has failed to innovate and create strong new markets. Environmental services markets are emerging, spurred by some federal policies and funding, but organized efforts to foster them are missing. Further, the paucity of innovation stems from a decline in research and development funding and a subsequent drop in R&D capacity.

Rebuilding the R&D capacity of the U.S. forest sector requires fundamental change. That change will not happen overnight. In addition to more funding, the sector needs new models and a new culture of enterprise. Coordination of public and private research programs and a clear focus on innovation will help rebuild traditional forest industry and exploit opportunities, thereby securing for the future the benefits that America's forests provide.

With this report, the Blue Ribbon Commission on Forest and Forest Products Research & Development in the 21st Century calls for renewed private support for R&D and a contemporary federal research agenda, coordinated with the university community, that addresses sector's needs. We will work with partner organizations to lead a sector-wide commitment to implement the recommendations and foster American leadership in forest sector innovation.

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