

Phase One Summary Document 2016-2020



Sponsored by the Maine Forest Products Council and prepared by The Write Way, December 2020, this document provides a summary of the Phase One research and strategic planning of the Forest Opportunity Roadmap/Maine coalition. Reports summarized here: FOR/Maine, Maine Wood Volume and Projections Study (May 17, 2018); FOR/Maine, Global Market Analysis and Benchmarking Study, Phases One and Two (August 23, 2018); FOR/Maine, Wood Energy (March 2018); FOR/Maine, Transportation Best Practices (February 2020); and FOR/Maine, Community Revitalization Overview (September 2018). These reports can be found at: www.formaine.org

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Introduction

Maine's forest products industry is critical to the state's economy, with an estimated \$8.5 billion in economic impact. Technology, globalization and shifting consumer demands are bringing change and new opportunities to Maine's traditional forest products economy. While some markets, like media paper, including copier, printing, news and magazines, have declined, demand for newer, higher technology products is increasing. If Maine takes the necessary steps now to ensure a strong forest products industry, the state can maintain its leading role in the global forest economy. Already there are signs of optimism and significant investment in the future of Maine's forest industry by investors and entrepreneurs.

The Forest Opportunity Roadmap (FOR/Maine) is a unique cross-sector collaboration of industry, communities, government, education and nonprofit organizations that have come together to ensure that Maine strategically adapts and capitalizes on changing markets.

The Forest Opportunity Roadmap establishes a vision for a thriving and diverse forest economy. Developed by a statewide coalition of citizens, industry leaders, policy makers, nonprofit organizations and forest science experts from the University of Maine, the recommendations from this unique coalition are based on two years of intensive research and strategy development. From that work came this vision: **That Maine will be a global leader in the forest products economy with a thriving, innovative and diverse industry that provides good jobs in vibrant Maine communities.**

When six Maine paper mills closed between 2013 and 2015, industry, academia and state and federal leaders came together to address the severe economic impacts and to develop strategies to sustain and grow the forest products industry. The FOR/Maine coalition was created with support from the U.S. Economic Development Administration, the U.S. Department of Agriculture and the Maine Timberlands Charitable Trust. Its charge is to assess Maine's current industry,

assets and readiness and determine a strategy to capitalize on new opportunities.

Maine is the most forested state in the nation, with the largest contiguous, privately owned working forest in the U.S. Maine also boasts the highest percentage of certified sustainably managed forestland in the country. FOR/Maine's wood supply analysis concluded that there is a significant opportunity for increased use of Maine's softwoods, most notably the spruce/fir species.

In addition to this forest asset, Maine has a skilled forest products workforce, a well-established industry infrastructure that can sustainably produce more than 16 million tons of wood per year, and cutting-edge research and development facilities at the University of Maine. The state is located near the largest consumer market in the world, the Eastern U.S. seaboard, and there is infrastructure to support new development, including deep-water ports for direct shipping to Europe and around the world.

Global markets for new and existing forest products offer Maine incredible opportunities. Public awareness of global climate change has driven consumers, governments and manufacturers to recognize that products produced with plant materials can be used to replace those made with petroleum products. Growing worldwide demand for sustainably produced, climate-friendly products presents opportunities for Maine to be a leader in the global forest bioeconomy. A bioeconomy strategy for Maine will require diversification of our forest economy through the pursuit of the best and highest use for every part of the tree, resulting in greater environmental and economic resilience and the reduction and repurposing of waste.

Research indicates that a strong cluster of incumbent firms is a predictor of future entrepreneurship. In order to leverage its considerable assets, Maine must aggressively market itself both nationally and globally to attract capital investment, promote homegrown

scaling up, and accelerate innovation in forest products applications. Public and private sectors must work together with focus and persistence. With leadership and a plan, Maine's forest products sector has the real potential to expand by 40 percent and grow to \$12 billion by 2025. Maine can be a global leader in the forest products economy and provide good jobs for Maine people. The question is: Will Maine take the necessary steps in time?

Research conducted between 2016 and 2018 by the FOR/Maine coalition reported in this summary includes:

- Maine Wood Supply and Projections Study (May 17, 2018), prepared by the James W. Sewall Company, was conducted to determine Maine's current and potential sustainable wood supply. The James W. Sewall Company provides forest inventory surveying and mapping for the lumber industry in Maine and Canada, and is based in Old Town with seven other offices nationwide. The firm specializes in geospatial, engineering, natural resource and forestry consulting; it works in 40 states, most of Canada, and 12 other countries.
- Global Market Analysis and Benchmarking Study (August 23, 2018), prepared by Indufor North America, including: "Phase One: Global Market Analysis," "Phase Two: Regional Descriptive Report," and "Phase Two: Product Ranking and SWOT [Strengths, Weaknesses, Opportunities and Threats] Analysis," with an Executive Summary and

Recommendations, identified current and emerging global demand for forest products and Maine's most promising markets. It is accompanied by further analysis by FOR/Maine's Emerging Technologies Committee. Indufor North America, LLC, is one of the world's largest forest consulting service providers and specializes in feasibility and market studies, strategic industry advisory and benchmarking, and process improvements.

- Wood Energy (March 2018), analyzed Maine's current wood energy markets for forest and sawmill residuals. Natural Resource Solutions, LLC, provided analytical modeling of specific biomass energy scenarios and prepared the report.
- Transportation Best Practices (February 2020), prepared by AECOM, one of the world's leading infrastructure consulting firms, outlined transportation infrastructure improvements and industry practices to increase the efficiency of transporting raw materials from the forests to the mills and on to markets. The FOR/Maine Transportation Committee provided additional recommendations, which can be found in the Appendix.
- Community Revitalization Overview (September 2018), with the Maine Development Foundation, provided technical support for communities impacted by mill closures and other forest products communities, to develop community economic development strategies.



Executive Summary

Extensive data collection, global benchmarking and industry expertise inform the recommendations of the Forest Opportunity Roadmap. The wood supply data, global market analysis, transportation analysis, wood energy analysis, emerging technologies evaluation, and work with communities and stakeholders all support the vision that Maine can grow its forest products sector by 40 percent by 2025.

The same market challenges that led to the closure of six pulp and paper mills in Maine have also led to increased global demand for new, environmentally sustainable products. In response, Maine is building the next generation of the great Maine forest bioeconomy. The bioeconomy uses renewable biological resources from land and sea—such as fish, forests and microorganisms—to produce energy, food and value-added materials.

A forest bioeconomy encompasses traditional sectors such as recreation, forestry, paper and wood products, as well as emerging new products including textiles, chemicals, new packaging and building materials, biomedical materials and services related to these products. A circular bioeconomy maintains the value of products, materials and resources as long as possible, and minimizes generation of waste, while sustainably managing the forests. With the right investments in research and development, Maine's abundant forests can help meet rising global demand for environmentally sustainable products.

Themes for New Growth

While Maine's forest products industry has succeeded in the past, rapidly changing dynamics and markets require new approaches in order for the industry to be sustained and to grow. Through the two-year process of research and strategy development undertaken by the coalition, five key themes for new growth emerged as guiding principles:

Theme 1: Maine's forest products industry is highly interconnected and interdependent. The success of

landowners, loggers, truckers, industry owners and workers relies on the health of the whole industry.

Theme 2: A strong forest products industry supports vibrant Maine communities. For generations Maine's forest products manufacturing has provided economic opportunity for Maine families and communities. Maine's forest economy communities have existing sites with the infrastructure to support new and redevelopment, and they are eager to attract forest products manufacturing. Maine's working forests provide social and environmental benefits for Maine residents, including opportunities for recreation and habitat for wildlife. Our forests sequester carbon and produce clean water.

Theme 3: Wood is a sustainable, renewable resource. More than half of Maine's forests are certified sustainable by an independent third party, and are managed for the health of the forest, wildlife, water quality and economic contributions to surrounding communities. Consumer demand for sustainable products and materials is growing globally, and companies from toy manufacturers to beverage makers are looking for safer, greener alternatives to petroleum. Wood can meet that growing demand.

Theme 4: Wood is versatile. In addition to traditional products such as sawn timber and packaging papers that will continue to be strengths for Maine, forest outputs can be made into a staggering array of products, including advanced building materials, eco-friendly chemicals and biodegradable plastics (replacing petrochemicals), textiles, and cutting-edge medical and technical products made of nanocellulose, that are the future of the forest products bioeconomy.

Theme 5: Embrace the global economy. The forest products industry is global, with companies manufacturing products and shipping them all over the world. Maine must be ready to compete with other states and countries for the forest products investments of the future.

Goals of the Forest Opportunity Roadmap

With these themes as guiding principles, the work of the Forest Opportunity Roadmap is focused in a collaborative and strategic way on the following five goals:

Goal 1: Sustain and grow Maine's existing and emerging forest products economy, reaching \$12 billion in economic impact by 2025. We must strengthen and optimize existing wood products manufacturing, dedicate resources to a forest products industry attraction and diversification program to increase capital investment in markets that are a good fit for Maine, and improve Maine's attractiveness for new capital investment in the forest products industry. We need to accelerate innovation in new forest products and applications to strengthen Maine's leadership position. Maine must maximize the highest and best use of the wood supply, support development of markets for efficient energy derived from wood, and improve transportation and logistics infrastructure for moving wood and finished wood products to market. Strategies to achieve Goal 1:

1A. Strengthen and optimize existing wood products manufacturing in Maine. Support industry growth with a private/public market attraction team that can facilitate connections between Maine businesses and new markets, as well as attract investment in existing technologies that are at commercial scale but aren't yet in Maine.

1B. Dedicate resources to a forest products industry attraction program to increase capital investment in the state in markets that are a good fit for Maine. The state of Maine should provide assistance to help businesses navigate regulations and incentives, including industry-specific expertise. FOR/ Maine and Maine Technology Institute should continue their collaborative effort to attract the most viable, commercially relevant forest industry technologies.

1C. Accelerate innovation in new forest products and applications to strengthen Maine's leadership position and diversify our forest products economy. Maine must continue to support the University of Maine's role as a research and development partner to the forest products industry, as well as encourage and expand private research and development in the forest products industry. The state should invest in research and development that leads to commercialization of new bio-based forest products, and increase efforts to attract the manufacturing of those products.

1D. Improve the attractiveness of Maine for new capital investment in the forest products industry. We need to make the state more attractive for investment by making our regulatory environment more predictable for investors and addressing the high energy prices that discourage investment in manufacturing facilities by examining the component costs of power, transmission and distribution.

1E. Maine's forest products industry is interdependent. Maine needs to encourage markets for sawmill residuals so that the forest can be managed responsibly. We must take advantage of new wood products and applications that use residuals and low-value wood, including ensuring that advanced biofuels made from Maine's naturally regenerating forests qualify for the federal Renewable Fuel Standard.

1F. Sawmill residuals and low-value wood can be used to generate heat and electricity for Maine homes, businesses and institutions, with significant and ongoing positive economic impact in the state and across the forest industry supply chain. Modern wood heat systems burn wood chips or pellets at stable, cost-competitive prices using a local, renewable resource. Combined heat and power facilities can provide lower cost and value-added opportunity for manufacturing co-locations to take advantage of the heat and electricity they generate.

1G. Improve transportation and logistics infrastructure for moving Maine wood and value-added wood products to markets. FOR/Maine is working with the Maine Department of Transportation to identify priorities for capital investments, including existing highways, haul-route upgrade projects

and forest transportation facilities and equipment. To ensure Maine stays competitive, we need a long-term funding strategy to make critical investments in the rail, road and port infrastructure necessary to cost-effectively move wood out of the forest and wood products to regional and global markets.

Goal 2: Manage the wood resource using sustainable and responsible forest management practices. Our forest resource is our greatest asset. Long-term responsible forest management of Maine's diverse forest resources provides opportunity for increased and more efficient use of the resources. The key strategy to achieve Goal 2:

Strategy 2A: Use accurate and current data about Maine's forest to inform investment and monitor sustainability. In order to continue to sustainably harvest wood from Maine's forests for forest products manufacturing, we must maintain and communicate current data about wood resources, ensure that wood harvest and growth will remain in long-term balance by updating forest modeling every 10 years, and use that data to ensure that the forest is managed to maintain Maine's forest stewardship legacy.

Goal 3: Prepare the workforce for the future of the forest products economy. Maine needs a skilled workforce in order to attract new forest products opportunities. This includes providing incumbent workers with new skills, as well as attracting new workers for emerging products manufacturing. Strategies for Goal 3:

3A. Attract young people into the industry. The industry needs to market job opportunities and partner with schools and post-secondary institutions in Maine to establish pathways to careers in Maine's forest industry.

3B. Ensure that new, replacement and incumbent workers have the skills needed for existing jobs. The industry needs to assess the need to replace retiring workers and develop a recruitment plan for skilled replacements.

3C. Prepare the workforce for emerging products and technologies in the forest products industry. We need to identify the skills needed for employment in the emerging industry and work with education and training providers for training, retraining and recruitment of skilled workers.


Goal 4: Increase prosperity in Maine forest economy communities, especially those in rural Maine, including those affected by mill closures. Maine's working forests provide jobs, including forestry, logging, trucking and manufacturing jobs, as well as indirect employment in the local businesses that provide supporting goods and services. Strategies for Goal 4:

4A. Strengthen Maine's capacity for local, regional, and state community and economic development. We must work closely with economic development entities across the state to attract capital investment using a coordinated approach.

4B. Encourage community efforts to create conditions that attract diverse investment, including efforts to redevelop mill sites and improve broadband and other infrastructure. We need to support community efforts to improve the quality of place and make Maine communities a place where people want to live and work. We must support local and regional efforts to attract investment and grow job opportunities by providing technical and funding support through agencies such as the Rural Manufacturing and Industrial Site Redevelopment Program.

4C. Leverage community incentives to support these efforts. We need to help local communities utilize available economic development tools such as Pine Tree Zones, Tax Increment Financing, federal Opportunity Zones and expedited permitting to attract capital investment.

4D. Leverage federal resources to support these efforts. We must engage with federal agencies to support economic and community development.



Goal 5: Organize the forest products industry with committed public sector partners, including the University of Maine, to implement the FOR/Maine vision for a thriving and diverse forest products industry. This will take persistent, organized and focused efforts. Strategies for Goal 5:

5A. Develop and communicate an ambitious forest based economy strategy. To position Maine as a leader in the global forest bioeconomy, we need a clear, focused and sustained commitment from all partners.

5B. Continue to work together to ensure the recommendations are implemented and stakeholders remain engaged, committed and supportive of each other. The FOR/Maine collaborative will develop the appropriate governance structure to oversee the implementation of this plan. This collaborative of industry, education, nonprofit and government leaders must work with Maine state government to ensure appropriate levels of public investment, regulatory control and marketing and promotional leadership.

FOR/Maine has finished its preliminary data-gathering phase and released its goals and strategies in the Forest Opportunity Roadmap. The next phase of FOR/Maine's work will move this process from fact-finding to implementation. We are moving forward to commercialize new uses of wood and place Maine as the global center of wood technology innovation. We are developing a marketing plan to bring more capital investment to Maine, and we are building a communications plan to promote career opportunities in a resurging forest industry. Together, we are realizing the next generation of Maine's great forest economy.

We invite you to review the coordinated research that forms the basis of these goals and strategies.

Wood Supply and Sustainability

Maine's 17 million acres of forest represent an abundant, diverse and renewable resource. In order to position Maine's forest products sector to meet changing global demands, attract appropriate investment and grow the forest economy, the Forest Opportunity Roadmap (FOR/Maine) coalition conducted research into the potential for sustainable expansion of the wood supply by assessing Maine's current wood supply and analyzing future sustainable wood harvest capacity over the next 50 years.

FOR/Maine's report, *Maine Wood Supply and Projections Study* (May 17, 2018), provides data on the current inventory of Maine's six major commercial species and projections for the capacity of each for sustainable expansion. The report outlines the current status of Maine's forest resources, land ownership patterns, and resource potential by species and region. The results of the wood supply analysis support FOR/Maine's long-term vision to grow Maine's forest economy by 40 percent, or by \$12 billion in economic impact, by the year 2025.

Methodology

The United States Forest Service's Forest Inventory Analysis (FIA) provides solid baseline data on existing forest resources and historic trends. However, FIA data has limitations when used to predict future forest inventory. This study used the FIA data as the basis and employed growth models widely used in the industry, using modeling constraints that reflect real-world conditions and trends, to study the supply and potential of six major commercial species. Using 2017 as the baseline, the report models forward in 10 five-year periods to predict the level of sustainable harvest for each commercial species over the next 50 years. Though there are multiple definitions for the term "sustainable," the modeling constraint used in this study is the amount of wood that could be harvested while maintaining a non-declining inventory.

Given Maine's geography and forest diversity, and the fact that modeling data is most useful when applied over larger regions, the study divides the state into four mega-regions: Northern (Aroostook, Piscataquis and Somerset counties, with 8.1 million acres of timberland); Eastern (Penobscot, Hancock and Washington counties, with 4.2 million acres); Western (Franklin and Oxford counties, with 2.1 million acres); and Southern (York, Cumberland, Androscoggin, Sagadahoc, Kennebec, Lincoln, Knox and Waldo counties, with 2.2 million acres). Approximately half of the state's timberlands are in the Northern region, a quarter in the Eastern region, and about an eighth are located in the combined Southern and Western regions.

Current Status: Diversity of the Forest Resource and Ownership Patterns

Land ownership is a major consideration in determining the commercial availability of wood predicted during modeling. Differing land management goals and priorities impact harvest levels. The report identifies four primary forest ownership groups:

- Large private landowners (primarily corporate, industrial, large family and institutional) representing 53.9 percent of Maine's timberlands;
- Small private landowners who own less than 500 acres, representing 40.2 percent;
- Federal lands (including national forest, parks, Department of Defense, and other federal lands), comprising 0.4 percent;
- Other public lands (including state, county and municipal/local government lands), representing 5.5 percent.

FOR/Maine discounted the modeled growth capacity for each type of ownership to reflect a more realistic percentage of potential harvest. Federal lands were discounted by 100 percent for all species since none is considered working forest. Other public lands were

discounted by 30 percent for all species, as harvest on public lands is one of many planned uses, not all of which require harvesting. Small private lands were discounted by region (for hardwood only) with 50 percent of harvest considered unavailable in the Southern region and 20 percent unavailable in each of the other three regions. These discounts are a tool used by FOR/Maine for planning purposes to predict a more realistic level of harvest across ownership types and regions.

Resource Potential by Species and Region

The report analyzed the six major categories of commercial species groups in Maine and the potential for increases in sustainable harvesting for each.

Spruce and fir: One quarter of all commercial timber in the state is spruce and fir; 82 percent of that resource grows in the Northern and Eastern regions. FIA data show this resource increased by 10 percent between 2000 and 2008 across all regions of the state and across all owners. The analysis shows that there is a significant opportunity for expanding the sustainable harvest of spruce and fir, with more than 3 million tons of potential spruce and fir available annually. The expanded availability of merchantable spruce and fir is due to the species rebound after the major spruce budworm infestations in the 1970s and early 1980s.

FOR/Maine's modeling predicts that the spruce and fir harvest could be sustainably increased over the next 25 years by 84 percent, to 5.9 million green tons per year, with a continued increase to 7.6 million green tons in years 26 through 50. The most significant harvest expansion in the 50-year model is seen in the Northern region (59 percent), followed by the Eastern region (25 percent), the Western region (10 percent), and the Southern region (10 percent). When discounts for land ownership described above are applied, the modeling still shows a potential increase in sustainable harvest of spruce and fir of 5.8 million tons per year over the next 25 years and 7.5 million tons per year in years 26 through 50.

Pine: This species comprises 11 percent of merchantable wood volume in Maine; small private landowners own 70 percent. Two-thirds of this land is located in the Southern and Eastern regions and clustered near the coast. Modeling shows that the harvest could sustainably be increased by 56 percent. Discounting 100 percent of federal lands and 30 percent of other public lands would still allow an increase of 50 percent above 2017 harvest levels.

Historically, 70 percent of the pine harvest was for lumber and 30 percent for pulpwood. Pulpwood demand has decreased in recent years, but this use, and pine's use as sawlogs, should see gains. Since small private landowners hold 70 percent of the pine volume, the increased availability of pine will depend on their willingness to harvest at a rate of annual growth.

Cedar: Stocks of this species are scattered across the northern two-thirds of the state. These resources meet the current demand, which is primarily for fencing, cedar homes and shingles. Because of gaps in harvest data, it is difficult to adequately model this species group. FOR/Maine's analysis shows that cedar stocks will be shrinking, aging or both. No significant pipeline of younger stands exists, so projections show that cedar will continue to decline gradually. Based on these results, FOR/Maine recommends for planning purposes that this resource is sustainable at current harvest levels.

Other softwood: Although use of other softwood—mostly hemlock used for pulpwood—has seen declines, the inventory has remained constant or gained slightly over the past two decades. Modeling shows that, starting immediately, the harvest of hemlock could sustainably increase to 1.42 million tons per year, or an increase of 89 percent over 2017 harvest levels. Again discounting federal lands by 100 percent and other public lands by 30 percent, the model shows a capacity to increase harvest by 84 percent. As with pine, the increased capacity of this resource is concentrated in the small private landowner category, at 54 percent of the timberlands.

Mixed dense hardwood: For small private landowner timberlands, the model predicts that this category could be sustainably increased by 78 percent; however the number drops to 48 percent if estimates of unreported firewood harvests are factored in across all lands and all commercial hardwood species. For mixed dense hardwoods, landownership type is a factor in harvest potential. Given management practices and consumption levels on large, industry-owned lands, the harvest could be maintained at current levels with minimal expansion.

On small private lands with lower harvest levels of mature stands, there is potential to sustainably expand harvest. Hardwood stands on small private lands are more weighted to older trees, and the report suggests this may indicate that not all landowners are harvesting on their lands. Growth rates for hardwood

are expected to increase over time as the vigorous young forests in the North reach merchantable size. This may increase inventory and available harvest volume in the future.

Even after discounting harvest levels by ownership and region as described above, the model shows the potential for an increase in harvest capacity for mixed dense hardwoods of 7.4 million tons per year for the first 25 years and 7.8 million tons in years 26 through 50. This scenario would require that 39 percent (or 2.9 million tons per year) of the increased harvest would come from small private lands.

Aspen: The inventory of aspen is declining overall, so there is no significant opportunity for industry expansion. Modeling shows that the resource is sustainable at 2017 harvest levels, and 60 percent of projected harvest would be from small private lands. Aspen are now only a minor component of mixed hardwood stands and too scattered to be harvested separately economically. Most of the aspen harvested in Maine is used for pulpwood or oriented strand board (OSB).

Opportunities to Grow and Diversify

One of the guiding principles of the FOR/Maine strategic plan is the recognition that Maine's forest products industry is highly interconnected and interdependent. The success of each industry subsector—landowners, loggers, truckers and mill owners—depends on the health of the entire sector. With Maine's forests 90 percent privately owned, and 54 percent of these timberlands under industry ownership, changes in the large landowner sector will impact resource projections and industry needs.

The FOR/Maine wood supply analysis shows significant opportunity for sustainable expansion of the wood harvest in Maine, most notably in the spruce and fir species. Recognizing this potential, the goal of the Forest Opportunity Roadmap is to expand Maine's forest products sector by 40 percent, to reach \$12 billion in economic impact by the year 2025. This can be accomplished while managing the state's wood resource using sustainable and responsible forest management practices, the second goal of the Roadmap. With an ample, renewable wood supply, Maine can be a global leader in a diverse forest products economy that provides good jobs to support vibrant Maine communities.



Global Market Analysis and Benchmarking

In order to grow and prosper, Maine's forest products industry must embrace the global economy and adapt to rapidly changing global markets. As part of its two-year coordinated research and strategic planning, FOR/Maine conducted market research to identify which current and emerging forest products will fill the gaps in Maine's forest products supply chain and create a diverse mix of products to capitalize on the state's abundant forest resources.

Wood is a sustainable, renewable resource, and FOR/Maine's wood supply data shows Maine can sustainably increase the harvest of softwoods. FOR/Maine's market analysis focused on the best current and emerging softwood-based industrial products to position the sector for growth. The benchmarking study identified the state's competitive advantages and its ability to competitively produce the products identified in the marketing study. The information from these studies provides a foundation for a focused and coherent strategy to grow Maine's forest products industry and make it competitive in the global marketplace.

Global concerns about climate change have stimulated new markets for sustainable wood products, including construction and packaging materials, which can replace petroleum-based products and have potential for carbon sequestration. The global demand for environmentally sustainable products has driven governments, industry and venture capitalists to investigate the potential of plant-derived chemicals. Maine's forest products industry already has the infrastructure in place to harvest trees sustainably and convert this resource into a variety of products.

Sawn timber has been the backbone of Maine's forest products industry. Other products, such as a group collectively known as cellulosic nanomaterials, are less well known but offer great potential. Cellulosic materials are byproducts of current manufacturing, so they provide the opportunity to diversify as well

as use materials that would otherwise be wasted. When the technology to produce cellulosic materials is added to existing mills, the mills can expand production with higher-value products that also use materials efficiently, sustainably and economically.

Global Market Analysis

FOR/Maine evaluated 21 established and emerging softwood-based industrial products for their suitability for Maine: sawn timber, laminated veneer lumber, oriented strand board, medium density fiberboard, white pellets, wood plastic composites, bio-plastic composites, biochar, activated carbon, dissolving pulp, nanocellulose, polylactic acid (PLA), lactic acid, succinic acid, furfurals, levulinic acid, lignin, pyrolysis oil/bio crude, 2G ethanol, lignocellulosic biobutanol and xylitol.

Each of the initial 21 products were analyzed and scored using the following criteria: Markets (U.S. and global) and anticipated growth; competition; barriers to entry; product opportunities; and product constraints. Product fit within the forest industry cluster in Maine was an important factor. Selected products ideally would increase use of Maine's sustainable softwood supply; provide markets for residues of current industry; provide long-term, sustainable high-value employment for Maine workers; and produce products profitably for local, regional or global markets.

The members of the FOR/Maine collaborative who have knowledge of the industry in Maine discussed initial results of the global market study. Considering that sawn timber is a healthy, well-established industry; two oriented strand board facilities are currently in operation; and cross-laminated timber is already being considered for investment in Maine, it was decided that additional study would focus on newer products such as emerging bio-based products and engineered construction materials. Cellulosic sugars and pyrolysis oil were added to the

list because they are platform materials for other emerging bio-based wood products and are key building blocks for a growing bioeconomy.

Therefore, further study evaluated the state's advantages to produce and competitively market these six selected products: **Dissolving pulp; laminated veneer lumber (LVL); medium density fiberboard (MDF); nanocellulose; cellulosic sugars; and pyrolysis oil.** For three of these six products—dissolving pulp, nanocellulose and pyrolysis oil—a strengths, weaknesses, opportunities and threats (SWOT) analysis was also done.

Global Benchmarking

The benchmarking portion of the study compared Maine's advantages with respect to the six selected products with eight competitive regions that produce and market these forest products: three other states (Georgia, Minnesota and Oregon) and five countries (Canada [Ontario], China, Finland, Germany and Russia).

Each of the six products was ranked using nine indicators weighted for each product depending on its relative importance to that product. The nine indicators were: raw material availability; cost of raw material; cost of labor; skill of the labor force; logistics and transportation; regulatory climate; enabling environment; energy cost; and taxes.

The benchmarking analysis shows that Maine has five competitive advantages in four of these nine indicators:

- *A plentiful and sustainable supply of moderately priced softwood raw material and large private land ownership* (cost of raw material and raw material availability). The chief advantage of large private land ownership, a unique asset among the compared market regions, is the ability to rapidly adjust to market changes.
- *A skilled labor force and existing harvest and logistics infrastructure* (logistics and transportation). The study suggests that high worker productivity and focusing initially on the highest value products and products with a lower labor-cost-per-product value will counteract comparatively higher labor costs.
- *Proximity to very large population centers in the Northeast* (logistics and transportation). While some products such as dissolving pulp, nanocellulose

and cellulosic sugars are traded on international markets, medium density fiberboard, laminated veneer lumber and pyrolysis oil are considered regional products. Pyrolysis oil has the potential for replacing heating oil and fossil-based jet fuel; both would benefit from the large Northeast market. Investments in transportation infrastructure such as improved railways and seaports would enable the industry to take better advantage of Maine's location near large markets.

- *Maine's world-class research and development capacity at the University of Maine* (enabling environment). The University of Maine's Process Development Center, a research program with a pilot production facility, was established in conjunction with the U.S. Forest Products Laboratory in 2012. The Center is at the leading edge of the research and development in forest products and currently works with some of the largest companies in the world, putting Maine in a strong position to be a global leader in the production and development of nanomaterial. The state could attract more corporate research and development in this field of products.

The University's Forest Bioproducts Research Institute is a global research and development leader in nanocellulose science. The institute shares individual types of this product—nanofibrils, cellulose nanocrystals, and tempo-oxidized nanofibers—with researchers, laboratories, companies and other educational institutions all over the world for study and commercialization.

Cost and availability of raw material

The downsizing of the pulp and paper industry has created lower prices for wood, so the cost of raw material is a comparative advantage for Maine. Forest ownership and accessibility to wood were considered when assigning ratings for raw material availability. Maine is uniquely situated in comparison to the other eight regions studied to significantly increase its sustainable wood harvest. Wood supply data shows that the state's annual harvest is only 46 percent of its annual allowable cut; the spruce harvest is an area of particular potential. In addition, most of Maine's timberlands are majority owned by corporations and private families, with the ability to quickly adjust to market demands, making the wood more readily accessible.

Finland, Germany, Russia and China are not situated to expand their harvests for a variety of reasons. Russia's resources are remote and not readily accessible. Finland is close to its annual sustainable harvest limit, and timberland ownership is fragmented, with small private ownership that restricts industrial-scale wood harvesting. In Germany half of the timberland is privately owned and half of these properties are small. The political climate in Germany also largely precludes expansion of the wood harvest. China is already dependent on imports for its wood supply.

In the United States, Oregon is already expanding its harvest to fulfill its high level of exports to China and Japan. Georgia is already importing some roundwood, and private families that will see significant generational turnover in the next decade largely own the state's commercial forestland. Minnesota has the potential to increase harvest, but more than half of the timberlands are in private hands, with small landowners typically owning less than nine acres, and those landowners not always willing to sell their wood.

Labor cost and skill levels

The benchmarking indicator "cost of labor" was determined by its relative share of end-product cost. In the pulp and paper industry, Maine's labor costs are the highest of all compared regions due largely to social costs and benefits, such as insurance. In other woodworking industries, including sawmills, engineered wood, plywood and veneer production, wood preservation, fiberboard and particleboard production, Maine is comparable to Georgia, with the third highest labor costs of the four U.S. regions. The highest levels of worker productivity in the pulp and paper industry, and in sawmilling, are found in the U.S., Finland and Canada. High productivity compensates, in part, for high labor costs.

The level of education and specialized skills required and available determined the skill of the labor force indicator. A skilled forest industry labor force is a competitive advantage for Maine. The labor skill weight was determined by using the general level of education and skills needed to produce the end product. Historically, education levels have not been a factor in the forest industry, but increased levels of technology and automation have increased the necessary skills, especially in the bio-refinery mills.

Education level comparisons between countries are difficult given the differences in educational systems and terms, but the U.S. regions are all comparable.

Logistics

The cost of logistics and transportation in relation to access to end markets includes the cost of inland truck transportation, sea freight transportation, and rail freight transportation. Products consumed locally were given higher scores. Maine's location is a key advantage, as transportation costs to Boston and the large U.S. Northeast markets are the lowest of the regions. In terms of Chinese markets, Maine's seaports make shipping to this market competitive.

Policy

The regulatory climate indicator assesses the position of each product with respect to regulations that govern forestry, environment, emissions and construction. Products with processes that have high emissions, such as medium density fiberboard and dissolving pulp, received higher scores for the weight of this factor in their production. The weights were determined by the position of the product within the regulatory climate and the weight for each product. Maine's regulatory climate is, overall, considered neutral.

The enabling environment indicator includes policies and incentives regarding research and development. For state-of-the-art products, this indicator was considered to have a higher relevance because of dependence on public policies. For Maine this is rated "medium" in incentives and logistics infrastructure and—because of the University of Maine—high in research and development. Maine is rated low in access to financing because, of the four U.S. states, it has the lowest access to foreign direct investment and venture capital.

Energy weights were based on the cost of industrial energy when compared to the overall cost in the end products, and was of low significance across the board among the regions. Taxes were also considered to be of low weight for all products because the corporate tax, which is most relevant, is approximately equal across all the regions.

Results for Maine's Top Six Products

For each of the six products, Maine was compared with other regions that produce each product. (Not all of the regions produce all six products.) The higher each region's total score for each product, the stronger the competitive advantages are for that region. Each region's score, from one to five, with one being not an advantage for an indicator and five being the highest competitive advantage, was then multiplied by the one-to-five product ranking; these indicator-times-product ranking scores were combined, by region,

for a final score for each product in the regions that produce that product.

For example, in the table below, for dissolving pulp, for the indicator "raw material availability," the weight of that indicator for that product is a 5, and Maine's advantage score for that product is 3, so those multiplied is 15, and that would be added to the results of all of the factors to derive the score for that product for Maine. So, for dissolving pulp, the total score is 73, and that is then compared to the total scores of the other countries that produce that product.

Dissolving pulp comparative advantage score by country/region

Indicator	Weight	FIN	RUS (NW)	CAN (ON)	US (GA)	US (ME)	US (MN)
Raw mat. availability	5	2	2	4	2	3	2
Raw mat. cost	4	2	5	2	4	4	4
Labor cost	2	3	5	4	1	1	2
Labor skill	3	4	1	3	2	3	3
Freight/infrastructure	2	3	2	2	3	3	3
Regulations	3	3	2	3	4	3	3
Taxes	1	4	4	3	3	3	2
Enabling environment	3	4	1	3	4	3	3
Energy	2	3	5	4	4	2	3
Weighted score		73	70	78	75	73	71

Source: INDUFOR: 8117 FINAL REPORT WITH EXECUTIVE SUMMARY AND RECOMMENDATIONS (ID 123240) – August 23, 2018

1. Dissolving pulp is a chemically produced, bleached wood pulp used mainly in the textile industry. It is different from the pulp used in papermaking. It is also used for ethers and filament as well as specialty applications for casings, tire cord and cellophane. Hardwood dissolving pulp is used for textiles such as viscose. Softwood dissolving pulp is used mainly for ethers and acetate. As seen in the table above, the total benchmark score for dissolving pulp for Maine is 73, making the state competitive with the other U.S. regions, Finland, Russia and Canada.

Some softwood dissolving pulp mills are integrated with other products, such as bio-refineries, and this is a path Maine could take. Maine has an abundance of conifers, but softwood produces lower yields. Production methods are expected to improve, and the market for this product is expanding rapidly. China consumes 40 percent of the dissolving pulp produced globally for its textile industry. However, China's government and duties will continue to make competing in this market a challenge. Market demand for dissolving pulp is very high and growing, but so is competition.

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A few companies dominate the dissolving pulp market. Sappi is the largest producer, supplying 17 percent of the global demand from its two mills in South Africa and one in Minnesota. There are several expansions of mills planned around the globe, and the major competition for this fabric is cotton. Production of dissolving pulp requires technical expertise, and there are high capital costs. The market opportunities

for Maine reside in the conversion of existing paper-grade mills, which would take two to four years as compared to three to seven years for a new mill, at a substantially lower capital cost.

Given the typical size of a modern dissolving pulp mill, the availability of raw material is a critical factor. Maine has a comparative advantage in raw material and cost, as well as an existing pool of skilled labor and the presence of the University of Maine. Because dissolving pulp is traded internationally, affordable freight rates (to reach the East Coast) and competitive sea rates (to reach markets in China and Europe) are also important advantages. The state performed well for this product in most areas when compared with other regions.

Some of the competitive disadvantages include higher labor costs, but the high productivity of Maine's pulp and paper employees (one of the highest in the U.S.) is an advantage that largely negates the issue of labor cost. Energy costs are also on the high side, but the weight of that indicator is relatively low, so the rank does not detract significantly from the final rating.

A "strengths, weaknesses, opportunities and threats" (SWOT) analysis was done for three of the top six products, including dissolving pulp. The SWOT diagram can be found in the Appendix.



2. Nanocellulose is among the most attractive options for Maine. The expected market for nanocellulose is significant, with an annual growth rate estimated to be 30 percent during the period 2016 to 2021. Commercialization has just begun, but already the market is highly competitive. As seen in the table below, the competitive ranking for nanocellulose is 72, placing Maine in a strong position. Only four regions—Maine, China, Germany and Finland—were scored for this product; Maine placed second in the overall rankings.

Nanocellulose is derived from plant cellulose, with properties that make it adaptable to a variety of applications from packaging to textiles to medical products. The different forms of nanomaterials

are also collectively referred to as cellulosic nanomaterials. Nanocellulose can be manufactured for industrial applications in large quantities at a relatively low cost. It is even being considered as a sustainable alternative to flooding agents used in the oil and gas industries.

Nanocellulose, currently used as fillers and additives in packaging, is commonly divided into three groups:

- Nanofibrillar cellulose, made mainly from wood pulp, has chemical properties that make it suitable for strength, reinforcement and rheology (flow and deformation) modification. Nanofibrillar cellulose is an alternative to resin and synthetic thickeners, and it can be used to strengthen plastics.

Nanocellulose comparative advantage score by country/region

Indicator	Weight	FIN	GER	US (ME)	CHN
Raw mat. availability	3	5	3	5	2
Raw mat. cost	2	2	2	4	1
Labor cost	2	3	4	1	5
Labor skill	4	3	3	4	2
Freight/infrastructure	1	3	4	3	4
Regulations	2	3	3	3	2
Taxes	1	4	3	3	3
Enabling environment	5	4	4	3	5
Energy	2	3	2	2	1
Weighted score		76	70	72	64

Source: INDUFOR: 8117 FINAL REPORT WITH EXECUTIVE SUMMARY AND RECOMMENDATIONS (ID 123240) – August 23, 2018

- Cellulose nanocrystals, also made from wood pulp, have optical, electrical and chemical properties that allow ample customization; this product is used in composites, packaging, paper, electronics, 3D printing, textiles and medicine.
- Bacterial cellulose is a thick, gel-like material produced through bacterial biosynthesis; this form of cellulose has a wide range of applications including food, biomedical and tissue engineering.

A commercial nanocellulose facility would likely be integrated into an existing pulp mill and use the mill's byproducts as raw material, and Maine has ample resources to meet the need. Availability and price are comparative advantages, as are the skilled labor force and the University of Maine's research and development in applications for this material. Maine's enabling environment is average compared to other regions in the U.S., but with aggressive policies and bioeconomy strategies to attract investment, this rating could be improved.

One difficulty in analyzing this group of products is that there is no standard terminology, as production is still in the early days of commercialization. The potential is considerable, especially in paper and paperboard applications, where nanocellulose could gain 5 percent of the market value. It's a highly competitive product globally, and current commercial applications are scarce, but the University of Maine is already a key player in the market, and a growing demand for packaging will be a factor.

New applications for nanocellulose are continually emerging from the biomedical, construction, electronics, oil and gas industries. Nanocellulose presents an attractive opportunity even with constraints such as the high cost of production. A SWOT analysis was done for nanocellulose, and this can be found in the Appendix.

3. Laminated veneer lumber (LVL) is an engineered wood product made of multiple layers of dried wood veneer bonded under heat and pressure with glue on the face. LVL has been produced since the 1970s. Nonstructural LVL is used primarily in furniture, stairs and balustrades; it is made mostly of softwood or softer hardwoods such as poplar. Structural LVL is

used in construction and load-bearing applications. It is made with softwoods such as Douglas fir, larch, hemlock, southern yellow pine, spruce and radiata pine; a few mills use hardwood.

As seen in the table below, Maine's overall score for Laminated veneer lumber (LVL) is 62. Businesses in the state are already showing great interest in LVL because demand for the product has increased. Markets have grown on average 7 percent per year, with North America the largest market. A mill would have average dependency on raw material, and Maine has the necessary supply. Maine also has the advantage of being close to large end markets in Boston and Toronto.

Most LVL manufactured in the U.S. is structural LVL. Existing sawmills could easily adapt to manufacture this material. The demand for this product is tied to the residential home construction market. Nearly all North American demand is filled domestically through regional markets. Currently, 12 companies in North America operate 21 mills, with only two mills located in the Northeast. The three largest producers are Boise-Cascade, Weyerhaeuser and Louisiana-Pacific.

LVL comparative advantage score by country/region

Indicator	Weight	FIN	RUS (NW)	CAN (ON)	US (GA)	US (ME)	US (OR)
Raw mat. availability	3	2	4	4	2	3	2
Raw mat. cost	5	2	4	3	4	2	1
Labor cost	3	3	5	3	2	2	2
Labor skill	2	3	2	3	3	3	3
Freight/infrastructure	4	2	1	2	4	3	3
Regulations	2	3	2	3	4	3	3
Taxes	1	4	4	3	3	3	3
Enabling environment	2	4	1	3	4	3	3
Energy	2	3	5	4	4	2	4
Weighted score		63	75	73	81	62	58

Source: INDUFOR: 8117 FINAL REPORT WITH EXECUTIVE SUMMARY AND RECOMMENDATIONS (ID 123240) – August 23, 2018

A Louisiana-Pacific mill in Houlton, Maine, produces a similar product, laminated strand lumber. It is the only mill producing laminated strand lumber in the U.S., and sales have been increasing. The research suggests that there is a market opportunity for an LVL mill in Maine. However, national and global issues could have an impact on Maine's opportunity. If mothballed plants outside the Northeast U.S. were to restart operations, Maine would have to reevaluate entering the market. Internationally, Great Britain's exit from the European Union will open a potential market, but as that market is highly competitive, the product would have to be competitively priced.

4. Medium Density Fiberboard (MDF) is a reconstituted wood-based panel made of either hardwood or softwood. It can be worked, molded and formed while maintaining a high-quality finished surface. First developed in the 1960s, it is very popular globally, with its major use in flooring. Because of its homogeneous structure, ease of use, and high-quality finish, it is also used in furniture. In Canada it is used in construction. There are currently no MDF production facilities in Maine.

The table below shows that Maine's benchmarking score for MDF was 67, about the middle of the pack when compared to seven other regions studied. Global production is strong, especially in China. In the U.S. and Canada, annual market growth of 3 percent per year is expected over the five years from 2017 to 2022. Maine's proximity to large markets in the Northeast U.S. is an advantage, and the potential for this product would improve with infrastructure improvements.

Currently, the U.S. is a major importer of MDF, with imports supplied mainly by Canada, China, South America and Europe. Exports of American-made MDF are slowing due to strong demand in the U.S. market, and the use of MDF in the U.S. is expected to increase. Pulp mill and sawmill residues can be used for MDF, so the location of a mill here would be a complementary use of mill byproducts, and Maine's supply of inexpensive raw materials is a key advantage. Producing MDF is energy intensive, so a source of competitively priced power is important. Higher labor costs are a disadvantage, but again, higher labor productivity ameliorates this issue.

MDF comparative advantage score by country/region

Indicator	Weight	FIN	GER	CAN (ON)	US (GA)	US (ME)	US (MN)	US (OR)	CHN
Raw mat. availability	3	4	3	4	3	4	2	3	1
Raw mat. cost	4	2	3	2	3	3	3	1	2
Labor cost	3	3	3	3	1	1	2	3	5
Labor skill	3	3	4	3	2	3	3	3	3
Freight/infrastructure	4	1	5	2	4	3	3	3	5
Regulations	3	2	2	3	3	3	3	3	2
Taxes	1	4	3	3	3	3	2	3	3
Enabling environment	1	3	4	3	4	3	3	3	4
Energy	2	3	2	4	4	2	3	4	1
Weighted score		61	79	69	70	67	65	66	70

Source: INDUFOR: 8117 FINAL REPORT WITH EXECUTIVE SUMMARY AND RECOMMENDATIONS (ID 123240) – August 23, 2018

5. Pyrolysis oil is a liquid fuel that can serve as a substitute for petroleum products in heat and power production. This bio-oil is produced when biomass—including wood chips and sawdust, which might otherwise be considered waste—is rapidly heated in an oxygen-free environment to a prescribed temperature and then rapidly cooled. This product can also be used as a platform to develop other high-value chemicals. Pyrolysis oil was not included in the marketing study but was added to the list for benchmarking.

In the table below, Maine's score of 70 for pyrolysis oil places it in the middle of the pack compared to the five other regions that produce this product. The study shows that Maine could compete most promisingly in regional markets.

Pyrolysis oil from biomass can be used as a substitute for petroleum in heating and transportation. Maine has an ample supply of biomass at competitive prices, using sawdust, a sawmill residue, and wood chips. Pyrolysis oil can be further refined to be used similarly to fossil diesel fuel. Environmental concerns and the push to lower greenhouse gases will open market opportunities. According to the U.S. Energy Information Administration, the U.S. Northeast

consumes 84 percent of the residential heating oil in this country, so in this region alone, the potential for a substitute for fossil fuel with a sustainable, locally sourced product is substantial.

Pyrolysis oil is lower in sulfur than fossil fuel and reduces greenhouse gas emissions by between 70 and 90 percent when compared with fossil fuel. Equipment modification to use pyrolysis oil is minimal. This fuel is easier to store than solid biomass because the volume is reduced by a factor of 12. Although this product has been used since the 1980s, the market is in its very early stages and there are only a few producers in the world. Pyrolysis oil is acidic, so it must be stored in acid-proof containers such as stainless steel. Because it would compete directly with oil and natural gas, its pricing would have to be competitive.

More research and development must be done before this product can be fully commercialized, and sustainability standards need to be established before the potential for this product can be realized fully. As in the other bio products, the advantage of the University of Maine's research capabilities is critical in considering this product for Maine. A SWOT analysis for this product can be found in the Appendix.

Pyrolysis oil comparative advantage score by country/region

Indicator	Weight	FIN	GER	RUS (NW)	CAN (ON)	US (ME)	US (MN)
Raw mat. availability	3	3	2	3	4	4	3
Raw mat. cost	3	3	2	5	2	3	3
Labor cost	2	3	3	5	4	1	2
Labor skill	3	4	4	1	3	3	3
Freight/infrastructure	3	3	5	1	2	4	3
Regulations	3	4	2	2	3	3	3
Taxes	1	4	3	4	3	3	2
Enabling environment	4	4	4	1	4	3	3
Energy	1	3	2	5	4	2	3
Weighted score		80	66	59	73	70	66

Source: INDUFOR: 8117 FINAL REPORT WITH EXECUTIVE SUMMARY AND RECOMMENDATIONS (ID 123240) – August 23, 2018

6. Cellulosic Sugars, derived from cellulose in wood pulp, are chemicals with unique properties that are integral to the emerging bio-based economy. These sugars are an intermediate step toward developing higher-value chemicals that include polylactic acid (PLA), used in bio-plastics; lactic acid to preserve food and beverages; and succinic acid, used in resins and coatings. The sugars can also be used as a base for ethanol for fuel and are thought to avoid the dilemma posed by burning a corn-derived product, which is seen as burning food. (Cellulosic sugars were not included in the marketing study, but were added for benchmarking during discussions with industry stakeholders.)

The study concludes that Maine's benchmarking score of 69, shown in the table below, could be improved with a focused bioeconomy strategy that would also take advantage of the significant and ongoing research and development work at the University of Maine.

Production of cellulosic sugars would likely be folded into an existing mill, and there is an ample supply of lower-priced raw materials in Maine. Although the score for Maine for this product is not the highest of

the countries analyzed, the product is considered a platform material for the bioeconomy and should be considered for Maine.

Sawn Timber, structural lumber sawn from softwood, was not included in the benchmarking study, but the marketing study shows it is still a top product for Maine. It is a natural material with a lower carbon footprint than steel or concrete. The most common use for this product is in wood framing for U.S. residential construction. Given unfavorable exchange rates with Canada, the market for Maine lumber lies in the United States. The U.S. market for sawn lumber is the most relevant market option for Maine.

The market has seen continued growth since 2009, but it has yet to reach the peak from a few years earlier. Overall, the market is expected to grow; the expected annual growth rate is 4 to 5 percent over the next five years. The mills in the U.S. Midwest and the Northeast generally serve the markets within their regions. Due to the large number of companies in each area, there is no centralized control over the market, and this is also true of the log suppliers. Existing companies build most mills. Overall, there are no other materials that would threaten the dominance of lumber in home construction.

Cellulosic sugars comparative advantage score by country/region

Indicator	Weight	FIN	CAN (ON)	UG (GA)	US (ME)	US (MN)	CHN
Raw mat. availability	4	2	4	2	3	3	1
Raw mat. cost	3	2	2	4	4	4	1
Labor cost	2	3	4	1	1	2	5
Labor skill	3	4	3	2	3	3	2
Freight/infrastructure	2	3	3	3	3	3	4
Regulations	3	3	3	4	3	3	2
Taxes	1	4	3	3	3	2	3
Enabling environment	4	4	3	4	3	3	5
Energy	2	3	4	4	2	3	1
Weighted score		73	77	73	69	72	62

Source: INDUFOR: 8117 FINAL REPORT WITH EXECUTIVE SUMMARY AND RECOMMENDATIONS (ID 123240) – August 23, 2018

Prices can be volatile based on supply, demand and inventories, and are impacted by duties between Canada and the U.S. Increased production in other lumber-producing regions has been limited by the availability of timber. The outlook for U.S. softwood lumber looks strong, and there is a strong opportunity for increased lumber production in Maine. One of the constraints to this growth, however, is the problem of mill byproducts, and increases to mill production are heavily tied to increasing the capacity to use softwood chips. (For a summary of this issue, please see Section 6, Wood Energy.)

Though **oriented strand board** (OSB) was not included in the benchmarking portion of the study, the marketing analysis shows that OSB is one of the most attractive options for Maine. Global demand for OSB is growing, so given Maine's supply of pulp-grade logs, this product would be a good fit for Maine. OSB is a structural reconstituted wood product developed as an alternative to plywood. The product is used extensively in sheathing, flooring and roofing construction. To make this product, adhesives are added to layers of wood flakes, the flakes are generally oriented in one direction per layer, and the layers are pressed into a board. A typical board has three to five layers, with each layer oriented at right angles to the adjacent layer. Both hardwood and softwood are used, usually with pulp-grade logs.

North America is the dominant market. Competition has been consolidating, and there are currently nine companies that produce OSB in North America. Greater use of OSB in construction is expected. Maine, with available softwood material, has opportunities to supply the U.S. East Coast markets. Improvement of Maine's rail infrastructure would be a plus in shipping this product to markets.

Moving Maine Forward

This multistep market research process formed the basis for key recommendations to position Maine's forest products industry for growth:

- Develop an ambitious bioeconomy strategy for the state
- Invest in key infrastructure improvements
- Identify ways to add onto or repurpose existing industry infrastructure for new products

- Support bio-energy to utilize industry byproducts and reduce energy costs
- Market Maine's competitive advantages to attract investment

A critical first step is for Maine to develop and communicate an ambitious **bioeconomy strategy**. For example, cellulosic biofuels, bio-plastics, pyrolysis oil and polylactic acid-based compostable bags all provide market opportunities that already exist and are likely to grow in the medium and long term. This market is and will continue to be highly competitive. A clear strategy is a must if the state is to compete effectively. The state must also be more proactive in attracting investment in the state's forest products industry.

Key **infrastructure investments** for Maine should include improvements to established road and rail systems, several seaports, and expanded broadband and mobile coverage. Transportation infrastructure improvements would allow the state to take full advantage of its location near large markets. Identified barriers include lack of rail services to all key sites, some problematic interstate connections, and turnpike fees. Although far from perfect, the state's infrastructure does not present an insurmountable hurdle for the development of new forest products or the growth of existing products.

There is potential to **add to existing mill production or repurpose existing infrastructure** by using co-location and commercial off-take contracts, arrangements whereby one large company buys the majority of, or the entirety of, a plant's production. With more companies committing to increased use of bio-plastics, investing in market studies to identify and target potential add-ons would support the reopening of former pulp and paper mills, especially for pilot-scale products such as nanocellulose and cellulosic ethanol. Production of these types of products can be added to existing pulp mills quicker and more cheaply than building new mills.

In the area of energy costs, the marketing analysis shows that **the state should support bio-energy** to reduce costs and utilize industry byproducts. Bio-energy includes combined heat and power at mills, as well as stand-alone biomass boilers. In addition,

conversion to pyrolysis oil where applicable would also be a step toward meeting the state's renewable energy portfolio standards.

Maine must market its competitive advantages to attract capital investment. Maine could better capitalize on the global research and development leadership at the University of Maine. The University of Maine's leadership in research and development—including all products emerging from wood biotechnology—is a major competitive advantage. If Maine develops a strong bioeconomy strategy and supports that strategy with the right incentives and access to financing, the state could draw significant investments in the emerging forest biotechnology sector. A stable regulatory system, skill retraining programs for workers to meet the requirements of the automation and digitization revolution, tax incentives, and grants for new research and development are also key strategies that would all make Maine more business friendly.

The major products for Maine include those already established, such as sawn timber, and those already showing investments or interest in the state, such as oriented strand board. Emerging products like dissolving pulp, laminated veneer lumber, medium density fiberboard, nanocellulose and cellulosic sugars, have market potential, as well as the potential to grow and diversify the industry in Maine.

A thriving, innovative and diversified forest products industry will provide good jobs for Maine people and fill global demand for environmentally sustainable products. The *Global Market Analysis and Benchmarking Study* shows that Maine has key competitive advantages for growth in the forest products industry: ample supplies of moderately priced softwood, an existing harvesting infrastructure, significant private land ownership, proximity to a large population in the Northeast U.S. and Canada, a skilled forest products workforce with strong communities that support the industry, and world-class research and development facilities at the University of Maine to help this vital sector grow.

With the right investments and policies at the right time, along with collaborative, focused and persistent efforts to leverage the state's considerable competitive assets, FOR/Maine's research shows that Maine is well positioned to maintain its status as a global leader in the forest products industry.

Emerging Technology and Markets

FOR/Maine's research shows that Maine's forest products industry is uniquely positioned with key competitive advantages: a skilled forest products workforce, existing industry infrastructure, large private landownership, proximity to large markets in the Northeast U.S., an ample supply of moderately priced softwood, and the University of Maine's leadership in research and development of wood biotechnology. Sustaining and growing the industry will require a deliberate and comprehensive strategy focused on innovation and diversification that embraces the global economy and can adapt to rapidly changing global markets.

Diversification of Maine's forest products economy requires understanding of unique and emerging applications of our forest resources. Emerging technology companies are seeking opportunity in Maine's forest economy. To stay engaged with trends and aware of new technologies, FOR/Maine established the Emerging Technologies Committee. The charge to this committee was to:

1. Analyze potential emerging technologies opportunities and inform the FOR/Maine effort on research coordination and marketability of potential new markets.
2. Integrate emerging technology efforts by Biobased Maine and the University of Maine into the forest products industry strategic plan.
3. Ensure that promising new technology opportunities are incorporated into FOR/Maine's strategic planning.
4. Develop a process to assist the industry and communities with funding due diligence and vetting of emerging technologies and opportunities.

1. Analyze potential emerging technologies opportunities and inform the FOR/Maine effort on research coordination and marketability of potential new markets.

In order to analyze potential emerging technologies opportunities and coordinate research and marketability of potential new markets, the FOR/Maine Emerging Technologies Committee partnered with Biobased Maine and Maine Technology Institute (MTI) to create an Emerging Technologies Database.

Biobased Maine is a trade association representing manufacturers, raw material suppliers, landowners, farmers, consultants, researchers, private equity and nongovernmental organizations. Its mission is to grow a sustainable bio-based manufacturing industry in Maine. The Maine Legislature founded MTI in 1999 to support Maine's innovation economy with expertise and funding for new ideas, products or methods that will grow and diversify the state's economy. MTI distributes funds bonded by the State of Maine in seven technology sectors, including Forest Products and Agriculture.

MTI and Biobased Maine are working with FOR/Maine to develop a database using publicly available information that currently includes more than 100 emerging forest industry technologies. The emerging technologies database is designed to assist economic development officials and leaders in Maine mill communities in their business attraction efforts. When complete, the database will be an important resource to these communities and to all business development agencies in the state as they identify the emerging technology opportunities that are ready for commercialization and are a good fit for Maine.

Categories of information in the database include:

- Basic Information, including the name of the company, its headquarters, the point of contact, chief executive officer, status of operations, and public trading information;
- Technology/Product or type of technology or product manufactured, byproducts for co-location opportunities, value proposition and market disruption, existing customers and off-takes, patents or licenses;

- History/Track Record, including the year founded, level of technology deployment, existing facilities, planned facilities, total funds invested in the company to date, primary investors, current joint ventures;
- Wood Resource or generation and type of wood feedstock required, and other raw material specifications;
- Facility Needs, including utility requirements, transportation requirements, energy/thermal load, and acreage;
- Community/Maine Relevance, including the number of jobs to be created, and Maine contact;
- Financing; and
- Other, including links to presentations and other resources.

In addition to the database initiative, Emerging Technology Committee members participated in national and international conferences and trade shows to expand FOR/Maine's breadth of knowledge about emerging technologies that should be included in Maine's forest economy strategy. They also gathered information on new opportunities that should be included in the emerging technologies database. Committee members focused on identifying emerging technologies that are a good fit for Maine and developing relationships with prospective companies.

Conferences of note included the Advanced Bioeconomy Leadership Conference, held in San Francisco in 2018, a gathering of the top global trade associations and major companies in the global forest products industry, as well as key government agencies and leaders in the investment and financial sectors. Also in 2018, the World Bio Markets Conference in Amsterdam, The Netherlands, one of the leading strategic conferences supporting the advancement of the global bioeconomy, brought together leaders and innovators from across the supply chain of environmentally sustainable products. Participation at these conferences proved to be an exceptional way to raise Maine's profile for global investors and to market Maine's unique competitive advantages, including its vast working forest and the University of Maine's cutting-edge forest products research and development.

2. Integrate emerging technology efforts by Biobased Maine and the University of Maine into the forest products industry strategic plan.

The Forest Opportunity Roadmap's first goal is to sustain and grow Maine's existing and emerging forest products economy. To achieve this goal and strengthen Maine's leadership in the industry requires a focus on innovation in new forest products and applications to diversify the state's forest products economy. Biobased Maine and the University of Maine are partnering with the Emerging Technologies Committee, and the ongoing work of two key players in Maine's growing bioeconomy is integral to FOR/Maine's strategic plan.

Maine must not only support policies to invest in research, development and commercialization of new forest products, the state must also attract investment in new and emerging forest products that leads to value-added production here in Maine. This research and development will lead to commercialization of bio-based forest products, including environmentally friendly chemicals and bio-plastics, textiles and advanced building materials. Existing mills can be revitalized as innovation centers and/or technology parks for both the pilot-scale and full production-scale of new products.

Since investors and entrepreneurs are already making regular inquiries into opportunities to invest in Maine, the Emerging Technologies Committee has worked to ensure that these opportunities are incorporated into FOR/Maine's strategic planning. One issue that came up repeatedly in FOR/Maine's research and work with industry stakeholders is the dearth of information on both sides of the investment equation. For investors and entrepreneurs, there has been no single point of contact for information on Maine's existing forest products infrastructure. On the state's economic development side, there needs to be a process for vetting the emerging technologies to ensure that they are the right fit at the right time for Maine and the local communities that will host them.

3. Ensure that promising new technology opportunities are incorporated into FOR/Maine's strategic planning.

The Committee worked to ensure that inquiries into opportunities in Maine's forest economy from

emerging technology companies can easily be matched with existing industrial assets through advising the development of an interactive site database. To develop this database, the Committee worked with the Sewall Foundation to identify and characterize the assets of Maine's industrial sites.

The database shows the potential for the future location of bio-based manufacturing projects, including co-locating new technologies at active industrial sites with excess capacity or new commercial-scale development at shuttered mills, or other promising industrial brownfield or greenfield locations. The database, which will be launched in its final form in 2021, currently includes 20 sites, with data on each site's environmental features, wood supply, incentives, infrastructure and other forest products economy information.

4. Develop a process to assist the industry and communities with funding due diligence and vetting of emerging technologies and opportunities.

On the community economic development side of the investment equation, there is the need to develop an approach to assist with funding due diligence and for vetting of emerging technologies and opportunities both for the industry and communities. As a model approach, the Emerging Technologies committee, in partnership with Biobased Maine, advised the development of a forest resources challenge grant through MTI. As stated in the Request for Proposals, MTI issued this grant "in recognition of this unique moment in Maine's forest products industry," and in collaboration with FOR/Maine's efforts to chart a new course for the industry.

The purpose of the grant was to encourage investment in promising technologies through MTI cost-sharing and to demonstrate success of these new ideas in Maine. The specific challenge to the technology enterprises was to deploy a forest industry technology in Maine, preferably co-located at an existing industrial facility, where forest biomass is used in the production of a value-added product for sale into a well-defined, promising market. MTI's "Emerging Technology Challenge for Maine's Forest Resources" offered grants totaling \$1.5 million to be awarded for one or more projects and required a one-to-one match.

Proposals were evaluated based on the strength of their business case and through demonstrating how the proposed technology was both innovative and responsive to market and consumer needs in a way that other technologies were not. Bidders had to demonstrate their fit with Maine in terms of feedstock needs to be met with biomass, as defined as “all grades of lignocellulosic biomass, which may include whole tree, dimension lumber, pulp wood, chips, sawmill residuals, low-grade biomass.”

Grantees had to demonstrate their technical and economic merit, showing evidence that the technology works. They had to demonstrate their economic benefits to Maine in terms of job creation and technology deployment in Maine. And, though the grantees were not required to have a Maine presence at the time of award, they would need to be registered to do business in Maine and be able to meet MTI's Maine-based requirement at the time of contract execution. Biobased Maine vetted and evaluated the proposals.

From this competitive Request for Proposals, two companies, GO Lab, Inc., and Biofine Developments Northeast, were each awarded \$750,000. In the announcement of the awards, MTI described the awardees as follows:

- The first \$750,000 award was made to GO Lab, Inc. GO Lab, a building products manufacturer in Belfast, Maine, will transform the insulation market in the next 10 years. Its insulation, made from wood fiber, is renewable, recyclable, nontoxic, and performs as well, or better than, other available insulations. GO Lab's production facility, located at the former UPM paper mill in Madison, Maine, will consume 180,000 tons of softwood chips annually, create 100 jobs and generate approximately \$70M in annual revenue. They will become the leader in manufacturing wood-dominant, environmentally preferred building materials. The company will help fill the void left by the demise of paper manufacturing in Madison, and, in turn, will improve the long-term viability of Maine's rural, forest-based economy.
- The second \$750,000 award was made to Biofine Developments Northeast (BDNE). The funding will allow BDNE to carry out the commercial development of the first large-scale bio-refinery

deploying Biofine's technology in Bucksport, Maine. This plant will enable the conversion of woody biomass to the chemical intermediate, levulinic acid, allowing economic production of a completely renewable heating oil substitute. Biofine will work with Treadwell Franklin-Sewall as development consultants and the University of Maine at Orono for technical operations.

Levulinic acid was one of the 21 products evaluated in FOR/Maine's marketing analysis. Made from pulpwood, wood chips or sawdust, the global market for this platform chemical is expected to be significant, with potential use in a wide range of products from cosmetics to coatings. These types of chemicals fit well with Maine's abundant sources of pulpwood, sawdust and wood chips.

FOR/Maine's goals of finding the best and highest use of all parts of the tree encourage the use of biomass from forest and manufacturing residuals to produce value-added products. New uses of biomass will continue to be a critical component in the growth of the forest products industry. Insulating wood fiber composites made from softwood chips were specifically identified by FOR/Maine as a potential new product with a good fit for Maine, so the GO Lab, Inc., proposal was an attractive proposal for Maine's industry.

The value-added products that will be produced by these two firms are representative of the innovative and diverse new products that are possible in the near future, and are attractive complements to Maine's traditional wood products. The strength of the University of Maine's research and development will continue to play a pivotal role in the new forest products and bioeconomy in Maine. Grant programs through MTI are also a critical component in the development of Maine's bioeconomy, as this grant project demonstrates.

Wood Energy

Wood energy, or energy from biomass, is a locally sourced, renewable form of energy and an integral part of the forest products industry supply chain. The Forest Opportunity Roadmap Coalition's Wood Energy Committee studied the wood energy market in Maine as part of the development of a strategic plan to grow Maine's forest products industry. Stable markets for low-grade wood and sawmill residuals are a key component of FOR/Maine's strategic plan to expand Maine's forest products industry.

Recent challenges to the wood energy sector have impacted the entire forest products industry. Landowners, truckers, loggers and other sectors of the industry have been impacted, and the loss of markets for mill byproducts has had ripple effects across the entire supply chain. The potential loss of forest products infrastructure, including facilities, equipment and expertise, has long-term impact, as these facilities and labor skills will be hard to replace. With these challenges in mind, the committee conducted research to analyze the wood energy sector and develop recommendations for its report, *Forest Opportunity Roadmap/Maine Wood Energy, March 2018*.

Previously, the 127th Maine Legislature had established the Commission to Study the Economic, Environmental and Energy Benefits of the Maine Biomass Industry, co-chaired by Senator Thomas Saviello and Representative Jeff McCabe. In December 2016 the commission made recommendations to the full legislature that subsequently formed the basis of the FOR/Maine Wood Energy Committee's work.

The legislature's Biomass Commission recognized the important role that biomass energy plays not only in Maine's renewable energy sector, but also in the forest economy supply chain, and determined that it was in the state's interests to stabilize the industry, and further, that a comprehensive strategy for the entire forest products industry in Maine should be a priority. ([Click for report >>](#))

A Home for Every Part of the Tree

Maine's forest products industry is organized around using every part of a tree in order to maximize the use of the wood resource. Fuel for biomass comes from low-grade wood from harvesting operations and residuals from sawmills, paper mills and other wood manufacturing operations, for example, the tree limbs and tops that are stripped in the process of manufacturing a finished product.

Maine's biomass industry includes stand-alone biomass energy plants, community-scale biomass, and the combined heat and power (CHP) plants co-located at Maine mills. The FOR/Maine wood energy report examines the current biomass market in Maine with a focus on biomass consumers, biomass fuel prices and the position of biomass in the forest products supply chain.

The committee examined the causes and impacts of the downsizing of this industry on the forest economy, and gathered data on biomass fuel prices, how biomass compares with other energy sources in Maine, and how biomass fits into the state's renewable energy goals. The long-term goal of FOR/Maine is to seek higher-value uses for low-grade wood and mill byproducts, but in the shorter term, deriving wood energy from these products is still an essential part of Maine's forest economy.

Market Changes

Maine's wood energy market has seen rapid change over the past several years. Since 2014, the industry has sustained heavy losses resulting from the closures of five of the state's nine pulp and paper mills—in Bucksport, Lincoln, East Millinocket, Old Town and Madison. Not only were these mills using biomass energy in their combined heat and power operations, but they were also using other forest residues such as sawdust and lumber edgings or slab

wood for pulp making, so the decreased demand had a double impact on the industry supply chain.

Some of the remaining energy-consuming pulp and paper mills that had access to pipeline natural gas reduced their biomass use when the price for natural gas became competitive with the cost of biomass, and the stand-alone biomass plants were facing similar competitive pressures as energy producers. (Reenergy, LLC, closed two of its four Maine biomass plants, located in Ashland and Fort Fairfield, shortly after this study was concluded.)

Changes to Renewable Portfolio Standards in Massachusetts and Connecticut that have effectively limited the use of biomass energy created volatility in the markets for renewable energy credits, decreasing the profitability of biomass plants in Maine and other New England states. While the cost of other renewable energy decreased, and natural gas made inroads into Maine at competitive prices, the wood energy sector experienced further turmoil.

According to Maine Forest Service data, in 2010 the total Maine timber harvest was 13.9 million tons. Biomass from timber harvesting accounted for 26 percent of the harvest volume. By 2016 the statewide harvest decreased by 2.6 million tons and biomass represented only 20 percent of the harvest, due mainly to the loss of pulp mills and associated biomass units. (Maine Forest Service, annual *Wood Processor Reports* and *Stumpage Price Reports*.)

Truckers and loggers suffered significant losses from the erosion of this market. Economic activity associated with trucking and logging of biomass fuel dropped from \$90.5 million in the 2010s to \$48.2 million in 2016. In the trucking industry, the number of jobs dropped from 440 to 221. Maine has more than 4,000 loggers harvesting for a range of markets. Between 2010 and 2016, Maine loggers lost \$34 million in annual economic activity due to loss of biomass markets.

Since biomass represented 20 percent of the Maine timber harvest in 2016, and assuming it requires equivalent effort to harvest a ton of wood regardless of end product, this suggests that more than 800 logging jobs were tied directly to biomass fuel supply. The importance of retaining these skilled workers and specialized equipment for the future of the state's forest industry cannot be overstated.

Maine's more than 100 sawmills annually produce 800 million board feet of lumber from high-value logs and sell 1.6 million tons of mill residues—chips, sawdust and bark—to biomass facilities. Income from mill residues helps keep product costs down in a competitive lumber market. Without a market for biomass, mills pay for its disposal. If a product producing a small return instead becomes an expense for disposal, lumber prices could increase, putting Maine mills at a competitive disadvantage.

Nearly 2,000 people work in Maine sawmills, with \$85 million in annual payroll. These jobs, in rural parts of the state, are especially important because employment opportunities in these regions are limited. Demand for Maine lumber is increasing, but additional production also increases mill residues, and mills need economically feasible disposal options.

At the time of this study, Maine had six stand-alone biomass electric facilities and five combined heat and power plants that operated at pulp and paper mills. Biomass thermal is also used in a number of other forest industries (providing heat for kilns, for example) and in community-scale facilities that provide heat and power to institutions such as schools and hospitals. Given the high costs and environmental impacts of using fossil fuels, there are opportunities to increase the use of lower-cost, renewable biomass energy sourced in Maine, especially in Maine's most rural areas located far beyond where natural gas pipelines are likely to be built.

Maine is not alone in these challenges in the biomass market. Other states in New England with similar situations have acted to support the use of biomass energy. Underscoring the importance of this industry as a forest management tool, California has also focused on its biomass industry in its ongoing efforts to prevent forest fires. The FOR/Maine Wood Energy Committee reviewed other states' responses and found ways Maine can learn from their experiences.

Although there are problems with the current model, at least in the short term, wood energy needs to be part of Maine's renewable energy mix to keep the forest industry supply chain balanced. Valuable existing forest products infrastructure must be maintained in order to grow the industry, maintain and expand employment opportunities and provide economic

benefits to the entire state. In the longer term, as seen in the FOR/Maine Global Market studies, the vision is to create higher-value uses for the low-grade wood harvested in Maine.

Renewable Portfolio Standards

Portfolio standards have been the primary means of supporting expansion of renewable energy generation and sustaining existing facilities. In this system, qualifying renewable electricity generators—such as wind, solar, biomass, geothermal and hydro—receive one Renewable Energy Certificate for each megawatt hour of electricity produced. Regulated utilities and competitive energy suppliers, collectively known as retail service providers, are required to purchase a minimum of certificates based on their total electricity sales. Statutes establish price ceilings, but the market sets the prices. In general, the percentage of renewables increases over time.

Twenty-nine states and the District of Columbia

have statewide Renewable Portfolio Standards or the equivalent. New Hampshire, Vermont and California include biomass energy generation in their Renewable Portfolio Standards, with credits and enhancements to incentivize new biomass generation and support existing generation. New Hampshire, Massachusetts and New York offer rebates for wood pellet and wood chip boiler systems.

Maine's Renewable Portfolio Standard has two classes: Class One for new renewable development projects operating after 2005 and Class Two for qualified renewable generation operating before 2005. In 2017 a utility was obligated to purchase 10 percent of the state's electric load, or about 1.2 million megawatt hours, from renewable sources. Utilities met more than 92 percent of their Class One obligations with biomass generation, followed by wind (7 percent) and a small amount of hydro (1 percent). The utility Class One obligation remains at 10 percent, and there currently is no provision to increase it.



Recommendations

The FOR/Maine Wood Energy Committee's consultant, Innovative Natural Resource Solutions, provided energy efficiency models standard in the industry to review possible strategies and combinations of strategies. These strategies are consistent with the 2016 recommendations of the Maine legislature's Biomass Study Commission. The overarching goal is to stabilize the biomass energy industry in Maine and position it for growth as the forest products industry in Maine grows.

After examining the results of the modeling, key recommendations emerged that, when implemented in combination, would stabilize and expand Maine's biomass sector and provide benefits above costs, including:

- Gradually increase the state's Renewable Portfolio Standard from 10 percent to 15 percent. The model shows that this increase would result in 750,000 tons of new annual biomass demand, create 190 new jobs at biomass facilities, and benefit the forest industry supply chain, with benefits eight times more than costs.
- Co-locate new industry with existing biomass facilities. This strategy would increase demand for biomass, create new jobs, and provide benefits to the industry supply chain in excess of costs; it could be implemented with modest public policy support. Existing biomass plants in Maine are actively seeking co-location partners.
- Convert current heating systems from oil and propane to biomass (using either wood chips or wood pellets). This option has benefits including fuel cost savings and reducing the use of fossil fuels. When the fuel savings are combined with a Thermal Renewable Energy Certificate, the payback period necessary to incentivize installation of these systems decreases, leading to a significant increase in the use of biomass heating. With this scenario, the model results show 175,000 more tons of annual biomass demand and 110 new jobs, with benefits exceeding costs.

From a policy perspective, these strategies are a mixture of market-based business-as-usual mandates (i.e., the Renewable Portfolio Standards

requirements) and potential incentives. For example, the Maine Community Renewables Program could support the conversion of current heating systems from fossil fuels to biomass fuels. The modeling examined the costs and benefits of each strategy. (For the results of all of the tests for each possible scenario, please see pages 58–94 in the full report, *Forest Opportunity Roadmap/Maine Wood Energy Analysis, March 2018*.)

An Excel-based financial model was created to examine the costs and benefits of four potential biomass strategies that could be used to increase biomass demand. The goal of these strategies would be to support increased biomass demand in Maine, create jobs and benefit the forest products industry supply chain; benefits would need to exceed costs.

The FOR/Maine Wood Energy Committee analysis concludes that the best approach to achieve the goals established by the legislature's Biomass Study Commission is to implement the top-rated strategies in a comprehensive way, in combination: to gradually increase Maine's Renewable Portfolio Standard from 10 percent to 15 percent, encourage new industry co-location with existing biomass facilities, and incentivize conversion of heating systems currently using fossil fuels to biomass fuels, such as wood chips or pellets. This combination of strategies results in the most benefits for the least cost for participants and ratepayers.

While ongoing research finds new, higher-value ways to use every part of the tree, biomass remains an important link in the forest industry supply chain. Biomass energy uses locally produced fuel, with prices more stable than fossil fuels. Sawmill and pulp mill manufacturers are dependent on bioenergy outlets for their residuals that would otherwise currently require disposal outlets. Wood energy provides significant and ongoing positive economic impacts, especially in rural areas of the state that have been hard-hit by mill closures and job losses. These strategies to support the wood energy sector are integral to the comprehensive plan that will grow and sustain Maine's forest economy.

Transportation

Growing Maine's forest products industry will require improvements and innovation in all areas of the product supply chain. A key link in this supply chain is the transportation of raw materials and finished products. The FOR/Maine transportation study focused on targeted investments, innovative strategies and operational policies that would reduce costs and improve the efficiency of the forest products transportation infrastructure.

Industry leaders from the forest products sector collaborated with Maine Department of Transportation's (the DOT) Office of Freight and Business Services and Bureau of Planning to frame these preliminary findings and recommended next steps. The overall goal of this effort is to identify near-, mid- and long-term capital investments and regulatory actions that will enhance forest product transit times, improve access to resources and load centers, improve the reliability of transportation infrastructure, and increase load limits on a targeted basis.

In pursuit of this goal, industry leaders, working cooperatively with Maine DOT, sought to advance the competitive position of the forest products sector. The intent in the first phase was to provide an initial overview that would lead to recommendations for further research, analysis and implementation actions. Recommendations are summarized here:

Highway and Bridge Improvement Initiatives:

- Survey forest product manufacturers, landowners, loggers and transporters to further refine and complete a prioritized list of highway improvements that would advance the competitive position of Maine's forest products sector. The final list should be presented to Maine DOT by summer 2017 to allow for consideration by Maine DOT in its next Three Year Work Plan. (This has been done.)

- Study the options for improving travel times, reducing mileage and enhancing traffic safety by creating connections on I-95 between Pittsfield and Fairfield to Route 139. Support the completion of the I-395/Route 9 and Presque Isle Bypass initiatives. In the survey noted in the prior recommendation, include a question soliciting further suggestions for potential new alignment roads.
- Test interest in the Route 11 waiver and, if found sufficient, request an engineering review and cost estimate from Maine DOT, and then prepare a financing strategy. In the survey noted in prior recommendations, request feedback on the list of potential waiver locations noted above asking for additional locations to consider.
- Prepare a scope of work with Maine DOT that identifies alternatives for reducing hauling distance and in generating income through back-hauling, including but not limited to a central dispatch center.

Port Initiatives:

- Further research opportunities to expand the use of Maine ports to export value-added forest products with particular attention given to container shipping of finished products and the bulk movement of industrial wood pellets.

Rail Initiatives:

- Design the Forest Products Industrial Rail Access Program concept focusing on the many needs cited by the railroads and forest products sector, including but not limited to railcars, sidings, branch lines, rail yards and loading facilities and equipment. Examine in the design of this initiative the merit of using the Maine Port Authority as a vehicle to capitalize a revolving loan fund that supports the expansion of rail transport of forest products.

Transportation Planning:

- Data should be periodically collected, analyzed and reported to Maine DOT that depicts the movement of forest products to help guide and inform departmental capital improvement planning. A forest products transportation map of the state should be included with each update. The department should be consulted to assure the most appropriate data collection process is established.

This collaborative effort with the Maine DOT was very productive and established a strong communications channel for ongoing planning. This process set the stage for seeking more in-depth analysis of possible transportation infrastructure improvements.

FOR/Maine's Transportation Best Practices (February 2020) presents an analysis of the current infrastructure and outlines opportunities and challenges in this vital sector. Six areas were studied: integrating rail, port and truck infrastructure; overall operational efficiencies; improved truck coordination; policies regarding vehicle specifications for wheel configuration; load size; and seasonal weight limits. Currently the rail, port and truck infrastructure in Maine is fragmented. There are opportunities to make the movement of raw materials from the forests to the processing facilities and finished products to markets more efficient and reduce costs.

The transportation of forest products is largely dependent on trucking, so the study analyzed specific vehicle characteristics and how they impact product transportation. The study's recommendations for the industry and policy makers focus on both short- and long-term strategies to improve the transportation network in Maine to position the forest products industry for growth.

Analysis of Existing Infrastructure

Maine has 1,100 miles of rail and four primary seaports. In addition to public roads, there are 10,000 miles of private roads. In analyzing how to better integrate rail, port and truck infrastructure, it is important to have a basis for cost comparisons between the different modes of transportation and how they can best work in tandem. When comparing rail with truck hauling, rail can be most cost-competitive with trucking when shipping high-volume, low-cost bulk cargos over

medium to long distances of 125 to 210 miles. While many forest products cargos fall into this category, the average truck haul distance in Maine is approximately 60 miles, or less than half of the minimum distance considered to be cost-effective for rail.

Maine's rail network was built to connect Maine to Montreal and the Great Lakes, so the state's rail infrastructure is predominantly east-to-west oriented. This limits access for Maine's forest products to the lucrative Northeast markets. The only company that currently provides access to the Northeast markets is Pan Am Railways. With a fragmented network, limited access to larger markets and service and capacity restraints, the viability of expanding rail freight for the forest products industry is limited.

Maine DOT outlined key improvements in its 2014 Maine State Rail Plan. While Maine has steadily improved rail service and capacity across the state, additional investments will be required before transporting the bulk of forest products across the rail network is feasible. The forest products industry is the primary customer base for the state's rail network. However, the amount of forest products shipped by rail in Maine has decreased due to mill closures.

Shipping forest products by rail means multiple railroad handling operations, adding time and cost. It can take weeks versus days to ship by rail instead of by truck. The network also has capacity issues, including weight limits, and Maine's lines are limited in their capacity to accept double-stack containers. The state has obtained federal funding that has been matched by rail operators to improve the network, but many tracks in the state still need investments to bring them into good repair. Some areas are not accessible by rail during spring floods.

Obstacles to the use of rail to transport forest products in Maine include these:

- Rail is not cost-competitive for shorter haul distances.
- Transit times are too long to be competitive.
- There are limited options to ship finished products to South and West markets.
- Rail operators prefer to haul longer trains, meaning smaller loads wait.

- Tracking product is difficult.
- Competition is limited.
- Reluctance of processing facilities to experiment with rail for fear of losing trucking capacity if rail doesn't work.
- Railroads can be difficult to work with.
- Processing facilities are concerned about tying up inventory in railcars.
- Flooding can result in line closures.
- Forest products do not travel long distances by rail standards.

For shipping to foreign markets, competitive ports are critical infrastructure. FOR/Maine has identified key products that can be competitive in global markets, especially in Asia, but there are currently few forest products actually being exported through Maine's ports, located in Portland, Searsport, Eastport, and Bucksport. Maine's higher shipping costs are a competitive disadvantage when compared to forest products competitors in Western states. Maine's ports are located on the periphery geographically, so they will have to work harder to develop a competitive advantage over ports located closer to maritime and other transportation networks and large domestic markets.

Maine could better build on its competitive advantages by developing a more customized client approach in its efforts to attract investment and develop markets. One key improvement would be to establish a single point of contact in the state to direct queries from abroad to the proper resources. Currently, it is difficult for buyers or investors to know which products Maine's ports can handle. (This issue crosses all areas of the forest products industry.)

A better-performing inland transportation network connecting to Maine's ports would also make them more competitive. The research also shows a notable trend in the increasing use of containers for shipping, with roughly half of all timber now shipped by containers. This trend provides opportunities if Maine's ports were better equipped to handle containers.

Operational Efficiencies

According to stakeholder discussions and a review of the literature, transportation costs account for as much as 50 percent of the total delivered cost of timber harvesting operations. Increasing equipment

efficiency would provide cost reductions, but the largest gains would come from larger-scale changes such as fleet management and logistical planning to account for fluctuations in demand and productivity. Overall, obstacles in the efficient transportation of forest products include the following:

- Maine's forest products industry is dispersed across a wide geographic area.
- Geography and climate create difficult road conditions.
- Empty trucks on return trips—or lack of back-hauls.
- Labor shortages in logging, vehicle operators and truck drivers.
- There are wide variations in design, maintenance and fuel efficiency of trucks and trailers used across the state.
- Inefficiencies in handling raw forest products at the processing facilities.

With Maine's forest products processing facilities scattered across the state, the distances that raw materials must be transported from the harvest sites to the point of use are long, even if not long enough to make rail transportation economically feasible. The average one-way distance for forest products in Maine is roughly 60 miles, though some trips are as much as 100 miles. This problem is not unique to Maine, and the problem impacts the cost of forest products from all the Northeast states. Though there is no direct solution to this problem, it is an area for further study.

Across the country and in Maine, the rate of young workers entering the forest products industry has not kept pace with the retiring truck drivers and loggers. There are also fewer loggers to harvest the wood, and processing facilities are forced to obtain product from greater distances, increasing costs. Given the high cost of entering the logging industry and all the uncertainty around it, the labor shortage is not likely to improve in the short term, but there are ways to address labor shortages in the forest products industry in the longer term.

When raw forest products are trucked to processing facilities, they usually return empty. The challenge is that much of the equipment used is specialized for specific tasks and is not easily adaptable to "back-haul," or to use the empty trucks for other loads.

Vertically integrated companies that own multiple portions of the supply chain are more likely to be able to back-haul other loads. Trucking finished products is more efficient than transporting raw forest products because there are more opportunities to transport other loads. With the uncertainties in the industry and adherence to traditional practices, the supply process tends to be reactive and not proactive.

Long turnaround times for trucks at processing facilities are inefficient and increase costs. Better planning and coordination of the fleet, either company-wide or region-wide, would greatly improve operational efficiency. Strategies such as a Central Dispatch Model (CDM), consolidation yards, truck reservation systems, decision support systems and coalition logistics are investments that can reduce trucking costs and expand capacity. A CDM is an open-platform logistical model that operates on a common system for use by truckers covering a defined geographic area. Such a system would increase truck utilization by making spare hauling capacity available to logging crews that might be short of trucks.

A middle ground between a CDM system and the current operational model of each trucking firm operating independently is the use of consolidation yards for raw forest products. Similar in function to a warehouse, a consolidation yard would serve as a landing area to store logs between sites and processing facilities. Yards improve logistics for truckers and loggers through better use of equipment, especially within remote areas of the state. Consolidation yards are already in use in Maine by a few logging and trucking companies.

Recommendations for the Industry

To address labor shortages:

- Increasing compensation could attract and retain skilled workers.
- De-coupling the logging and trucking industries could allow for outsourcing trucking to independent contractors and thus put downward pressure on trucking costs, as long as there is enough competition in the newly created market.
- Outsourcing the transportation sector of the industry could provide opportunity to restructure from a salary-based to an invoice-based system, making economies of scale possible.
- Linking two or more trucks in convoys using

connectivity technology could also alleviate labor constraints and reduce costs.

To increase efficiencies in trucking:

- Increase use of training programs for trucking companies, as such programs have been shown to lower operating costs.
- Use of automatic control for tire pressure allows log trucks to increase access to steep logging roads, even in bad weather.
- Upgrading the truck fleet could increase loading capacity, and use of modern technology would increase fuel efficiencies.
- Using integrated scale systems in trucks reduces the potential load loss because without it drivers do not know if they have a full authorized load.
- Use of integrated fuel consumption control systems reduces excessive fuel consumption.
- Use of a trucking simulator to optimize the combination of vehicle characteristics and route planning.
- Appropriate alignment of vehicle characteristics, such as engine design, number of axles, trailer types and length can improve overall performance of trucks.

Decreasing turnaround times for trucks:

- Improved scheduling and coordination of deliveries to avoid peak surges in the arrival of raw materials at processing facilities would benefit both truckers and the mill operators.
- Utilize self-loading trucks to reduce congestion in space-constrained landing sites.
- Use of more unloading cranes or other systems such as front-end loaders with grapples at the processing facilities.
- Improve communication and coordination between the different processing facilities in the same area when dispatching and procuring materials.
- Wider and adequately spaced paved roads at the landing sites would reduce congestion and make traffic passage more efficient.
- Optimizing yard design at the processing facilities can also increase efficiency.

Long haul distances:

- Extend the planning horizon at processing facilities and with loggers to reduce the reactive environment of the supply chain.
- Increase notice on mill order changes so that loggers can adjust transportation times.
- Develop a model that uses metrics from core suppliers, including location, volume, type of harvest system and seasonal operating windows to allow processing facilities to allocate quota according to capacity.
- Implement a system that allocates quota according to capacity.

Lack of back-hauls:

- Improve planning and coordination among loggers, processing facilities and shippers to reduce the frequency of empty return trips.
- Identify convenient transportation routes that are conducive to back-hauling.
- Create more concentrated landing sites or develop consolidation yards.
- Develop networking and communications strategies between processing facilities from different regions.
- Track trucks in real time using embedded devices or cellular applications.

Policy Considerations

- The state could support the standardization of equipment by incentivizing facilities to follow suggested guidelines when replacing older equipment.
- Other incentives would encourage the replacement of older equipment with newer, more efficient equipment that would improve industry competitiveness.
- The state could also assist with worker training programs and programs to assist trucking companies to focus on planning routes and lowering operating costs.
- The state should continue to build on the work outlined in the 2014 Maine State Rail Plan.
- Though not directly tied to transportation logistics, the lack of a single point of contact to coordinate inquiries from abroad is a challenge across the industry, not just in the transportation sector. In discussions with stakeholders from across the state, the lack of a central coordinating entity in the state makes it challenging to facilitate connections and advance business opportunities in the forest products industry.
- Implement specific improvements to Maine's transportation infrastructure as recommended in the *FOR/Maine Transportation Committee Capital Improvement Plan* (April 2018), found in the Appendix.



Community Revitalization

For generations, the forest products industry in Maine has provided good jobs and economic opportunity for Maine families and communities. This 8.5 billion dollar industry is the backbone of Maine's economy, particularly in rural parts of the state. The industry sustains more than 33,000 jobs in Maine, including loggers, truckers, workers in paper mills, sawmills, board mills and lumber companies, and thousands of craftspeople and support workers. In 2016 Maine's forest products generated one out of every 20 dollars of the state's gross domestic product.

Worldwide, the decline in the demand for paper and other rapid changes in the global forest products economy have negatively impacted Maine's paper industry, resulting in six mill closures across the years 2013 to 2015. These closures not only impacted employment and state and local economies, they impacted community identity and pride. But change also brings new opportunities. The Forest Opportunity Roadmap, FOR/Maine, is a statewide collaboration that includes community, government, education, nonprofit and industry leaders that have come together to envision a new, stronger and more diverse forest products industry in Maine.

One of FOR/Maine's guiding principles is that a strong forest products industry supports vibrant Maine communities. One of FOR/Maine's five goals is to "Increase prosperity in Maine forest economy communities, especially those in rural Maine, including those impacted by mill closures." Achieving this goal will require coordinated efforts at the community and state levels to create the conditions that will attract investment, including efforts to redevelop mill sites and improve broadband and other infrastructure.

A major component of FOR/Maine's two-year process of coordinated research and strategy development included working with local communities through its Communities Committee. The committee focused on economic diversification and resilience, providing forums for leaders from impacted communities to

come together to find common solutions. In early 2017, FOR/Maine hosted two initial sessions focused on mill site redevelopment (including brownfields) and examining marketing and national case studies to attract new investment.

Maine's local municipalities lacked the resources to address global market changes on their own. In 2017 the State of Maine established the Rural Manufacturing & Industrial Site Redevelopment Program at the Maine Rural Development Authority (MRDA). The program is intended to provide grants for technical assistance, planning or implementation related to the rehabilitation, revitalization and marketing of manufacturing and industrial sites in rural communities. In the initial round, MRDA earmarked \$600,000 for grants for this effort.

In June 2018, FOR/Maine held "Industrial Site Readiness 1.0" with commercial site location scout Chris Steele of Boston, who presented to the community leaders the factors and data that matter in industrial site selection. This was followed in October 2018 with "Industrial Site Readiness 2.0," with three international industrial site readiness consultants to work with communities on a one-to-one basis about their specific needs and opportunities.

In 2017 the FOR/Maine Communities Committee also worked with Maine Development Foundation staff to bring together leaders from the six communities that had experienced mill closures: Bucksport, Millinocket and East Millinocket, Lincoln, Madison, and Old Town, as well as the Town of Jay. Subsequently, the committee held listening sessions with residents of each town to establish the greatest needs and assets. While each community is unique, from these listening sessions FOR/Maine identified recurrent themes to guide where resources could have the most community impact. These themes were housing, economic development, infrastructure and demographics.

Housing

In many of the impacted communities, the housing stock was built more than a century ago in a rush to accommodate a massive influx of mill workers. A large number of these small, clustered houses are now suffering from decades of deferred maintenance. Papermaking peaked in Maine in the late 1960s, and housing improvements reflect that era of prosperity as well as the uncertainty from the industry's ensuing decline. Current buyers are seeking better quality real estate with amenities like large yards and garages that old mill housing cannot accommodate.

Economic Development

Former mill communities know they must diversify their economies for future stability. This means identifying assets and leveraging them for new opportunities. It also means cultivating new markets and attracting investment beyond redevelopment of former mill sites. However, these towns also lack a history or culture of volunteer leadership in economic development. Among the six former mill towns, there are two full-time economic development directors and two part-time directors. Building local capacity to form economic strategy will take cultivation, training and leadership.

Infrastructure

Even as they've lost tax revenue from mill closures, local communities are grappling with how to invest in new necessities, such as broadband Internet, economic development directors or housing commissions. Residential taxpayers have had to make up the losses from the corporate tax base, and this has created stress on all municipal services.

Demographics

Economic conditions and housing availability have created demographic challenges and led to higher concentrations of retired residents and poverty. As the mills closed, a portion of working families left to seek work, and this skewed the average household age higher. The sudden increase in vacant housing collapsed prices and in many cases attracted poorer families. There are few rental units in most former mill towns, deterring young people or single individuals from moving there. Concentrations of poverty and a

dearth of housing options are significant challenges to the long-term success of these towns.

In response to the four key themes identified in the community listening sessions, FOR/Maine convened three learning sessions to assist the impacted communities, and additional learning sessions will be held as communities develop coordinated local economic development strategies.

Broadband

In December 2017, FOR/Maine organized a forum on community broadband models with funders, advocates, technical experts and attorneys present to provide targeted expertise. As a result of the broadband forum, FOR/Maine was able to further assist efforts already under way by the towns of Millinocket, East Millinocket and Medway to bring consistent broadband to their region.

In 2016, Our Katahdin, a nonprofit organization focused on community development, received a planning grant from the ConnectME statewide broadband promotional entity. The group assessed the potential of running fiber through the three communities, but with limited funds opted for a high-impact project to connect as many people as possible on a limited budget. A public wireless hub was placed in downtown Millinocket, and one is planned for Main Street in East Millinocket. Already the hub in Millinocket has attracted thousands of subscribers.

Since FOR/Maine had worked with two other Maine towns, Baileyville and Calais, who collaborated to form a public utility to deliver broadband, Our Katahdin asked FOR/Maine to convene interested citizens from their three towns to meet with an attorney from Eaton Peabody, a firm that had assisted Baileyville and Calais in the formation of their utility.

After six months and several meetings with representatives of each of the three towns, the group discussed conditions, goals and a process to establish the new Katahdin Regional Broadband Utility. The legal paperwork is complete and awaits ratification in the towns of Millinocket, East Millinocket and Medway. The process to develop the Katahdin broadband initiative is an inspiring example of what can happen when community members come together collaboratively to focus on their communities' futures.

Summary:

The FOR/Maine Communities Committee has also worked with several other communities in Maine that have active mills or are experiencing forest products economic development, including Baileyville, Rumford and Ashland.

The committee will continue to bring Maine's forest economy communities together for shared learning and best practices around identified topics of interest, and will support local and regional efforts to attract new investment and to diversify local economies. A critical aspect of the project has been the linkage of the communities to the global search for investment opportunities.



From Fact-Finding to Implementation

Maine is 89 percent covered by one of the most advanced, productive and sustainable resources imaginable—the forest. Maine's forests have been the longstanding anchors for the state's overall economy, and for generations Maine families and communities have thrived because of them. Maine forest communities can once again be thriving with high-quality jobs for Maine people.

FOR/Maine's vision is that Maine will be a global leader in the forest products economy with a thriving, innovative and diverse industry that provides good jobs in vibrant Maine communities. Maine has the forest resources and the economic assets, including a skilled workforce, industry infrastructure and the University of Maine's renowned research and development facilities, to be a global forest products leader.

Through a collaborative effort with industry, government, academia and community leaders, FOR/Maine has developed a bold strategic plan based on sound data. Phase One of the Forest Opportunity Roadmap established an important baseline for Maine's forest economy, and Phase Two work has already begun.

Global demand for environmentally sustainable products is driving innovation, and Maine is building a forest bioeconomy to meet the demand. There are signs of progress in the industry, and FOR/Maine has made steady progress toward its ambitious goals. The two years since the FOR/Maine work began have also brought more challenges that have impacted the industry.

Early in 2020, the COVID pandemic and the explosion at the Pixelle Specialty Solutions pulp mill in Jay created a staggering immediate impact on Maine's forest economy. But recoveries were quick for sawmills that experienced record demand, slower for the pulp and paper sector, and remaining challenges

for the logging sector as market forces adjust. The experiences of 2020 reinforced the need for Maine to diversify its portfolio of products and markets in order to create greater industry resilience. During the pandemic, the forest industry continued to operate as one of the largest functioning sectors of the state's economy, despite dramatic losses in other sectors, especially tourism.

With increased demand for tissue paper, boxboard and packaging, pulp mills have been able to diversify and build capacity away from lower-demand media paper. Toward the end of 2020, capital investments in the industry in Maine were significantly rebounding, and consumption of wood appeared to dramatically increase. In the transportation sector, two regional rail lines were purchased by a national firm, which has created the potential for expanded service opportunities. The forest products industry is a major customer for the state's railroads.

Sustainable Forest Management

An in-depth wood supply analysis in Phase One showed capacity to sustainably increase the state's wood harvest. Managing the state's wood resource using sustainable and responsible forest management practices is foundational to the growth of the forest products economy. Maine has a competitive advantage in its large private forest landownership that allows the industry to quickly respond to market changes.

Smaller landowners are also critical to the industry's growth, so in Phase Two the FOR/Maine collaborative began working with the state's smaller woodlot owners to encourage active forest management. Active forest management includes planning for a wide range of species by creating more diversified habitats. Thinning forest stands to focus growth on healthy trees builds forest resilience to insects, disease and the effects of climate change.

Maine's Burgeoning Bioeconomy

Through a global market analysis of current and emerging forest products, FOR/Maine identified promising new products with potential to grow and sustain a strong and globally competitive forest industry in Maine, including a forest bioeconomy. Identifying Maine's most competitive assets, a benchmarking study concluded that Maine is well positioned to diversify its product range to meet a growing global demand for environmentally sustainable products. In Phase Two, a marketing plan is being developed to capitalize on identified opportunities for growth and diversification in Maine's forest economy. Using credible data, Maine is marketing its assets in the most promising markets for the most promising products.

Focusing on the bioeconomy, FOR/Maine's participating trade associations worked with government policy makers to move recommendations for growing Maine's forest industry into action. In the 129th Maine legislative session (2019–2020), a biochemical and biofuels production tax credit was established to incentivize the commercialization of new environmentally sustainable energy fuels and the growth of the state's emerging bioeconomy.

In 2021, a new company, Standard Biocarbon Corporation, announced plans to locate a biocarbon processing plant at the former Great Northern Paper mill in East Millinocket. The proposed pyrolysis plant will convert low-grade biomass into biocarbon, or biochar. This product can be used as a soil amendment. Biochar also binds with heavy metals, phosphorus and other soil and water contaminants, making it useful in environmental remediation. And, because it remains in the soil for hundreds of years, biochar permanently sequesters carbon dioxide from the atmosphere, assisting in the fight against climate change. (*Mainebiz*, February 4, 2021) Biochar was one of the 21 products analyzed in FOR/Maine's marketing analysis.

The University of Maine continues to build its reputation as a center for wood innovation and has received numerous grant awards to continue its work on wood energy, composites, nanocellulose and bioplastics research. The research and development done by the university will continue to be one of the forest industry's greatest assets in the effort to

establish Maine as a global leader in the emerging forest bioeconomy. The Process Development Center at the University of Maine is the only facility in the U.S. that produces cellulose nanofibrils, and ongoing leadership in this innovation has earned Maine the nickname "Nanocellulose Valley."

Wood Energy

Encouraging higher uses for low-grade wood continues to be FOR/Maine's focus. However, FOR/Maine has also identified policy recommendations for the wood energy market such as encouraging enhanced combined heat and power opportunities and other policy initiatives. Challenging market dynamics have impacted efforts to modernize the wood energy field, especially the increased availability of lower-cost natural gas.

To stabilize the state's wood energy sector and encourage more renewable energy production, in 2019 the Maine Legislature increased the state's Renewable Portfolio Standard from 10 percent to 40 percent. The legislature also established a Thermal Energy Credit program similar to one that was recommended by both FOR/Maine and a previous legislative study committee. Both of these efforts will expand opportunities for wood heating and help to address critical needs for outlets for forest and mill residuals as the industry grows.

Public Policy Leadership

FOR/Maine was invited to participate in the Governor's Economic Recovery Committee, created in 2019. The committee report, *Recommendations to Sustain and Grow Maine's Economy* (November 24, 2020), made comprehensive cross-sector recommendations to grow Maine's economy. In the agriculture and forest products sector, the committee encouraged increased support for research and development to grow Maine's bioeconomy, building upon the University of Maine's leadership in bioenergy initiatives. The report also recommended that the state provide bond funding to invest in diversified agricultural and forest product innovation and key transportation infrastructure improvements. (*Click for report >>*)

FOR/Maine also participated in the Maine Climate Council created by the governor and legislature in 2019. The council's report, *Maine Can't Wait: A Four-Year Plan for Climate Action* (December 2020),

calls for growing Maine's forest products industry through bio-product innovation, and establishing the University of Maine as the "hub" for research on climate-friendly forest products innovation.

(Click for report >>)

FOR/Maine Phase One research shows that Maine needs to better coordinate its efforts to attract capital investment and business development. In Phase Two, FOR/Maine again engaged the services of Indufor North America, LLC, the consultants who assisted with the Phase One Global Market Analysis and Benchmarking Study, to assist forest industry representatives, Maine's Department of Economic and Community Development, the University of Maine, and Maine & Co., to bring prospective investors to Maine. Maine & Co. is a private nonprofit corporation led by government and business leaders that provides free and confidential consulting services to businesses looking to relocate to or expand within Maine. Work is ongoing to bring investment opportunities in Maine's forest products industry into the global limelight.

Preparing the Workforce

With a skilled forest products workforce among Maine's greatest assets, one of FOR/Maine's key goals is to prepare the next generation of Maine's workforce for the future of the forest products economy. Maine needs to attract young people into the industry and ensure that they have the skills they need for emerging products and technologies.

In Phase Two, FOR/Maine has joined in state efforts to build a resilient workforce, working with the Maine Center for Business and Economic Recovery at the University of Southern Maine to conduct an inventory of current and emerging workforce needs and skills. Marketing strategies are being developed to inform Maine citizens of the vision for a strong future for Maine's forest economy and communicating career path opportunities in the forest products industry.

Measures of Success

While Maine's forest economy has succeeded in the past, a rapidly changing global economy requires new approaches to sustain and grow the industry. The goal to grow and diversify Maine's forest products sector by 40 percent by the year 2025 is ambitious, but the data and early efforts show that the five goals and 17 strategies set forth in the Forest Opportunity Roadmap are achievable.

Sustaining and growing the industry at this scale will require concerted and coordinated effort by leaders

from the forest products industry and committed public sector partners, and these efforts are already showing success. Managing the state's wood resource with sustainable and responsible forest management practices is essential. Maine's skilled forest products workforce, a key asset for growth of the sector, must be prepared for the skills needed in the future forest economy. All of these efforts center on increasing prosperity in Maine forest economy communities, especially those in rural Maine that have been most negatively impacted by mill closures and rapid changes in global markets.

FOR/Maine's work continues to ensure these recommendations are implemented and that stakeholders remain engaged, committed and supportive of each other. To monitor progress and success toward strengthening and diversifying our forest products industry FOR/Maine will use the following measures:

1. Increased volume and dollar value of production and sales of manufactured forest products;
2. Number of companies located in Maine active in value-added forest products and the number of people employed by these companies;
3. Investment dollars attracted to Maine;
4. Public and private research and development dollars invested in the forest products sector;
5. Volume of residual and low-value fiber markets, including energy;
6. Number of biomass and or combined heat and power plants in the state and percentage of the state's thermal energy generated from wood;
7. Number of mill sites redeveloped or transformed into technology parks; and
8. State rankings relative to competitors on regulatory environment, taxes and energy prices.

These key measures will mark progress as Maine attains its position as a global leader in the forest products economy with a thriving, innovative, and diverse industry that provides good jobs in vibrant Maine communities. Maine is already building on the strengths of its industry to create the next generation of Maine's great forest economy.

Appendix

Maine Department of Transportation, *2014 Maine State Rail Plan* (July 2014)
www.maine.gov/mdot/ofbs/docs/Rail_Plan_7-9-2015.pdf

FOR/Maine, *Transportation Committee Recommendations* (April 23, 2018)
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From For/Maine, *Global Marketing Analysis and Benchmarking Study*, Executive Summary, Figure 3.2, p. 15, "SWOT of nanocellulose manufacturing in Maine."
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From FOR/Maine, *Global Marketing Analysis and Benchmarking Study*, Executive Summary, Figure 3.3, p. 16, "SWOT of pyrolysis oil manufacturing in Maine."
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