Ryegate Power Station Closure Contingency Scenario & Remediation Report

March 8, 2022

PUBLISHED
March 8, 2022

ISSUED
March 8, 2022

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Contingency Scenarios that May Reduce Economic Impacts, Remediate Workforce Challenges, and Address Forestland & Forest Economic Impacts of Potential Future Plant Closure

In accordance with Act 39 (2021), the Secretary of the Agency of Commerce and Community Development, in consultation with the Department of Forests, Parks, and Recreation submit the following report and contingency scenarios. This report is intended to provide information and a set of recommendations to help inform Legislature on how to reduce potential economic, workforce, forest industry and forest health impacts that may occur if the baseload renewable power plant (Ryegate Power Station) closes.

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EXECUTIVE SUMMARY

CONTINGENCY SCENARIOS

This report considers the scenario where the Ryegate plant is no longer in operation. The following contingency scenarios are based on three sets of economic activities that will cease based upon plant closure.

1. 160,000 MWh of baseload electricity is not generated.
2. 130,000 tons of wood chips are not purchased from Vermont sources (and 270,000 tons of wood chips are not purchased from the woodshed around the Ryegate plant).
3. $14 million of economic activity not related to the purchase of wood chips is not taking place.

The purpose of this report is to present contingency scenarios that address the economic impacts that may occur if the Ryegate Power Station should close. This report examines the economic contributions of the existing low-grade wood market in Vermont, as well as the workforce, forest health and sustainability, and electricity production contributions the Ryegate Power Station.

The intent of this report is to explore contingency scenarios that replace electricity production, support alternative low-grade wood market options, and replace lost non-chip economic activity in the State and catchment region. This report does not reflect the Administration's position regarding the closure of the Ryegate Power Station, but rather explores the economic impact should a closure occur.

For Vermont, low-grade wood harvest material goes to four, only partly overlapping end use markets – whole tree wood chips for power generation, bole wood chips for heating, pulp for paper making, and unchipped logs for firewood. When considering the general topics of expanding and exploring new markets for low grade wood, Vermont is not alone. Maine has a much larger wood products industry and faces the same challenges for maintaining the demand of low-grade wood. Unfortunately, there is no obvious solution resulting from that research at this point and the development of new markets for wood products will require continuous attention and partnerships with the business interests in Vermont and elsewhere that can sponsor any new product development.

Should the Ryegate Power Station close, there is no other readily available market for the whole tree chips it consumes. Alternative markets are not currently in development and would take considerable amounts of time and capital to develop, and it is unlikely that a new enterprise will form on the site of the plant.

To further explore the possibility of developing nascent markets and the level of investment required to bring those to scale, it is recommended that additional study be commissioned with expertise in those fields.

CURRENT PLANT OPERATIONS AND REGIONAL ECONOMIC CONTRIBUTIONS

The Ryegate Power Station (Ryegate) produces electricity from the combustion of locally sourced whole tree wood chips and sawmill residues. The current owner, Stored Solar LLC, is a Maine-based company with assets across northern New England. In the past few years, the plant has averaged a production of approximately 160,000 Mega Watt hours (MWh) which represents 3% of Vermont's total electricity consumption. However, because Vermont imports more than half of the electricity that it consumes, the Ryegate plant represents a higher proportion (7.4%) of the electricity produced in the state. In addition to the sale of the electricity to Vermont electric distribution utilities, Ryegate receives payments for the Renewable Energy Credit attributes (RECs) of the electricity generation based on its production through a renewable resource. The electricity sales amount to $16.8 million and the RECs add another $5 million in revenues. 90% of the REC revenues are retained by Vermont electric distribution utilities and are not revenues to the Plant owner.

In addition to electricity, the Ryegate plant produces wood ash as a by-product of combustion. This ash is high in calcium and potassium and is used as a soil amendment for Vermont farmers. In fact, in the early days of Vermont settlement, farmers clearing their land burned wood for its "potash" and this was an important product sold to the rest of the North American market through Lake Champlain ports.

The closure of the Ryegate plant will decrease the availability of this wood ash. Currently, RMI, a Holderness, New Hampshire company distributes the Ryegate ash to farmers and others in the area near the plant. Each year the facility produces approximately 3,000 tons of ash. The Wisconsin Extension services estimates the value of wood ash at between $24 and $38 per ton meaning that the Ryegate ash has a value of between $75,000 and $115,000 per year. The replacement for wood ash is often lime for calcium and pH control supplemented with fertilizers to provide the potassium and phosphorus in wood ash.

INTEGRATED HARVESTING

Because sustainable forestry focuses on improving the future forest, harvests often produce wood with a wide range of economic values, suitable for diverse markets. There is no such thing as a "low-grade harvest;" A logger optimizes the products possible within any harvested tree.

Although it generates little direct and immediate revenue for the landowner, harvesting wood with lower economic value is critical to achieving Vermont landowners' desired outcomes: growth of long-lived and more valuable forest products, enhanced wildlife habitat, forest health, recreational opportunities, carbon storage, resilience to climate change, and more. When less commercially desirable wood markets (fuelwood, pulp) are absent, these forest management goals are financially difficult or impossible to achieve.

The primary input to the Ryegate plant is wood chips that are purchased from local sources and the wood chip market is a primary part of this report. In addition, the Ryegate plant employs on average 20 workers and provides more than $1.8 million in compensation annually (wages, plus benefits). Furthermore, the plant requires ancillary services such as utility purchases, insurance, and management support. These together with property taxes paid to the Town of Ryegate and Vermont's Education Property Tax represent another $4 million per year in economic activity.

The operation of the Ryegate plant requires about 240,000 tons of wood chips per year. Of this 240,000, a bit more than half (53% or 130,000 tons per year[1]) comes from Vermont forests. In an average year, Vermont logging contractors produce approximately 400,000 tons of wood chips per year and the two wood fired electricity plants (Ryegate and the McNeil plant in Burlington) consume the majority of this volume. As required by Ryegate's Certificate of Public Good (CPG), suppliers to the generating station must follow a harvesting policy approved by the Public Utilities Commission (Appendix A).

These harvesting policies are among the most the most stringent regulations required of any purchaser of forest products in Vermont and include pre-approval by the Vermont Fish & Wildlife Department after wildlife habitat assessment; periodic on-site inspections; strict adherence to practices to maintain water quality; protection of archeological sites; use of scientific silvicultural practices; limitations on size of clearcuts; and adherence to all applicable State and Federal laws. Failure to comply with standards results in the plant not purchasing fuel from the operation. The value of wood chips ranges from $20-$30 per ton delivered, paid to the supplier, and the Ryegate plant spends almost $8 million per year for the purchase of the fuel. A bit more than 50% of Ryegate's spending going to Vermont logging contractors (about $4 million).

Approximately 30-40 different logging contractors supply wood to Ryegate on a regular basis and another 10-15 on an infrequent basis. This includes operations which pile treetops at a landing and have another contractor chip and truck the chips to the plant. Approximately two-thirds of these contractors are based in Vermont. Logging contractors in the delivery range of wood chip powered electric plants, such as Ryegate Power Station, have invested heavily in the past three decades in wood chip producing equipment that meets the expectations of landowners and foresters for harvesting systems to attain forest management goals and to supply local markets. It should be noted that this wood chip producing equipment and machinery is tailored only to producing whole tree chips, for which the only customer is Ryegate.

Wood chips are one of several products that are the result of the execution of sustainable forest management plans. Forest management results in products of high economic value such as saw logs, and products of lower economic value such as wood chips and firewood. Additionally, forest management

[1] The wood chip values are an average over the 2018-2020 period and supplied by the Ryegate Power Station.

works towards agreed upon goals such as wildlife habitat, biodiversity, forest health, water quality improvements, and timber management.

Wood chips are derived from treetops, limbs, and lower grade trees[2], or portions of trees harvested as a part of forest management that benefits from the extraction of low-grade timber. This extraction facilitates the growth of higher-grade timber for dimensional lumber and other high value wood products which realize a much higher value to landowners. Wood chip production demands fully mechanized harvesting and the processing of trees. Mechanized harvesting practices utilize equipment to fell, transport, and process the trees from the safety of a machine. This machinery is far safer and more efficient at handling the high volume of lower value trees that are harvested to meet forest management objectives.

CURRENT FOREST INDUSTRY & FOREST HEALTH CONDITIONS

The purchase of low-grade material is a support for the entire wood products sector of Vermont's economy. The market for wood chips used in combustion (i.e., whole tree chips for electricity production and bole chips for direct thermal production, such as that used in many Vermont public schools and the State Capitol complex) are closely related to the wood pulp market where wood chips are used to produce pulp for paper making. An example of how closely related these markets can be found when the demand for pulp wood decreased the resulting sales of wood chips for combustion expanded[3] in Vermont in 2016.

While the dollar value of timber used for wood chip production is lower on a per ton basis than sales for trees converted to lumber or other high value wood products, their sales help loggers' financial margin when harvesting forest land. The loss of pulpwood and wood chip markets in the region has created an oversupply of these products in the remaining markets which has resulted in a lower "mill delivered price" -- and in certain cases, no demand or market -- for these products. Logging contractors now must deliver some products farther for less revenue.

This puts downward pressure on the rest of the supply chain, including less available capital to reinvest in rural forest-based businesses, less revenue to

[2]The term "lower grade tree" is based on the grading of timber from a forest products perspective. Trees that are straight, with few knots and of certain species provide higher value for the lumber and forest products market. Lower grade trees may provide ecological benefits, but do not have the same economic value.

[3] 2019 Vermont Forest Resource Harvest Summary

pay workers and implement best practices, and a lower payment to the forest landowner that supplied the chips. The number of loggers working Vermont's forests often declines when timber prices decline, providing evidence that increasing the margins for timber removal is critical to the long-term viability for the logging sector.

In addition to the economics supporting the removal of low-grade timber, the health of Vermont forests may be improved when some silvicultural removal takes place. Before 1900, it was common practice for loggers to harvest wood by cutting all the merchantable timber on a property. Frequently, if partial cutting was practiced, only the biggest and most vigorous trees were removed. This "high-grading" or "take the best and leave the rest" approach undermined sustainability, focused solely on the timber's economic value, and left a legacy on the land that in some cases affects what our forests look like today. Forest management is about much more than simply what is harvested - it is also about what will be growing in the future forest. Modern, sustainable forestry combines timber management and forest regeneration with the science of forest ecology. It recognizes trade-offs between carbon and other ecological services such as biodiversity with harvesting to meet societal needs. Sustainable forestry optimizes management goals and can help sustain active carbon sinks by maintaining a forest age-class distribution that includes a share of young, vigorously growing stands. It also recognizes the importance of using management to help remediate some of the issues we see in our woods today that are the results of poor decisions made many decades ago and non-native organisms which threaten forest health and the viability of native plants and animals.

The Emerald Ash Borer (EAB) is a good example of the latter. Found in Vermont in 2018, EAB is expected to kill 95% of Vermont's 11 million ash trees within the next decade. The best and safest way to deal with infested material is to chip it to destroy the EAB. Plants such as Ryegate provide a valuable disposal site for that material as EAB spreads across the state.

The Department of Forests, Parks & Recreation estimates that in 2020, the total volume of low-grade wood harvested in Vermont was 1,684,000 tons. Approximately, 1,047,000 tons was used as residential firewood and industrial roundwood, 400,000 tons used as pulp and the remaining 243,000 tons was chipped for use in electric generating and thermal plants.

The Department of Forests, Parks, and Recreation (FPR) regularly monitors and reports on the health of Vermont forests and a part of that reporting is the measure of "Net Available Low-grade Wood Growth" (NALG), as reported in the 2010 and 2018 Vermont Wood Fuel Supply Studies. This value takes into account the fact that not all of Vermont forest land is available or appropriate for low-grade wood harvest. Even with those constraints, in its most recent report, Vermont continues to have almost one million tons of NALG, and this figure is in addition to the low-grade wood currently harvested for wood chips, pulp and firewood.[4]

[4] 2018 Vermont Wood Fuel Supply Study

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1. Replacing the electricity

Vermont utilities obtain electricity from a combination of owned generation, long term contracts with in-state and out of state generators, and short-term purchases from our northeastern regional market. One factor leading to the request for this report is that electricity can be purchased in the regional market for prices less than the current contract price for electricity from the Ryegate plant of $105 per MWh. The Vermont Department of Public Service estimates that the market price of electricity averaged over the next ten years is approximately $70 per MWh. The difference between the market price and the contract price for electricity from the Ryegate plant is $35 per MWh meaning that Vermont utilities (and, by extension, Vermont rate payers) will pay about $5.6 million more for electricity per year if the Ryegate plant continues to operate under its current contract than if Vermont utilities purchase power from the regional market. It is this dollar figure that serves as the basis for considering the additional value of the Ryegate plant for its economic contributions to the area. The Department acknowledges that the electric market is volatile and there is the possibility of an increase in the market rate above the current calculated value, especially for electricity produced during low temperatures where the regional system relies on natural gas fired power plants that can face spikes in the price of their fuel. Any increase in the market rate of electricity decreases the extra costs faced by Vermont utilities and rate payers.

Biomass power plants such as Ryegate have an advantage over other renewable sources of power in that they are able to operate in any weather conditions. Solar photovoltaic (PV) production declines in the winter with decreased sunlight and wind power is of course reliant on there being wind. Because it is able to run at any time, biomass power is a baseload power source. Woody biomass is a solar battery; trees absorb and store energy from the sun as they grow. That energy can then be made available when solar PV is unable to produce electricity. This is a symbiotic relationship that makes both power sources more valuable as we move away from electricity generated by fossil fuels.

2. Replacing the market for wood chip production

140,000 tons of Vermont wood chips or 270,000 of wood chips in the woodshed surrounding the Ryegate plant is a significant proportion of overall low-grade wood harvested in the region. For Vermont, low-grade wood harvest material goes to four, only partly overlapping end use markets – whole tree wood chips for power generation, bole wood chips for heating, pulp for paper making, and unchipped logs for firewood. It should be noted that the chips used at Ryegate are whole tree chips and are not an appropriate input for other woodchip applications such as heating and pellet manufacturing. This is due to the high bark content in the material. Additional processing, at additional cost, would be required to debark logs before chipping to be used for these applications. Top and limb material would not be able to be utilized, meaning that an expansion in pellet manufacturing and wood chip heating would not be able to absorb 100% of the whole tree chip material.

One set of contingencies is to consider the expansion of pulp, chip, and firewood markets to take the volumes available by a closure of the Ryegate plant.

The pulp wood market has been the subject of significant fluctuations as paper mills in northern New England close in response to changes in global demand for a variety of paper grades and products, among other regional and global forces. While newsprint and printing grade papers have seen sharp declines in demand due to the use of electronic media and communications, tissue and packaging grade demand has seen marked increases. Both New Hampshire and Maine continually pursue strategies for strengthening the economic viability of those mills, and it is hard to envision how Vermont can contribute meaningfully to influence paper mill viability.

The use of low-grade logs for firewood is a part of an entirely different -- but related -- market. Most firewood is harvested and distributed by very small-scale loggers and many only on a seasonal basis. This contrasts with the wood pulp market that is dominated by very large mills, and it is for this reason that the pulp market is so much more volatile than the firewood market, but also determines the difficulty to design a policy intervention that influences firewood demand.

New Hampshire Case Study

New Hampshire faces a similar situation with regards to its wood chip fired electric plants. There are six plants in New Hampshire very similar to Ryegate with electric generating capacities of 15-25 MW. All except a plant in Bridgewater were closed by 2019 and the Ryegate owner (Stored Solar, LLC) has purchased four of them with the intent of re-starting. In 2021, the Springfield plant re-opened and is currently generating electricity. While the Ryegate-scaled plants were closing, there are two larger, newer plants in place in the Granite State. In 2006, Public Service of New Hampshire converted a 50MW boiler at the Schiller plant in Portsmouth to operate on wood chips and waste wood. The boiler had previously been a coal fired facility. In 2020, the entire plant closed down. In 2014, the Burgess plant opened in Berlin on the site of a formerly paper mill. The Burgess plant is a 75 MW generator and continues in operation today. In total, New Hampshire electricity production from wood fired plants has fluctuated and the closure of the Schiller plant led to the low point in generation in 2020. With the decrease in generation from wood chip fired plants, the regional market for low-grade wood has also been stressed. The *New Hampshire Bulletin* produced an article that tells the story of the New Hampshire low-grade wood market during the summer of 2021.[5]

Growing the demand for low-grade wood by increasing the amount of advanced wood heat is a policy supported through work of the Clean Energy Development Fund.[6] Vermont has a goal in its Comprehensive Energy Plan of meeting 35% of its thermal energy needs from advance wood heat by 2030. If that goal were to be met, it would replace or add another 900,000 green tons of Vermont market demand for low grade wood.[7]

There are other uses of low-grade wood that go beyond pulp, chips for power generation, and firewood. Vermont currently has one operating wood pellet mill that uses approximately 45,000 tons of white pine each year for the production of ultra-premium pellets under the name of Vermont Wood Pellet. There are interests in pursuing options for starting other pellet mills in Vermont that could take some of the available low-grade wood for that purpose. However, Vermont scale wood pellet mills are not simple to start up and maintain. Another pellet mill in Springfield, Vermont had to shutter in 2018 after finding it difficult to maintain financial viability. While there is additional capacity at pellet mills in New Hampshire should demand for pellets increase enough to bring additional shifts online, they would not accept whole tree chips and additional processing would be necessary.

There are potential options under consideration for the use of woody fiber as a feedstock for the production of chemicals and bulk material currently made with fossil fuels. While promising as possibilities, there is yet to be a production-scale operation in place in the region. These technologies include:

- Pyrolysis Oil - mostly used as industrial/commercial heating fuel. Highly acidic and requires heating system modifications.
- Green Diesel - has promise but likely would need changes to Federal Renewable Fuel standard to be competitive.

[5] https://newhampshirebulletin.com/2021/06/07/foresters-loggers-grapple-with-loss-of-markets-for-low-grade-wood/

[6] The Clean Energy Development Fund currently has a proposal to support the replacement of older wood chip heating plants in Vermont's public schools.

[7] http://www.revermont.org/wp-content/uploads/FINAL-2030-Wood-Heat-Road-Map.pdf

- Wood Fiber Insulation - unclear if whole tree chips would be a suitable feedstock. A wood fiber insulation plant is currently under construction in Central Maine but is not yet in production.
- Biochar - small but potentially profitable market producing filtration product. Large potential market for soil amendments but may be cost prohibitive for agricultural uses.

Smaller market opportunities exist in mulch production and composting with manure, food scraps, and sewer sludge. Other replacement markets are limited.

When considering the general topic of expanding markets for low grade wood, Vermont is not alone. Maine has a much larger wood products industry and faces the same challenges for maintaining the demand of low-grade wood. Maine has sponsored several years of analysis into the options for using greater volumes of forest products as part of its' FORMaine process; Vermont is fortunate to have access to that research[8]. Unfortunately, there is no obvious solution resulting from that research at this point and the development of new markets for wood products will require continuous attention and partnerships with the business interests in Vermont and elsewhere that can sponsor any new product development.

Should the Ryegate Power Station close without an alternative market, the investments logging contractors have made will be devalued and they will lose equity in their equipment. In addition, contractors would need to retool their operations with mechanized equipment that delimbs trees in the forest to eliminate the need for hauling limbs and treetops in two directions. This equipment retooling can cost from $100,000-$1.5 million depending on the equipment setup and is only compatible on specific terrain and tree types. Retooling the approximately 40 regular suppliers to Ryegate would then cost $400,000 to $60 million. A cost share option with the State would be one possible solution to helping them adapt to serve other woodchip markets.

Another set of contingencies could consider mechanisms that support pre- and non-commercial management and restorative practices such as payment for ecosystem services. This set of strategies would manage and foster habitat, biodiversity, carbon storage and sequestration, resilience, recreation, and other benefits as appropriate.

The summary of this review of contingencies is that a direct replacement for the wood chips currently going to Ryegate is not readily available. Therefore, it is of utmost importance that Vermont continue to explore markets for the wood chips currently sold to the Ryegate plant. The contingencies, with respect to any decline in logging contractor activity, such as providing other job opportunities is described in the following section about general economic development.

[8] https://formaine.org/wp-content/uploads/2020/09/FORMaine_Report_DL_041119.pdf

3. Replacing the non-wood chip economic activity

The 20 jobs at Ryegate, associated compensation, and additional ancillary economic activities associated with the plant can be replaced by other economic activities, but those are not likely to be at the plant site. When considering the specifics for replacing the Ryegate mill, one set of options is to consider an alternate use of the plant property and its machinery and equipment. Unfortunately, wood chip fired electric plants are closing across the region and there is no obvious replacement activity being identified at those sites. For that reason, it is not clear that the Ryegate site will be a prime option for a new economic activity.

The operations of the plant represent an additional set of economic activities for the region that will need to be repurposed, including 20 employees and $14 million in activity. While 20 jobs and $14 million of economic activity, not including the $8 million spent on wood chips, is significant, its loss in the Ryegate area does not trigger any specific opportunity for alternate use of the workers from the plant or those losing jobs within the logging contractor community. A portion of the $5 million in rate payer savings could be utilized to leverage economic development activities in the form of grants and loans, following the same model as was executed after the closure of Vermont Yankee. The Vermont Legislature established the Windham County Economic Development Program to counter the effects of the closure of the Vermont Yankee nuclear power station. That program, initiated in 2014 has distributed $10 million for economic development activities. A 2016 Annual report provides a flavor for how the program was initiated and the types of support programs it established.[9]

RECOMMENDATIONS FOR ECONOMIC IMPACT MITIGATION

Should the Ryegate Power Plant close, the following menu of recommendations would help to mitigate the economic impacts.

- Cost share program to aid loggers supplying Ryegate retool their equipment. Area loggers have invested in costly equipment that is specialized to making whole tree chips specifically to serve the Ryegate plant. In order to create bole chips to serve other markets, this equipment will have to be retooled or replaced.
- Incentives to install advanced wood heating systems, specifically wood chip boilers and combined heat and power systems, in the region. While wood chip boilers cannot take the

[9] Report available at https://brattlebordevelopment.com/wp-content/uploads/2016/05/2016WCEDPAnnualReport-Final.pdf

whole tree chips currently going to Ryegate, they would provide a new local market opportunity for low grade wood and displace fossil fuels in accordance with the goals outlined in the Comprehensive Energy Plan.[10]

- Incentivize the development of a pellet plant on the plant site or in the region.
- Incentivize landowners to support pre- and non-commercial management and restorative practices such as payment for ecosystem services. This would provide funds to support sustainable forest management activities that have little economical value but support the forestry community and landowner goals including growth of long-lived and more valuable forest products, enhanced wildlife habitat, forest health, recreational opportunities, carbon storage, resilience to climate change, and more
- Establish an economic development program like that that followed the closure of the Yankee Nuclear Power Plant in Windham County.

CONCLUSIONS

Should the Ryegate Power Station close there is no other readily available market for the whole tree chips it consumes. Alternative markets are not currently in development and would take considerable amounts of time and capital to develop.

It is unlikely that a new enterprise will form on the site of the plant, utilize its equipment, or employ the 20 workers.

The long-term effects on forest health in the region are unknown. In the short term it is unlikely that forest health would be affected. Left unmanaged, forests will continue to be forests; but this ignores other economic and ecologic forces. Active management can improve forest health, wildlife habitat, and resilience to climate change as well as providing us with wood products. The loss of a major low grade wood market will make executing forest management plans financially more difficult. This may discourage young people from entering the fields of forestry and logging, where there is already a shrinking, aging workforce, and may make is less tenable for landowners to keep large forest parcels intact.

[10] 2022 Vermont Comprehensive Energy Plan available at https://publicservice.vermont.gov/content/2022-plan

APPENDIX A: PUBLIC MEETING ARCHIVE

The Agency of Commerce and Community Development, in accordance with the enabling statute, hosted a virtual public meeting on February 17, 2022, from 6:30-8:30 PM. The meeting was hosted via the Microsoft Teams application and was attended by approximately 40 individuals. The meeting was moderated by Jessica Vintinner, Legislative Director for the Agency of Commerce.

A full recording of the meeting, and an archive of the public comments that were submitted electronically, can be found on the Agency's website.

Full recording and public comment archive: Economic Opportunity & Mitigation for Ryegate Plant Meeting & Discussion | Agency of Commerce and Community Development (vermont.gov)

RYEGATE ASSOCIATES

RYEGATE POWER STATION

Harvesting Policy for Whole Tree Chipping and Roundwood Operations in Vermont

It will be the policy of Ryegate Power Station to accept delivery of whole tree chips and roundwood only from harvesting operations in Vermont certified by a professional forester as meeting the criteria of "good forestry practice" as outlined below. Ryegate Associates (**RA**) forester(s) or their agent(s) will conduct periodic on-site inspections to insure compliance with the following practices to the satisfaction of **RA** and/or applicable State authorities. Unresolved violation of these practices will result in the termination of chip and/or roundwood purchases from the offending producer.

1. The use of necessary and applicable erosion control practices will be required

   Every harvesting contractor will become familiar with the publication ***Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont*** (also known as "The Orange Book"). Contractors will implement procedures outlined in the guide to the satisfaction of RA foresters and/or applicable State authorities.

2. Consideration for visual quality will be required

   a. All refuse will be removed from the logging site prior to termination of the operation.
   b. Appropriate techniques will be used adjacent to major hiking trails to protect the integrity of the trail and the hiking experience. Trail treadways will be kept clear of logging debris. Crossing of the trails by logging vehicles will be at right angles and kept to the minimum number necessary. Cutting within 50 feet of either side of major trails will be limited to the removal of high risk trees or removal of less than 30% of the basal area of existing trees greater than 5 inches DBH, whichever is less.
   c. Landings will be laid out so as to reduce adverse visual impact. Newly constructed landings along public highways will be screened by a strip of undisturbed vegetation at least 25 feet wide when such vegetation exists. Where open areas or abandoned landings are suitable for use as landings, they will be so used in spite of the lack of buffer strip in order to reduce the amount of area cleared for such use.

3. Wildlife and fisheries habitat protection will be provided

   a. Landowners will be made aware of any impacts to wildlife or fisheries relating to a proposed chip or roundwood harvest operation on their property.

b. For all sites within Vermont from which wood fuel will be purchased by **RA**, an **RA** forester will visit the site with the landowner and/or harvesting contractor and confer in developing a harvesting procedure which meets the forester's approval. In turn, the **RA** forester will develop a "Whole Tree Chip/Roundwood Harvest Notification" to be sent to the appropriate Vermont Department of Fish & Wildlife biologist. This notification will include: a map showing the location of the proposed operation and the location of all streams, rivers, lakes & ponds; information regarding the nature of the harvest (including the type of cut and acreage); name of the prospective contractor(s) and approximate dates during which the harvest will be conducted. The biologist will have 15 days in which to respond to the **RA** forester with an approval or modification of the proposed operation. If the biologist determines that a modification of the harvest plan will be necessary to protect deer wintering areas, wetlands or the habitat of threatened or endangered species, such modifications will be included in the response to the **RA** forester within the 15 day time period. No harvesting operation will begin before approval by the Vermont Department of Fish & Wildlife biologist.

c. When landowner goals require silvicultural manipulation for wildlife management purposes, guidance may be sought from the Vermont Department of Fish & Wildlife or other qualified sources as well as the publication ***Model Habitat Management Guidelines for Deer, Bear, Hare, Grouse, Turkey and Non-game Wildlife*** by the Vermont Department of Fish & Wildlife.

d. Protection of fisheries resources will be provided through the use of acceptable erosion and sedimentation control practices including the use of filter (or "buffer") strips and protection of streamside shade. Harvesting contractors will implement applicable procedures outlined in the publication ***Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont***. Additional measures will be implemented when so specified by **RA** foresters and/or applicable State authorities.

4. <u>Protection of archeological sites will be required</u>

   a. Ryegate Associates foresters will seek guidance in protecting significant archeological sites. Such guidance will be provided by the Vermont Division for Historic Preservation in the form of State-sponsored training to aid in on-the-ground identification of such sites and/or in the form of guidance from the Division of Historic Preservation in the determination of the likelihood of occurrence of significant archeological deposits within areas scheduled for harvesting. **RA** will require the modification or termination of harvesting areas thought to be archeologically significant by the Division for Historic Preservation until such time as examination of the area has been completed. **RA** will also make the landowner aware of significant archeological sites on the property and aid him/her in adjusting the management decisions to protect such sites.

5. Timber Harvesting Requirements

a. The development of **management goals** will involve the consideration of:
   1. The objectives of the landowner and alternatives available to him/her.
   2. The characteristics of the site and forest stand(s).
   3. The impacts on related resources (water quality, wildlife, scenic, recreation).

b. The landowner or land manager and/or the harvesting contractor will confer with a professional forester representing RA in developing a harvesting procedure which meets the forester's approval. In all cases, harvesting will incorporate (to the extent reasonably possible) the protection of residual trees, minimization of waste and assurance of rapid and adequate regeneration. Every effort will be made to put harvested products to their most valuable use. In developing specific silvicultural techniques for meeting management goals, reliance will be placed on a combination of the forester's professional judgment and recognized silvicultural guides, including (but not limited to):
   1. ***A Silvicultural Guide for Northern Hardwood Types in the Northeast*** by Leak, Solomon and DeBald;
   2. ***A Silvicultural Guide for White Pine in the Northeast*** by Lancaster and Leak;
   3. ***A Silvicultural Guide for Spruce-fir in the Northeast*** by Frank and Bjorkholm;
   4. ***A Silvicultural Guide for Developing a Sugarbush*** by Lancaster et.al;
   5. ***Uneven-aged Management of Northern Hardwoods in New England*** by Leak & Filip;
   6. ***Model Habitat Management Guidelines for Deer, Bear, Hare, Grouse, Turkey, Woodcock and Non-Game Wildlife*** by the Vermont Department of Fish & Wildlife;
   7. ***Manager's Handbook for Red Pine in the North Central States*** by North Central Forest Experiment Station, USDA Forest Service;
   8. ***A Guide to Hardwood Timber Stand Improvement*** by Northeastern Area State & Private Forestry, USDA Forest Service;
   9. ***Establishing Even-age Northern Hardwood Regeneration by the Shelterwood Method – Preliminary Guide*** by North Cen. Forest Exp. Station, USDA Forest Service.

c. Specific types of cutting will include (but not limited to):

   The Selection System: A silvicultural system involving the removal of trees of all sizes singly or in groups, at regular intervals resulting in an uneven-aged stand. This system involves a continuous forest cover and favors shade-tolerant species.

   The Seed Tree System: A silvicultural system involving the retention of a very light stocking of selected trees after an initial cut. The role of the residual trees is to furnish seed for the next crop and results in an even-aged stand.

   The Shelterwood System: A silvicultural system that involves the removal of the overstory in several stages. Partial overstory removal provides favorable conditions for the establishment of regeneration. The residual overstory is removed after the new stand is well established. Shelterwood cutting results in an even-aged stand.

The Clearcutting System: A silvicultural system which involves the harvesting in one cut of all trees larger than two (2) inches in diameter and results in an even-aged stand. The size and configuration of the cut area is variable (as small as a fraction of an acre). Clearcutting is recognized to be useful in certain silvicultural and wildlife management situations. However, due to public sensitivity, only modified forms of clearcutting will be allowed by **RA** (narrow progressive strips and small blocks up to 25 acres in size). Land clearing operations involving land use conversions may employ larger openings; however, the objective in such cases is not future timber production. For land use conversion operations, the landowner must submit a letter of intent to **RA** stating the number of acres to be cleared, the name of the harvest contractor and the purpose of the clearing.

Improvement Cut: An improvement cut is an intermediate cut which can be prescribed by a forester as part of either the previously mentioned silvicultural systems and can be carried out at various times during the rotation (in even-aged stands) or as part of the regeneration cut (in the Selection System). The objective of an improvement cut is the reduction of low-value and low potential-value stand components through the removal of poorly formed stems and less-valuable species.

Thinning: Thinning is an intermediate cut prescribed by a forester to reduce the level of tree stocking to a recommended level in order to concentrate tree growth on fewer, selected stems.

Due to variability in forest stands as a result of site conditions and past treatments, it will often be necessary to incorporate more than one of the above-mentioned types of system within a single woodlot. In addition, dependent upon the intensity of past high-grading, it will often be necessary to leave numerous poor quality trees uncut in order to maintain recommended stocking levels.

6. Adherence to applicable local, State and Federal regulations, including (but not limited to):
   a. Occupational safety and insurance coverage;
   b. Forest fire prevention and control;
   c. Protection of property of others;
   d. Water quality protection;
   e. Harvesting and transportation of forest products.

7. Stumpage sale contract

   Landowners will be made aware of the desirability of having a stumpage sale contract outlining the details of the harvest operation. If the landowner elects to utilize such a document, the harvesting contractor will be required to meet the terms of that contract in addition to the terms of this harvesting policy.

Forest & Wood Products Industries' Economic Contributions: Vermont

May 2020

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Foreword

Vermonters depend on forests and their $2.1 billion annual economic contribution to the state's economy. Our forests provide a full range of forest products, from sawtimber and veneer to firewood and pellets to maple syrup. And yet there are many forest products and services which are much harder to value—water quality protection; flood control and resilience; wildlife habitat, biodiversity, and connectivity; clean air; and carbon sequestration. Moreover, our forests provide the natural infrastructure for our increasingly diverse outdoor recreation economy. On a landscape scale, our forests, farms, and historic human settlement patterns provide the scenic backdrop for our world-class tourism economy. Thus, Vermont's forests are our unique competitive advantage; we cannot outsource the benefits and values they produce. We are utterly dependent on our forests!

As Vermonters, we understand that one of the best ways to keep forests as forests is to promote forest health through active, thoughtful forest management. But with roughly 80 percent of the state's forests privately owned, this simply cannot happen without a vital and robust forest economy where landowners can sell the products of their forest management in a thriving marketplace, which reduces the threat of conversion of forests to non-forest use.

The forest resource and forest and wood products economy data contained in this report represent a snapshot in time. It provides a detailed view of the state of the industry as it currently exists in Vermont, but when viewed in conjunction with the forest resource data presented, it also highlights opportunities for future growth. It is my hope that this document will help to stimulate a collaborative approach to growing the forest products economy in Vermont for the benefit of both our environment and our citizens.

Michael Snyder
Commissioner

Vermont Department of Forests, Parks and Recreation

Public Sector Consultants and Paul Frederick. 2020. *Forest Products Industries' Economic Contributions: Vermont*. Lansing: Public Sector Consultants.

Acknowledgements

This report was produced as part of a 20-state project supported by a U.S. Department of Agriculture Forest Service 2017 Landscape Scale Restoration Grant, administered by the Michigan Department of Natural Resources, Forest Resources Division on behalf of the Northeast-Midwest State Foresters Alliance Forest Markets & Utilization Committee. Paul Frederick, Vermont Department of Forests, Parks & Recreation, contributed extensively to the Vermont report and to the region-level report entitled "Forest Products Industries' Economic Contributions in the Northeast and Midwest." We thank him for his contributions.

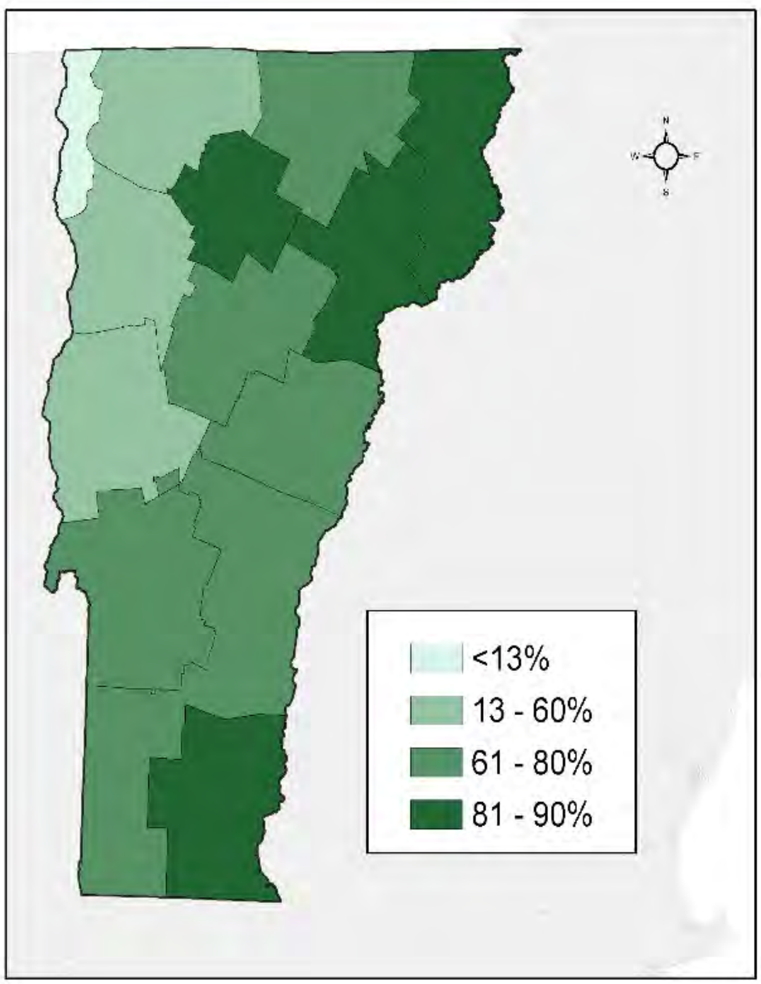
Table of Contents

Executive Summary

This report assesses broad forest conditions and economic contributions of forest products industry in Vermont. It is one of 20 coordinated and comparable state reports prepared for states in the northeastern and midwestern United States that provides an improved assessment of forests and the economies they support. The report presents several measures of the industry's contributions to Vermont's economy including number of full- and part-time jobs, labor income, value-added (Gross State Product, abbreviated as GSP) and output (sales). Forest data come from the U.S. Forest Service's Forest Inventory and Analysis website, and economic data come from the 2017 Impact Analysis for Planning (IMPLAN), a commercially available economic input-output (IO) model.

Vermont has 4.5 million acres of forest land that cover 76 percent of its land base, with most of this forest land able to produce commercial timber. The majority, 79 percent, is privately owned, while state and local governments own about 10 percent and the federal government owns about 11 percent.

Exhibit 1. Percent Forestland by Vermont County



Vermont's forest product industries are part of a much larger regional and global forest products economy. Wood flows freely across state lines and international borders. As of 2017, slightly less than half of the sawtimber[1] harvested in Vermont is processed in-state. Vermont mills imported over 30 percent of their raw materials from surrounding states. In that year for all products, a total of 946,000 cords[2] were harvested in the state.

The forest and wood products industries in Vermont provided direct employment to over 9,100 people (including maple syrup production) leading to $1.4 billion in output, in 2017. Labor income was $291.5 million and value-added was $393.4 million. In terms of total contributions[3] (including multiplier effects), the industry supported over 13,800 jobs, $521.9 million in labor income, $770.8 million in value-added, and $2.1 billion in output (Exhibit 2).

This report presents seven forest products industry sectors, which are based on 32 economic sectors in IMPLAN, 26 of which are present in Vermont:

- Forestry
- Logging
- Primary solid wood products
- Secondary solid wood products
- Wood furniture
- Pulp, paper, and paperboard mills
- Secondary paperboard and other paper products

While maple syrup production is typically considered an agricultural industry, this report includes information on the maple industry because of its importance as a forest-based crop in Vermont.

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[1] Sawtimber: Portion of a tree suitable for processing into lumber or veneer.

[2] Volume for all products converted to cords. A standard cord of wood typically contains about 79 cubic feet of solid wood, excluding air space.

[3] Contributions can be viewed in terms of value-added (GSP), output, employment, and/or labor income. Value-added is commonly used to describe the economic contributions of an industry. It is a conservative measure of economic contributions. Value-added is the difference between an industry's output or sales and the costs of intermediate inputs. When a sawmill sells a board, the value of the log and other inputs is not counted in value-added because they were counted when produced by loggers and others. Thus, only new additions to value (e.g., labor income, etc.) are included. Labor income is the major component of value-added and includes employee compensation and proprietor income. Value-added, summed across all sectors, is equal to the gross state product (GSP). Another measure of economic contribution is industry output or sales. For example, if a log is sold to a sawmill that sells boards, both sales are counted as part of the overall region's sales or output—they are important economic activities. Another measure, employment, includes both full- and part-time jobs. As the number of sectors in an analysis increases, there can be overlap in the number of part-time jobs across sectors.

Exhibit 2. Jobs and Gross Output of Forest-based Manufacturing Sectors in Vermont, 2017

Industry Group	Jobs	Output (Millions of Dollars)
Forestry (excluding maple syrup)*	706	$22.3
Maple syrup	2,636	$53.5
Logging	1,737	$91.0
Primary solid wood products	941	$306.0
Secondary solid wood products	1,053	$218.0
Wood Furniture	1,318	$173.7
Pulp, paper, and paperboard mills	641	$447.4
Secondary paperboard and other paper products	76	$32.1
Sum of Direct Contributions	**9,107**	**$1,370.9**
Total Contributions (with Multipliers)	**13,816**	**$2,057.0**

*Note: Elsewhere in this report the maple syrup industry is included in the forestry industry group.

Overall, in Vermont, forest and wood products industries provide more direct labor income, value-added, and output than agricultural production industries (plant crop and animal). Forest and wood products industries (including maple syrup production) accounted for 5.7 percent of the nonfood manufacturing jobs in Vermont. Agricultural production provided the most employment. Over 12 percent of Vermont's 33,000 direct manufacturing jobs in 2017 were in the forest and wood products industries (i.e., one in eight manufacturing jobs).

When viewed regionally, forest and wood products industries in Vermont, New Hampshire, Massachusetts, New York, and Maine employed over 95,500 workers and accounted for almost $27.0 billion in direct output. New York's forest products economy was the largest in the region in terms of direct employment, followed by that of Maine.

Introduction

Vermont is known as the Green Mountain State and is defined by its forests. We have much to be thankful for when it comes to Vermont's forests—they provide a multitude of benefits. This forested ecosystem forms the basis for biological diversity, natural communities, wildlife habitats, scenic landscapes, and recreational opportunities. As a natural resource, forests support a diverse forest products industry and provide an economic base for employment, tourism, and recreation. Livable communities and our quality of life depend on healthy, sustainable forests. Sustainable forests begin with healthy forests, which have the capacity for self-renewal of their ecological productivity, diversity, complexity, and resiliency. A healthy forest can meet the needs of present generations without compromising the needs of future generations.

Vermont's forests provide jobs and raw materials that are turned into finished goods that generate additional economic activity throughout the state, region, and nation. Previous studies of Vermont's forest products industries' economic contributions have focused primarily on Vermont and surrounding states but have not examined the interaction of those industries at the large regional or national level. In part, this is due to a lack of a consistent reporting format across the northeastern and midwestern United States. Previous state-level reports in this area were not comparable because they used different methods and data.

To help quantify these relationships and consistently document the industries' contributions, the Forest Markets & Utilization Committee of the Northeast—Midwest State Foresters Alliance secured federal grant funds to conduct an analysis of 20 midwestern- and northeastern–area states as well as Nebraska. As part of this work, a 20-state report was published for the region summarizing the economic contributions of forest and wood products industries from the 20 northeastern and midwestern states, and separate state-level reports have been produced for each state within the region, and for Nebraska. This work was funded by the U.S. Forest Service through a 2017 Landscape Scale Restoration grant.

Much of the data used in this report were derived from the U.S. Forest Service Forest Inventory and Analysis database and from IMPLAN, a widely used economic modeling system. These data and related information are presented in three major sections: Forest Resources of Vermont, Forest and Wood Products Industries and the Economic Contributions of the Forest and Wood Products Industries to Vermont's Economy. Due to rounding, some figures in the following tables may not sum to the exact total indicated. The appendices present the economic methods and detailed economic sector data used for this report.

Forest Resources of Vermont

Vermont's forests cover 4,494,000 acres of land; equal to 76 percent of the state (Exhibit 3). While the level was relatively steady from the 1980's through the early 2000's, Vermont's forest land area has decreased slightly since 2012 (Morin et al. 2020).

Exhibit 3. Vermont Land Area by Land Use Type, 2017 (U.S. Forest Service)

Land Use Type	Acres	Percentage
Forest land	4,494,125	76%
Nonforest land	1,442,108	24%
Total land area	**5,916,233**	**100%**

Private ownerships make up 79 percent of Vermont's forest land ownership (Exhibit 4). The Green Mountain National Forest has two large blocks of land in Vermont, and the State of Vermont and numerous municipalities own many parcels of forests and parks, which account for the remaining 21 percent of the forest.

Credit: Erica Housekeeper for the Vermont Sustainable Jobs Fund (VSJF), reproduced by permission of Christine McGowen

Exhibit 4. Forest Land by Ownership Group in Vermont, in Acres (2017)

Ownership Group	Acres	Percentage
National forest	451,259	10.0%
Other federal	50,844	1.1%
State and local governments	435,071	9.7%
Private	3,556,951	79.2%
Total	**4,494,125**	**100.0%**

Sugar maple is the most common tree species in Vermont by volume, followed by red maple and eastern hemlock. During the five-year period from 2012–2017, yellow birch, white ash and balsam fir experienced the most significant volume increases while paper birch experienced a substantial decrease.

In terms of number of trees, American beech accounts for nearly 16 percent of the stems, followed by sugar maple, balsam fir, and red maple.

Exhibit 5. Forest land Area by Forest Type Group in Vermont (2017)

Forest Type Group	Acres	Percentage
Maple/beech/birch	3,176,032	70.7%
White/red/jack pine	394,359	8.8%
Spruce/fir	312,397	7.0%
Aspen/birch	221,494	4.9%
Oak/hickory	154,949	3.4%
Other	234,894	5.2%
Total	**4,494,125**	**100.0%**

Overall, the volume of trees continues to increase, and net growth continues to exceed the harvest annually, by a ratio of 2:1 (Exhibit 6). Simultaneously, the average age class of Vermont's forests is increasing, and as a result, the average net annual growth rate is slowing.

Exhibit 6. Characteristics of Growing Stock in Vermont, 2017 (million cubic feet)

Measure	Total	National Forest	Other Federal	State and Local Government	Private
Net volume	9,248.7	971.4	132.2	892.3	7,252.9
Average annual net growth	165.5	10.7	1.6	9.9	143.3
Average annual harvest removals	72.5	2.0	0.0	2.3	68.2
Average annual mortality	81.6	8.1	1.2	11.1	61.1

Note: Net volume is merchantable volume, in cubic feet, of growing-stock trees for timber species (trees where diameter is measured at breast height) from a 1-foot stump to a minimum 4-inch top diameter, or to where the central stem breaks into limbs all of which are less than 4.0 inches in diameter. Volume loss due to rotten, missing, and form cull has been deducted. Growing stock is defined as live trees of commercial species that meet minimum merchantability standards and only includes trees at least 5 inches in diameter at breast height. Net growth is the average annual change (gross growth minus mortality) in merchantable volume, in cubic feet, of growing-stock trees on forestland. Harvest removals are the average annual merchantable volume, in cubic feet, of growing-stock trees at the time of removal from forest land. Annual mortality is the average annual merchantable volume, in cubic feet, of growing-stock trees at the time of mortality on forest land.

Vermont’s Forest Products Industries

Vermont’s forest products are synonymous with high quality. From forest to finished product, the state enjoys a reputation of growing, harvesting, processing and crafting products of exceptional quality. The sugar maple, the state’s most abundant hardwood species, has a well-deserved international reputation for high quality and bright color, but our forests support a wide variety of diverse markets and products. From the spruce/fir forests of the Northeast Kingdom to the mixed hardwood forests of the Green Mountain chain and the impressive stands of white pine in the Connecticut River Valley, Vermont’s forests provide raw materials for a wide variety of products and producers within Vermont and across the region.

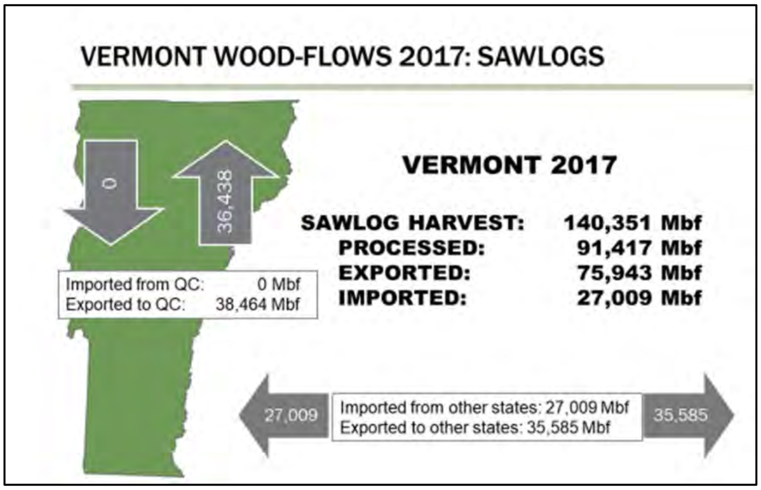
Sawmill photo courtesy of Vermont Department of Forests, Parks, and Recreation, and used by permission of Paul Frederick.

Vermont’s forest product industries are a part of a much larger regional and global forest products economy. Wood flows freely across state lines and international borders. As of 2017, slightly less than half of the sawtimber was harvested and processed in Vermont, and Vermont sawmills imported over 30 percent of their raw materials from surrounding states. In that year for all products, a total of 946,000 cords[4] were harvested in the state.

[4] All product volumes converted to cords.

Primary wood producers in Vermont range in size from part-time portable sawmills to multi-national corporations with thousands of employees across many states. These companies supply hardwood and softwood lumber and veneer for everything from local construction and woodworking shops to overseas export markets. Likewise, the state's secondary manufacturers and woodworkers work in businesses ranging in size from one-person shops to furniture companies with a worldwide presence, adding value to that raw material and supporting our working landscape.

Exhibit 7. Vermont Wood-flows 2017: Sawlogs



Note regarding the abbreviations: QC is Quebec and Mbf is 1,000 board feet.
Graphic: Vermont Department of Forests, Parks, and Recreation. Used by permission of Paul Frederick.

A significant proportion of Vermont's low-grade harvest is exported from the state for processing. There are no pulp mills in the state, so all of Vermont's pulpwood harvest is exported to mills in New York, Maine, and Quebec for processing. In 2017, Vermont produced in excess of 148,000 cords of pulpwood for these markets.

With no in-state pulping capacity, wood fuel is an important market for low-grade wood and plays a significant role in Vermont's energy portfolio. During the 2018–2019 heating season, over a third of Vermont's households used cordwood as a heating source, and wood heat in the institutional and commercial sectors consumed nearly 79,000 green tons[5] of wood chips in 2016. Approximately 21 percent of the state's thermal energy is generated by wood. Vermont is also home to two wood-fired electrical generating stations which account for nearly one-fifth of the state's in-state electrical generation (U.S. Energy Information Administration 2019).

[5] A green ton is 2,000 pounds of fresh-cut woody material at a "green" moisture content.

Economic Contributions of the Forest and Wood Products Industries to Vermont's Economy

This report used IMPLAN to estimate economic contributions[6] of the forest products industries. IMPLAN is a widely used input-output (IO) model that is comprised of economic data and software. IO models characterize financial linkages among and between sectors, households, and institutions. Within these models, various sectors have production functions that show the value of inputs used in production of outputs or commodities. Vermont's economy was represented by 380 sectors in 2017, the most recent year available for IMPLAN data at the time of the analysis. These sectors are based on the North American Industrial Classification System (NAICS).

Vermont's forest products and maple syrup industries' total economic contribution in terms of output was $2.1 billion in 2017, based on direct output of $1.4 billion (Exhibit 8). Approximately 9,100 direct jobs were associated with this level of economic activity, and the total number of jobs supported was 13,816. Direct labor income, which includes employee compensation and proprietor income, was $291.5 million, or $32,000 per job. Total labor income, which includes income paid directly to industry employees and proprietors, their suppliers, and other industries they support, totaled $522.0 million.

Exhibit 8. Economic Contribution of the Forest Products Industries* in Vermont, 2017 Dollars

Effect	Employment	Labor Income (Thousands of Dollars)	Value-added** (Thousands of Dollars)	Output (Thousands of Dollars)
Direct	9,107	$291,472	$393,406	$1,370,850
Total	13,816	$521,860	$770,800	$2,057,036

*In this report, the forest products industries, and specifically the Forestry industry group, include maple syrup production.
**Value-added in IMPLAN is equivalent to GSP.

Each direct job in the forest and wood products industries supported 0.52 additional jobs, and every $1 million in direct labor income supported an additional $0.79 million in indirect and induced labor

[6] Contributions can be in terms of value-added (GSP), output, employment, and/or labor income. Value-added is commonly used to describe the economic contributions of an industry. It is a conservative measure of economic contributions. Value-added is the difference between an industry's output or sales and the costs of intermediate inputs. When a sawmill sells a board, the value of the log and other inputs is not counted in value-added because they were counted when produced by loggers and others. Thus, only new additions to value (e.g., labor income, etc.) are included. Labor income is the major component of value-added and includes employee compensation and proprietor income. Value-added, summed across all sectors, is equal to the gross state product (GSP). Another measure of economic contribution is industry output or sales. For example, if a log is sold to a sawmill that sells boards, both sales are counted as part of the overall region's sales or output—they are important economic activities. Another measure, employment, includes both full- and part-time jobs. As the number of sectors in an analysis increases, there can be overlap in the number of part-time jobs across sectors.

income. Most state economies are large relative to any particular industry or group of industries. The forest and wood products industries are no exception. In 2017, Vermont's population was estimated at 623,700 people, with total employment of 436,200. The gross state product (also known as value-added) was $32.6 billion from 380 economic sectors (of the possible 536 in the US). The GSP's largest component was labor income, which was $21.5 billion.

Direct value-added for forest and wood products industries was $393.4 million, 1.21 percent of Vermont's total GSP, increasing to 2.36 percent when considering total value-added effects. These percentages hold for other economic measures (e.g., jobs) as well.

Direct and Total Contributions by Forest Product Industry Groups

As previously noted, the 32 IMPLAN forest products sectors (only 26 of which were present in Vermont) were combined into seven industry groups (Appendix B). In Vermont, forestry was the largest of these groups in terms of direct employment, but sixth in labor income, value-added, and output, largely due to the maple syrup industry's inclusion in this group (Exhibit 9). Logging was the second largest group in terms of direct employment and labor income, fifth largest in terms of value-added and output. Two groups—pulp, paper and paperboard mills and primary solid wood products—accounted for over half the output of forest products industries. Half of forest products industries employment was in the forestry and logging groups.

Exhibit 9. Direct Economic Contributions in Vermont, Industry Groups, 2017

Industry Group	Employment*	Labor Income (Thousands of Dollars)	Value-added (Thousands of Dollars)	Output (Thousands of Dollars)
Forestry**	3,342	$34,873	$43,968	$75,732
Logging	1,737	$50,332	$52,799	$90,979
Primary solid wood products	941	$47,374	$79,769	$305,966
Secondary solid wood products	1,053	$45,676	$75,042	$217,960
Wood furniture	1,318	$58,983	$57,502	$173,733
Pulp, paper, and paperboard mills	641	$49,841	$78,548	$474,397
Secondary paperboard and other paper products	76	$4,393	$5,779	$32,082
Total	**9,107**	**$291,472**	**$393,406**	**$1,370,850**

*Full- and part-time jobs
**Includes maple syrup production.

Exhibit 10. Total Economic Contributions in Vermont, Industry Groups, 2017

Industry Group*	Employment	Labor Income (Thousands of Dollars)	Value-added (Thousands of Dollars)	Output (Thousands of Dollars)
Forestry**	3,200	$40,576	$58,092	$100,986
Logging	1,099	$32,015	$39,369	$67,766
Primary solid wood products	2,701	$115,348	$179,645	$462,769
Secondary solid wood products	1,973	$87,577	$140,978	$343,448
Wood furniture	2,084	$94,278	$115,223	$280,370
Pulp, paper, and paperboard mills	2,601	$143,615	$225,169	$757,808
Secondary paperboard and other paper products	158	$8,451	$12,324	$43,890
Total	**13,816**	**$521,860**	**$770,800**	**$2,057,036**

*Forestry and Logging are reported in this table; but most of their contributions are as indirect inputs or intermediate inputs that are used in the production in the other five industry groups.
**The forestry group also includes maple syrup production.

For the following sector-specific discussions, refer to Exhibit 9 for direct contribution details and Exhibit 10 for total contribution details. See Appendix C for detailed economic measures for industry groups and their component sectors.

Forestry

The forestry group includes timber tract operations and support activities for forestry. In this analysis maple syrup production was also included in the forestry group. Timber tract operations include establishments primarily engaged in the operation of timber tracts for the purpose of selling standing timber, and support activities for forestry such as estimating timber; forest firefighting; forest pest control; treating burned forests from the air for reforestation or on an emergency basis; and consulting on wood attributes and reforestation related to timber production, wood technology, forestry economics and marketing, and forest protection.

Photo courtesy of Vermont Department of Forests, Parks, and Recreation, and used by permission of Paul Frederick.

Direct contributions were $75.7 million in output, 3,342 jobs, $34.9 million in labor income, and $44.0 million value-added. Total contributions are based, in part, on backward linkages to suppliers. Total contributions for forestry can be lower than direct contributions (i.e., initial IMPLAN levels) because many of the contributions are inputs into other industries. For example, 16 percent of forestry jobs are counted as contributions in other industries, mostly logging and primary solid wood products (e.g., sawmills). Hence, the total contributions displayed in Exhibit 8 underrepresent the industry's broader contributions—reporting total contributions for forestry is somewhat misleading because much of the forestry total contribution effects are hidden in the total contributions of other industries. The same holds true for logging below.

Maple Syrup Production

Maple syrup is an important forest-based crop in Vermont. In fact, Vermont is the leading producer of maple syrup in the United States, accounting for 46 percent of US production in 2017 (Exhibit 11). Because of the regional nature of the overall analysis and the varying degree of importance of the industry across the 20-state region, maple syrup production was included in the forestry industry grouping. The maple syrup production sector is only a portion of IMPLAN sector 10, all other miscellaneous crop farming (NAICS 111998).

Exhibit 11. Maple Syrup Estimated Employment, Production, and Output, 2017

State	Estimated Employment*	Production (Thousands of Gallons)	Output (Thousands of Dollars)
Vermont	2,636	1,980	$53,460
New York	1,275	760	$29,640
Maine	567	709	$23,893
Wisconsin	240	200	$6,280
New Hampshire	724	154	$6,699
Pennsylvania	127	139	$4,768
Michigan	238	110	$5,632
Massachusetts	370	84	$4,217
Ohio	149	80	$3,080
Connecticut	71	20	$1,244
Minnesota	19	14	$932
Indiana	19	12	$602
West Virginia	42	9	$330
United States	6,241	4,271	$140,777

*Estimated employment is based on the ratio of maple syrup sales to all other crop farming sales for each state. The states listed in the exhibit are the only ones engaged in maple syrup production and are referred to collectively as the United States at the bottom of the table. The sum of employment for the states does not equal the U.S. estimated employment.
Note: For production and output value figures, see NASS 2018. For estimated employment, see Gibson et al. 2020.

Most sectors in the forest and wood products industries are completely counted within the industries, but several sectors (including maple syrup production) are not. These are treated as partial sectors in this report. Within the IMPLAN modeling framework, the relationships among sectors are defined by mathematical production functions derived from national-level relationships. Hence, the sawmill sector relies on logging, trucking and many more sectors for inputs. For maple syrup production, the production function is for all other miscellaneous crop farming. Maple syrup production includes the gathering, concentrating, and reducing of maple sap.

Given the importance of maple syrup production in Vermont, a single-industry contribution analysis was completed (Exhibit 12). For Vermont, the National Agricultural Statistical Service (NASS) estimated $53.5 million in maple syrup direct output in 2017; over 2600 jobs were estimated for this output level (NASS 2018). These direct-effect figures are slightly under the lower bound presented in *The Economic Contribution of the Maple Syrup Industry* (Becot et al. 2015), but maple syrup output does vary annually.

Exhibit 12. Vermont Economic Contribution of Maple Syrup Production, 2017 Dollars

Effect	Employment	Labor Income (Thousands of Dollars)	Value-added (Thousands of Dollars)	Output (Thousands of Dollars)
Direct	2,636	$17,188	$25,908	$53,460
Total	2,986	$29,785	$46,501	$87,188

Based on this analysis, the maple production industry supported 2,636 jobs and $53.5 million in output in 2017. It is the leading forest products sector, in terms of number of jobs, in Vermont.

Logging

The logging industry group contains establishments primarily engaged in one or more of the following: cutting timber, cutting and transporting timber, and producing wood chips in the field. Logging was the second largest in terms of direct employment. The direct contributions of logging were $91.0 million in output, 1,737 jobs, $50.3 million in labor income, and $52.8 million in value-added. Most logging activity is an input into production in other industries, especially for manufacturing primary solid wood products (e.g., lumber), paper, and paperboard. In Vermont, 57 percent of logging jobs are included in the total contributions of other industries. As with forestry, logging's total contributions are underrepresented due to their inclusion in other industries.

Photo courtesy of Vermont Department of Forests, Parks, and Recreation, and used by permission of Paul Frederick.

Primary Solid Wood Products

The primary solid wood products industry group was the fifth largest group in terms of direct employment in Vermont. Primary solid wood products sectors include wood-based electric power generation, sawmills, wood preservation, veneer and plywood manufacturing, and reconstituted and wood product manufacturing industries. The direct contributions of the group were $306.0 million in output, 941 jobs, $47.4 million in labor income, and $79.8 million in value-added. Total contributions for primary solid wood products, including direct, indirect and induced effects, were $463.0 million in output, 2,701 jobs, $115.3 million in labor income, and $179.6 million in value-added. Many primary solid wood products (e.g., lumber and panels) are inputs in other industries, which counted in other industries' total contributions.

Secondary Solid Wood Products

Secondary solid wood products was the fourth largest group in terms of direct employment in Vermont. The group contains engineered wood member and truss manufacturing; wood windows and doors manufacturing; cut stock, resawing lumber, and planing; other millwork, including flooring, wood container, and pallet manufacturing; manufactured home (mobile home) manufacturing; prefabricated wood building manufacturing; and all other miscellaneous wood product manufacturing. Direct contributions of secondary solid wood products were $218.0 million in output, 1,053 jobs, $45.7 million in labor income, and $75.0 million in value-added. Total contributions were $343.5 million in output, 1,973 jobs, $87.6 million in labor income, and $141.0 million in value-added.

Wood Furniture

Wood furniture was the third largest group in terms of direct employment in Vermont. Wood furniture includes wood kitchen cabinet and countertop manufacturing; upholstered household furniture manufacturing; non-upholstered wood household furniture manufacturing; institutional wood furniture manufacturing; wood office furniture manufacturing; custom architectural woodwork and millwork manufacturing; and showcase, partition, shelving, and locker manufacturing. Direct contributions of wood furniture were $173.7 million in output, 1,318 jobs, $59.0 million in labor income, and $57.5 million in value-added. Total contributions of wood furniture were $280.4 million in output, 2,084 jobs, $94.3 million in labor income, and $115.2 million in value-added.

Credit: Erica Housekeeper for the Vermont Sustainable Jobs Fund (VSJF), reproduced by permission of Christine McGowen

Pulp, Paper, and Paperboard Mills

The pulp, paper, and paperboard mills industry group ranked sixth in terms of direct employment in Vermont. The group includes pulp mills, paper mills, and paperboard mills that make paper or pulp from raw wood and from purchased pulp. While there are no pulp mills located in Vermont, there are several smaller paper or paperboard mills which utilize market pulp and/or recycled paper in their production processes. The pulp, paper, and paperboard mills group's direct contributions were $474.4 million in output, 641 jobs, $49.8 million in labor income, and $78.6 million in value-added. Total contributions were $757.8 million in output, 2,601 jobs, $143.6 million in labor income, and $225.2 million in value-added.

Secondary Paperboard and Other Paper Products

The secondary paperboard and other paper products group was the smallest in terms of direct employment in Vermont. The group comprises paper and paperboard manufacturing, paper bag and coated and treated paper manufacturing, stationery product manufacturing, sanitary paper product manufacturing, and all other converted paper product manufacturing. Facilities in this group manufacture products from purchased pulp, paper, paperboard, or recycled materials. The direct contributions in 2017 were $32.1 million in output, 76 jobs, $4.4 million in labor income, and $5.8 million in value-added. Total contributions were $43.9 billion in output, 158 jobs, $8.5 million in labor income, and $12.3 million value-added.

Top Nonforest Industries Impacted

Contribution analysis using IMPLAN relies on backward linkages from forest and wood products industries sectors among themselves and to other sectors in Vermont. Including the 26 forest products industries, 114 sectors were impacted in 2017 (counting sectors with ten or more jobs supported). The top ten sectors (excluding forest products sectors) included wholesale and retail trade, restaurants, real estate, hospitals, and maintenance and repair construction of nonresidential structures (Exhibit 13). This set of sectors reflects indirect and induced spending by forest products companies, their suppliers, and individuals.

These data were at an aggregate level, so 108 jobs in truck transportation included log trucks, delivery trucks, and office jobs for some trucking companies, among others. Five of these sectors were among the top ten sectors in the state of Vermont (hospitals and real estate were second and third in the state—each had over 14,000 jobs).

Exhibit 13. Direct Jobs Impacted by the Forest Products Industries Among Vermont's Top Ten Non-Forest Products Industries in 2017*

Sector	Description	Jobs
395	Wholesale trade	406
501	Full-service restaurants	187
440	Real estate	166
482	Hospitals	147
62	Maintenance and repair construction of nonresidential structures	147
468	Services to buildings	137
485	Individual and family services	118
502	Limited-service restaurants	114
411	Truck transportation	108
461	Management of companies and enterprises	96
Sum of Top Ten Industries	**NA**	**1,627**
Total Jobs in Affected Industries	**NA**	**18,410**

*Including maple syrup production

Neighboring States

Vermont, New Hampshire, Massachusetts, New York, and Maine are part of an important region for forest products. Forest and wood products industries in the region employed 95,621 workers and account for $27.1 billion in direct output (Exhibits 14 and 15). New York had the largest forest products economy with 43,024 direct jobs and output in excess of $13 billion.

The two largest industry groups within the region, each with over 18,000 employees, were wood furniture and secondary paperboard and other paper products.

Exhibit 14. Forest and wood Products Industries Direct Employment in Vermont, New Hampshire, Massachusetts, New York, and Maine, 2017

Industry	Vermont	New Hampshire	Massachusetts	New York	Maine
Forestry*	3,342	1,250	1,030	1,658	3,558
Logging	1,737	1,732	835	4,013	5,052
Primary solid wood products	941	1,107	300	2,861	2,986
Secondary solid wood products	1,053	1,170	2,790	7,113	2,484
Wood furniture	1,318	1,181	3,195	11,791	1,590
Pulp, paper, and paperboard mills	641	389	1,845	4,898	3,137
Secondary paperboard and other paper products	76	460	6,087	10,689	1,312
Sum of Direct Contributions	**9,107**	**7,289**	**16,083**	**43,024**	**20,119**

* Includes maple syrup production

Exhibit 15. Forest and Wood Products Industries Direct Output in Vermont, New Hampshire, Massachusetts, New York, and Maine, 2017

Industry	Vermont (Thousands of Dollars)	New Hampshire (Thousands of Dollars)	Massachusetts (Thousands of Dollars)
Forestry*	$75,732	$35,685	$58,990
Logging	$90,979	$265,556	$126,321
Primary solid wood products	$305,966	$441,289	$104,095
Secondary solid wood products	$217,960	$229,118	$533,076
Wood furniture	$173,733	$170,622	$546,528
Pulp, paper, and paperboard mills	$474,397	$287,943	$1,247,694
Secondary paperboard and other paper products	$32,082	$190,198	$2,738,083
Sum of direct contributions	**$1,370,850**	**$1,620,412**	**$5,354,786**

*Includes maple syrup production

Industry	Vermont (Thousands of Dollars)	New York (Thousands of Dollars)	Maine (Thousands of Dollars)
Forestry*	$75,732	$48,511	$84,542
Logging	$90,979	$265,205	$416,480
Primary solid wood products	$305,966	$895,177	$1,066,877

Industry	Vermont (Thousands of Dollars)	New York (Thousands of Dollars)	Maine (Thousands of Dollars)
Secondary solid wood products	$217,960	$1,346,545	$445,458
Wood furniture	$173,733	$1,956,501	$252,539
Pulp, paper, and paperboard mills	$474,397	$3,620,763	$2,340,964
Secondary paperboard and other paper products	$32,082	$5,351,321	$629,856
Sum of Direct Contributions	**$1,370,850**	**$13,484,023**	**$5,236,715**

*Includes maple syrup production

Importance of the Forest and Wood Products Industries in Context

To help contextualize the relative importance of the forest and wood products industries, it is useful to compare the contribution of Vermont's forest and wood products industries with others. Natural resources and agricultural industries significantly contribute to the diversity of economic activities reflected in Vermont's $32.6 billion GSP (Exhibit 16). The forest and wood products industries provide more direct labor income, value-added, and output than commercial fishing, hunting, and trapping; mining and oil and gas production; and agricultural production industries. Vermont's forest and wood products industries comprised 1.2 percent of the GSP in 2017. Agricultural production provided the largest amount of employment (full- and part-time) of these industries.

Exhibit 16. Natural Resources and Agricultural Production Industries in Vermont, 2017

Industry	Employment	Labor Income (Thousands of Dollars)	Value-added (Thousands of Dollars)	Output (Thousands of Dollars)
Forest & wood products*	9,107	$291,472	$393,406	$1,370,850
Commercial fishing, hunting, and trapping	72	$123	$460	$564
Mining, and oil and gas production**	1,190	$48,502	$299,698	$396,414
Agricultural production (plant crop and animal)	9,860	$151,487	$304,909	$884,188
Total	**20,229**	**$491,584**	**$998,473**	**$2,652,016**

*Includes maple syrup production
**quarrying, mining, and petroleum/coal manufacturing

Labor income per job is highest in mining and oil and gas production ($40,772) and lowest in commercial fishing, hunting, and trapping ($1,694). For agricultural production, the average per job is $15,363; forest products has the second highest average income at $32,006.

Most of the forest and wood products industries are manufacturers, however the forestry, logging, and biomass power are not. There were nearly 33,000 manufacturing jobs in Vermont in 2017. 3,970 were in the forest and wood products industries, 12.1 percent of the total. Of 16 industries, forest and wood products manufacturing was third in terms of employment behind food manufacturing and computer and electronic product manufacturing. It was fourth in terms of labor income and third in value-added and output (Exhibit 17).

Exhibit 17. Manufacturing Industries in Vermont, 2017

Manufacturing Industries	Employment	Labor Income (Thousands of Dollars)	Value-added (Thousands of Dollars)	Output (Thousands of Dollars)
Food	6,810	$367,425	$452,873	$3,928,550
Computer and electronic product	4,327	$466,813	$546,038	$1,908,934
Forest & wood products	3,970	$201,229	$277,018	$1,160,578
Machinery	2,756	$212,777	$235,977	$741,847
Miscellaneous	2,266	$112,020	$152,304	$585,907
Fabricated metal	2,079	$125,556	$168,956	$436,278
Transportation equipment	1,791	$167,285	$160,044	$915,548
Nonmetallic mineral product	1,726	$102,531	$129,010	$360,061
Chemical	1,392	$110,363	$141,683	$1,074,270
Printing	1,300	$63,509	$79,488	$190,699
Plastics and rubber products	1,237	$80,391	$115,812	$371,609
Electrical equipment	1,194	$91,589	$122,284	$419,640
Beverage and tobacco product	1,011	$52,393	$125,199	$459,451
Textiles and apparel	776	$30,015	$40,144	$130,384
Primary metal	136	$12,203	$19,326	$101,333
Petroleum and coal**	64	$6,894	$25,049	$55,507
Total	**32,835**	**$2,202,992**	**$2,791,205**	**$12,840,596**

**Quarrying, mining, and petroleum/coal

Summary

This report serves as a snapshot of economic contributions of the forest and wood products industries in Vermont for 2017, as well as a baseline report for future analyses. State data were used in this report, but given IMPLAN's structure, substate and multistate analyses can be developed. However, future analyses may again require funding from the U.S. Forest Service or other institutions for assessments across multiple states. Methods used in developing this report are consistent across the region.

IN Vermont, there were 9,107 direct jobs in the forest products industries, and overall, 13,816 jobs were supported. Direct labor income was $291.5 million with total labor income at $521.9 million. Direct value-added was $393.4 million, and the total contribution for value-added was $770.8 million. Finally, direct output was $1.4 billion with a total contribution of $2.1 billion in output. Similar report findings are available from other states in the region and are summarized in a regional report.

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Glossary

The following technical terms are used throughout this report when discussing forestry and economic contributions.

Forestry Terms

Average annual harvest removals: The average annual merchantable volume of growing-stock trees that were live at the time of the previous inventory and were either cut and removed by direct human activity related to harvesting or died as a result of silvicultural or land-clearing activity by the time of the current inventory.

Average annual mortality: The average annual merchantable volume of growing-stock trees that were live at the time of the previous inventory and are dead in the current inventory.

Average annual net growth: The average annual change in merchantable volume of growing-stock trees, after deducting mortality volume, between inventories.

Forest land: Land that is at least 10 percent stocked by trees of any size, including land that formerly had such tree cover and that will be naturally or artificially regenerated. Forest land includes transition zones, such as areas between heavily forested and nonforested lands that have at least 10 percent canopy cover with live tally trees, or recently had at least 10 percent canopy cover by live tally trees based on the presence of stumps, snags or other evidence, and forest areas adjacent to urban and built-up lands, including pinyon-juniper and chaparral areas in the western U.S. and afforested areas. The minimum area for classification of forest land is one acre and 120 feet wide measured stem-to-stem from the outermost edge. Unimproved roads and trails, streams, and clearings in forest areas are classified as forest land if less than 120 feet wide.

Growing stock: Live trees of commercial species that meet minimum merchantability standards and only includes trees at least 5 inches in diameter at breast height. In general, these trees have at least one solid eight-foot section, are reasonably free of form defect on the merchantable bole, and at least 34 percent or more of the volume is merchantable. Excludes rough or rotten cull trees.

Timberland: A subset of forest land that produces or can produce crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation. (Note: Areas qualifying as timberland can produce at least 20 cubic feet per acre per year of industrial wood in natural stands. Currently inaccessible and inoperable areas are included.)

Economic Contribution Terms

Direct effects/contributions: The economic activities (e.g., output, employment, labor income, and value-added) associated with an industry or sector in the study area. These can describe the current economic sectors or changes to those sectors.

Employment: The number of full- and part-time jobs associated with an industry.

Indirect effects/contributions: The impact of local industries purchasing goods and services from other industries, leading to others' outputs, employment, and labor income. This report uses "indirect effects" to refer to the combination of indirect and induced effects.

Induced effects/contributions: The impact of labor income (employee compensation and proprietor income) via goods and services purchased due to the direct and indirect spending by industries. For this report, induced effects are included with indirect effects and referred to as indirect effects.

Labor income: The dollar total of employee compensation and proprietor income; the latter is associated with self-employed individuals.

Output: The dollar measure of production within an area; it is also viewed as sales.

Social Accounting Matrix (SAM) multipliers: These multipliers are derived by dividing the sum of direct, indirect, and induced effects by the direct effects. The social accounts include payments made between households, households and government, and more. These are available for output, employment, labor income, and value-added and are used to assess effects of changes in industry activity (i.e., "ripple effects").

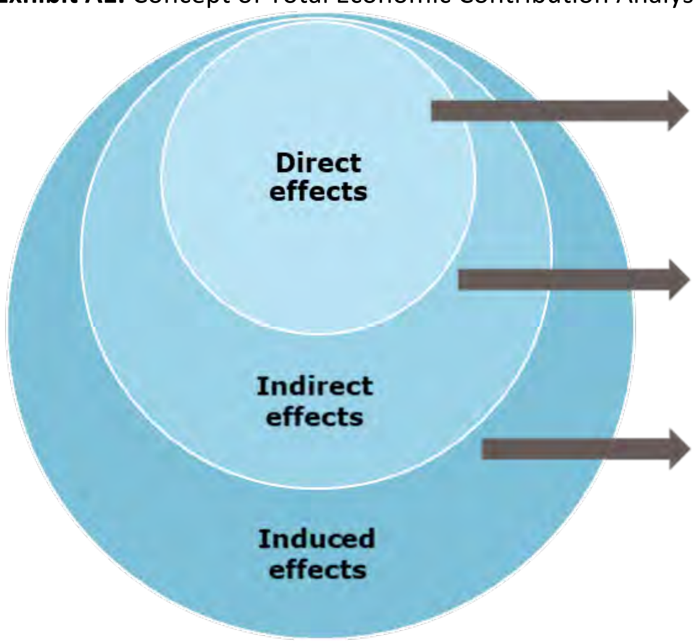
Total effects/contributions: The sum of direct, indirect, and induced effects.

Value-added (also known as gross state product, or GSP): The sum of labor income, other property income (e.g., rents and profits), and indirect business taxes (e.g., excise and sales taxes). It is the difference between an industry's total output and the cost of its intermediate inputs. The sum of value-added for all economic sectors within the region equals the total GSP.

Appendix A: Methods and Data[7]

Forest and wood products industries influence the economy in three ways: direct effects (when industries sell commodities in response to demand), indirect effects (as suppliers to directly impacted sectors), and induced effects (household spending by employees in the directly and indirectly impacted sectors) (Exhibit A1). The total economic contribution is the value of production required to meet all the needs stemming from the initial activity—in this case, forest product-related purchases.

Exhibit A1. Concept of Total Economic Contribution Analysis



Direct effects: The economic activities (sales, value-added, and employment) associated with an industry or sector in the study area.

Indirect effects: The impact of local industries purchasing goods and services from supplier industries, leading to others' output, employment, and labor income.

Induced effects: The impact of labor income (employee compensation and proprietor income) via expenditures on goods and services purchased due to the direct and indirect spending by industries.

The total contribution is the sum of direct, indirect and induced effects.

Input-Output Analysis: IMPLAN

Contribution analysis focuses on industries' role in an economy. The first step is often defining the region (e.g., a state). One of the next steps is to define exactly which economic sectors comprise the focus industries. To analyze the contributions of the forest industries, the project team, in consultation with representatives of the states, selected 32 sectors by consensus for inclusion in the analysis. A description of the methods and data follows.

[7] This appendix contains information located in the Forest Products Industries section of other state reports.

To concisely describe and communicate the economic contribution of the forest products industries, these 32 sectors were aggregated into seven broad groups (Appendix B):

- Forestry
- Logging
- Primary solid wood products
- Secondary solid wood products
- Wood furniture
- Pulp, paper, and paperboard mills
- Secondary paperboard and other paper products

While it is not considered a wood product, the report also includes information on the maple industry because of its importance as a forest-based crop in Vermont.

In total, these sectors cover forest-specific manufacturing activities including the conversion of trees into primary products, and the manufacture of products used by other sectors and households. Primary industries (e.g., sawmills, OSB [reconstituted wood products], and power plants) use wood directly from the forest, including roundwood, chips, or similar forms. Secondary industries (e.g., trusses and furniture) use one or more primary forest products (e.g., lumber and paperboard) in their manufacturing processes. Value is added as the timber is processed through primary and secondary manufacturers. Several sectors included wood and nonwood products (e.g., institutional furniture manufacturing). Therefore, output and other measures were reduced to better reflect the wood-only component by using published government data or surveys (Gibson, Leefers, and Poudel 2020).

This report used IMPLAN to estimate economic contributions of the forest products industries. IMPLAN is a widely used input-output model that comprises economic data and software. IO models characterize financial linkages among and between sectors, households, and institutions. Within these models, various sectors have production functions that show the value of inputs used in production of outputs or commodities. Vermont’s economy was represented by 380 sectors in 2017, the most recent year available for IMPLAN data at the time of the analysis. These sectors are based on the North American Industrial Classification System (NAICS).

IMPLAN models can be constructed for different geographic areas. State data were used in this report, but given IMPLAN’s structure, substate and multistate analyses can be developed.

Economic Contributions Defined

Input-Output Analysis and IMPLAN

IO modeling using IMPLAN software and data is a conventional approach for documenting the economic contribution of forest and wood products industries. IMPLAN is commercially available and widely used by government, academia, and businesses.

This analysis uses the matrix inversion approach with external IMPLAN model adjustment recommended by Henderson and Evans (2017) as a primary method for estimating economic contributions of forest and wood products industries in Vermont (Gibson, Leefers, and Poudel 2020). Major economic indicators generated by IMPLAN include employment (full and part-time jobs), labor income, total output, and value-added.

Interaction Between State and Regional Analyses

IMPLAN models are based on interactions across the economy. One important aspect of these interactions is whether commodities are sourced locally or imported. In smaller areas (e.g., counties), fewer commodities are sourced locally. As a result, leakages occur when purchases are made—that is, fewer dollars stay in the local economy.

It follows that larger economies have fewer leakages and more commodities are sourced locally. For example, an examination of the logging industries (IMPLAN sector 16) in Maine, New Hampshire, and Vermont, reveals that the direct employment for 2017 was 5,052, 1,732, and 1,737 jobs, respectively. Summing the individual state's total employment contributions (direct, indirect, and induced) yields 12,218 jobs. However, if the states are combined as one region, the total employment contribution increases to 12,325 jobs. This increase reflects less leakage and more local purchases.

The larger role is due to trade, but IMPLAN does not explicitly show trade with specific states, only overall imports and exports. The regional analysis highlights the larger role of forest and wood products industries in the region's economy. Consequently, the state-level analyses underestimate the actual contributions from a regional perspective.

Several key decisions related to methods were developed through a consensus process (Gibson, Leefers, and Poudel 2020). Consensus decisions were made regarding the modeling method for estimating economic contributions, the forest products sectors to include in analysis (either in total or in part), the IMPLAN year for reporting results, and the use of an analysis spreadsheet for consistent reporting.

The economic contributions of the region and each state's forest and wood products industries relied on 2017 IMPLAN software and data. IMPLAN is a widely used economic IO model that focuses on the interdependence among various producing and consuming sectors in the economy. IMPLAN has 536 industry sectors for the 2017 data set and is based on the NAICS. IMPLAN data are compiled and linked by the IMPLAN software (Version 3.1.1001.12); data come from various government agencies, including the U.S. Census Bureau, the U.S. Bureau of Labor Statistics, and the U.S. Bureau of Economic Analysis. Economic measures in IMPLAN include employment, labor income, value-added, output, and others. More detailed information on data sources is available at the IMPLAN website.

Wassily Leontief developed IO modeling in the mid-20th century. Impact analysis examines the effects of changes in demand in a regional economy, while contribution analysis can evaluate the role of several related sectors in a region. IMPLAN provides the software and data to conduct such analyses. Each sector has a production function tracing the backward linkages (i.e., suppliers) to other sectors. Various sectors produce commodities (e.g., the logging sector produces logs). Leakages (e.g., foreign and domestic imports/exports) to and from other regions are also modeled. Social accounting flows among industries, households, government, and capital are included in IMPLAN.

The analysis process begins with creating an IMPLAN model. One or more geographic areas (e.g., counties or states) are selected as the region. Then, models are run through the creation of multipliers. This report uses Social Accounting Matrix (SAM) multipliers. Next, activities are selected to estimate either economic impacts or contributions. For example, analysts can estimate the impacts of expanding or contracting industries. In the case of contribution analysis, it is important to ensure that the level of production does not exceed the actual level of production in the region. Contribution analysis essentially counters the effects of the multipliers.

The economic contributions of the forest and wood products industries serve as a snapshot of direct economic activity associated with given industries and other economic activities linked to those industries. Economic contributions are defined as "the changes in a region's existing economy that can be attributed to a given industry" (Watson et al. 2007). Hence, economic contributions define the role of an industry within a state or region. Several terms are used to describe economic effects, as shown in the glossary.

Contributions can be in terms of value-added, output, employment, and/or labor income. Value-added is commonly used to describe an industry's economic contributions and is a conservative measure of these contributions. Value-added is the difference between an industry's output, and the costs of intermediate inputs. When a sawmill sells a board, the value of the log and other inputs is not counted in value-added because they were counted when produced by loggers and others. Thus, only new additions to value (e.g., labor income) are included. Labor income is the major component of value-added and includes employee compensation and proprietor income. Value-added, summed across all sectors, is equal to GSP.

Another measure of economic contribution is industry output. For example, if a log is sold to a sawmill that sells boards, both sales are counted as part of the overall region's output, as they are important economic activities. Another measure, employment, includes both full- and part-time jobs. As the number of sectors in an analysis increases, there can be overlap in the number of part-time jobs across sectors.

Methods

IMPLAN estimates economic impacts (i.e., effects of economic changes) and contributions (i.e., effects of existing industries). Two methods for multisector economic contribution analysis are available (Parajuli et al. 2018), both requiring significant data manipulation.

The first method customizes the IMPLAN model by changing selected endogenous tables, whereas the second method adjusts input values based on matrix inversion prior to analysis. In method one, the changes are internal to IMPLAN and difficult to monitor from a quality control perspective.

Method two relies mostly on spreadsheet-based manipulation and is easier to monitor. When the contribution analysis is completed, direct effects from the IMPLAN sectors of interest equal the amounts shown in IMPLAN's "Industry Detail" table, and the total contributions (direct plus indirect plus induced) are estimated. Both methods prevent overreporting of total effects, which can occur if standard economic impact analysis is used when contribution analysis results are desired.

IMPLAN was designed for economic impact analysis. Multipliers ensure that the ripple effect manifests across the economy. A portion of those effects often involve self-purchases within the sector of interest. That is, if the output from the logging sector is $1 million in a local economy, the economic impact of $1 million in sales would be greater than that amount due to self-purchases. The contribution methods are designed to yield the $1 million direct contribution and its associated effects. Put simply, the amount of sales (direct contribution) estimated cannot exceed the amount that actually exists. Methods one and two accomplish this.

The matrix inversion approach relies on developing detailed SAM output multipliers for each sector in the forest products industries. Hence, a 32x32 matrix is developed with the diagonal yielding a value close to 1.0 for the detailed multipliers relating each row-column sector to itself (e.g., logging to logging, sawmills to sawmills, etc.). The actual matrix can be developed in several ways. For example, the SAM matrix can be exported from IMPLAN and narrowed down to the appropriate row and columns for the forest products industries. Then, it can be used to develop detailed multipliers via matrix inversion. Alternatively, detailed multipliers can be exported and rearranged into a 32x32 matrix. The approach used in this report was to rely on a matrix developed by IMPLAN staff for the state. Then, the matrix was inverted and multiplied the initial IMPLAN output values for forest industries sectors to yield inputs for IMPLAN analysis.

Supplemental Economic Contribution Information

Gibson, Leefers, and Poudel (2020) provide a detailed discussion of which sectors were included and excluded in the analysis. Most economic data used in this report were derived from IMPLAN, with two notable exceptions.

First, for most of the partial sectors (Appendix B), ratios of published government data were used to identify a portion of the industry that would be treated as forest products. In cases where only part of an IMPLAN sector was associated with forest products, analysts faced three options. The most conservative option was to include only sectors viewed as 100 percent in forest products, excluding sectors where only part produced forest products. At the other end of the spectrum, analysts could have focused on sectors producing any forest products at all, even if the forest products represented a small part of total output. Between these extremes, analysts could choose a third option—selecting the portion of a sector that produced forest products and include only that portion, mindful to include a means for assessing the magnitude of that portion. That is the approach used in this report.

Second, for sector 47, electric power generation–biomass, the IMPLAN employment figures appeared low based on prior knowledge of this sector. As a result, six facilities were surveyed to assess their 2017 employment. The updated direct employment figure (increased from 9 to 58) was used in IMPLAN analysis; other sector metrics were increased proportionally.

Wood is used in many other products not covered by the 26 sectors highlighted in this report. For example, boats, blinds, musical instruments, burial caskets, organic chemicals, and pharmaceuticals may use wood directly or as an extract. However, the wood-only component of these product groups is difficult to quantify and was unable to be included in this report. Surveys could be designed and conducted to determine the forest products component of these sectors. In practice, the production functions, employment, output, and other metrics would need to be compiled and inserted into IMPLAN.

Appendix B: Forest and Wood Products Industries Groupings and IMPLAN Sectors

Exhibit B1. Forestry Industry Grouping and IMPLAN Sectors

IMPLAN Sector	Sector Name
10	Maple syrup production*
15	Forestry, forest products, and timber tract production
19	Support activities for forestry*

Note: Sectors with an "*" indicate that only a portion of the sector is included in the forest products industries.

Exhibit B2. Logging Industry Grouping and IMPLAN Sector

IMPLAN Sector	Sector Name
16	Commercial logging

Exhibit B3. Primary Solid Wood Products Industry Grouping and IMPLAN Sectors

IMPLAN Sector	Sector Name
47	Electric power generation—biomass*
134	Sawmills
135	Wood preservation
136	Veneer and plywood manufacturing
138	Reconstituted wood product manufacturing

Note: Sectors with an "*" indicate that only a portion of the sector is included in the forest products industries.

Exhibit B4. Secondary Solid Wood Products Industry Grouping and IMPLAN Sectors

IMPLAN Sector	Sector Name
137	Engineered wood member and truss manufacturing
139	Wood windows and doors manufacturing
140	Cut stock, resawing lumber, and planing
141	Other millwork, including flooring
142	Wood container and pallet manufacturing
143	Manufactured home (mobile home) manufacturing
144	Prefabricated wood building manufacturing
145	All other miscellaneous wood product manufacturing

Exhibit B5. Wood Furniture Industry Grouping and IMPLAN Sectors

IMPLAN Sector	Sector Name
368	Wood kitchen cabinet and countertop manufacturing
369	Upholstered household furniture manufacturing
370	Nonupholstered wood household furniture manufacturing
372	Institutional wood furniture manufacturing*
373	Wood office furniture manufacturing
374	Custom architectural woodwork and millwork manufacturing
376	Showcase, partition, shelving, and locker manufacturing*

Note: Sectors with an "*" indicate that only a portion of the sector is included in the forest products industries.

Exhibit B6. Pulp, Paper, and Paperboard Mills Industry Grouping and IMPLAN Sectors

IMPLAN Sector	Sector Name
146	Pulp mills
147	Paper mills
148	Paperboard mills

Exhibit B7. Secondary Paperboard and Other Paper Products Industry Grouping and IMPLAN Sectors

IMPLAN Sector	Sector Name
149	Paperboard container manufacturing
150	Paper bag and coated and treated paper manufacturing
151	Stationery product manufacturing
152	Sanitary paper product manufacturing
153	All other converted paper product manufacturing

Appendix C: Detailed Economic Contribution Results

Direct Economic Contribution by IMPLAN Sector

Exhibit C1. Direct Economic Contributions, Forestry Detail, 2017

Sector	Employment	Labor Income (Thousands of Dollars)	Value-added (Thousands of Dollars)	Output (Thousands of Dollars)
Forestry, forest products, and timber tract production	67	$1,993	$2,155	$3,918
Support activities for forestry	638	$15,692	$15,906	$18,355
Maple syrup production	2,636	$17,188	$25,908	$53,460
Subtotal	**3,342**	**$34,873**	**$43,968**	**$75,732**

Exhibit C2. Direct Economic Contributions, Logging Detail, 2017

Sector	Employment	Labor Income (Thousands of Dollars)	Value-added (Thousands of Dollars)	Output (Thousands of Dollars)
Commercial logging	1,737	$50,332	$52,799	$90,979
Subtotal	**1,737**	**$50,332**	**$52,799**	**$90,979**

Exhibit C3. Direct Economic Contributions, Primary Solid Wood Products Detail, 2017

Sector	Employment	Labor Income (Thousands of Dollars)	Value-added (Thousands of Dollars)	Output (Thousands of Dollars)
Electric power generation—biomass	58	$5,038	$19,621	$43,561
Sawmills	638	$28,548	$38,964	$179,582
Wood preservation	40	$1,443	$4,954	$23,948
Veneer and plywood manufacturing	204	$12,346	$16,229	$58,875
Reconstituted wood product manufacturing	-	-	-	-
Subtotal	**941**	**$47,374**	**$79,769**	**$305,966**

Exhibit C4. Direct Economic Contributions, Secondary Solid Wood Products Detail, 2017

Sector	Employment	Labor Income (Thousands of Dollars)	Value-added (Thousands of Dollars)	Output (Thousands of Dollars)
Engineered wood member and truss manufacturing	-	-	-	-
Wood windows and doors manufacturing	283	$14,826	$23,560	$68,070
Cut stock, resawing lumber, and Planing	45	$1,184	$2,666	$9,921
Other millwork, including flooring	198	$8,630	$15,854	$43,565
Wood container and pallet manufacturing	53	$1,292	$1,894	$7,293
Manufactured home (mobile home) manufacturing	40	$1,559	$3,587	$10,195
Prefabricated wood building manufacturing	161	$8,224	$10,646	$28,970
All other miscellaneous wood product manufacturing	273	$9,961	$16,835	$49,947
Subtotal	**1,053**	**$45,676**	**$75,042**	**$217,960**

Exhibit 1. Direct Economic Contributions, Wood Furniture Detail, 2017

Sector	Employment	Labor Income (Thousands of Dollars)	Value-added (Thousands of Dollars)	Output (Thousands of Dollars)
Wood kitchen cabinet and countertop manufacturing	207	$8,180	$8,175	$26,838
Upholstered household furniture manufacturing	38	$1,008	$1,002	$6,293
Nonupholstered wood household furniture manufacturing	869	$38,770	$37,627	$103,580
Institutional wood furniture manufacturing	6	$181	$182	$897
Wood office furniture manufacturing	46	$2,171	$2,071	$8,514
Custom architectural woodwork and millwork manufacturing	39	$1,850	$1,848	$5,601
Showcase, partition, shelving, and locker manufacturing	113	$6,822	$6,597	$22,009
Subtotal	**1,318**	**$58,983**	**$57,502**	**$173,733**

Exhibit 2. Direct Economic Contributions, Pulp, Paper, and Paperboard Mills Detail, 2017

Sector	Employment	Labor Income (Thousands of Dollars)	Value-added (Thousands of Dollars)	Output (Thousands of Dollars)
Pulp mills	-	-	-	-
Paper mills	231	$17,505	$28,436	$163,375
Paperboard mills	410	$32,336	$50,112	$311,022
Subtotal	**641**	**$49,841**	**$78,548**	**$474,397**

Exhibit C7. Direct Economic Contributions, Secondary Paperboard and Other Paper Products Detail, 2017

Sector	Employment	Labor Income (Thousands of Dollars)	Value-added (Thousands of Dollars)	Output (Thousands of Dollars)
Paperboard container manufacturing	38	$2,264	$2,885	$16,707
Paper bag and coated and treated paper manufacturing	38	$2,128	$2,894	$15,376
Stationery product manufacturing	-	-	-	-
Sanitary paper product manufacturing	-	-	-	-
All other converted paper product manufacturing	-	-	-	-
Subtotal	**76**	**$4,393**	**$5,779**	**$32,082**

Note: Value-added in IMPLAN is equivalent to gross state product.

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Northeast Wood Markets Retention and New Market Recruitment Initiative

North East *State* Foresters Association

State North East Foresters Association

MAINE · NEW HAMPSHIRE · VERMONT · NEW YORK

NEFA

The State Foresters cooperating with the US Forest Service State and Private Forestry

REPORT Sections III & IV: Forest Products Selection & Benchmarking

May 13, 2021

Produced by the North East *State* Foresters Association for the Northern Forest Center, U.S. Department of Commerce Economic Development Administration and the U.S. Endowment for Forestry & Communities.

Contents

Figures

Section III: Best Forest Products for Economic Development for New Hampshire, New York and Vermont.

Introduction

This is the 3rd and 4th reports in a series of 5 reports produced by the North East *State* Foresters Association for the Northern Forest Center's federal Economic Development Administration funded Future Forest Economy Initiative. This project is intending to provide valuable background information and data that can guide seeking out new private investment in expanding existing forest products markets and creation of new markets in the three-state New Hampshire, New York and Vermont region.

The first report covered standing timber supplies in the New Hampshire, New York and Vermont region along with timber projections and a forest products supply chain overview. The second report covered the unique regional attributes, weaknesses and opportunities for wood market maintenance and growth in the three-state region.

This report covers the selection of preferred forest products markets most suited to the region and the benchmarking of those products with most likely competitors for the three-state region.

The final report that will follow this report will be a database of possible industrial site locations on which expansion or new forest products markets might occur.

A. Review of Indufor Forest Product Analysis – FOR/Maine

The Forest Opportunity Roadmap / Maine (FOR/Maine) is a collaborative process begun in 2016 among industry, communities, government, education, and non-profits. These individuals and institutions/organizations/agencies have come together to encourage forest products market development in Maine amidst changing economies in the region and world. The coalition was created with support from the U.S. Economic Development Administration and U.S. Dept. of Agriculture.

It is the intent with the analyses and conclusions for New Hampshire, New York and Vermont to use a similar approach and process to reach conclusions on preferred forest products to pursue for economic development purposes. The FOR/Maine effort has had resources many magnitudes greater than the effort for NH/NY/VT and also had the benefit of a huge team of individuals on a Steering Committee and many working committees. Lastly, a significant difference between the Maine effort and that undertaken through these reports is that these cover three states, whereas Maine is a single state. Working with three states complicates these analyses in a major way.

FOR/Maine seeks to promote continued growth in this sector through implementation of the Roadmap's goals and strategies. Through a Phase I research effort, FOR/Maine identified the global wood products that can be competitively made in Maine given timber supply projections. That was further refined through a strengths and weaknesses analysis and benchmarking with other countries and states.

Phase II of the Maine project focuses on implementation of the Forest Opportunity Roadmap which seeks to commercialize new uses of wood and place Maine as a global center of wood technology innovation by bringing more capital investments to Maine and building a communications strategy to promote career opportunities in a resurging forest industry.

The efforts to retain forest products markets and encourage new markets in New Hampshire, New York and Vermont will build upon the investment and knowledge gained in the FOR/Maine process.

I. Indufor Reports Overview

a. Desirable forest products for which to seek expansion

In the Phase I portion of FOR/Maine, three reports set up the information needed for Phase II of the project – the actual recruitment of capital and developers to expand existing and add new forest products markets to Maine's forest products infrastructure. In this and the following two sections, we provide a brief overview of the information in those reports as background for approaching these issues for New Hampshire, New York and Vermont.

The first Indufor[1] report focused on narrowing possible target forest products from which to launch economic development efforts. First, based on the timber resource analysis done in other FOR/Maine contractor reports, FOR/Maine concluded that in the coming years, Maine will have excess softwood roundwood and also biomass chips – both hardwood and softwood. All product efforts were based on this knowledge.

From this point a long list of possible forest products to focus on were selected. These included the following (see the Appendix for definitions for these products):

[1] Indufor, hired by FOR/Maine is one of the world's leading international forest consulting service providers. They provide high-quality knowledge and services for clients over the forest and forest industry value chains.

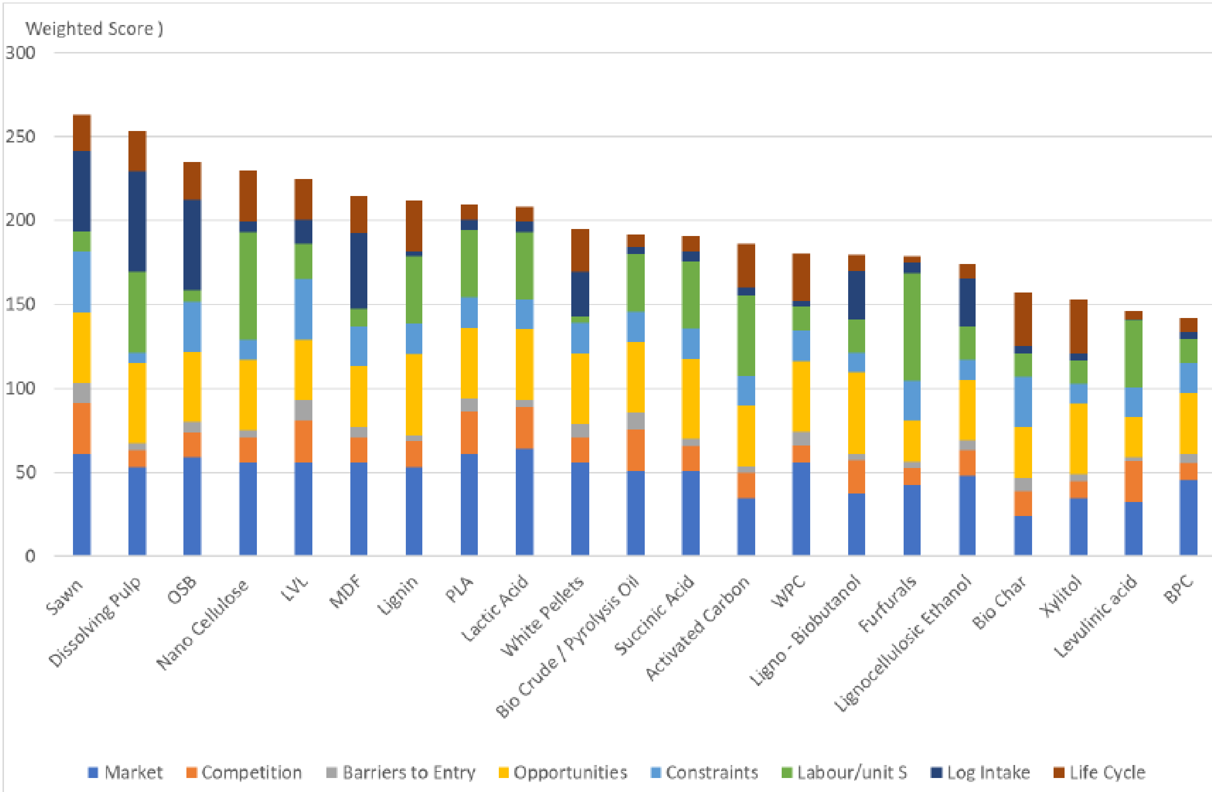
Activated Carbon	Lignocellulosic Ethanol
Biobutanol	Laminated Veneer Lumber (LVL
Biochar	Mass Plywood
Bio-Crude	Medium Density Fiberboard (MDF)
BioPlastic Composites (BPC)	Nano Cellulose
Black pellets	Oriented-Strand Board (OSB)
Cross laminated timber (CLT)	Polylactic Acid (PLA)
Combi Particle Board	Plywood
Dissolving Pulp	Pyrolysis Oil
Ethanol	Sawn (structural)
Furfural	Softwood Kraft Pulp
Lactic Acid	Succinic Acid
Laminated Timber	White Pellets
Levulinic Acid	Wood Plastic Composites (WPC)
Lignin	Xylitol

Indufor then ranked (with several interim alternative ranking attempts) the long product list using the following criteria:

1. Market
2. Competition
3. Barriers to Entry
4. Opportunities
5. Constraints
6. Labor/unit
7. Log Intake
8. Life Cycle

The results of this ranking are showed in the following graph from the first Indufor report:

Figure 1 **Indufor Product Ranking**



Source: Indufor FOR/Maine Report 1 Page 17

This ranking was further modified as described below (Indufor FOR/Maine Report 1 Page 17):

"Although sawn timber is ranked as the highest scoring product, Indufor has suggested that due to the existing, healthy sawn timber industry, the benchmarking study will focus on lesser-known products.

During the April 26 [2017] workshop with FOR/Maine committee members, the final selection of six products for benchmarking was determined to include: dissolving pulp, nanocellulose, LVL, MDF, cellulosic sugars (which provide a base for derivatives), and pyrolysis oil. Phase 2 will benchmark these products and the regions where they are produced."

This narrowing of the target product list is very important for the work in New Hampshire, New York and Vermont. We will discuss this later in this report after we further review the other Indufor report conclusions below.

b. Benchmarking Chosen Forest Products

Once the narrowing of the forest products list was complete, Indufor began a benchmarking effort to determine where Maine's strengths and weaknesses lie relative to these potential forest products compared to other key states and countries. This section highlights the conclusions to that work on the 6 chosen products.

Benchmarking[2] work was conducted comparing Maine's prospects with the 6 chosen forest products against:

<u>Countries</u>	<u>US States</u>
Finland	Georgia
Germany	Minnesota
Russia	Oregon
China	
Canada (Ontario)	

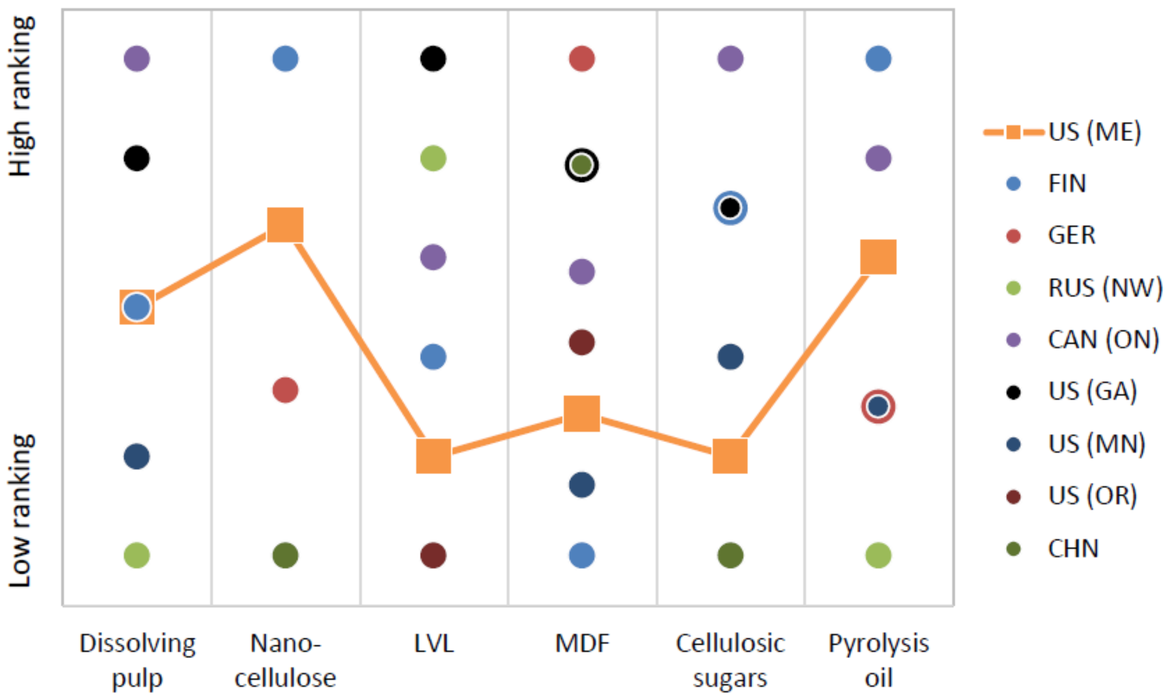
The benchmarking work compared Maine with the other countries and states relative to the following issues:

Raw material availability
Forest ownership
Raw material cost
Labor cost
Labor availability and skills
Logistics cost
Other costs
Regulatory climate
Taxation
Policies and enabling environment

A single graphic from Indufor's third report best illustrates the results of the product ranking and benchmarking analysis for the 6 chosen forest products:

[2] Benchmarking is the practice of comparing business processes and performance metrics to, in this case, countries, provinces or states where similar forest products markets are found. The FOR/Maine effort compared the six products for Maine production to the other countries and states.

Figure 2 **Indufor Product and Benchmarking Analysis**



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This concluded that Maine's best opportunities for forest products market growth include nanocellulose and pyrolysis oil followed by dissolving pulp. Nanocellulose and dissolving pulp require existing or new pulp mills to manufacture. Pyrolysis oil requires new manufacturing facilities.

Our selection of forest products for New Hampshire, New York and Vermont can be found on page 71 and they differ from Maine's choice for reasons cited later in this report.

Some of the products chosen as preferences for NH, NY & VT are also chosen by Maine and we believe that for the many reasons we cite later, the three-state region can compete with Maine and/or there is great market opportunity for the product so that both Maine, New Hampshire, New York and Vermont can produce similar products – just as the forest products industry in all of these states currently successfully compete with their respective sawmill businesses.

c. SWOT Analyses of Chosen Direction

The Strengths, Weaknesses, Opportunities and Threats (SWOT) analyses conducted by Indufor for FOR/Maine took a deep dive into the issues. The results of that analyses are summarized here directly out of the final Indufor report that included the SWOT analysis:

> "Maine's primary advantage is its plentiful supply of moderately priced softwood raw material available in an area with existing harvesting and logistics infrastructure. However, a major increase in pulpwood demand (in the range of several million tons per year) would inevitably erode both availability and raw material cost competitiveness. Therefore, a processing option that moderately increases the wood use is best suited for the area.
>
> The labor cost competitiveness of Maine is internationally weak, but on par with other regions in the United States. Therefore, the focus in attracting new wood processing industries should be in products in which the labor cost component is small relative to product value. Labor cost constitutes only a relatively small share in dissolving pulp cost structure. While hardwood dissolving pulp currently dominates the growing viscose for textiles market, dissolving pulp derived from softwood is used predominately for acetates and ethers with increasing use for viscose production observed in the market. As the total market for dissolving pulp is growing at an attractive pace - specifically as a raw material in the textile industry (viscose) – softwood dissolving pulp may see increasing growth potential.
>
> Maine has a more stable operating environment compared to China or Russia and similar to the other regions. Yet, the state has consistently been ranked low for ease of doing business compared to other states. In many respects the investment climate in Maine is similar to that of Finland several years ago. Forestry companies in Finland subsequently innovated and focused on the highest value products in order to counteract its high wood costs and labor costs.
>
> Maine's forest industry will very likely need to do the same. Therefore, nanocellulose, pyrolysis oil and cellulosic sugar products appear to be attractive complements to the traditional wood industry. Maine is also closer to very large population centers in the Northeast compared to most other regions, including Eastern Canada or the U.S. South. Therefore, Maine has an advantage in products that are not economical or suited for long-distance transport have an advantage. Moreover, the sea freight cost from Maine to China was found competitive, which opens opportunities. Maine could improve its comparative advantage through investments in infrastructure and take full advantage of the proximity to end-markets. Investments in infrastructure would include improved railway network and

sea ports. MDF, LVL and pyrolysis oil are considered regional products, whereas dissolving pulp, nanocellulose and cellulosic sugars are traded on the international markets.

Pyrolysis oil as a replacement of heating oil is one such product that would benefit significantly from the large local markets. As technology improves and markets open, the use of pyrolysis oil for jet fuel product could expand the market for Maine. Improvements in logistics infrastructure would especially benefit MDF production placing Maine among the most attractive locations for MDF investment. In attracting new wood pulp-based investments, Maine can make use of the existing pulp mills by repurposing them or integrating new manufacturing lines to the mills. Modernization of mills is likely to be less capital intensive and the start-up period is notably shorter than constructing a new mill. Maine has a disadvantage in that it is not a home to numerous large forest industry companies. Therefore, it lacks the lobbying power brought to many of the competing regions by large international forest industry companies (such as UPM, or Stora Enso in Finland, or Norbord in Ontario, Canada). On the other hand, it has the University of Maine Process Development Center, which works with many forest industry groups from various regions of the world. This can be an important avenue for introducing Maine to these companies.

Additionally, Maine's large private forest ownership – compared to competing regions with fragmented or large public forest ownership – presents an opportunity to quickly take advantage of market shifts.

The state's traditional forest industry could be complemented by a strong bioeconomy strategy. Improving Maine's enabling environment in the forest and bioeconomy sector through stimulus in the form of incentives, bioeconomy focused funds, R&D funding and low-interest rate loans could support such a transition."

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The final recommendations from Indufor are reproduced here verbatim:

Recommendations

"The State of Maine has a long and proud history in the forestry industry in North America. Today, Maine remains an important supplier of a range of valued forest products and with expanding availability of logs over the coming years, it has the unique opportunity to become a leading forest products producer in North America. Based on the analysis of market opportunities for Maine's softwood and biomass resources and the state's current competitive position, Indufor has produced the following recommendations for the FOR/Maine to consider in its next steps. Some of the recommendations are near-term and likely achievable, while others require bolder and longer-term concerted effort.

1. Develop and communicate an ambitious bio economy strategy with enhanced access to financing for new investments

Market opportunities for new bio-products exist and are likely to grow in the medium to long term, which means that Maine, as a location for new investments will be competing against other national and global competing locations. The EU, Canada and China are already implementing policies to strengthen the operating environment and incentivize bio-product investments.

As an example, Finland's bio economy strategy was produced in 2014 and identified key steps and assigned responsibilities to government agencies, trade associations and research institutes. Maine has a narrow window to develop a state-wide bio economy strategy to assess external competitors and changes to be made in the state. Developing a bio economy strategy that has broad public support will require significant communications efforts to key constituencies and potential investors. The state must also keep track of changes to the market and competitive landscape over time, by updating the current benchmarking study regularly and organizing annual or biannual meetings with the relevant stakeholders.

As part of the bio economy strategy, Maine can take a leadership position to stimulate demand and encourage investment. Many of the emerging products are currently more expensive to produce than their fossil-based counterparts. Maine can stimulate the market demand through ambitious mandates to use "made in Maine" cellulosic biofuels in all or part of the government vehicles, adopt building codes that promote the use of new wood products, promote the substitution of wood based plastics, or mandate that all state facilities use bioplastic products.

Additionally, a mandate to phase out the use of conventional heavy fuel oil, to be replaced over time with pyrolysis oil, or promotion of compostable bags like PLA-based bags would increase overall market demand. Maine can also use its political influence at the national level to push for stimulus packages targeting bio-products and federal procurement policies. Providing marketing and commercialization support for its leading R&D projects like nanocellulose can help Maine position such manufacturing for growth. While Maine does provide some tax credits for new job-creating investments and commercial production facilities, they could be enhanced to attract the substantial new investment required to make Maine a true competitor in the bio economy. Concessional finance with lower interest rates for high CAPEX projects might be required for converting existing mills to dissolving pulp production. New, creative forms of financing that blend grants with first-loss debt could attract more equity investment interest in the emerging products (cellulosic sugars, fuels and chemicals). Working with foundations or banks that have experience arranging such deals will be essential.

Lastly, communicating Maine's bio economy image to national and global audiences will be a key factor in success. The Nordics and parts of Canada are known globally to be eco-friendly investment locations. Maine will need to deliver clear messages on its intent to be a leading bio economy to compete.

2. Identify and target commercial off-take contracts

Increasing consumer awareness of environmental sustainability has led leading consumer brands to commit to a switch from fossil-based chemicals and plastics to bio-based alternatives. Innovative bio-based products, such as nanocellulose, biochemicals and PLA, would be able to supply a number of markets. As many of these are intermediate products, partners include fuel, plastic, packaging, textiles, and polymer producers, among others. This creates a large potential for a captive offtake market, by which one large company could buy the majority or entirety of a plants' production.

While overall volumes remain small, the products have a high added-value and, as such, are viable exports. Companies such as Unilever, P&G, Ikea, Coca-Cola and Lego have all committed to increase their consumption of bio-based plastics. Currently, bioplastics sell at an average premium of 15-40% over the price of conventional plastics. Thus, investing in market studies to identify potential off-take customers for these products, even in smaller volumes, would be a small investment with potentially large returns. Supporting small businesses to re-open previously shut-down mill sites from the pulp and paper industry to demonstrate and scale up biofuel technology would bring new jobs and prestige to the area. As some examples of demonstrated technology can now be found, the next step would be to find off-take partners willing to buy all or large portions of the product, particularly for existing pilot scale products, such as nanocellulose and cellulosic ethanol.

Generally, understanding the market dynamics and global megatrends, such as the growth of the middle class in developing countries, leading to a rapidly increasing demand for hygiene products, or the growing demand for sustainable packaging materials through the onset of the on-demand and online consumer revolution, would highlight the opportunities for investment that would pique the interest of many large brand-owners and build investment confidence.

3. Invest in infrastructure

Maine has an advantage thanks to proximity to end-markets and competitive long distance transportation costs, however the benefit of the location is undermined by outdated (and degrading) infrastructure. Public support for infrastructure investment appears to be growing in the United States. To ensure that Maine stays competitive it must maintain rail, road and port infrastructure to cost-effectively reach regional and global markets.

4. Make Maine "business-friendly"

Maine's historically low ranking for ease of doing business is tied to high corporate taxes and the complexity and stability of regulations. Given the current labor situation in Maine (not being a "right to work state"), negotiations with the labor unions to update and modernize the way in which people are employed are recommended. Modern industries require greater flexibility – both regarding hours/shifts, but also in terms of where and how people fulfil their role in the workplace. Likewise, the efficiency of employees can be improved as the global forestry industry embraces the automation and digitalization revolution. The shift towards greater automation requires upfront CAPEX investment by industries but is considered an integral part of evolving and keeping industries competitive.

Thus, the need for large-scale retraining activities is urgent in many forest sectors. By creating investment support through tax rebates or favorable depreciation rates, Maine could increase the competitiveness of their existing forest industry and spur the economy, leading to increased employment opportunities. Grants for new solutions and research, education, re-training, upskilling etc. should be employed. At the same time, this necessary transition into automation will potentially displace some of the work force for which new employment opportunities can be created in innovative and emerging market segments, such as biofuels and biochemicals.

5. Drive down energy costs and support bioenergy
While bioenergy is currently being utilized in Maine, the majority of this is utilized by the forest industry. Additionally, the use of bioenergy in combined heat and power (CHP) is low outside of the forest industry. As increased subsidization to bioenergy is likely to draw criticism from some political adversaries, other support mechanisms should be considered. For example, a minimum requirement for new state-owned facilities to utilize biomass for CHP would encourage not only the use of sawmilling residues, but also improve the carbon footprint of the heating sector. As Maine has a relatively high heating demand, the transition away from heavy fuel oil with biomass boilers and pyrolysis oil would be a large step towards meeting their renewable portfolio standards and targets. Pyrolysis oil would qualify as a Class I renewable source. This is an issue that can be turned into a major plus for the forest industry.

Many forest industries have the potential to be either self-sufficient or energy positive when using mill and forest residues. Promoting the use and generation of this energy can be directly supported by the State of Maine. This could be in the form of attractive feed-in tariffs, carbon credits, support with investment costs for biomass power plants (integrated into processing facilities) and various other incentives and favorable regulation. If done well, Maine could use this as a major upside to the State and attract new bio-based industries, including but not limited to bioenergy and liquid biofuels. As a comparative example, Europe has made major achievements by mandating a minimum target level of renewable energy and renewable transport fuels, for which a penalty is incurred if these targets are not reached.

6. Go Out and Attract Investment
Indufor suggests that Maine actively attract investment in the forest products industry by directly targeting potential investors. Potential investors should be identified, ranked and monitored, and those that are attractive and appear to be evaluating investments should be engaged, ensuring that a Maine location for their new investment will be considered and evaluated fairly based on detailed and accurate information on Maine's resource availability, operating costs and supportive regulatory environment."

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B. Differences between FOR/Maine and NH/NY/VT Analyses

I. Timber Inventory and Availability

Although there are similarities, there are also stark differences between the Maine forest products economy and infrastructure and the opportunities and challenges facing the New Hampshire, New York and Vermont region. This section of the report reviews those differences.

Standing timber inventory on a per acre basis is much higher in NH, NY and VT. Average stocking per acre in Maine statewide is 17.47 cords while in NH, NY and VT the stocking is 26.82, 25.33 and 26.06 cords per acre respectively (Figure 3). Averaged together, the stocking per acre comparing New Hampshire, New York and Vermont is 51% higher than Maine's. Simply put – there is a lot more timber per area in the three-state region than in Maine. This higher timber stocking on all forest ownerships in the three-state region compared to Maine is significant and it may have ramifications for availability and pricing that give advantage to New Hampshire, New York and Vermont

Figure 3 **Acreage and Timber Stocking ME, NH, NY & VT (2019)**

STATE	Timberland Acreage	Stocking in cubic ft	Stocking in cords	Cords per acre
ME	16,867,541	23,580,510,892	294,756,386	17.47
NH	4,420,004	9,483,859,212	118,548,240	26.82
NY*	15,151,229	30,571,089,164	382,138,615	25.22
VT	4,275,652	8,914,822,442	111,435,281	26.06

Source: USDA Forest Service FIA *Note: NY's data does not include southern counties near and around New York City

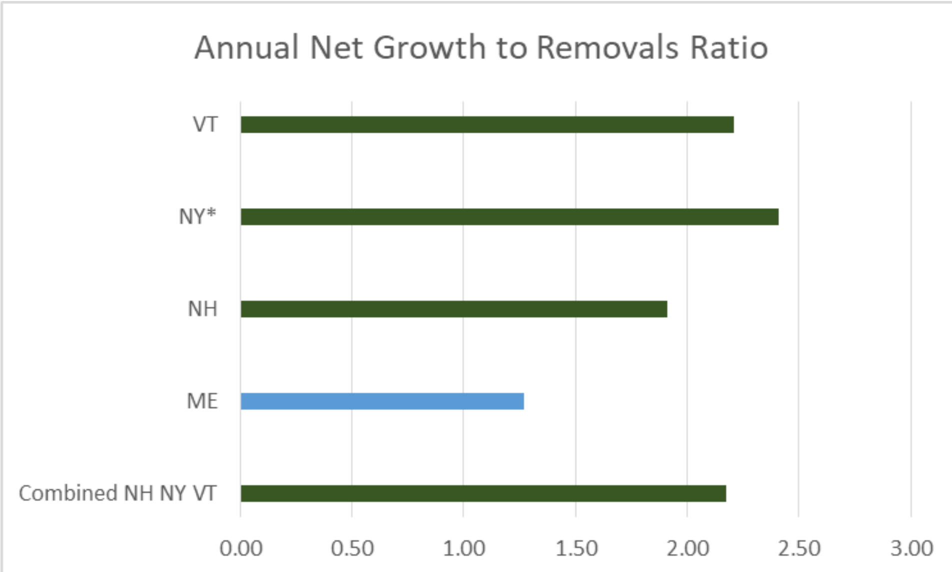
over Maine but the relationship of standing timber stocks to availability and pricing is complex. Furthermore, Maine's private forest ownership is dominated by large industrial/business ownerships. New Hampshire and New York have a few of those kinds of forest owners but covering a small area compared to Maine and Vermont has virtually none. Having small private landowners further complicates issues of timber availability as a result of differing landowner objectives between small and very large private forest owners.

It would seem that more standing timber in the three states would result in more supply and in the classic economic conclusion that greater supply while demand remains the same equals lower prices. But supply of timber in this case means supply to the market (i.e. a mill using the timber). Given available timber supply from the forest, the other key part of the economic equation is the supply-chain infrastructure to get the timber from the forest to the market. With greater standing timber in the three-state region as compared to Maine, prices to the mill may be similar or lower if there is adequate capacity in the supply chain. If the capacity to get timber to market from the forest has been reduced, as it has been in the three-state region as timber markets have shrunk in recent years, the conclusion about price of timber in the three-state region may or may not be different from Maine because of the supply-chain infrastructure.

With substantial reduction in low-grade timber markets in the three-state region since 2019 (closure of many biomass electricity plants and a pulp mill in western Maine) it would seem logical that prices for low-grade timber products (wood chips as a good example) should be lower than they were because there is more supply today looking for a market as compared to early 2019. But we also know that the number of loggers and truckers in the supply chain has been reduced during that time due to the lost markets. So price for wood chips from the forest may be reduced somewhat but maybe not as much as we think. Further, there is a low-point on pricing timber products, whether high or low-grade, below which loggers and truckers cannot sell because they will lose money on their operations. If this occurs in a widespread fashion, some loggers and truckers will simply park or sell their equipment and leave the business. Another outcome of reduced low-grade markets is that tree tops, branches and low grade timber felled may simply be left in the woods or be left standing.

Other timber metrics are also helpful to compare. Growth to removals comparisons are helpful as they describe a basic tenet of timber sustainability – whether timber standing inventory is growing or shrinking over time. In Figure 4, the growth to removal ratios among the states are all positive (increasing inventory over time) but it shows that Maine's, at 1.27, is 73% lower than the combined ratio of NH, NY and VT at 2.18. A higher positive net growth to removals ratio means that the net standing timber inventory in a state with a

Figure 4 **Annual Net Growth v. Removals Comparisons**



Source: USDA Forest Service FIA *Note: NY's data does not include southern counties near and around New York City

higher growth to removal ratio is growing faster than one with a lower ratio. This reinforces the data in Figure 3 above that the NH, NY and VT region has more available timber standing for growth in the forest products industry – and a faster rate of increase in that standing timber - than Maine does.

In terms of species differences in excess timber, the NH, NY and VT region has excess timber in all species and quality categories as previously described in other sections of this report. In the Maine analyses, future excess timber is projected to be softwood (particularly Spruce/Fir but also White Pine) and for all species for low-quality biomass.

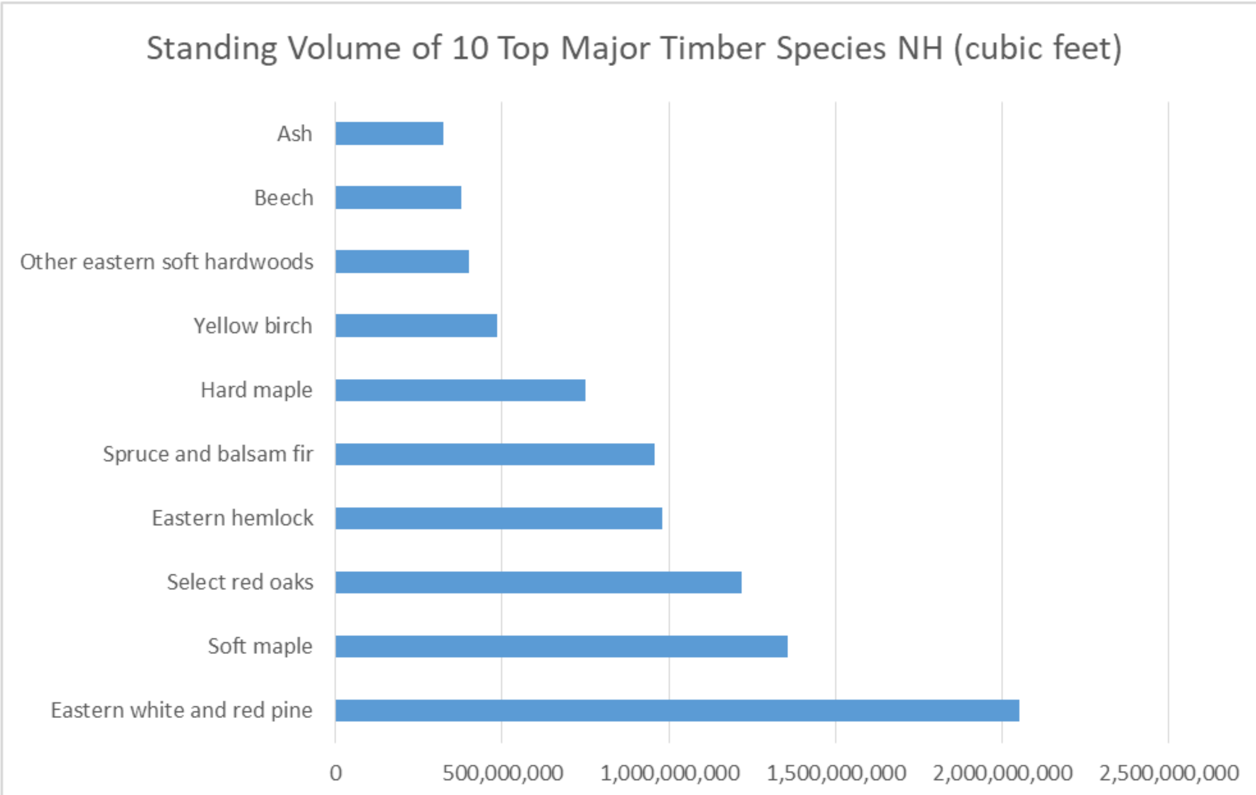
In NH, NY & VT our future timber projections were detailed volume-wise but not by species. The three-state region's forests are middle-aged and getting larger and older all the time. Depending on the silvicultural choices made when harvesting occurs, the species make-up of the forests may change over time although projections show much more timber volume standing in 20 years time from year of this report.

In the NH, NY and VT region, the tree species with the most volume break down as follows:

For New Hampshire, the top 10 timber species by volume are shown in Figure 5. Eastern White Pine, Red (soft) Maple and Red Oak are the top species followed by Eastern Hemlock, Spruce and Balsam Fir (found mostly in the north) and

Sugar (hard) Maple. Both high quality and low quality timber is accessible in all of these species.

Figure 5 **Top Timber Species by Volume - NH**

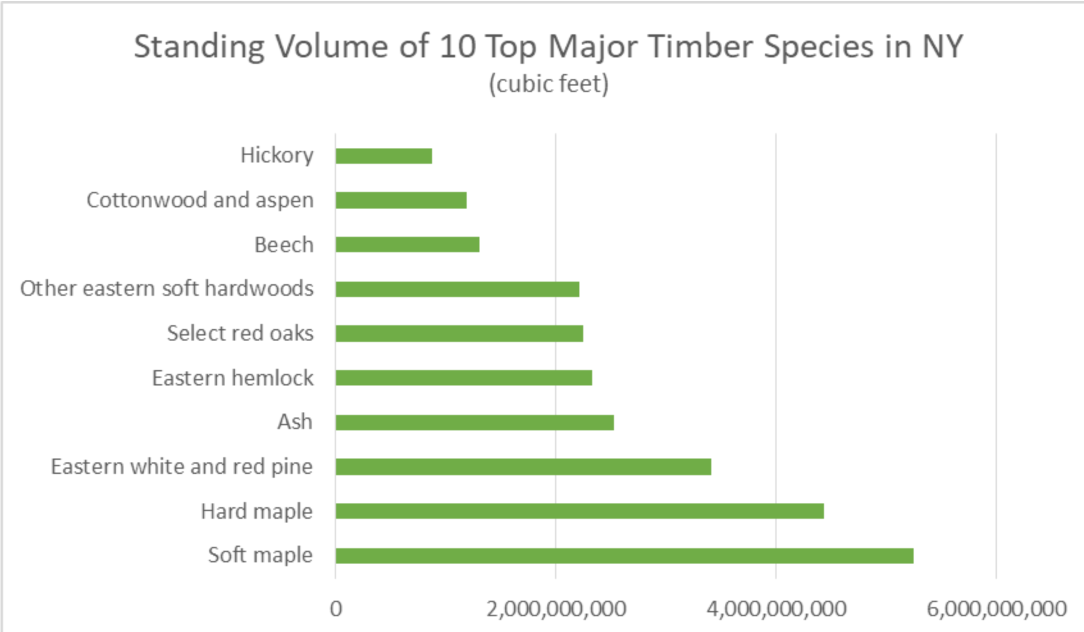


Source: USDA Forest Service Forest Inventory and Analysis

<u>New York</u>

For New York, the top 10 timber species by volume are shown in Figure 6. Red (soft) Maple, Sugar (hard) Maple, Eastern White Pine and Ash are the top species followed by Eastern Hemlock, Red Oak Spruce and Other Hardwoods. Both high quality and low quality timber is accessible in all of these species.

Figure 6 **Top Timber Species by Volume - NY**

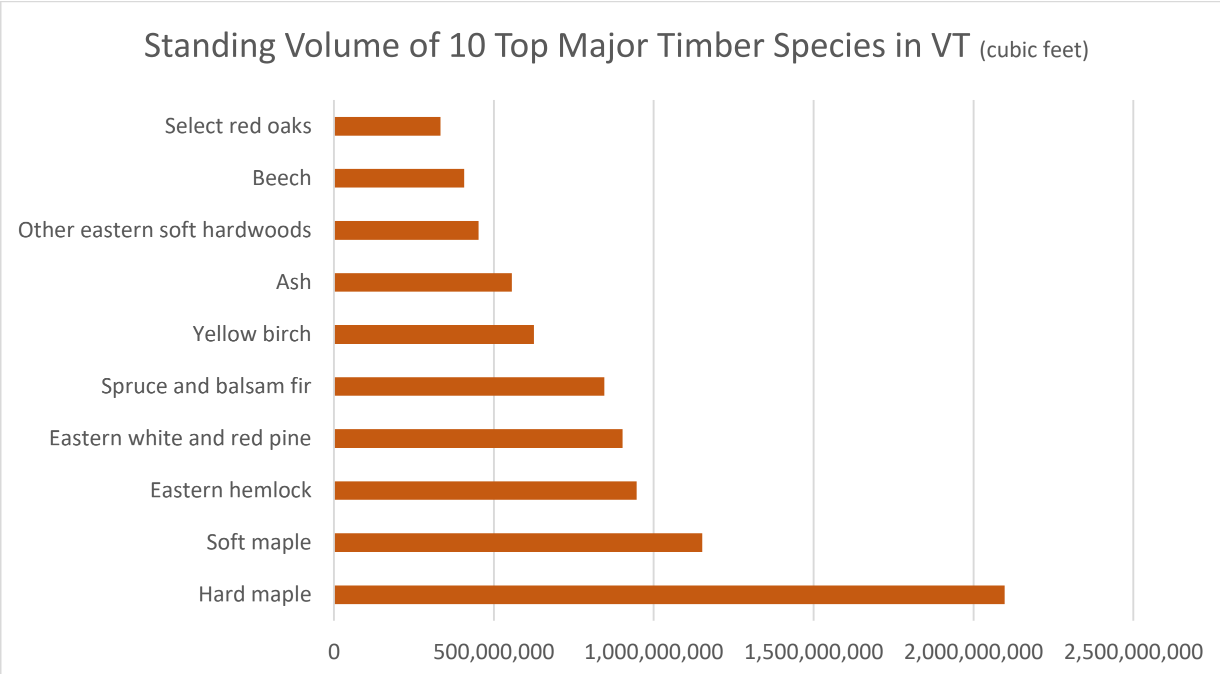


Source: USDA Forest Service Forest Inventory and Analysis

Vermont

For Vermont, the top 10 timber species by volume are shown in Figure 7. As might be expected, Sugar (hard) Maple is #1 by almost double that of Red (soft) Maple. This is followed by Eastern Hemlock, White Pine, Spruce & Fir and Yellow Birch. Ash, other hardwoods, Beech and Red Oak round out the top 10. Both high quality and low quality timber is accessible in all of these species.

Figure 7 **Top Timber Species by Volume - VT**

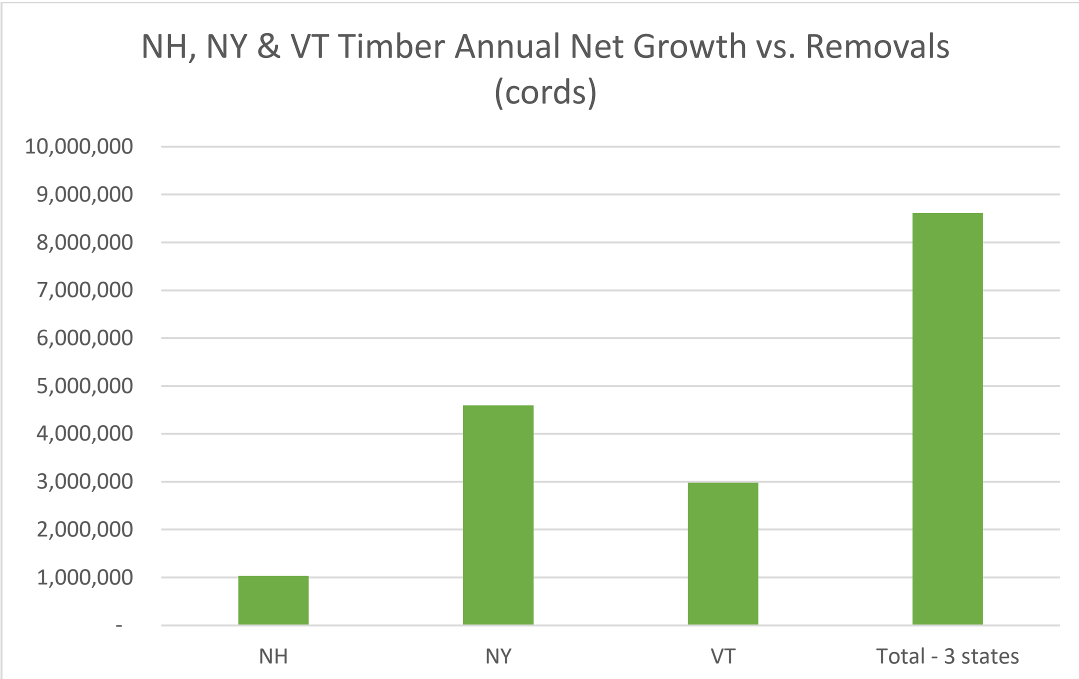


Source: USDA Forest Service Forest Inventory and Analysis

A reminder from our earlier report on timber supplies in the New Hampshire, New York and Vermont regions that all three states have significant excess timber available for expansion of existing markets and creation of new timber using markets. The species above are not being utilized fully in all three States.

Figure 8 shows that ***annually***, over 8.6 million cords (21.5 million tons) of excess timber can be found across the three-state region. If all of this excess timber were utilized annually, the states would have stable forest inventories as this already accounts for existing uses. While we don't believe the majority of this timber would be used if expansion efforts are successful, it merely confirms that timber supply is not a restraint to forest products markets expansion in the region.

Figure 8 **Excess Timber in NH, NY and VT**



Source: USDA Forest Service Forest Inventory and Analysis

II. Supply Chain Infrastructure

The supply chain infrastructure in NH, NY and VT is robust as demonstrated in the previous report in this series. The Figure 9 table, taken from the supply chain report[3] shows the number of businesses in the supply chain in these states.

Figure 9 **Supply Chain Infrastructure in NH, NY & VT[4]**

Industry Category	New Hampshire	New York	Vermont	TOTAL
Foresters	177	80	292	549
Logger/Truckers	305	635	309	1249
Sawmills	61	154	50	265
Pulp & Paper mills	0	2	0	2
Biomass Power Plants	4	1	2	7
Concentration Yards	17	15	20	52

Compared to Maine, the basic woods infrastructure in NH, NY and VT that is necessary to get timber from the forest to mill is similar. The number of fulltime sawmills in Maine is approximately 82 which translates to approximately 1 sawmill to every 220,000 acres of timberland in the state. The 265 sawmills across NH, NY and VT translates to 1 sawmill per 90,000 acres of timberland so the number of mills is more dense in the three-state region compared to Maine. The caveat to that comparison is that the timber usage per mill in Maine is higher – showing the average mills size is greater in the Maine mills, particularly for the spruce/fir mills of which there is only one large-scale example in the NH, NY & VT region whereas there are many in Maine.

Operating biomass electricity generation plants are comparable in the three-state region to Maine. In Maine there are two standalone biomass electricity plants in operation as of the date of this report in early 2021 (approximately 50 MW capacity). In New Hampshire two still operate (approximately 100 MW of capacity), in Vermont two still operate (approximately 75 MW capacity), and New York one (approximately 60 MW capacity). A note of importance about

[3] Northeast Wood Markets Retention and New Market Recruitment Initiative PHASE I, North East State Foresters Association DRAFT REPORT: FIA, Timber Projections & Supply Chain, July 29, 2020, Page 132

[4] It should be noted that the sawmills listed are essentially full-time operating sawmills, some large and some small. Part time operations or portable sawmill operations, of which there are many and growing all the time, are not included in this listing.

these remaining wood biomass electricity plants - unless major public policy changes occur at the state and/or federal level, the fate of these remaining biomass plants is uncertain at best. Without policy change that favors this kind of renewable electricity generation, it is likely that not all of these remaining biomass plants will be operating in five years time. The single biggest difference between the three-state region and Maine is the density of pulp and paper mills. In the three-state region there are only two operating pulp mills, both located in New York. Several other Canadian pulp mills are accessible markets for forest landowners and timber harvesters operating in the northern reaches of the three-state region, but the distance to those mills soon becomes too costly as you move south from the northern areas of the NH, NY & VT.

Maine's supply of 5 pulp and paper mills (a 6th is just over the border in Edmonton, New Brunswick with its paper mill located just in Maine on the US side) is substantially more than the NH, NY & VT region. One of the five operating pulp & paper mills in Jay, Maine has ceased to be a pulp mill. The pulp side of the operation suffered a major explosion in April of 2020 and owners have recently said that the pulp mill will never be rebuilt so that pulpwood market appears to be lost.

Regardless of the Jay, Maine pulp mill issue, the capacity of the other functioning mills in Maine provides a much more substantial opportunity for seeking new markets for forest products through making changes or wholly re-purposing one or more of the pulp and paper facilities. Indeed the FOR/Maine process is seeking to do just that with its emphasis on dissolving pulp, nanocellulose and chemicals as target product areas.

The New Hampshire, New York and Vermont region can explore those opportunities since two operating pulp mills exist in New York but the likely target products, discussed later, will need to emphasize other directions.

III. Transportation Infrastructure

As it relates to the forest products industry or any industry that needs to move products from one place to another, cost is key. Assuming adequate supply of a particular transportation method, it matters not whether it is trucks, planes, ships or rail – or some combination thereof. The least expensive alternative will be used.

As described in the transportation section of the second report in this series[5], the NH, NY and VT region has a generally good road transportation infrastructure for

[5] Northeast Wood Markets Retention and New Market Recruitment Initiative PHASE I, North East State Foresters Association, DRAFT REPORT Section 2: The unique regional attributes, weaknesses and opportunities for wood market maintenance and growth, October 14, 2020, Page 32

trucking forest products. There are limitations in several areas including: the Tug Hill plateau in western NY, the Adirondack and Catskill Parks, also in New York as well as certain portions of the Green Mts. spine and Northeast Kingdom (northeastern) Vermont along with the White Mt. National Forest and north of the national forest in New Hampshire – where the public road infrastructure is not as robust as it might be. The interstate highway system in these three states is stronger north/south than east-west although New York, the far largest of the three states, has interstates that are both north/south and east/west although there are, of course, gaps. Lastly, in all three states, there are limitations on some secondary public roads due to bridge weight restrictions. This is a never ending issue that forest products truckers must address no matter where they travel in the region and the world for that matter. These local public road restrictions (county and town) also included seasonal weight limits controlled by local political jurisdictions. The forest industry is well-versed in the annual spring closure of local and county roads as the frozen roads thaw to protect them from heavy weights of large trucks.

There are no extreme disadvantages of that in the three-state region compared to elsewhere, and in fact Maine and Vermont have higher weight limits on their interstate highways than many other regions in the country.

The situation for commercial rail is less positive than for traditional trucking infrastructure. The commercial rail opportunities with the most desired Class I rail lines is extremely limited in the three-state region except for northern/northwestern New York which has some access to Class I rail, though the anticipated sale of Guilford Transportation to a Class I carrier will bring Class I to parts of New Hampshire and provide one-carrier access to much of the Eastern United States. Clearly, this is a limitation when compared to other regions with better commercial rail service, but Maine's rail situation is only marginally better.

One of the keys to effective rail service is the volume of traffic – when large volumes travel over rail corridors, the rail company invests in the people and infrastructure to assure service. Other regions of the country that produce large quantities of commodities (particularly oil, coal, ethanol, corn) or are sent to large consumers (refineries, coal-fired power plants, etc.) often have the traffic to justify these investments in rail. New England, with no refineries and only one operating coal power plant that may close soon, does not have this same dynamic.

Salt water ports are available throughout the three-state region, however, there are major gaps due to distance – especially to get product from certain areas of the northern reaches of NH, NY & VT. Despite these limitations, any business wishing to get product shipped to foreign markets can find a port that will work although cost may be an issue with the longest truck hauls. The freshwater port at Albany, NY is included as it reaches salt water. Also, Canadian ports, especially the Port of Montreal, is a shorter haul than some of the US northeastern ports for northern areas in NH, VT and NY.

FOR/Maine's analyses include a robust review of transportation strengths and weaknesses in that state. A summary of the findings and recommendations are:

- A series of recommendations to improve various sections of state maintained highways and bridges;
- Changes to the Maine DOT's Industrial Rail Access Program (a competitive cost-sharing grant program) to allow funds to be used beyond rail improvement functions including yard development for truck, rail and marine forest product handling, loading and off-loading equipment, haul route upgrade projects;
- Financing of port related (but outside of the ports) transportation projects through the Maine Port Authority; and
- Identification of sources of possible funding (taxes and general fund) for the transportation system improvements described above.

It was beyond the scope of this project to conduct a detailed forest products transportation survey of the industry across the three-state region. This idea should be explored should further work be done following these initial assessment research studies. It was also beyond the scope to get specific about state road improvements – i.e. road by road discussions.

IV. Internet, Mobile Coverage and Electricity Cost

Internet

Internet coverage in the northeast region has some variation as documented in the second report in this series[6]. New York has the best average download speeds and geographic coverage, followed closely by New Hampshire and then Vermont. Maine's average download speed and coverage are similar to

[6] Northeast Wood Markets Retention and New Market Recruitment Initiative PHASE I, North East State Foresters Association, DRAFT REPORT Section 2: The unique regional attributes, weaknesses and opportunities for wood market maintenance and growth, October 14, 2020, Page 40

Vermont's. New York and New Hampshire are above the national average in these metrics and Vermont and Maine are just below the national average.

The remote areas of these states – primarily in the north (in VT the northeastern portion of the State – the Northeast Kingdom) tend to have less coverage and average download speed. Improvement is needed in these more rural regions of all four states. On average, the NH/NY/VT region has better overall coverage and download speed than Maine.

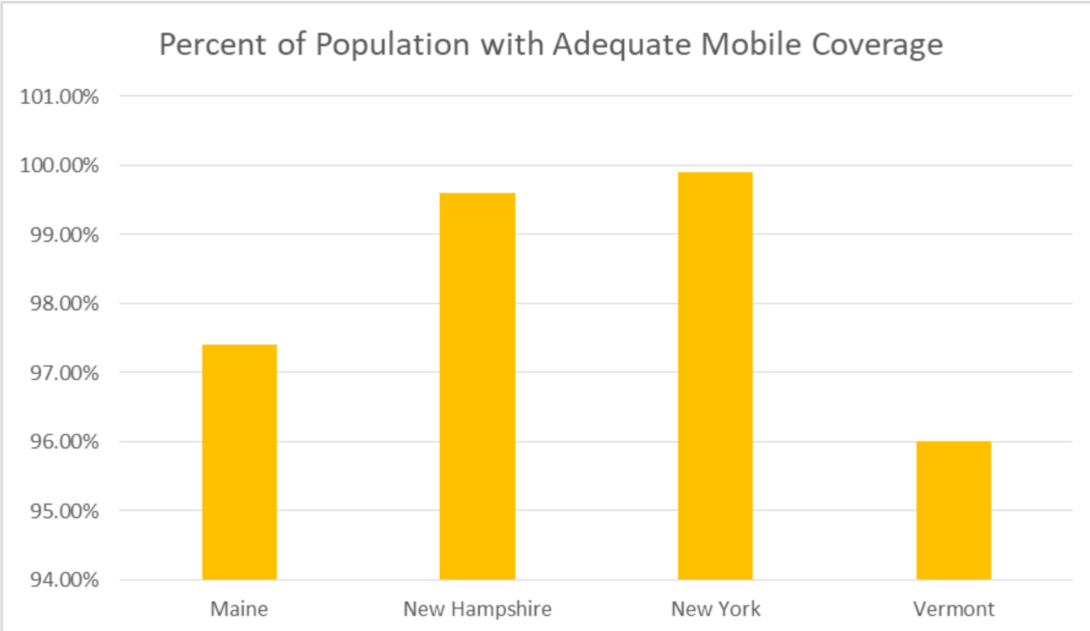
Mobile Coverage

Mobile phone coverage is extremely important to business expansion anywhere in the world and no less so for forest products markets expansion. The key metric for adequate mobile coverage is "advanced telecommunication capacity". The Federal Communications Commission defines "advanced telecommunication capacity" for mobile phones as having an advertised download speed of at least 5 Mbps, and an upload speed of at least 3 Mbps.[7]

New York and New Hampshire have the best mobile coverage for the four states followed by Maine and then Vermont (Figure 10). Mobile coverage is improving rapidly as new towers are being installed in recent years even in more rural areas. According to this FCC data, 99.9% of New York's population has adequate mobile coverage while 96.0% of Vermont's has adequate coverage. It is important to note that despite this FCC data, there are still many areas in the rural parts of the three-state region where mobile coverage is spotty at best. The methodology that the FCC uses to develop their statistics results in data that suggests whole zip code regions have coverage even when only a small portion of the geography does.

[7] Federal Communications Commission. *2018 Broadband Deployment Report.* https://www.fcc.gov/reports-research/reports/broadband-progress-reports/2018-broadband-deployment-report

Figure 10 **Mobile Coverage for NH NY VT and ME**

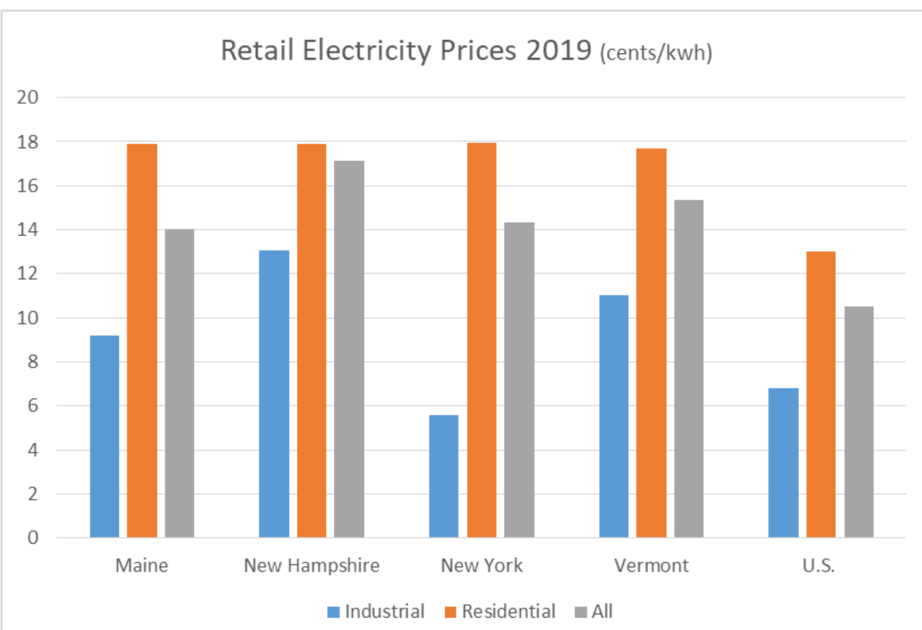


Source: FCC

Electricity Cost

Electricity cost is a critical factor in the expansion of forest products manufacturing or new manufacturing in these northeastern states.

Figure 11 **Retail Electricity Costs ME NH NY VT & US**



Source: U.S. Energy Information Administration 2019 data

Retail electricity costs in the four state region are generally higher than national averages – particularly for residential customer rates (Figure 11). The sector we are most interested in is for industrial retail electricity rates. Maine's industrial average rate is higher than New York's but lower than New Hampshire's and Vermont's.

As we noted in the second report in this series[8] - within each state there are multiple electric utilities, each with a unique service territory and in some cases with competitive suppliers. Rates that a user pays for electricity, whether residential, commercial or industrial, may depend upon their utility service territory, competitive supplier, time of use and other factors. In other words, it is possible to get, and many large industrial power users do, a rate that is lower than the average for that sector.

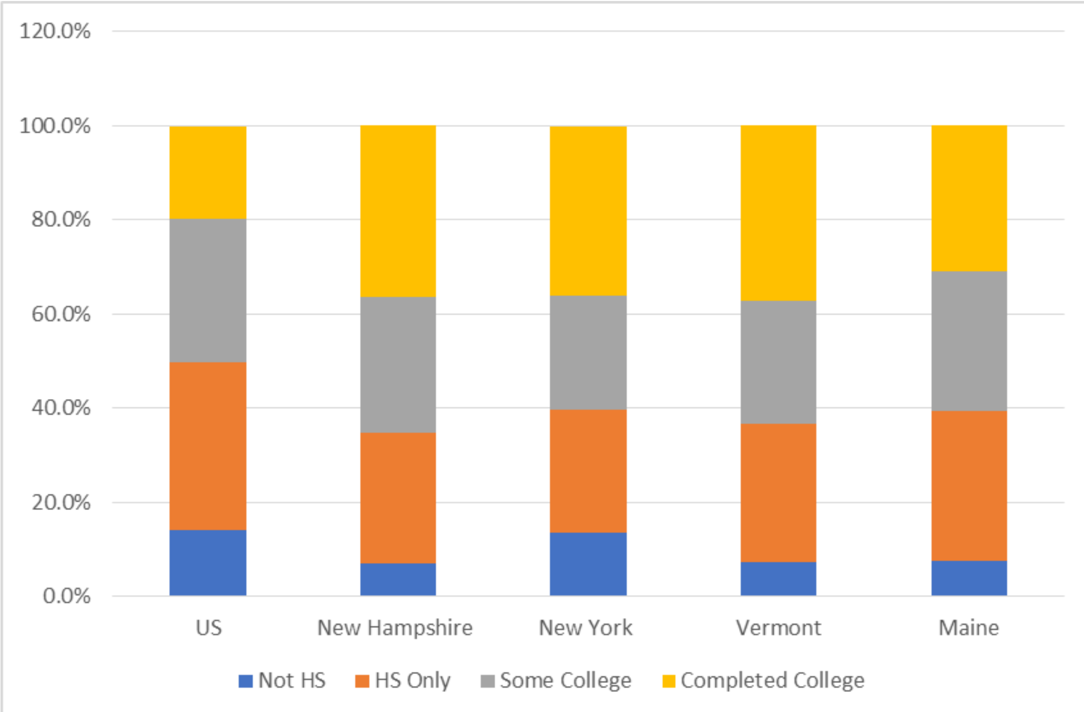
We must recognize and conclude, however, that relative to other parts of the U.S., the northeast as a whole, and NH, NY and VT specifically, is at a disadvantage when it comes to promotion of more forest products manufacturing relative to electricity costs. But this disadvantage must be coupled with other comparable attributes. We do this overall comparison in the final section of this report. Electricity cost, given the opportunities to receive competitive rates through many supplier options and even self-generation through combined-heat and power (CHP), is not necessarily the deciding factor for a manufacturer to site or not site in the three-state region.

Workforce

The COVID pandemic aside, workforce issues in NH, NY and VT are not different from Maine to any great degree.

[8] Northeast Wood Markets Retention and New Market Recruitment Initiative PHASE I, North East State Foresters Association, DRAFT REPORT Section 2: The unique regional attributes, weaknesses and opportunities for wood market maintenance and growth, October 14, 2020, Page 44

Figure 12 **Highest Level of Education by State (2014-2018)**



Source: US Census

Compared to Maine, New Hampshire, New York and Vermont all have a higher percentage of working age adults who have completed college (Figure 12). New Hampshire and Vermont are nearly identical in the percentage of working age adults who have a high school or greater education – just slightly higher than Maine in that regard. New York has a lower percentage of working age adults with at least a high school education compared to Maine, New Hampshire or Vermont.

Figure 13 **Education Completion: ME, NH, NY, VT and US**

State	Not HS	HS Only	Some College	Completed College	HS or Above
US	14.0%	35.7%	30.6%	19.6%	85.9%
New Hampshire	7.1%	27.6%	28.8%	36.5%	92.9%
New York	13.5%	26.1%	24.4%	35.9%	86.4%
Vermont	7.4%	29.2%	26.1%	37.3%	92.6%
Maine	7.7%	31.8%	29.6%	30.90%	92.3%

Source: US Census

The forest products industry in all four of these states struggle – at the entry level – to find skilled employees for forest products manufacturing or logging/trucking work. Several new student training programs in Maine and New York, in their infancy stages, are attempting to give high school aged young people a taste of work in the forest products industry. To date (these efforts are only a few years old) some individuals have found forest industry work and are employed in that field from these programs.

<u>Business Climate</u>

There are significant differences in business climate among NH, NY and VT and documented in the second in this series of reports[9].

Maine, New York and Vermont all have both sales and income taxes while New Hampshire does not. All four states have business taxes although New Hampshire has a lower rate than ME, NY and VT. The Small Business Entrepreneurial Council most recent Small Business Tax Index (2017) ranks the four states as:

New Hampshire 32 (out of 50 states)

New York 43

Vermont 44

Maine 48

The Tax Foundation's current ranking for its State Business Tax Climate Index shows:

New Hampshire 6 (out of 50)

Maine 29

Vermont 43

New York 48

The Fraser Institute[10], based in Vancouver, Canada, issues an annual Economic Freedom index and their Economic Freedom of the World: 2020 Annual Report is

[9] Northeast Wood Markets Retention and New Market Recruitment Initiative PHASE I, North East State Foresters Association, DRAFT REPORT Section 2: The unique regional attributes, weaknesses and opportunities for wood market maintenance and growth, October 14, 2020, Page 50

[10] The Fraser Institute, based in Vancouver, Canada, which has a mission "to improve the quality of life for Canadians, their families, and future generations by studying, measuring, and broadly communicating the effects of government policies, entrepreneurship, and choice on their well-being.

the world's premier measurement of economic freedom, ranking countries based on five areas—size of government, legal structure and property rights, access to sound money, freedom to trade internationally, regulation of credit, labor and business. In their 2020 report, which compares 162 countries and territories, Hong Kong is again number one and Canada (9th) trails the United States (6th).

In the northeast US, the 4 states of interest for this section of the report ranked;

New Hampshire 1 (out of 50 US States)

Maine 20

Vermont 34

New York 48

The Fraser Institute's Economic Freedom index,

"…measures the extent to which—in 2018, the year with the most recent available comprehensive data—the policies of individual provinces and states were supportive of economic freedom, the ability of individuals to act in the economic sphere free of undue restrictions. There are two indices: one that examines provincial/state and municipal/local governments only and another that includes federal governments as well. The former, our subnational index, is for comparison of individual jurisdictions within the same country. The latter, our all-government index, is for comparison of jurisdictions in different countries."

On the whole, in the three-state region, New Hampshire is considered having the least intrusive government in terms of business development while New York the most. Having said that, New York tends to have the most generous financial incentives to encourage business while New Hampshire the least. Maine and Vermont both, to a limited extent, have state-based financial incentives to encourage business development.

Product Target List for NH, NY & VT

FOR/Maine began its narrowing of forest products to focus on by developing a long list of possible primary[11] forest products, given the timber resource availability. This list is shown above.

[11] It is important to note that there are thousands of secondary products that can be made from wood but this effort is focused on primary wood products made in the first manufacturing process whereby raw material in the form of timber and wood chips are turned into a product.

This list is not a priority list in any sense. It merely represents all of the primary forest products that could theoretically be produced in the region, given the tree species available.

For our purposes in this analysis for NH, NY and VT, given the substantial options provided because of the more wide-ranging timber stocks in these states compared to Maine, we are adding to the long list:

Sawn Wood sub-categories:

- Cross Laminated Timber
- Structural softwood (timbers, 2 by material, etc)
- Stock for laminated structural
- Misc hardwood sawn wood
- Misc softwood sawn wood

Green diesel

Cellulose insulation

Animal bedding shavings (as a finished product as opposed to a residue)

We expanded the sawn wood categories simply because there are finer detail primary products included in the generic "sawn wood" category and by expanding the detail into the long list, it gives more options to prioritize potential forest products for the region – because all sawn wood products are not the same.

We added green diesel, a chemically different liquid fuel made from woody biomass as compared to pyrolysis oil, because this product was not included in the FOR/Maine effort, as it was still in the research stage in 2017 but is now breaking into the commercial stage and shows promise.

We added cellulose insulation because, although it was being produced in Europe when the FOR/Maine analysis was conducted, it was left off the list for reasons unknown.

Lastly, we added animal bedding shavings – also not included in the FOR/Maine long list - not because it is a new product worthy of exploration, but simply because the market for this simple wood product is expanding as more horse farms in particular are being developed in the northeastern U.S. according to USDA data.

C. Product List and Ranking Products for NH/NY/VT

Based on the timber resource analysis for NH, NY and VT described in the first of the reports in this series, there are nearly unlimited options for timber availability across species and products. A reminder, in the FOR/Maine effort, based on the timber resource analysis done by their contractors, FOR/Maine concluded that in the coming years, Maine will have excess softwood roundwood and also biomass chips – both hardwood and softwood. All product efforts in Maine were based on this knowledge.

For NH, NY and VT, virtually all species and products are available for forest products industry expansion in the region. This provides for more options than Maine in that regard.

Taking the long list of potential products from FOR/Maine with additions added above in the previous section of this report, our final long list of products for ranking in NH, NY and VT is:

Activated Carbon
Animal bedding shavings (as a finished product as opposed to a residue)
Biobutanol
Biochar
Bio-Crude
BioPlastic Composites (BPC)
Black pellets
Cellulose insulation
Combi Particle Board
Dissolving Pulp
Ethanol
Furfural
Green Diesel
Lactic Acid
Laminated Timber
Levulinic Acid
Lignin
Lignocellulosic Ethanol
Laminated Veneer Lumber (LVL)
Mass Plywood
Medium Density Fiberboard (MDF)
Nano Cellulose
Oriented-Strand Board (OSB)
Polylactic Acid (PLA)
Plywood
Pyrolysis Oil
Sawn - CLT
Sawn - Structural softwood (timbers, 2 by material, etc)
Sawn - Stock for laminated structural
Sawn – Misc. hardwood sawn wood
Sawn – Misc. softwood sawn wood
Softwood Kraft Pulp
Succinic Acid
White Pellets
Wood Plastic Composites (WPC)
Xylitol

In order to develop a more workable target list for the 3-state region, we ranked the above list using the following criteria:

Product Ranking Criteria:

1. **Market** – regional sales growth opportunities in Boston to Newark megalopolis.

2. **Competition** – will other states or regions in the US or internationally be in a better position to produce and sell this product into the eastern seaboard mega-market.

3. **Barriers to Entry** – is it prohibitively expensive to enter this market (capital, facility, labor, etc).

4. **Opportunities** – is there a good opportunity with this product due to ample raw material, existing manufacturing capability that could be expanded or other positive attributes.

5. **Constraints** – are there severe restraints to successfully developing or expanding manufacturing of this product.

6. **Labor/unit** – does this product require a high, medium or low product output per employee.

7. **Raw material** – can the product use as suitable feedstock the multitude of hardwood species or white and red pine, eastern hemlock, and limited spruce/fir species available in this region.

8. **Ability to positively affect carbon equation** – does this product have a positive effect carbon life cycle such as: long-lived solid product, fossil fuel substitute etc.

The partner staff at Innovative Natural Resource Solutions, LLC – Eric Kingsley, Charles Niebling and Charles Levesque – each conducted the ranking step in seclusion, product by product using a 1-3 ranking system for each criteria for each product (3 is high and 1 is low), the result from which is shown in the table below:

Our premise here is to focus on forest products with regional sales growth opportunities in the Boston to Newark megalopolis region of the eastern seaboard that are well suited to the timber species/volumes (available in NH, NY and VT). This doesn't preclude more distant or export markets for products from the region but that will not be the focus in order to take advantage of the tremendous savings in transportation costs associated with geographically close markets for expanded or new forest products manufacturing facilities.

Also, it is assumed that we cannot expect more than a $250 million investment for any one facility in the region (i.e. a new pulp mill or something of that mega-scale will not be built in this region in the foreseeable future or long-term).

The initial ranking of the long-list of products, then, based on the above criteria, yielded the following top fourteen product prospects (10-14 had identical ranks):

1. Pyrolysis Oil
2. Cellulose insulation
3. Green Diesel
4. Medium Density Fiberboard (MDF)
5. Sawn - CLT
6. Lignin
7. Biochar
8. BioPlastic Composites (BPC)
9. Oriented-Strand Board (OSB)
10. Bio-Crude
11. Combi Particle Board
12. Ethanol
13. Nano Cellulose
14. Sawn – Structural Softwood

From this ranking, the following target list was finalized as the focus for this project:

1. **Pyrolysis oil**
2. **Cellulose insulation**
3. **Green diesel**
4. **Sawn – mass timber**
5. **Biochar**
6. **BioPlastic Composites**

From the top fourteen ranked list we eliminated or adjusted due to the following:

Sawn – CLT – we changed to Sawn – mass timber to recognize the full suite of re-manufactured solid wood products instead of focusing in on one particular product – CLT – in the mass timber realm of products.

Lignin, Fufural and Nano Cellulose – these require a pulp mill and we assume that the two pulp mills operating in the region (NY) are exploring all of the pulp mill chemical options, and as we stated above, we do not believe it is realistic to assume a new pulp mill would be constructed in the region.

Medium Density Fiberboard and Oriented-Strand Board – There is simply too much in-region and worldwide manufacturing of this commodity product with lower input costs to allow for NH/NY/VT to compete.

Combi Particle Board – Same as MDF/OSB.

Sawn Structural Softwood – As in the FOR/Maine effort, we eliminated sawn structural because this manufacturing is already established in the three-state region and is robust.

And a note about Biochar[12] – the potential for this product is great although the commercial scale is currently very small compared with other products on our list. The great potential here is if using biochar as a soil amendment receives credit as a carbon sequestering technique either through US or foreign regulation. This is currently under serious discussion in the Biden Administration among many carbon-friendly practices. If this becomes part of federal incentives mechanisms for carbon friendly practices, the market could turn into something very large.

The ranking summary is as follows:

[12] Biochar - A solid material obtained from the carbonization thermochemical conversion of biomass in an oxygen-limited environment. In more technical terms, biochar is produced by thermal decomposition of organic material (biomass such as wood, manure or leaves) under limited supply of oxygen (O2), and at relatively low temperatures (<700°C)". Used in soil amendment and filtering applications.

	Kingsley	Levesque	Niebling	Combined total	Collective rank
Activated Carbon	19	17	18	54	19
Animal bedding shavings	17	18	17	52	27
Biobutanol	16	18	17	51	29
Biochar	22	16	20	58	**7**
Bio-Crude	18	20	19	57	**10**
BioPlastic Composites (BPC)	18	19	21	58	**8**
Black pellets	15	18	18	51	30
Cellulose insulation	21	20	20	61	**2**
Combi Particle Board	18	18	21	57	**11**
Dissolving Pulp	16	14	21	51	31
Ethanol	17	20	20	57	**12**
Furfural	17	19	19	55	17
Green Diesel	20	19	22	61	**3**
Lactic Acid	17	20	17	54	20
Levulinic Acid	19	17	16	52	28
Lignin	18	19	22	59	**6**
Lignocellulosic Ethanol	18	16	20	54	21
Laminated Veneer Lumber (LVL)	16	16	22	54	22
Mass Plywood	16	15	22	53	25
Medium Density Fiberboard (MDF)	19	19	22	60	**4**
Nano Cellulose	19	17	21	57	**13**
Oriented-Strand Board (OSB)	18	18	22	58	**9**
Polylactic Acid (PLA)	18	18	17	53	26
Plywood	17	15	22	54	23
Pyrolysis Oil	21	20	21	62	**1**
Sawn - CLT	21	18	20	59	**5**
Sawn - Structural softwood (timbers, 2 by material, etc)	21	16	20	57	**14**
Sawn - Stock for laminated structural	21	16	19	56	15
Sawn – Misc. hardwood sawn wood	18	17	19	54	24
Sawn – Misc. softwood sawn wood	20	17	19	56	16
Softwood Kraft Pulp	16	14	19	49	33
Succinic Acid	16	16	16	48	34
White Pellets	20	15	20	55	18
Wood Plastic Composites (WPC)	18	16	17	51	32
Xylitol	17	14	16	47	35

Product background information

A product by product criteria background information narrative from which the ranking was derived follows. First, we have separated the top 6 products from Page 36 with all the others in the long list for this analysis. The analyses for the top 6 products are found next in this report while the other products from the long list can be found in the Appendix A.

A note on these product analyses – much more detailed analyses can be found for most of these products in FOR/Maine's contractor *Indufor* reports produced in 2017 for that project and found at https://formaine.org/home-page/resources/studies-reports/.

Bio-oils and Diesel from woody biomass – Two products in our top list fit into the bio-fuel category. Raw timber in chip form is the raw feedstock used to produce fuel-oil/diesel products, including Pyrolysis Oil and Green Diesel. An important note and background - #2 fossil fuel oil used to heat most buildings (and dominates this market in the northeast) is a nearly identical product as diesel fuel used for transportation purposes. The color of fuel-oil diesel is reddish while transportation diesel is more a clear greenish blue hue. Fuel oil diesel and diesel used off public road are reddish color because a colored dye is added to the greenish blue diesel because off-road and fuel-oil diesel are not taxed as a highway fuel and the dye differentiates the two in the marketplace and for law enforcement purposes.

Green Diesel has exactly the same chemical make-up as fossil-fuel derived diesel and is considered a “drop-in” fuel (i.e. a direct substitute for fossil diesel that requires no hardware change to the appliance or vehicle using the fuel). Pyrolysis Oil is not the same, chemically, as fossil diesel or Green Diesel although it is similar. Pyrolysis Oil has more acid and water in the fuel and, as a result, requires changes to hardware in the building heating appliance. Green Diesel does not require hardware changes since it is chemically identical to fossil diesel. Green Diesel is also a ready substitute for transportation diesel.

Lastly, Green Diesel is much newer to the woody biomass feedstock sector and no full-scale manufacturing plants yet exist in North America although testing demo sized manufacturing is taking place.

A note about federal policies related to transportation fuels - The federal Renewable Fuel Standard (RFS) is a program to support markets for alternative, including wood-based, transportation fuels. In order to participate in the market support mechanism created by the RFS, producers need to use feedstocks that meet very specific set of criteria, contained in rules administered by the Environmental Protection Agency. These rules allow for the use of:

- wood from plantations established prior to 2007;
- wood from pre-commercial thinnings, and
- slash, including tops and branches from timber harvesting activities.

Slash from timber harvesting operations in the region are certainly available, and are an RFS-eligible feedstock. Wood from plantations is extremely limited; an estimated 2.2% of the timberland in the three-state region is planted forest. While there is an argument to be made that much of the timber harvesting in the region fits the EPA definition of "pre-commercial thinning", forest industry and the EPA do not yet have a shared understanding of what activities in the Northeast fit this definition.

Evaluation of liquid fuels technologies that rely upon the RFS as part of the revenue stream should make certain to fully evaluate the availability of wood that meets the qualified feedstock test.

Pyrolysis Oil - Pyrolysis oil is a liquid fuel produced from wood, that can be used in heat and power production to substitute for fossil-based-oil, or further refined as transport fuel. The attributes of pyrolysis oil are close to those of #2 fuel oil. Applicable raw materials are roundwood, forest residues, forest industry solid by-products (sawdust, wood chips) and black liquor. Feedstock is generally in wood chip form for woody feedstocks.

1. Market – The market is nearly identical to that for green diesel (see below) – except that pyrolysis oil requires hardware changes for heating appliances due to its more corrosive nature. Green diesel has the advantage over pyrolysis oil because no hardware changes are needed since the chemical structure is identical to fossil-fuel produced diesel. As a result, given similar retail and wholesale pricing, the market for transportation and heating fossil fuels and oils is enormous. This market has great potential should pricing similar to fossil alternatives become possible. If incentives develop through federal action, pyrolysis oil and green diesel will be a high priority product for the three-state region.

2. Competition – Pyrolysis-based bio-oils research started in the 1980s. The first European pilots began in the 1990s and ramp up to commercialization began in mid-2000s. Currently, there are still only a handful of commercial pyrolysis oil producers – Fortum, BTG BioLiquids/ EMPYRO and Ensyn. Ensysn, based in Canada with two plants in eastern Canada, has been selling its product in the northeast US since 2010 to a handful of institutions using it as a fuel oil substitute for heating buildings, including a hospital in New Hampshire and college in Maine.

Pyrolysis oil has also been produced in southeast Asia and in the U.S. at small scale plants at Genting in Malaysia and Ensyn in eastern Canada. Assuming pricing is consistent with fossil fuel alternatives (and this is as yet unproven at significant scale), the competition could be substantial as public policy may provide incentives to ramp up this bio-fuel production.

3. Barriers to Entry – The main challenges for pyrolysis oil are market-based. It is clear from Ensyn and others that the product works and the market is potentially huge assuming price is consistent with fossil alternatives. Currently, the main end-use segment of pyrolysis oil is commercial heating. Although there are some certain unfavorable properties, such as high water and oxygen content, instability, and corrosiveness for conventional pyrolysis bio-oil use making it unlikely as a transportation fuel. Green diesel (see below) may overcome that barrier, making its market huge. The technology to produce the pyrolysis products from wood is well known with certain industry secrets for optimizing the process. The limitation to entry is simply market-based – producing a bio substitute at an attractive price as compared to fossil fuel alternatives.

4. Opportunities – Should a pyrolysis oil or green diesel plant be built at substantial scale – not accomplished yet since the existing plants produce a few million gallons per year – the opportunity is great.

5. Constraints – Constraints for pyrolysis oil and green diesel are primarily cost and scale related. Pyrolysis oil, however, has other challenges. It is acidic, thus contacting materials (e.g., steel, plastic) must be acid-proof and stainless steel. In addition, its high-water content decreases its net heating value and contributes to corrosivity.

The retail price for pyrolysis oil (conventional or green-diesel) is dependent on the prices for oil and natural gas, as well as any incentives used to encourage the use of such fuel. There is a lack of internationally accepted and compatible sustainability requirements for pyrolysis oils and undeveloped markets. The federal government could set policy direction, if use of pyrolysis-based wood feedstock liquid fuels is seen as part of climate change mitigation, that could remove many constraints.

6. Labor/unit – At full scale the labor/unit of production will be similar to other fuel refining manufacturing. At the small scale the burgeoning industry is in, labor costs per unit of production are higher than fossil fuel refining, which is done at a significantly larger scale. A full scale pyrolysis oil manufacturing plant will require between 50 and 100 employees.

7. Raw material – Any tree species that is growing in the three-state region is suitable for making pyrolysis oil, whether conventional or green diesel. Lower cost sources of feedstock, such as mill residuals given the loss of low-grade timber markets in the region, could be an attractive source of feedstock rather than forest-derived chips although the latter is suitable. A full-scale plant is

anticipated to use between 100,000 and 300,000 green tons of wood feedstock per year.

8. Ability to positively affect carbon equation – Pyrolysis oil liquid fuel (conventional or green diesel) derived from woody feedstocks, especially wood manufacturing plant residues, will be very attractive as a fossil-fuel alternative relative to carbon. If the federal government agrees to have this as part of its climate policy, this sector could take off.

Green Diesel – Green Diesel (or renewable diesel) is second generation of biofuel produced from cellulose inputs, which has an identical molecular structure as petroleum diesel but comes from biomass feedstocks. It can be produced from Pyrolysis Oil (see above), gasification or liquefied lignin distillate. Green Diesel has a 65-70% carbon intensity advantage over fossil-fuel diesel.

1. Market – The market includes the thermal markets for pyrolysis oil but also includes the transportation sector as green diesel can be a direct substitute for fossil diesel in vehicles, while pyrolysis oil cannot be used for that purpose. Green diesel has the advantage over pyrolysis oil because no hardware changes are needed since the chemical structure is identical to fossil-fuel produced diesel.

2. Competition – In the U.S. the first commercial scale green diesel manufacturing facility using wood as feedstock is under construction in Oregon (Red Rock Biofuels). This plant is expected to be in production in 2022 and is projected to cost about $400 million to build. The plant is expected to use 300,000 green tons of wood feedstock annually. The federal Renewable Fuel Standard is a key part of the economics of this plant as are the state low carbon fuel standards in Oregon and California (and soon in Washington State). Assuming pricing consistent with fossil fuel alternatives (and this is as yet unproven at significant scale), the competition could be substantial as public policy, beyond the federal Renewable Fuels Standard, may provide incentives to ramp up this bio-fuel production under the Biden Administration.

3. Barriers to Entry – The main challenges for green diesel are market based and the fact that there are no commercial green diesel plants in North America. If the Red Rock Biofuels plant is typical for the scale necessary for a green diesel plant ($400 million), capital costs may be a significant barrier to entry. Also a challenge is using feedstock that meets the requirements of the Renewable Fuel Standard which allows for forest residue use but has vague definitions of what that means. The northeast has tremendous volumes of low-grade timber but it is

not clear that this timber can be considered forest residues for the purposes of the Renewable Fuel Standard.

4. Opportunities – Should a green diesel plant be built at substantial scale like the Red Rock Biofuels entry – not accomplished yet since the existing plants produce a few million gallons per year – the opportunity is great – especially because green-diesel won't require hardware conversions and should work as a transportation fuel substitute. As with pyrolysis oil, green diesel can be made from any species of wood.

5. Constraints – Constraints for green diesel are primarily cost and scale related as well as Renewable Fuel Standard applicability. It is likely essential for wood-based green diesel production to meet the requirements of the RFS.

The Biden Administration could set further policy direction for green diesel, if use of wood feedstock liquid fuels is seen as part of climate change mitigation, that could remove many constraints and provide the inventives needed for other plants to be built in the U.S.

6. Labor/unit – At full scale the labor/unit of production will be similar to other refining manufacturing. At the small scale the burgeoning industry is in, labor costs per unit of production are higher than fossil fuel refining. A full-scale plant would require 50 to 100 employees.

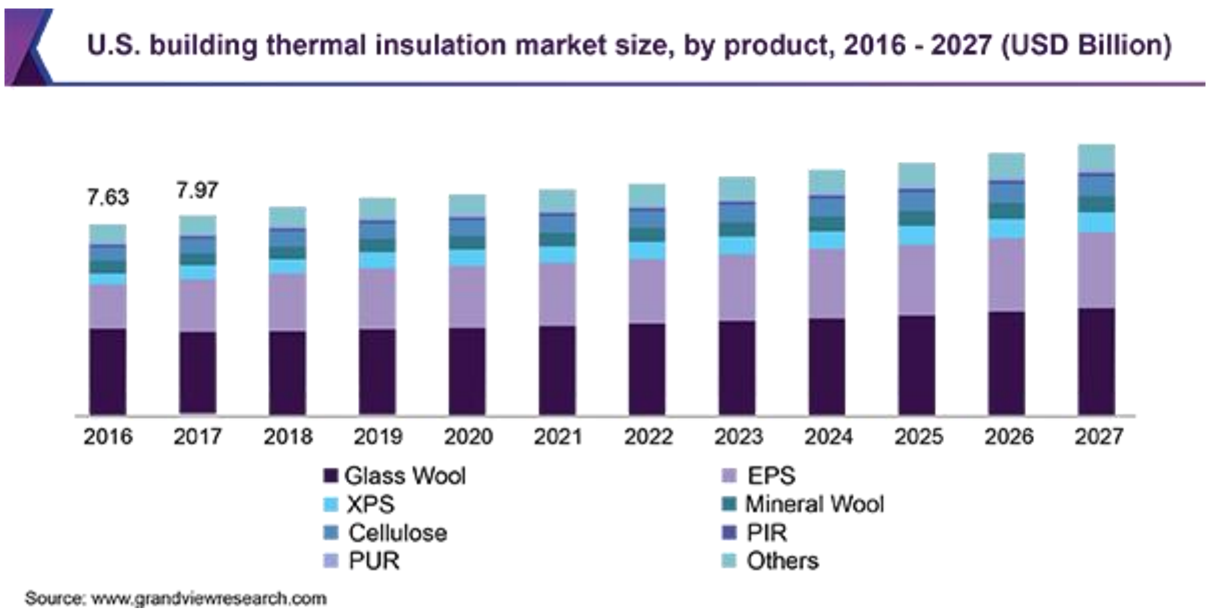
7. Raw material – Any tree species that is growing in the three-state region is suitable for making green diesel. Lower cost sources of feedstock, such as mill residuals given the loss of low-grade timber markets in the region, could be an attractive source of feedstock rather than forest-derived chips, although the latter is suitable. A full-scale plant would require between 100,000 and 300,000 tons of green chips annually.

8. Ability to positively affect carbon equation –Green diesel) derived from woody feedstocks, especially wood manufacturing plant residues, will be very attractive as a fossil-fuel alternative relative to carbon. If the Biden Administration agrees to have this as part of its climate policy, this sector could take off.

Cellulose Insulation

Building insulation markets in the U.S. and world are largest in the coldest regions of the world although similar uses to reduce cooling losses in warm-weather climates are also markets. Building insulation products are dominated by fossil-fuel-based products in batt, roll and hardboard forms. Wood or other biomass based cellulose fiber insulation has been available in recent decades but it has had much smaller market share than fossil-fuel based insulation, has generally cost more, and has been primarily been produced outside of the U.S., mostly in western Europe.

1. Market – The market for building insulation worldwide annually is over $30 billion. In the U.S. it is currently (2020 data) estimated at over $8 billion with projections for steady growth in the coming decade. Currently in the U.S., fossil-fuel based insulation products (glass wool or fiberglass, expanded polystyrene commonly known as Styrofoam, and XPS (blue or pink board)) account for over 80% of insulation used.



Various initiatives such as the Weatherization Assistance Program (WAP,) which is focused on large scale product adoption in low-income households are expected to play a pivotal role in driving growth.

Favorable building codes in the U.S. and Canada, coupled with the establishment of energy certification agencies such as the Leadership in Energy and Environmental Design (LEED) and the U.S. Green Building Council (USGBC) are expected to have a positive impact on the demand for building thermal insulation. However, stringent regulations imposed by the United States Environmental Protection Agency (EPA) on the use of foamed plastics, owing to their low biodegradability and carcinogenicity may hurt the market growth but provide an opportunity for non-fossil fuel based alternatives such as cellulose insulation.

Current major products in the insulation market include:

- Expanded Polystyrene (EPS) is expected to exhibit the highest growth in terms of revenue over the next 5 years, owing to its excellent thermal insulation properties and a long life span. Also, increasing preference for the product owing to its non-toxic, rot-proof, and recyclable properties is expected to boost the growth.
- Extruded Polystyrene (XPS) is estimated to witness significant growth over the forecast period, on account of its ability to reduce moisture-related damages, resistance to water, and the ability to enable energy savings. Besides, its ability to inhibit microbial or fungal growth in the insulated area is further expected to bolster growth.
- Mineral wool insulation accounted for a market share of 12.3% in 2018 and is estimated to exhibit significant growth over the forecast period, owing to superior characteristics of the product including fire safety, efficient heat barrier, ecological compatibility, and dimensional stability. Increasing usage of mineral wool in thermal barrier applications is expected to drive its growth over the forecast period.

Recyclable insulation is gaining popularity due to the stringent regulations governing conventional products such as plastic foams. Increasing preference for green, biodegradable, and recyclable products by homeowners, architects, and businesses, owing to increasing environmental awareness is expected to boost the threat of substitutes in the market over the forecast period.

Other products such as aerogel, cotton wool, wood-based cellulose insulation and wool slag are expected to register moderate growth rate over the 2020-2030 period, owing to the increasing product penetration in North America.

2. Competition – All of the fossil fuel based insulation described above are the direct competitors of wood cellulose insulation products. There are more than 15 manufacturing plants in Europe supporting $700M in sales across the EU, but there is currently no manufacturer of wood fiber loose fill, batt, or dry-process board in North America. A start-up that is expected to begin delivering cellulose insulation to market in 2022 – GoLab in Madison, Maine – will be the first North American producer of wood cellulose insulation. Given the size of the market, any government incentive that may result from climate initiatives that favor non-fossil fuel based products will give a boost for wood cellulose insulation to capture more of the large insulation market. GoLab proposes to expand to additional manufacturing plants in the northeast once their initial plant is up and running successfully.

The largest fossil fuel-based insulation companies in the U.S. and worldwide in 2021 include: Rockwool International A/S; GAF Materials Corporation; Guardian Building Products; Inc.; Huntsman International LLC.

3. Barriers to Entry – A manufacturing plant the size of the GoLab start-up is expected to cost $40 -50 million at a scale using approximately 200,000 tons of green wood fiber per year as feedstock. That investment level will be a significant barrier to entry. Since there are no wood cellulose insulation manufacturing plants in North America, it is unclear if a smaller scale plant could be successfully developed.

4. Opportunities – The size of the U.S. and North American market for insulation and the increasing interest in carbon friendly products provide a great opportunity to expand wood cellulose-based insulation manufacturing. Low-grade timber sources are abundant in the three-state area so feedstock availability and possibly price for feedstock could be a distinct opportunity for the region.

5. Constraints – Besides the cost of capital to a plant considered at proper scale (see Barriers to Entry above), constraints could be the necessary product price point to take over part of the fossil fuel-based insulation market, i.e. can wood cellulose insulation be competitive in the marketplace without public subsidies as an incentive for a carbon friendly product. Like all other wood products manufacturing in this region and manufacturing in general, entry-level labor could be a constraint.

6. Labor/unit – Labor per unit for cellulose insulation manufacturing as compared to the wood products industry will be average to slightly better with significant automation in the insulation making machines. The European plants manufacturing wood-based cellulose insulation employ over 100 employees at full scale and a similar labor profile is expected at the Go Lab plant in Maine when it begins operation in late 2021 and 2022. Steico, one of the largest wood cellulose insulation manufacturing companies in the world and based in Germany, has over 1,700 employees at three manufacturing facilities in Europe.

7. Raw material – The 15 European cellulose insulation plants together used approximately 3 million tons of wood feedstock collectively in 2019. The Go Lab Maine plant is projected to use 200,000 to 250,000 tons of green wood feedstock per year once operating at full capacity. This size is approximately the size of many of the existing (some closed) wood biomass electricity generation facilities. The Go Lab-sized facility appears to be in the average range of the European facilities, some of which have been operating since the 1980s.

8. Ability to positively affect carbon equation – Wood cellulose insulation turns natural carbon-based material into a stable long-term carbon sequestered product and, as such, is a very carbon friendly product, especially relative to its fossil fuel-based alternatives. Also, because insulation can cut the use of heating fuels, it has ongoing carbon benefits.

Sawn – Mass Timber products – The category of wood products called mass timber is actually a number of products that include cross-laminated timber, laminated timber, laminated veneer lumber and mass plywood. Mass timber products are generally solid wood that are made into larger sheets, panels or timbers through gluing, dowelling and gluing or nailing. The analyses for these products follow as a grouping:

Cross laminated timber (CLT) – mass timber made from alternating layers of glued small wood stock (2x6 or 2x8 or other dimensions) into long panels with generally either 3 or 5 layers. Used for structural wall and floor applications in small to multi-story buildings.

1. Market – The market for CLT is international, and in the U.S., spurred by substantial growth on the west coast, is now nationwide. While suitable for any building, CLT's advantage is strongest in the multi-story commercial sector where the carbon benefits and much shorter construction time bring it advantages over traditional steel and concrete construction. In the U.S., the number of large wood buildings made with CLT and other mass timber products has increased from only 30 in 2013 to 978 in 2020 and growth is expected to increase greatly in the coming decades.

2. Competition – Currently, European produced CLT can be purchased for delivery to an eastern U.S. site at an equal or lower cost than product produced in the CLT plants in Canada and the western U.S. A plant built in the northeastern U.S. would need to compete with both the North American and European producers but would have significant advantage with regard to transportation costs.

3. Barriers to Entry – The market is growing but it is not clear that the cost of raw material and production from a northeastern U.S. facility would compete on price with the alternatives. A CLT manufacturing plant would be a $10-40 million investment, depending on scale. Existing CLT manufacturers from the western U.S. or Europe would be the likely early developers in the northeast.

4. Opportunities – The market for mass timber and CLT is growing and the rate of growth is growing fast as well. The northeastern U.S. urban areas are

seen as prime area for growth and currently dozens of planned or under-construction mass timber/CLT buildings are being built using European or other North American produced product. The opportunity is there for a northeast plant to gain market share through reduced transportation costs and possibly raw material cost if new species, especially eastern hemlock which has been engineering tested for this product but not yet certified, can be used. Additionally, significant marketing work is already being done in the northeast by organizations such as WoodWorks and New England Forestry Foundation to increase demand for CLT and other mass timber in the northeast commercial building market sector for multi-story buildings.

5. Constraints – Outside of competition on cost and, as yet, no plants use eastern hemlock as a cheaper feedstock, there are few constraints to manufacturing CLT and other mass timber in the northeastern U.S. A new international building code allows for tall building to be built with CLT and other mass timber, but that code has not yet been adopted in much of the northeast though efforts are underway to make that happen. Despite this, the current code allows for buildings up to 6 stories for mass timber so there is ample current opportunity for expansion in this commercial building scale.

6. Labor/unit – Mass timber manufacturing is a modest labor/unit process. Since this is a relatively new forest products sector, all plants in the world use similar technology which sets the labor needs. Estimated labor needs for a plant using 20 -40 million board feet of lumber feedstock per year is in the 100-150 range. When a northeastern plant is built there may be interest in starting it up with lesser capacity with expansion possibilities to take advantage of a growing market over time.

7. Raw material – There are currently limitations on species for CLT simply because, outside of spruce/fir species group, none of the other species of trees grown in the northeast has been certified for use for CLT although eastern hemlock and white pine have been bench engineered tested and have been found to have adequate structural properties for use in CLT. That certification need may be addressed soon as some efforts are underway seeking to do so as this is written.

In the meantime, substantial spruce/fir lumber production by large plants in Maine and New Hampshire could provide adequate already-certified input feedstock should a plant be built. A key criteria for input lumber specifications is that it be light in weight per volume unit. Softwoods, the currently available and certified spruce/fir species group, along with engineer tested eastern hemlock and white pine, fit the weight to volume requirements. Many other species, such as red maple and other hardwood species in abundance, are much heavier than the softwood species available and, as yet, have not been considered likely candidates for use as CLT feedstock. Engineering testing has been discussed at universities in Maine and Massachusetts labs exist but, to date, no testing has been done for red maple or any other high volume available species. This is not considered a problem given the widespread adequate volumes of spruce/fir, eastern hemlock and white pine. A final note on yet-to-be certified eastern hemlock and white pine – while both of these species were proven to have adequate strength characteristics for use as CLT, white pine was weaker than hemlock and, more importantly, is a much more expensive alternative than eastern hemlock or spruce/fir since demand for white pine for other sawing purposes is significant and the many large white pine focused sawmills in the region already have markets for their output.

8. Ability to positively affect carbon equation – A key advantage over concrete and steel is the carbon benefit of mass timber. This is a major selling point for growth in this sector along with quicker construction times for large buildings.

Laminated Timber – Solid wood pieces such as 2 x12 material glued together to make very large beam products for structural purposes for use in generally large commercial buildings although they can be used in smaller structures as well. Laminated timber is sometimes knows as glulam beams or glulam timber. There are over 20 laminated timber manufacturing plants in the U.S. with many located in the Pacific Northwest and South.

1. Market – Laminated timber, aka laminated beams, have been used in mostly commercial structures for over 50 years. After using solid wood timbers for hundreds of years in the U.S. and elsewhere, laminated timbers allowed for heavier loads in bigger buildings because the lamination of nearly clear lumber removed defects that larger timbers often contain. Laminated timbers were the first new mass timber product. As mass timber structures grow (mostly commercial structures that use various manufactured solid wood products such as cross-laminated timber, laminated timber etc.) the demand for laminated timber, as part of these structures, is growing. With the adoption of the new Building Code 2021 which includes using mass timber for taller structures up to 18 floors in height, mass timber use is expected to grow throughout the U.S. and especially in the northeast where mass timber use growth has been slow relative to the Pacific Northwest in the U.S.

An important side note is that facilities that are capable of producing cross-laminate timber often also produce laminated timber since the manufacturing process is the same and only differs in the amount and layout of the timber glue-ups. CLT has long (up to 40 or more feet) and wide (8 or 10 feet) glued products whereas laminated timber is usually lumber just stacked on top of each other.

2. Competition – As mass timber use grows, laminated timber use will also grow but since the major use is in commercial structures, the competition is from users of traditional concrete and steel. In terms of siting a laminated timber plant in the northeast, a developer would compete with the existing laminated timber manufacturing plants in in North America including Unilam in New York State.

3. Barriers to Entry – The technology for laminated timber manufacturing is mature and the feedstock needs can be fulfilled in the northeast where graded sawn lumber (softwood in particular and spruce/fir specifically) is plentiful. Other species such as eastern hemlock and white pine are also possible but will complete with the mature use of spruce/fir. Market size and capital for a new manufacturing facility are the only barriers to entry. It is anticipated that as mass timber use grows, the demand for laminated timber will grow with it and provide a new opportunity for use of graded sawn lumber from the northeast. In 2021, the growth period is about to begin, especially as general economic growth is expected as the COVID 19 pandemic wanes.

4. Opportunities – As stated above, with mass timber posed for significant growth in the commercial building market in the northeast, there is a grand opportunity for increased laminated timber manufacturing as well.

5. Constraints – Currently the laminated timber market is stable and entry from new manufacturing would require careful pricing of the product to be competitive, but with growth in the sector expected as described above, constraints to new development of manufacturing will be fewer.

6. Labor/unit – The manufacturing technology for constructing laminated timbers is mature and known. This is an efficient manufacturing given this manufacturing maturity. Producing laminated timber from locally sourced graded sawn timber feedstock would be moderately labor intensive. Existing laminated timber manufacturing plants in the U.S. such the Rosboro and American Laminators plants in Oregon, and Arizona Structural Laminators all employ near or over 100 people at their plants.

7. Raw material – Generally laminated timber as a structural mass timber component is made from graded softwood timber. Primary species available in the three-state region that are potential feedstocks include spruce/fir, eastern hemlock and white pine. Laminated timber that would be produced in the

region would likely be produced using spruce-fir, but exploration of use with eastern hemlock is a possibility given its similar strength characteristics, ample supply and lower feedstock costs.

8. Ability to positively affect carbon equation – Replacing traditional concrete and steel commercial buildings with mass timber including laminated timbers results in a positive impact on carbon.

Laminated Veneer Lumber (LVL)- LVL is an engineered wood product that uses multiple layers of dried wood veneer, commonly oriented in the longitudinal direction of the grain and bonded together under heat and pressure using glue on the veneer face. Individual wood veneers can vary in thickness. The thickness is dependent on the physical properties of the species from where the veneer is derived and the intended purpose of the LVL. Individual veneer thicknesses of 2 mm to 4 mm are common. LVL shares a number of properties in common with plywood. A key difference is the orientation of veneers in the longitudinal direction (in plywood the direction of the grain of each veneer is alternated at right angles), the ability to produce very long lengths at depths which are well in excess of what is produced in plywood manufacture. Although normal practice is to orient the veneers in the longitudinal direction, there are some long-length, thick dimensioned cross veneer LVL products available in the market.

1. Market – LVL is another in the suite of products called mass timber. LVL comes in both structural and non-structural versions. Non-structural LVL is most commonly used for furniture components, interior joinery, stairs and balustrades. Most of the LVL made in China, Japan and the Philippines is non-structural. A sizeable amount of LVL made in New Zealand, Indonesia and Malaysia is also for non-structural applications. Panels are commonly 2.44 m or less in length. Non-structural LVL is made from softwoods and temperate hardwoods (such as poplar).

Structural LVL is for use in construction and in particular where there is a load bearing requirement. Essentially all LVL manufactured in North America, Europe, Russia and Australia is structural LVL. Structural end uses are further differentiated into I-joist flanges, solid section beams, headers, columns and industrial trim.

LVL as a commercial product has been manufactured since the early 1970s. Demand for the product has steadily increased over the years but uptake did not meet the initial enthusiasm to develop production capacity during the 1980s and 1990s. Since 2009 LVL markets have grown on average 7% per year. North

America is the largest market, currently estimated to be just over 2 million m3. Other significant markets include China and Japan, though these are largely non-structural markets. Europe is the second largest structural LVL market behind North America.

2. Competition – Nearly all of North American consumption of LVL comes from North American production with only a few percentages of import. The market fluctuates with the building economy. When the world experienced the great recession during the 2008-09 period and subsequent years, LVL production and consumption plummeted as did most wood products. Current levels, at least pre-COVID pandemic, surpassed the highs for production and consumption in the U.S. prior to 2008. A high percentage of LVL consumption is in the residential building industry and tends to be regional. So, the focus of northeastern seaboard as the best market for forest products produced in NH, NY & VT megalopolis is good for this product area. Competition from production in the three-state area will be from other areas of North America should manufacturing commence in the northeast for LVL.

3. Barriers to Entry – This is a mature wood products sector with over 50 years of experience so the long-standing producers have the edge in knowledge and manufacturing know-how for LVL as with other mature sectors. A new manufacturer of LVL would experience the same competition issues as any new manufacturer of product in a mature sector with many producers in the geography.

4. Opportunities – As home sales increase, as they had been doing steadily since the great recession hit in 2008 until the COVID 19 pandemic, the market for LVL has increased. With new interest in mass timber in the commercial sector (see CLT and Laminated Timbers above), the opportunity for use of more LVL as part of new larger mass timber structures increases.

5. Constraints – Constraints to new LVL production are as described above: entering a mature market with many producers and growth being limited to the trends within the buildings sector.

6. Labor/unit – LCL manufacturing technology is mature and so any new LVL manufacturing would use the latest machinery and be the most efficient in the LVL manufacturing sector. Labor/unit ratios are modest, as most modern wood products manufacturing is designed to limit labor requirements. An LVL plant is moderate in its need for labor and plants employing from 50 to over 100 people are common.

7. Raw material – Most LVL is made from softwood for structural LVL sector that is most of the North American market. Spruce/fir, eastern hemlock and white pine are all possible species. A plant would use lumber sawed by existing sawmills as its feedstock and would use between 5 million and 30 million board feet per year. Existing sawmills in the region will be able to supply this level of volume easily from their existing production.

8. Ability to positively affect carbon equation – Like all mass-timber products, LVL products are long-lived in structures and sequester carbon for very long periods of timer and so are a positive for the carbon equation.

Mass Plywood – Plywood glued in multiple-thicknesses for structural building applications. It is often stated that for the same structural strength as cross-laminated timber, mass plywood uses 20-30% less raw material – making panels lighter in weight than CLT. Plywood is made by peeling thin slices of logs (like peeling an apple) or slicing thin slices and then gluing these thin veneers into a 4 ft x 8 ft panel. CLT is made by stacking and orienting 2" by various widths into large sections that can be over 40 feet long and 8 or 10 feet wide.

Note: it is suggested that the reader also read the CLT section of this report as mass plywood and CLT have similar market and other criteria analysis.

1. Market – Instead of the limited thicknesses that traditional plywood is made of and used for sheathing purposes, mass plywood as a mass timber product takes the veneer sandwiching to new heights for structural purposes. The end result is a product that has similar market use as CLT.

2. Competition – Mass plywood is a direct competitor of cross-laminated timber and, if built in the northeast U.S., would be seeking the same markets as CLT. With few veneer manufacturing plants in the northeast, a new mass plywood operation would need to include a veneer mill whereas a CLT plant can purchase its feedstock an 2" x X" boards at any of dozens of existing sawmills that produce that softwood material.

3. Barriers to Entry – As stated above, veneer is the raw feedstock for producing mass plywood panels, and there are few veneer mills in the northeast region to provide feedstock for producing mass plywood if a plant were built. A new mass plywood facility would require a veneer plant too – a disadvantage over a CLT plant that has many sawmills from which to purchase feedstock in the region. The market is growing but it is not clear that the cost of raw material and production from a northeastern U.S. facility would compete on price with the alternatives – especially a mass plywood plant that may have a higher cost structure than a conventional CLT plant.

4. Opportunities – The market for mass timber and CLT is growing and the rate of growth is growing fast as well. Mass plywood is a substitute for CLT so all assumptions and conclusions about CLT apply to mass plywood. The northeastern U.S. urban areas are seen as prime area for growth and currently dozens of planned or under-construction mass timber buildings are being built using European or other North American produced product. The opportunity is there for a northeast plant to gain market share through reduced transportation costs and possibly raw material cost if new species, especially eastern hemlock which has been engineering tested for this product, can be used.

5. Constraints – Outside of competition on cost with European and other North American manufactured mass timber, there are few constraints to manufacturing CLT and other mass timber in the northeastern U.S. except that for mass plywood, a plant would likely need a new veneer mill to supply it and veneer quality logs are the most expensive on the market.

6. Labor/unit – Mass timber manufacturing, including mass plywood, is a modest labor/unit process. Since this is a relatively new forest products sector, all plants in the world use similar technology which sets the labor needs. A stand-alone mass plywood plant might only employ 25-50 people if a veneer plant was not also built to supply it.

7. Raw material – There are limitations on species for CLT as well as mass plywood. These limitations are primarily about strength and weight. Currently certain softwood species (spruce and fir in the east and Douglas fir in the Pacific Northeast and southern pines in the South) are used as feedstock species. Some University of Massachusetts testing has been done in the northeast on two other species – hemlock and white pine – but neither has been officially certified for CLT or for mass plywood use. Both are possible species for mass timber glued products but no northeast manufacturing yet occurs. Mass plywood would need to use one of those softwood species (or several) as well.

8. Ability to positively affect carbon equation – A key advantage over concrete and steel is the carbon benefit of mass timber. This is a major selling point for growth in this sector along with quicker construction times for large buildings.

Closing note on mass plywood – of the mass timber products, mass plywood is the least likely or desired for the northeast because this product requires veneer and/or plywood as its raw feedstock and the region has only two existing veneer/plywood plants. It is not likely that a new veneer mill would be built as a supplier for a new mass plywood plant. Further, logs to supply a veneer mill are the highest quality logs available, further affecting the cost structure of this product.

Biochar - A solid material obtained from the carbonization thermochemical conversion of biomass in an oxygen-limited environment – i.e. "cooking" raw wood in a heating machine where most of the oxygen has been removed. In more technical terms, biochar is produced by thermal decomposition of organic material (biomass such as wood, manure or leaves) under limited supply of oxygen (O_2), and at relatively low temperatures (<700°C). Used in soil amendment and filtering applications.

1. Market – The primary markets are for filtration (water treatment and other filtration needs) and as a soil ameliorant – i.e., a soil supplement for agriculture that allows more moisture retention by the soil. In these soil uses, the carbon is fixed and does not break down over time, making it a positive for the carbon equation. The filtration market is steady but small in the US, and the world and this market can pay for the product. This is the approach a Maine start-up is hoping to pursue as off-take.

For ag soil supplement use, there is a huge potential for use but the use as a paid-for soil amendment is just starting, and it is unclear whether the ag community can afford to pay for this product to add to soils as part of other soil amendment processes (limes and fertilizer) that are regularly undertaken.

A secondary market for biochar has begun in the European Union as part of climate change efforts but it is only just starting to become available to non-EU suppliers. In this marketplace, under third-party certification of the full life cycle (Life Cycle Analysis or LCA) of production of biochar, the producer is able to create a credit per ton of biochar manufactured. This credit is then sold in the marketplace where the buyers are those required to or making business decisions to reduce their operation's carbon footprint. Early information in this EU market suggests that the market price for a certified biochar credit to be much less than the value of the biochar as a filtration substrate.

A reminder, a certified producer of such a credit can also sell the biochar in the marketplace while a third-party purchases the certified carbon credit for the biochar – a dual income possibility. This EU opportunity is new and North American biochar producers are only just beginning to determine if they can enter this market for their biochar carbon credit. If this market proves accessible to North American operations, and/or if policies coming out of the federal government in the U.S. also recognize this credit, the biochar sector could see substantial growth in the coming decade using wood as feedstock.

2. Competition – Estimates of the biochar market today in the U.S. are in the few thousand tons per year range – a very small market that is being fulfilled by very small producers currently. The product is expensive to ship because it is very light in weight for its volume. If this product receives some kind of subsidy as a carbon-friendly product as part of U.S. and worldwide public policy (see above), the market size could change drastically allowing for more producers at larger scales to produce the product. There are tiny producers in the northeast but they are often part-time one person endeavors (Charcoal Group (NH), Next Char (MA), Vermont Biochar (VT)) are northeast U.S. examples.

3. Barriers to Entry – No real barriers to entry exist because the technology hardware is available for purchase so that anyone could theoretically enter the market. The chief barrier is the small size of the market and the price paid for the product as a filtration or soil amendment tool.

4. Opportunities – Should the market size grow, the key opportunity for biochar in the northeast U.S. may be as a by-product of a pyrolysis or green diesel facility. As a by-product, the economics might become more favorable. There are currently some biochar developers that are exploring stand-alone biochar plants using woody feedstock in the northeast. If the biochar EU or other carbon credit becomes available, stand-alone plants may be more feasible.

5. Constraints – Unless new public policy provides incentives, the market for biochar will remain very small and localized.

6. Labor/unit – Labor per unit of production (ton) is modest. Since no large commercial operations exist it is not clear if economies of scale will improve the labor component with large operations. Any new stand-alone biochar manufacturing facilities that might be constructed in the northeast would be small, with start-up employee numbers in the 5-10 range and full build-out labor requirements several times that number.

7. Raw material – Any tree species that grows in the three-state region can be used for production of biochar. Given the less-than-favorable economics, lower grade timber would be the feedstock, particularly softwood which currently has less low-grade market value than hardwood. A fully built out stand-alone biochar manufacturing facility might use 25,000 to 50,000 tons of green wood feedstock inputs annually but the current largest operations in the U.S. are more in the 10,000 green tons per year range.

8. Ability to positively affect carbon equation – Biochar has one of the highest potential along with solid wood products for positively affecting the carbon equation.

BioPlastic Composites (BPC) - Bioplastics are polymers (plastics) blended with non-organic additives (mineral fillers, UV stabilizers, color pigments, flame retardants, processing aids, and plasticizers) and further processed into composites. Wood-based bioplastics are mainly cellulose- and lignin-based. Bioplastic material can be biodegradable and non-biodegradable, and can be based on renewable or petrochemical raw materials.

1. Market – Bioplastic composites with cellulosic reinforcement are used in automotive parts, electronics, and household appliances. In other words, nearly anything you see that is made out of fossil-fuel based plastic, can be made from bioplastic composites. Biocomposite filaments are used in 3D printing. Interest in biocomposite materials and their use in various applications has grown steadily over the past decade. Increasing environmental awareness and lower material costs are the main driving forces for renewable materials, such as wood and cellulose fibers, as reinforcement in polymer composites. Innovations in material science continues to reveal materials and expanded uses for emerging products. Green bioplastic composites can be sustainable, carbon-friendly and economical materials that can serve as an alternative to synthetic fiber reinforced polymer composites or plastic materials that are available in markets today. Currently, green biocomposites are already available in markets for various applications such as automotive, construction, and buildings components. Some bioplastics biodegrade in a landfill or in weather in as little as a few months, a real advantage over fossil fuel based plastics.

2. Competition – This product mix competes with fossil-fuel based polymers. Unless public policy incentives become available, the best area for growth using wood feedstock is using residuals from other wood manufacturing operations rather than feedstock directly from the forest. As long as fossil fuels are inexpensive, competition by wood-based bioplastics will be a challenge. As the world becomes more focused on climate change mitigation techniques that include reducing or eliminating fossil fuel uses, wood-based bioplastics interest and demand will grow as use of fossil fuel-based plastics is ubiquitous in the world today. In the U.S. NatureWorks LLC, Corbion NV and FkuR Plastics Corp are three of the biggest manufacturers. A full-scale 2019 start-up wood-based bioplastics manufacturing company in British Columbia, Canada, Advanced

BioCarbon 3D Ltd, has been inching its production upward. The company now uses upwards of 100 tons of wood chip feedstock per day as it continues to scale upwards.

Industry sources (Ibis World) show 130 bioplastics manufacturers in the U.S., some of which are using wood as feedstock.

3. Barriers to Entry – Barriers to development include inconsistencies in natural fiber properties and high moisture sensitivity. Cost of production relative to fossil-fuel alternatives in current pricing scenarios is slightly higher for bio-based production but could come down with economies of scale and if world and/or U.S. climate policies provide incentives for non-fossil fuel product alternatives.

4. Opportunities – If public policy incentives become available to shift production from fossil-fuel alternatives, BPC could be attractive, especially using wood residues as feedstock.

5. Constraints – Currently competition from cheaper fossil-fuel based manufacturing processes is the main constraint to growth in the marketplace.

6. Labor/unit – Modest and no different than fossil-fuel based plastics manufacturing. Plant sizes range from niche producers with under 10 employees to the largest companies with over 100 employees.

7. Raw material – All species of timber growing in the region are possible feedstocks. A large bioplastics plant might use 50,000 or more tons of wood feedstock per year. As demand increases, larger plants are possible and expected.

8. Ability to positively affect carbon equation – Reducing fossil-fuel inputs into the polymer product sector by increasing wood fiber feedstocks would improve the carbon equation.

D. Benchmarking for NH/NY/VT Analyses

Benchmarking work conducted for the FOR/Maine effort is somewhat different than what is appropriate and needed for the NH/NY/VT region. From page 6 of this report, the summary of the benchmarking work from FOR/Maine is:

Once products were selected, Indufor began a benchmarking effort to determine where Maine's strengths and weaknesses lie relative to these potential forest products compared to other key states and countries.

Benchmarking[13] work was conducted comparing Maine's prospects with the 6 chosen forest products against:

<u>Countries</u>	<u>US States</u>
Finland	Georgia
Germany	Minnesota
Russia	Oregon
China	
Canada (Ontario)	

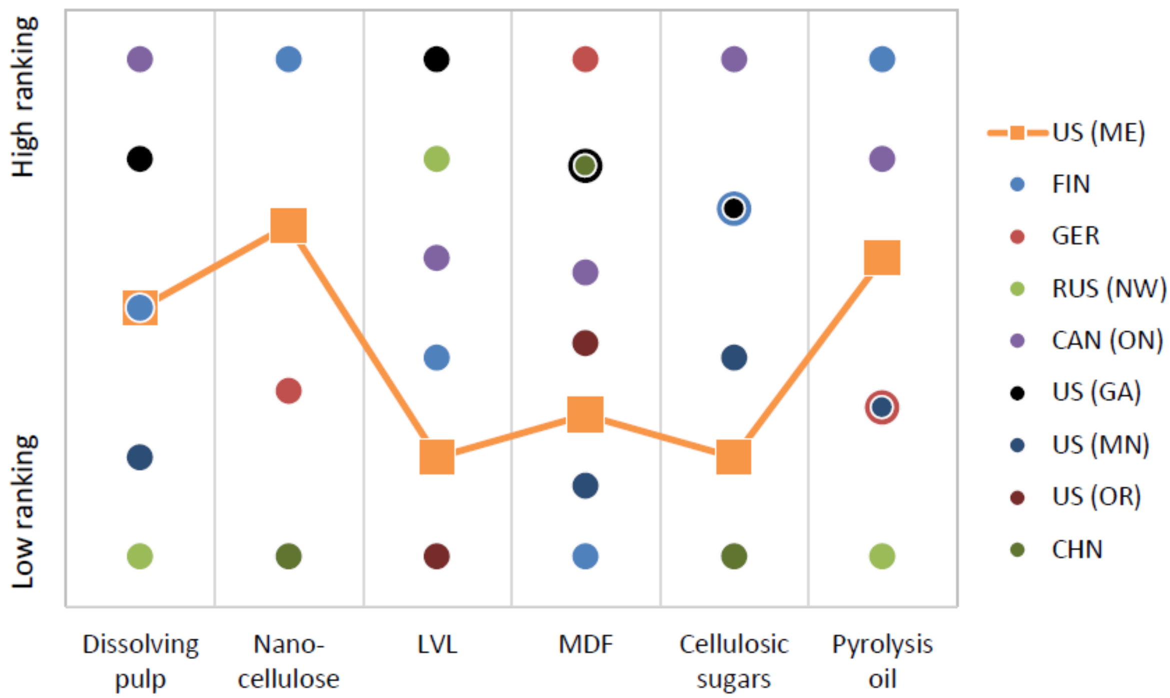
The benchmarking work compared Maine with the other countries and states relative to the following issues:

Raw material availability	Labor availability and skills
Forest ownership	Logistics cost
Raw material cost	Other costs
Labor cost	Regulatory climate

[13] Benchmarking (repeat footnote) is the practice of comparing business processes and performance metrics to, in this case, countries, provinces or states where similar forest products markets are found. The FOR/Maine effort compared the six products for Maine production to the other countries and states.

A single graphic from Indufor's third report best illustrates the results of the product ranking and benchmarking analysis for the 6 chosen forest products:

Figure 14 ***(Repeat) Indufor Product and Benchmarking Analysis***



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Again, this concluded that Maine's best opportunities for forest products market growth include nanocellulose and pyrolysis oil followed by dissolving pulp. Nanocellulose and dissolving pulp require existing or new pulp mills to manufacture. Pyrolysis oil requires new or substantially modified manufacturing facilities.

For New Hampshire, New York and Vermont, the products chosen and the market target of the northern eastern seaboard in the U.S. rather than the entire world, require a different approach to benchmarking the products. Only two of the benchmarked countries/states used in the Maine process are relevant to the needs in NH, NY & VT – Minnesota in the U.S. and Ontario in Canada. The benchmarking information from the Indufor reports on those two geographies can be found in the Appendix of this report.

In addition to those locations, we have added Pennsylvania, Tennessee, Kentucky and West Virginia to benchmark the chosen products against for NH, NY & VT. These states in particular are more relevant as competitors of NH/NY/VT given their forest types and current forest products markets mix.

E. Final Products Selection – Assessing Benchmarking Findings

Important Note: The final product selection analysis is based on the benchmarking work found in Appendix A for the comparison states of Kentucky, Pennsylvania, Tennessee and West Virginia. Summary findings are presented here; for full detail please consult the appendix.

A reminder that in FOR/Maine, the market geography chosen was worldwide. For the New Hampshire, New York and Vermont, we have chosen the population centers from Portland, Maine to Newark, New Jersey as the target geography because we believe short transportation distance to this market area is a distinct advantage to the three-state geography.

From the Product List and Ranking Products section 3 of this report (found above), the following target list was finalized as the focus for this project. A further reminder, the longer list was narrowed down and other products eliminated from the top 14 list (explained above before the product by product analyses section) so that our target list is:

1. Pyrolysis oil
2. Cellulose insulation
3. Green diesel
4. Sawn – mass timber
5. Biochar
6. BioPlastic Composites

Following this, substantial benchmarking research work was conducted to add to the benchmarking work conducted for the FOR/Maine effort by their contractor Indufor. As a result of the product selection above and the differences between Maine and the New Hampshire, New York, Vermont region (highlighted earlier in this report), we added the states of Kentucky, Pennsylvania, Tennessee and West Virginia to further benchmark against. To summarize the major differences between the NH, NY & VT region and Maine:

- Timber stocking in the NH, NY & VT region is much higher and the growth to removals ratio much higher than in Maine;
- Timber stocking is much heavier to hardwood species in NH, NY & VT compared to Maine;
- The NH, NY & VT region forest economy is not dominated by pulp and paper as it still is in Maine;

- NH, NY & VT are closer to the megalopolis along the northeastern seaboard as compared to Maine.

The Indufor analyses and benchmarking for Maine were focused on the world as a market whereas we are focusing on the northeastern megalopolis as the market core for NH, NY & VT. Secondly, we are focused on non-pulp and paper technology for the NH, NY & VT area along with hardwood dominating species.

We chose Kentucky, Pennsylvania, Tennessee and West Virginia for further benchmarking work because they have similar attributes to New Hampshire, New York and Vermont. Those attributes include:

- Timber resource is mostly hardwood with some softwood;
- Existing timber economy supply chain is similar to the supply chain in the three-states (robust sawmill sector, full geographic reach of the industry in the state, robust logging infrastructure with substantial competition, adequate trucking sector);
- An existing but small pulp and paper sector;
- Within relatively short transportation distance to the northeastern megalopolis as the core market for forest product market growth.

There are substantial learnings from this additional benchmarking work that yields the following major findings:

Raw material – Our target states of NH, NY and VT have ample and growing timber resource as compared with the benchmarked states. The benchmarked states also have substantial timber resource inventories that are growing but they have little softwood timber as compared to our target states. Timber prices, on average, in our benchmarked states are comparable to our target states.

The conclusion is that our target states have a slight advantage when it comes to the raw material that acts as feedstock to existing and potentially new forest products manufacturing.

Workforce – The entire forest products industry in the U.S. is experiencing either an aging workforce or difficulty in finding employees, especially for entry level jobs – or both. This is also the case in our target states as well as benchmarked states. General demographics show aging populations living longer in the target and benchmarked states. The target northeastern states show somewhat higher average education levels than our benchmarked states although this generally does not necessarily mean that this more educated workforce is accessible to employers in the forest products sectors.

Finding people to work in the forest industry is a challenge in the northeast, but this is not unique to the region. Finding, recruiting and retaining individuals to work as loggers, truckers, and at mills is often reported as a challenge everywhere. This is true in all forested regions across the country. A recent post by the Forest Resources Association (FRA) – a national trade association that works to support the forest industry supply chain – notes that "workforce continues to be one of the most critical topics to FRA members.[14]" USC Consulting notes that "staffing shortages" is one of the critical challenges facing the forest industry, noting (perhaps a little dramatically) that "organizations in the American forestry industry are suffering operational dysfunction linked to staffing shortages.[15]" Quotes in 2021 from hardwood lumber producers through the Hardwood Market Report include:

> "I cannot overemphasize the problem of the shortage of willing, qualified workers in the U.S."
>
> "Shortages [of workers] are severe for both skilled and unskilled positions, and this is a widespread problem."
>
> "Labor shortages come up in almost every conversation we have with our industry contacts, regardless of where they are or what sector they are in."

Clearly, any manufacturing facility locating in the region – or in any rural community in the U.S. – should carefully evaluate its workforce needs and the ability of the local workforce to meet those needs.

Comparing the states, unit labor cost is lowest in New York, New Hampshire and Pennsylvania among the seven comparison states and highest in Kentucky, West Virginia and Vermont.

Labor productivity is higher in Vermont and New Hampshire compared to the other states except for Pennsylvania. New York is at the bottom of worker productivity scale compared to the target states and other benchmarked states but still in the middle of states in the U.S. as a whole.

The target states have no significant advantage compared to the benchmarked states with regard to workforce issues.

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[14] Vicki Swanton, Western Regional Manager. The Workforce of Tomorrow. Woods2Mill Blog, Forest Resources Association. February 18, 2021. https://forestresources.org/resources/woods-to-mill/item/1983-the-workforce-of-tomorrow

[15] USC Consulting Group. 3 Challenges Facing the American Forestry Industry. Metrics Blog. January 19, 2019. http://www.usccg.com/blog/3-challenges-facing-american-forestry-industry/

Regulatory Climate & Taxes – The regulatory climate is less business friendly in some states in this study versus others. Particularly, New York, Vermont and Pennsylvania are generally considered to be less business friendly than New Hampshire in our target states and Kentucky, Tennessee and West Virginia in our benchmarked states. Cost and ease of doing business in these latter states is more favorable than in the former states.

For personal income taxes, only New Hampshire and Tennessee (as of Jan. 1, 2021) do not tax income from wages. But both of these states and the other 5 states tax business income. Of these, Pennsylvania and then Vermont business income taxes are highest. Sales taxes are levied in all the states but New Hampshire. Of the six states with an income tax, New York and Tennessee have the highest rates.

Of the 7 target and benchmarked states, New Hampshire has an advantage over all others in regulatory/business climate issues and taxes though the benchmarked states of Kentucky, Tennessee and West Virginia follow. New York and Vermont can be generally considered less business friendly and more tax heavy than the other states in our target and benchmarked group.

Energy Costs – Energy cost comparisons focus on retail electricity rates for commercial use. Fossil fuels, though critical to the supply chain of the forest products industry, are generally similarly priced across the eastern US where the three target states and four benchmarked states exist.

Electricity prices for commercial and industrial use vary widely across the seven states but outside of the industrial exception in New York (lower industrial retail rates for some markets) electricity prices are lower in our benchmarked states.

Overall, electricity prices put the three target states at a disadvantage when compared to the benchmarked states.

Infrastructure and Transportation – The infrastructure around high-speed internet access and mobile phone coverage puts the target states of New Hampshire, New York and Vermont at a distinct advantage over the benchmarked states although all rural areas in the target and benchmarked states have spotty internet and mobile coverage.

The transportation infrastructure appears to be similar in all seven states with some states in the benchmarked sample with more coordinated long-term road infrastructure improvement plans and implementation than the target states. The colder winter temperatures and higher use of road salt for road safety puts the target states at a disadvantage generally compared to the benchmarked states. The two real advantage the target states have over the benchmarked states are proximity to the target market area from Portland, ME to Newark, NY and better access to deep water ports. The benchmarked states may have some limited advantage in commercial rail access but rail has not been a major factor in forest products markets in the eastern U.S. in recent decades and will remain a second-tier transportation issue for the forest products sector.

The target states hold some limited advantage over the benchmarked states in infrastructure and transportation issues.

Research and Development for Forest Products Manufacturing – In recent decades, most forest products manufacturing research has shifted to government labs, rather than private company labs that used to dominate this sector. All seven states benefit from the research and development work undertaken by the federal government agencies – particularly the USDA Forest Service – and so no advantage is seen. There is some limited advantage for non-federal research and development at universities in the benchmarked states for forest products markets development.

The benchmarked states have a slight advantage over the target states in research and development in forest products production and markets.

Differences Among New Hampshire, New York and Vermont

These analyses differ from the FOR/Maine effort in that our target area is three states, not one. As such, the bulk of these analyses have focused on the three states as a "region", not as individual states although sections of previous reports did look at data state by state.

There are minor and major differences among New Hampshire, New York and Vermont that are worth articulating here. **Major differences** are:

1. Income Taxes – New York and Vermont both have personal and business income taxes. New Hampshire has a business income tax but no general personal income taxes. New York and Vermont personal income tax rates are among the highest in the country. There is a tax on personal interest and dividends income in NH with a high threshold starting tax.
2. Sales Taxes – New York and Vermont both have sales taxes on personal and business sales. Vermont's sales tax rate is among the highest in the country. New Hampshire has no sales tax for personal or business sales.
3. Regulatory Climate – Regulatory climate in a state is not a single issue or policy. It involves permitting and certification and limits on activity and often considered with the tax climate. New York and Vermont have regulatory regimes for business that are considered more aggressive than New Hampshire[16]. More regulations generally make doing business in a state more expensive than states with less regulation.

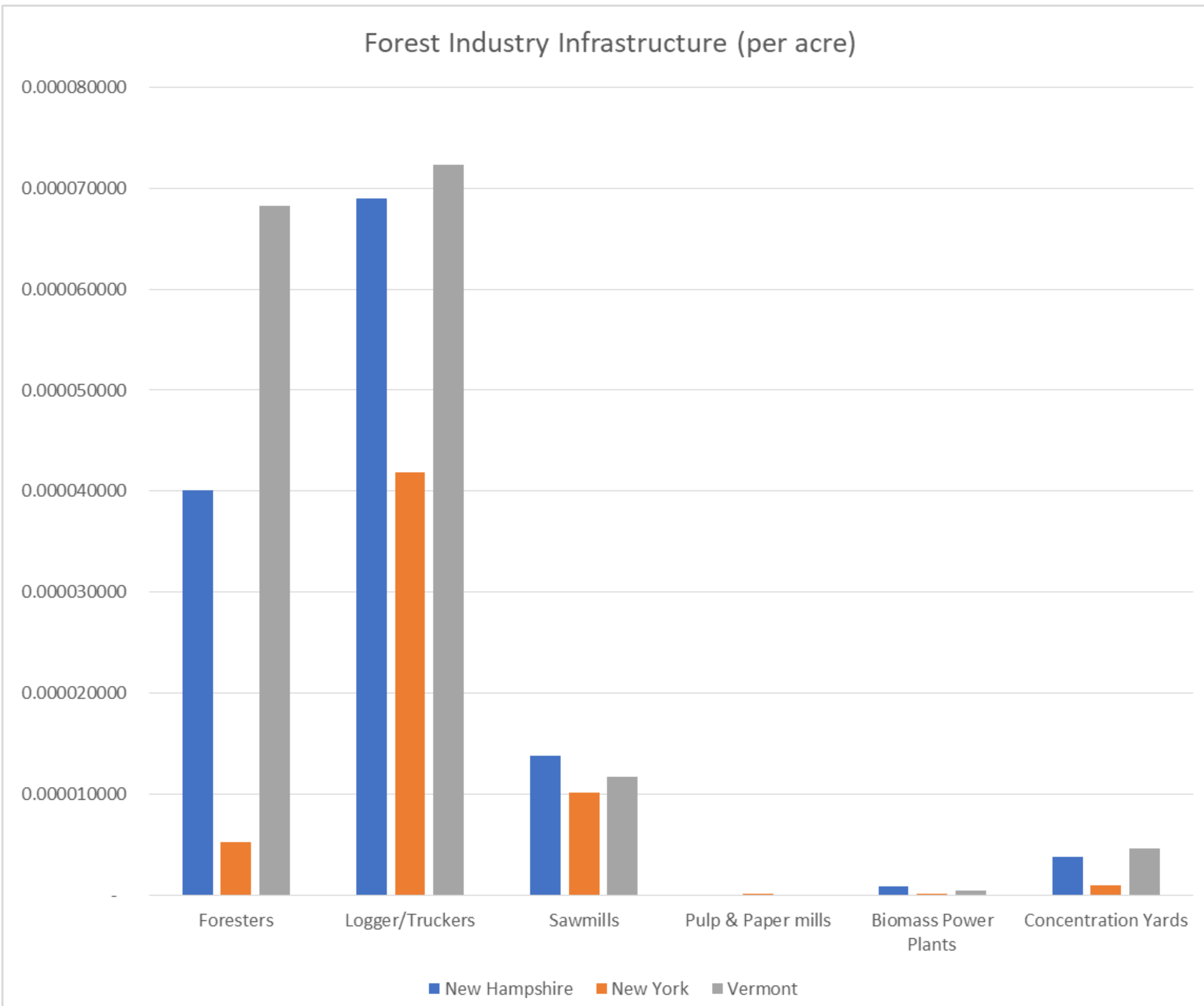
Minor differences are:

1. Timber resources – Timber stocking per acre is similar in New Hampshire, New York and Vermont as is growth to removal ratios. New York and Vermont's forests, however, are much heavier stocked with hardwood species whereas New Hampshire has a higher percentage of softwood species.
2. Timberland & ownership – New Hampshire has the highest percentage of timberland per surface area of the three states, followed by Vermont and then New York. New York has nearly 4 times the acreage of timberland compared to either New Hampshire or Vermont. Lastly, New Hampshire has a higher percentage of its timberland base in public land (23%) compared to Vermont (17%) and New York (11%). It is more likely that timber will be harvested on private land than public land.
3. Business assistance – With generally a smaller state government in New Hampshire and Vermont as compared to New York, a disadvantage for

[16] QuantGov, Mercatus Center, George Mason University 2018

Vermont and New Hampshire is that New York is able to offer financial and other incentives to prospective businesses to locate there whereas New Hampshire and Vermont have fewer incentives. Comparing New Hampshire and Vermont, New Hampshire has fewer incentives at its disposal compared to Vermont.

4. Forest industry infrastructure – In order to encourage new forest products businesses or expand existing businesses, it is necessary to have a complete forest products supply chain (foresters, loggers, truckers, equipment repair and parts companies, etc). While all three states have complete forest product supply chains, there are differences that the following chart demonstrates.



Source: NEFA

On a per acre basis, New Hampshire and Vermont appear to have an advantage of more foresters[17] and more loggers/truckers than New York. New Hampshire has the advantage of more sawmills as compared to New York and Vermont.

5. Truck Weight limits – Vermont has a slight advantage over New York and New Hampshire in that its truck weight limits are higher on the interstate system (99,000 lbs vs. 80,000 lbs.) compared to New Hampshire and New York. State road limits are similar in the three states.
6. Internet and Mobile Connectivity – Although likely more similar in rural areas, New York has a slight statewide advantage over New Hampshire and Vermont when it comes to internet connectivity and download/upload speeds. The same goes for the mobile network.
7. Electricity Costs – Although more similar than compared to the benchmarked states previously mentioned, commercial/industrial electricity rates, on average, are more favorable in New York as compared to New Hampshire and Vermont. Vermont's business rates are slightly lower than New Hampshire's.

[17] New York does not have forester licensing and so the data is likely not as accurate for foresters as is that for New Hampshire and Vermont where licensing exists.

Final Product Assessment Conclusion

As a result of the benchmarking analysis, showing that the three target state region of New Hampshire, New York and Vermont can at least be considered equal to the benchmarked states in the criteria analyzed and with a slight advantage due to the proximity of the target market area of the northeastern seaboard, we see no reason to alter the target products list of:

1. Pyrolysis oil
2. Cellulose insulation
3. Green diesel
4. Sawn – mass timber
5. Biochar
6. BioPlastic Composites

A reminder, Maine's chosen products were:

1. Nano-cellulose
2. Pyrolysis oil
3. Dissolving pulp
4. MDF
5. LVL
6. Cellulosic sugars

A re-cap of the decision making used to decide on the top six products for focus of economic development work in the New Hampshire, New York and Vermont region:

- The timber variety, standing volume and availability in this three-state region is exceptional and, as a result, lends itself to virtually any wood product manufacturing.
- While strained due to the results of the recent loss of significant low-grade timber markets, the supply-chain infrastructure is complete and adequate to get any species and virtually any volume of timber from the forest to the market for manufacturing of any wood product from the timber raw material in the region.
- Given the significant loss of low-grade markets in the region since 2019, there is an abundance of low-grade timber of any and all species that are available in large quantities. All but the mass timber suite of products on this chosen list of six can be considered as products requiring (or able to use) low quality timber feedstocks.

- The need for expanded or new markets that utilize low-grade timber as feedstock is important to all portions of the forest products supply chain including the forestry sub-sector. In order to conduct sustainable forest management that seeks to grow the highest value trees for market from the region's private forestland-dominated forest ownership, there is a need for low-grade timber markets. Otherwise, forestry will resort to less desirable forms of management and timber harvesting where only the higher quality and value trees are harvested while the lower grade trees are left in the forest.
- Substantial investment will be required to expand existing forest products markets and develop new ones in this region. We chose the products in the list in part because the investment required to develop them appear to be in the range of the possible. We explicitly decided that a project the size of a pulp mill (in the billions of dollars range) was not likely in this region. Development projects to bring manufacturing of the chosen six product areas range from as little as $10 million in a small start-up of biochar production to the $100 million range for some of the other products. These are capital amounts we believe are possible for development in the region.
- The sawn – mass timber group of products (except for mass plywood which we discuss in the product section) is a sector of new potential forest product markets that is very exciting given its potential for significant growth. The market for use of mass timber in tall buildings in very large in the geography of the eastern seaboard down to New Jersey – our target product market geography. If this sector even grabs 5% of the market currently dominated by traditional steel and concrete, the growth will be substantial and having manufacturing in this region of the raw materials will be necessary and attractive. Many groups are now working on encouraging mass timber use in the northeast region's commercial buildings and CLT, glulam beams and other mass timber products are ripe for expanded market share. Initially it is likely that manufacturing of mass timber will use traditional spruce/fir that is already sawed in large qualities by sawmills in the region but other species, particularly eastern hemlock, may be attractive soon.
- There are many other nuanced reasons for choosing the top six products embedded in this report. The reader is encouraged to re-read the previous sections and also the product by product analyses to better understand the decision making.

One final note on sawn wood products – at the time of this writing in 2021, sawn wood products from primary sawmills in the region are in a good position for growth. Despite the COVID pandemic (or possible partly because of the pandemic) the sawmills of the three-state region have been experiencing excellent demand for all of their products since the 2008-09 recession with the possibility for growth in both the hardwood and softwood sawmill sectors. We have chosen not to include these known and traditional forest products because they are not in need of outside marketing and development assistance as compared to the mostly newer potential products on our list of six. This sector, however, is poised for strength and growth in the coming decade as regional as well as world-wide demand for the solid sawed wood products from the sawmill sector is solid.

And lastly, just because a product from the long-list is not on the very-narrowed down list of six we have chosen to highlight as best alternatives, does not mean that there is no possibility for manufacturing of these products in the three-state region. We encourage readers to scrutinize the long-list and use the entire contents of this report to make decisions about where to focus economic development resources. We believe the six listed have the most promise given the current circumstances, natural resources, supply chain and other factors discussed in this report.

Appendix A

Forest Products Analyses – Products not favorable to NH, NY, VT

Activated Carbon - is carbon manufactured from high-quality coconut shell charcoal, wood and carbonized coal. When processed, activated carbons possess an exceptionally high developed pore structure to maximize its effectiveness. It shows a very high degree of durability and resistance to abrasion and associated breakdowns.

1. Market – Currently the market is very small. The end users – farmers for use as soil amendment and companies needing filtering material are few. Current estimates on market size in the US suggests a few thousand tons per year. This could change rapidly if public policy outcomes in the Biden Administration or elsewhere in the world see activated carbon and bio-char as part of climate solutions needing incentives to grow their production. Potential for growth is great.

2. Competition – Currently most major producers are outside of the US.

3. Barriers to Entry – Modest production hardware for this product can be purchased with building and site capital cost in the several million-dollar range. Market is tiny currently so an interested developer might have trouble raising capital without real prospects for significant growth.

4. Opportunities – As discussed above, the opportunity for significant growth resides in public policy discussions underway in the Biden Administration. If bio-char and activated carbon are deemed part of the climate solution and receive government incentives to encourage growth, there will be a grand opportunity in these fields.

5. Constraints – Small size of market and mature players, mostly outside of the US, in the market currently.

6. Labor/unit – This is not labor-intensive technology at the manufacturing plant.

7. Raw material – Can be made from any wood species. Some technology suggests softwoods are better suited but hardwoods are used as well.

8. Ability to positively affect carbon equation – This product and biochar may be seen as part of the climate change solution and result in substantial incentives to encourage growth.

Animal Bedding – Wood shavings prized for animal stock bedding and that can be produced from low-quality logs as a final product rather than a by-product of sawing processes.

1. Market – The animal bedding material market is large country wide but given the bulk to light weight ration of the product, markets must be close to production. The northeast is the market should production of a stand-alone bedding plant be built. USDA data suggests growth in the pleasure horse as the primary area for growth with secondary markets in the hobby farm animal sector. This is not a market that would lend itself to many production facilities. Currently supplied from residues (sawdust and shavings) from the solid wood manufacturing sector.

2. Competition – Mainly from the solid wood manufacturing sector residues. Since it is a by-product of those operations, not clear that a stand-alone manufacturing plant could compete.

3. Barriers to Entry – Capital costs for a stand-alone animal bedding plant would be low – less than a million dollars depending on scale.

4. Opportunities – This market is growing in the northeast but is small-scale.

5. Constraints – Current producers in solid wood manufacturing residues sector are the biggest constraint to a stand-alone plant. There are no stand-alone plants in operation in the northeast US.

6. Labor/unit – Moderate labor/unit operation. A small plant with two bagging lines could be run by 5 people. Many line operations would require more.

7. Raw material – Any tree species can be used to make animal bedding residues but currently softwood residues are deemed more desirable because they are seen as having better absorption capabilities. There are still opportunities for testing of various density hardwoods that might lead to better results.

8. Ability to positively affect carbon equation – Not a significant volume sector. Used animal bedding is sometimes buried which can lead to carbon storage. Not a clear player in the carbon equation.

Ethanol Related products. The following grouping of products related to ethanol (alcohol-based derivatives using wood as the feedstock): Biobutanol, ethanol, furfural, lignocellulosic ethanol and xylitol. We have grouped them together because they are related (some are the same product with a different name). Each has a separate analysis.

Biobutanol – Ethanol, such as that produced from agricultural products (corn, sugar beets, etc.) produced from woody biomass.

1. Market – Butanol (including ag based) is primarily used as a gasoline supplement (and also as a solvent) and has a global market of 3.7 million metric tons annually, with a market value of over $6 billion. Today nearly no wood feedstock butanol is produced because of low profitability using this feedstock. Growth of this and other non-fossil fuel transportation fuels is expected to grow.

2. Competition – Virtually all producers of bio-based butanol are using agricultural feedstocks as these processes are less expensive than using woody feedstocks. The leading bio-based biobutanol (isobutanol) players in the market are Gevo, Butamax Advanced Biofuels, and Green Biologics. There is US production using ag feedstocks. Little competition using wood feedstocks (virtually none in the US) and this is not likely to change unless methods and economics improve for using wood.

3. Barriers to Entry – Since no entity has developed a technical method using wood as feedstock to be competitive with ag feedstock alternatives, the economics remain the key barrier to entry.

4. Opportunities – One of the key opportunities of biobutanol is its potential to replace fuel ethanol from ag feedstocks. Biobutanol has higher energy content than ethanol making it preferable as fuel. It also prevents moisture absorption and reduces engine corrosion. Butanol is an attractive fuel alternative, as it is a drop in product and does not require modifications to the engines. Biobutanol as a fuel has also lower carbon emissions. Biobutanol is also a sustainable alternative to fossil-derived butanol in its applications.

5. Constraints – The relatively high costs of biobutanol have restrained biobutanol from break through to the market. The availability and increasing price of wood feedstock biobutanol raw materials as well as challenges with yield and selectivity in the production processes are inhibiting demand growth of bio-based butanol. In addition, the on-going debate over food versus fuel and uncertainty of regulations may hamper producers when making business plans.

6. Labor/unit – This is a low labor/unit product.

7.	Raw material – Ample wood feedstock raw material is available in the three-state region but the market price for even the lowest priced species makes it hard to compete with ubiquitous ag feedstocks in the Midwest US.

8.	Ability to positively affect carbon equation – Like ag-based ethanol, the biobutanol substitutes for fossil fuels is a positive carbon alternative.

Ethanol - Ethanol is colorless, flammable and antiseptic liquid. Ethanol is mostly used as transport fuel (about 90%). First generation (1G) ethanol is produced mainly of corn starch, wheat and sugar-containing plants such as sugar beet and sugar cane. Production of 1G ethanol is technologically well established and commercially developed for many years. 1G ethanol has been criticized for its limited GHG emission savings and for its raw materials that are also used for food production.

Over the last year, second generation (2G) or so-called lignocellulosic ethanol production has emerged to address these criticisms. 2G ethanol is produced exclusively of non-edible, cellulose and lignocellulose feedstock, such as wood, agricultural residues, straw, grasses and different industrial and even municipal waste streams. 2G ethanol production is not fully commercial yet (early phase of commercialization).

See Biobutanol for analysis.

Furfural - Furfural is most commonly produced via hydrolysis of agricultural wastes that contain pentosans (C5 carbohydrates are a major constituent of hemicellulose). Furfural may also be formed as a side product during production of ethanol from wood. The most common raw materials for furfural production include corncobs, cottonseed hulls, bagasse and rice hulls. In addition, byproducts from pulp production represent an important feedstock for furfural production.

Furfural is used as an extractive solvent for lubricating oils, in butadiene extraction, and in linking foundry sand. Furfural is also used in other minor applications, such as intermediate for the production of herbicides and insecticides, chemicals, pharmaceuticals, and fragrances, among others.

Furfural is mainly used for the production of furfuryl alcohol. Furfuryl alcohol is used primarily in the production of furan resins. Furan resins are mostly used for making metal parts by sand casting (furan resins serve as binders for the sand). Other uses for furan resins include corrosion-resistant mortars, grouts and cements for use in chemical manufacturing facilities, and in certain coatings for the automotive industry.

Lignocellulosic Ethanol - Lignocellulosic biobutanol is a bio-based alcohol produced from similar feedstock to ethanol (biobutanol) – see above - such as corn, sugar beet and different types of biomass (softwoods, hardwoods, sawdust, pulp, agricultural residues). It has been studied mostly for use as drop-in fuel in mixtures with gasoline. Biobutanol is an interesting biofuel as it has superior properties vs. bioethanol from ag waste:

• higher energy density

• lower volatility

• less corrosive

Biobutanol also shows promise as an industrial solvent. Other possible applications may include use in paints/coatings, resins, plasticizers, pharmaceuticals, food grade extractants, chemical intermediates and herbicides.

See Biobutanol for analysis.

Xylitol - Xylitol is a sugar alcohol used as an alternative sweetener to traditional sugar. Xylitol is a natural occurring sugar, that was first was discovered by German Chemist Emil Fisher and French Chemist M.G. Bertrand in 1890.

During the second world war, sugar shortages in Finland resulted in local manufacture using birch bark. Since the 1970's the University of Turku in Finland focused serious research on the manufacture of Xylitol resulting in commercial production from approximately 1975 onwards. Xylitol's is an ideal sweetener for diabetic patients because its metabolism is independent of insulin. It may also prevent dental decay. It is principally used in certain sweetened products such as confectionery, in personal health products such as mouthwash and toothpaste, and in the pharmaceutical industry such as a sweetener or coating agent for pharmaceutical products.

1. Market – There is strong global and local demand for this sugar substitute. US demand for xylitol has been estimated as some 60,000 tons in 2017. Xylitol production from corncobs is currently more competitive compared to wood-based xylitol, although wood-based xylitol is regarded as a superior product. The fast majority of xylitol is current produced from corncobs through the catalytic reduction of pure D-xylose. Alternative raw material includes various biomass types including agricultural and woody biomass. Currently, the world's largest producer is China. Current production using non-corn feedstock is low to non-existent. It is unclear whether wood feedstocks can be used in an economical way to make this product.

2. Competition – This is a commodity product that China dominates production in worldwide and shipping long distances is not a major cost problem. That, and the fact that wood-based xylitol is not currently competitive make this a difficult product for competitive purposes in the three-state region.

3. Barriers to Entry – Xylitol market worldwide had been growing at 10-15% per year prior to the COVID pandemic and is expected to increase again once the pandemic is over. The existing producers have the ability to ramp up production to meet expected increases in the coming years. Extreme competition for a global commodity is the biggest barrier to entry followed by the lack of substantial dry wood residues as feedstock.

4. Opportunities – Despite a projected growing market and a strong U.S. market for this product, there are few opportunities in the northeastern U.S. for new production, especially given the lack of large quantities of fry wood residue for feedstock.

5. Constraints – Constraints to xylitol production in the three-state region are many, the chief of which is the lack of large quantities of dry wood feedstock.

6. Labor/unit – Xylitol production is a mature industry and the newest plants have favorable labor to unit output ratios. Labor is not a huge input to production of this product if the manufacturing facility is built to proper large scale.

7. Raw material – Any dry wood residue can be used for feedstock and the three-state region has dry feedstock sources although not in concentrations that would attract a new facility. These dry feedstock sources are all currently being used in other manufacturing processes and so a price differential would be necessary to secure the fiber from existing markets.

8. Ability to positively affect carbon equation – Xylitol is already produced from agricultural feedstock sources and using wood as feedstock would not change the carbon equation for the product since it does not store the carbon long-term.

Black pellets – wood pellets manufactured through partial combustion in an oxygen starved environment.

See white pellets for complete analysis of wood pellets.

Today the term white pellets is most commonly applied to differentiate wood pellets (regardless of feedstock color) made through the pelletizing process from wood pellets that are made with the inclusion of a torrefaction or steam explosion step in the pelletizing process; the latter producing a pellet that is very dark in appearance and presently referred to as black pellets.

In spite of the rather large body of information that has been made publicly available on black pellets for many years, through research organizations, industry associations, producers and product champions—a significant market has yet to develop anywhere in the world. In Europe small amounts of black pellets are used. The same is true for Canada and there are indications that

black pellets are entering the Japanese market. Combined, the volumes involved do not exceed 100 000 tons in North America and Europe, with stagnant demand even after a decade of effort. Only in North Asia is there potentially an opportunity, but even there the potential is restricted to Japan and if certain legislation proceeds. It is unclear even if this market will develop.

From a quality and performance perspective black pellets should be a major element in global wood pellet markets. They are superior to white pellets in many ways. They are significantly more hydrophobic, more energy dense, create less dust in handling and transport, less susceptible to biological activity, and are generally more suited for use in coal-fired power plants. And yet, black pellets have essentially not taken any market share from white pellets due to cost. Other factors have played a role including the investment

in infrastructure around white pellets in Europe, the direction of technology development for residential heating units, and licensing and intellectual property issues. With the possible exception of a supply line to Japan, it is unlikely that black pellets will gain market traction in the coming years.

Combi Particle Board – Generally MDF panel faced with melamine or some other non-wood material.

See MDF for the analysis.

Dissolving Pulp - DWP is chemically produced bleached wood pulp, as a purer form of cellulose than other paper grade pulps. Dissolving pulp can be split into low alpha cellulose pulps (alpha cellulose content < 93%) and high alpha cellulose pulps. There are many factors which make dissolving pulp hard to produce. The most important of these are the high alpha cellulose content, low ash content, high purity, and uniform degree of polymerization needed.

The cost disadvantage is the low yield of dissolving pulp. About 20% more wood may be needed to produce dissolving pulp compared with paper grade chemical pulps, increasing the total roundwood demand significantly. Nearly

70% of dissolving wood pulp is produced from hardwood species, but it can also be made from softwoods.

The main uses of dissolving pulp are viscose staple fiber (VSF), acetate, ethers, filament, as well as some certain specialties (e.g. MCC, casings, tire cord, cellophane etc.).

Dissolving pulp and other pulp mill products are being discounted in this analysis because pulping capacity is severely limited and it is believed that a new pulp mill will not be constructed in this region.

See Biobutanol for analysis.

Lactic Acid - Lactic acid is produced by microbial fermentation of sugars from biomass. Lactic acid is a bulk chemical with long history; traditionally it has been widely used as an acidulant, flavor enhancer and shelf-life extender and preservation enhancer in food and beverage products. Lactic acid is also used as solvent in the pharmaceutical and chemical industries. Another use of lactic acid is as an ingredient in personal care products due to its moisturizing, pH regulating and skin lightening properties. A growing use for lactic acid is in production of biodegradable polymer polylactic acid for packaging (shopping bags, packaging films, disposable cups and lids, and rigid packaging).

1. Market – Lactic acid has a huge market internationally, and in the U.S. Food and beverages manufacturing use almost half of all worldwide production with polylactic acid a close second. It is believed that lactic acid's use as a feedstock for producing polylactic acid (PLA) will drive growth in the future. PLA is different than most thermoplastic polymers in that it is derived from renewable resources like corn starch or sugar cane. Most plastics, by contrast, are derived from the distillation and polymerization of nonrenewable petroleum reserves. Plastics that are derived from biomass (e.g., PLA) are known as "bioplastics."

PLA is biodegradable and has characteristics similar to polypropylene (PP), polyethylene (PE), or polystyrene (PS). It can be produced from already existing manufacturing equipment (those designed and originally used for petrochemical industry plastics). This makes it relatively cost efficient to produce. Accordingly, PLA has the second largest production volume of any bioplastic (the most common typically cited as thermoplastic starch).

There are a vast array of applications for Polylactic Acid. Some of the most common uses include plastic films, bottles, and biodegradable medical devices (e.g., screws, pins, rods, and plates that are expected to biodegrade within 6-12 months). For more on medical device prototypes (both biodegradable and permanent) read here. PLA constricts under heat and is thereby suitable for use as a shrink wrap material. Additionally, the ease with which Polylactic Acid melts allows for some interesting applications in 3D printing (namely “lost PLA casting” - read more below). On the other hand, its low glass transition temperature makes many types of PLA (for example, plastic cups) unsuitable to hold hot liquid.[18]

2. Competition – The lactic acid industry is concentrated with the four largest lactic acid producers accounting for almost 80% of world production capacity. Corbion and Cargill are the leading producers of lactic acid, covering more than 56% of the total capacity. Corbion is the world’s largest producer of lactic acid, with manufacturing facilities in the United States, Brazil, and Thailand.

NatureWorks is a joint venture of Cargill and PTT Global Chemical Public Company. 57% of the Lactic Acid production capacity is located in Asia-Pacific (APAC) region, followed by United States with share of 38%.

The most likely scenario for lactic acid production in the northeast U.S. is if one of these large producers decided to locate a wood-feedstock using lactic acid producing plant. These are large and highly capitalized operations that a newcomer to the sector would find difficult to compete with. No lactic acid plant has been proposed for the northeast U.S. as of this writing.

3. Barriers to Entry – The largest barrier to entry would be competition from the known four large worldwide producers. A new developer would find competition with these established firms difficult to overcome. If one of these four large firms chose to locate a new lactic acid production plant in the northeast using wood feedstock, there would not be a barrier to entry although wood feedstock price might be an issue relative to alternatives. Residue sources might provide some mitigation of that issue.

4. Opportunities – The market for lactic acid and for its offshoot Polylactic Acid is expected to grow rapidly as fossil-fuel sourced alternatives in the plastics markets are in high demand.

5. Constraints – Few constraints exist for one of the large companies already in the lactic acid production market to locate in the northeast. It is unclear whether the price point for locally derived woody feedstock – whether in-woods or residue sourced – would be a cost constraint relative to alternatives in the U.S. or abroad.

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[18] https://www.creativemechanisms.com/blog/learn-about-polylactic-acid-pla-prototypes

6. Labor/unit – The manufacturing technology for lactic is mature and known. This is an efficient manufacturing scenario given that maturity and locally produced wood feedstock already has a robust supply chain to get raw material to a plant.

7. Raw material – Any of the many species of trees that grow in the northeast U.S. could be used as feedstock for this product.

8. Ability to positively affect carbon equation – Alternatives to fossil derived lactic acid for plastics production (bio-plastics) are all carbon positive when sourced from renewable wood fiber source compared to fossil alternatives.

Levulinic Acid - Levulinic acid is a non-toxic organic compound. The bifunctionality of the keto and carboxylic acid groups found in levulinic acid make it a versatile chemical intermediate. It can also be converted into many other useful chemical products such as solvents, pesticides, herbicides, polymer resins, cosmetics, and even gasoline or diesel components.

1. Market – There is currently not a large market for wood biomass derived levulinic acid production. While it can be made from raw wood chips, it can also be made from paper sludge and other residues from the pulping process. We are not focused on pulp derived products for this analysis. Biofine has done a 1 ton per day test plant in Maine and has not ramped up production to commercial scale since first testing began in 2015. Internationally, GFbiochemicals has one demo plant in Caserta, Italy with capacity of 10,000 tons per annum. The facility started in 2015 operating at 1.2 kt per annum. The company has been active in an EU funded project called GreenSolRes, which was established in September 2016 to convert lignocellulosic feedstock into chemical building blocks and high-added value products initially focusing on levulinic acid. Future products will include 2-methyltetrahydrofuran (MTHF), gamma valerolactone (GVL) and methyl butanediol with the development of a novel catalyst. GFBiochemicals has also a pilot plant in Minnesota, US with a capacity of 113 t per annum of levulinic acid. The plant, which previously belonged to US-based Segetis, has been producing ketals-based products from a 1.4 kt per annum demo facility under a toll manufacturer also based in Minnesota. Some industry sources believe these facilities have stopped production.

GFBiochemicals and US-based American Process Inc. (API) in 2017 entered a joint development agreement to create an integrated cellulosic biorefinery, which they claim will be the largest in the world. The proposed biorefinery to be in the United States is expected to produce 50-200 kt per annum of bio-based products, including levulinic acid.

It is not clear that a stand-alone levulinic acid plant using wood biomass feedstock can be made to commercial scale given the limitations on market and pricing requirements versus production costs.

2. Competition – The competition is described above but all world production is still at pre-commercial scale.

3. Barriers to Entry – Not clear that a market exists for the acid output at a price point that can be covered by required manufacturing costs.

4. Opportunities – We do not see bright opportunities for wood biomass-based levulinic production in the three-state region.

5. Constraints – Limited market and dubious economics for a scale manufacturing plant are key limitations and constraints on wood biomass-based levulinic acid production.

6. Labor/unit – A scale levulinic acid plant using wood biomass feedstocks has not been demonstrated so labor costs are unknown for a fully functional commercial facility for this product.

7. Raw material – Any species of wood biomass or agricultural feedstock can be used to make levulinic acid.

8. Ability to positively affect carbon equation – As an expendable and non-stable end product, wood biomass-based levulinic acid will have little effect on the carbon equation.

Lignin - Around 50-70 million tons/year of lignin is produced as a side product of the pulping process, but most is burned for power and it is believed that only one million tons reaches the chemicals market. Lignin can be used in a broad range of applications. Lignosulfonates is the leading product group on the lignin platform. Other lignin-based products such as phenolic resins, composites, binders, sorbents, fuel additives, polyurethanes and other polymer materials are some of the products that have also been developed or are currently being marketed on a commercial scale. Phenolic resins are commonly used to manufacture construction materials such as plywood, oriented strand board, laminated veneer lumber, paper lamination and insulation materials.

There is significant technology development required in order to create higher-value chemicals from lignin given its non-uniform structure, unique chemical reactivity, organic and inorganic impurities, and other depolymerization challenges. The most common feedstocks used for lignin production include pulp wood (softwood) and wood chips. Other feedstocks include sawdust and lignocellulose residues.

Since we have decided that pulping related products are not in the mix for the New Hampshire, New York, Vermont region due to a lack of pulping capacity and no likelihood of a new pulpwood, we have not conducted an analysis for this product.

Medium Density Fiberboard (MDF) – MDF is a reconstituted wood-based panel sheet wood product for non-structural applications made from sawdust or sawdust derivatives. An alternative to plywood in non-structural uses. Due to its uniformity of density, it can be molded and shaped well.

1. Market – MDF is a worldwide commodity forest product with expanded production since the recession of 2008-09. It is produced all over the world and the leading producer by far is China. South America is the next largest producer (approximately 10% of China production) and the U.S. is 6th with Canada. For the U.S. market, Canada, China and Chile followed by Germany are the biggest sources. The U.S. production is small and consumption is moderate compared to other worldwide consumers. MDF use is expected to grow as building development grows coming out of the COVID recession.

2. Competition – China dominates the production of MDF and, as a worldwide commodity forest product, any new production on the northeast U.S. would compete directly with Chinese, Canadian and South American production. This is a fine-tuned production industry that has been around for decades and only 12 companies produce MDF worldwide. As a commodity product, competition is fierce worldwide. The nearest US plant is in Pennsylvania but there are 3 plants in Ontario and 1 in Quebec to the north.

3. Barriers to Entry – This is a mature industry with worldwide commodity production. To compete, new manufacturing plants must have the lowest cost structure possible and other parts of the world have a lower cost structure than the U.S. and northeast in particular.

4. Opportunities – The market is very large worldwide and the northeastern eastern seaboard part of that market. But as a commodity product in a mature industry where cost is paramount, there are few opportunities to site a new MDF plant in the northeast U.S.

5. Constraints – Constraints for MDF are many – chiefly other countries that dominate world production of MDF and can do so at much lower cost structures than in the U.S. Wood and electricity costs are key to MDF production.

6. Labor/unit – A modern MDF manufacturing facility is fine-tuned to run with the least amount of labor possible but these facilities are large and require a moderate overall labor to production unit ratio.

7. Raw material – MDF is made from softwood or hardwood and so there is suitable raw materials in the three-state region for MDF production.

8. Ability to positively affect carbon equation – All long-term uses of wood or wood derived materials are carbon positive. MDF can be used to make nearly any non-structural wood product – a direct substitution for solid wood in furniture, cabinetry – even flooring.

Nano Cellulose - Nanocelluloses are a group of materials that are defined as having at least one of its fibrous dimensions in nano-scale. According to the European Union definition, nanocellulose is a natural, incidental or manufactured material containing particles (in an unbound, aggregate oragglomerate state), where for 50% or more of the particles in the number size distribution, one or more external dimensions is in the size range 1 nm - 100 nm.

Nanocelluloses are most commonly divided into three different groups:

- Nanofibrillar cellulose
- Cellulose nanocrystals
- Bacterial cellulose

The terminology related to nanocelluloses is not standardized and there many of synonyms for nanofibrillar cellulose, cellulose nanocrystals and bacterial cellulose. Some producers also use product name microfibrillar cellulose for mixtures of microfibrillar and nanofibrillar celluloses. Nanocellulose includes a diverse field of nano-sized materials and possible applications. Nanocelluloses are in the majority of the applications added as filler or additives functioning as property enhancers (e.g., rheology enhancer, stabilizer or oxygen barrier enhancer). Presently, materials close to commercial stage are mixtures of microfibrillar and nanofibrillar and are mainly used as fillers and additives in existing applications such as packaging.

Since we have decided that pulping related products are not in the mix for the New Hampshire, New York, Vermont region due to a lack of pulping capacity and no likelihood of a new pulpwood, we have not conducted an analysis for this product.

Oriented-Strand Board (OSB)– OSB is made by gluing together "flakes" of raw dried wood into panels using a press mechanism – held together with resins (chiefly Phenol-Formaldehyde or Isocyanate). OSB is a structural re-constituted wood panel product. The product was developed as an alternative to plywood. The wood stands/flakes in OSB are orientated perpendicular – mimicking the traditional construction of plywood. Panels have typically 3 or 5 distinct orientated layers. The first commercial OSB plant in the U.S. was Elmendorf Board Corp. in Claremont NH. That facility, under other ownership, closed in the 1980s.

1. Market – OSB is sold as 4' x 8' sheets and also used in wooden I-beam alternatives to traditional solid floor joists, interior furniture parts, packaging and other temporary uses. Since the 1970s OSB has continuously taken market share over structural plywood worldwide because its retail and wholesale cost is significantly lower than structural plywood. There is an OSB plant owned by JM Huber in Easton, Maine. The vast majority of worldwide production (over 60%) of OSB is consumed in the U.S. As housing starts and light commercial building production increases, so does OSB demand as it is a key part of exterior sheathing in most houses in the U.S. and has other uses as well. OSB is generally always used as an interior product – covered by some other product for finishing.

2. Competition – Like MDF, OSB is a worldwide commodity product and cost of production and pricing determines which producers sell in the market. Key input costs are raw material (low-grade wood) and electricity. Competition among the producers in North America and elsewhere is fierce for OSB usually coming down to securing market through lower price points. When the 2008 recession hit and housing starts plummeted, over 15 OSB mills in North America permanently shut down. The U.S. consumption of OSB was close to pre- 2008 recession levels when the COVID 19 pandemic began. Currently Norbord and Louisiana-Pacific are the biggest North American producers with approximately 12 plants U.S.-wide.

3. Barriers to Entry – This is a mature industry and cost structure and product pricing are key to market share. Areas of the U.S. and world with lower wood and electricity costs are better alternatives to the U.S. and northeast specifically for OSB production.

4. Opportunities – The opportunities to compete in the world or North American OSB market are not great from the northeastern U.S. where cost of wood and electricity inputs are above average. The NH/NY/VT region has one advantage – close proximity to one of the world's biggest markets in the eastern seaboard megalopolis.

5. Constraints – The key constraint is the cost of production for the three-state region.

6. Labor/unit – Modern OSB plants are fine-tuned and as efficient as possible with labor. The labor to output unit is low for this product.

7. Raw material – OSB is traditionally made from pine and aspen – both of which are available in the three-state northeast region.

8. Ability to positively affect carbon equation – All long-term uses of wood or wood derived materials are carbon positive. OSB can be used in long-serving applications that sequester the carbon in the products.

Polylactic Acid (PLA) – PLA is a compostable (biodegradable) bioplastic. In industrial composting facilities, polylactic acid decomposes to carbon dioxide, water, and biomass (humus). The plant-based polymer has a small carbon footprint (cradle-to-plant-gate carbon dioxide emissions) compared with competing fossil fuel-based plastics such as polypropylene, polystyrene, and polyethylene terephthalate. It is produced by polymerization of fermented lactic acid.

Polylactic acid applications include food service ware (e.g., transparent bakery and deli containers and lids, carry out boxes and cutlery), fresh food packaging (e.g., foam trays), coffee capsules for single-serve coffee makers, and shopping bags, among others.

Packaging made of polylactic acid has excellent tensile strength, rigidity, glossiness and clarity. Polylactic acid acts as an aroma barrier and can therefore be used for packaging material for products such as fruits and vegetables.

See lactic acid for the analysis.

Plywood – Multilayer panels made from gluing thin solid-wood veneer together and using a press to compress and dry the product to completion. Most applications are structural in nature but finish plywood – for use as solid wood substitutes for applications like furniture, moldings etc. – are also produced.

1. Market – Plywood markets are highly depending on building markets. As the 2008-09 recession arrived, plywood, along with all other wooden building products, saw a sharp decline in demand that nearly rebounded to pre-recession levels by early 2020 when the COVID pandemic hit. Since then, demand has waned for some portions but as building starts have picked up, so has demand for plywood. Plywood, like several other products discussed, is a worldwide produced commodity product, produced in many thicknesses and quality. Over 20 major producers of plywood worldwide include (there are many other small companies):

- UPM
- SVEZA
- Georgia-Pacific

- Samkotimber
- West Fraser
- Greenply Industries
- Boise Cascade
- Rimbunan Hijau
- Samling
- Syktyvkar plywood mill
- Weyerhaeuser
- Swanson Group
- Potlatch Corporation
- Roseburg
- Demidovo plywood mill
- Columbia Forest Products
- Penghong
- Xingang
- DeHua
- Shengyang
- Happy Group
- Hunan Fuxiang
- King Coconut
- Fengling
- Jinqiu
- Luli
- Guangzhou Weizheng
- Ganli

2. Competition – While UPM and Sveza are the two largest companies producing plywood worldwide, combined they produce less than 2 % of worldwide production. Competition is brisk among the over 100 producers worldwide. Only two plywood manufacturing plants are found in the northeast (Vermont and Maine) and most plywood manufacturing in the US occurs starting in the Appalachian region to the south and then in the Pacific Northwest. Another plywood plant exists in Quebec, just north of the three-state region.

3. Barriers to Entry – Plywood is a more mature forest products manufacturing sector than all others except sawmills. As such, entering the highly competitive commodity market is not easy as price competition for similar plywood products comes from worldwide competitors, not just local competitors.

4. Opportunities – Opportunities for more plywood manufacturing in the northeast U.S. are not great, given the many worldwide producers, the higher cost relative to raw material compared to Pacific Rim and southern U.S. producers and the high cost of electricity, and important input. The only opportunity of significance is the proximity to large markets nearby in the northeastern seaboard megalopolis.

5. Constraints – Constraints are significant for the northeast U.S. for new plywood manufacturing. Particular constraints include strong worldwide competition including from local and other North American producers. The high cost of power is a significant constraint. Log supply is a constraint only in that

the cost of raw material is high in the northeast compared to other locations – particularly for softwood in the U.S. South.

6. Labor/unit – Modern plywood plants are fine-tuned and as efficient as possible with labor. The labor to output unit is low for this product.

7. Raw material – Structural plywood, the large sub-sector of plywood in this worldwide commodity product, is generally manufactured using spruce/fir, pine in the south and Douglas-fir in the Pacific Northwest. The northeast has species of timber suitable for structural plywood. Non-structural (finish) hardwood plywood is made from many different species. The three-state region has many suitable hardwood species options.

8. Ability to positively affect carbon equation – All long-term uses of wood or wood derived materials are carbon positive. Plywood can be used in long-serving applications that sequester the carbon in the products.

Sawn (structural) - Structural sawn lumber is considered as softwood lumber that is approved for structural construction use.

The sawn lumber sector is completely established in the three-state region and very mature – among the most mature solid wood sub-sectors. As a result, this analysis does not cover sawn wood because this is not an area that needs assistance or focus to maintain and grow.

Softwood Kraft Pulp - the paper industry's benchmark grade of wood pulp. The process involves "digesting" (cooking) wood chips in an alkaline solution for several hours, during which time the chemicals attack the lignin molecules, breaking them into smaller segments that are dissolved and later removed.

A significant feature of kraft pulping technology is its sophisticated recovery system; here, chemicals used in the process are captured and extracted for re-use, thereby helping to minimize both raw material costs and the environmental impact.

Unbleached kraft pulp is dark brown in color. Before it can be used in certain applications, it must undergo a series of bleaching stages, resulting in both a white product and an additional manufacturing expense.

Within the kraft pulp grades there are several subgrades used to define specific qualities.

Since we have decided that pulping related products are not in the mix for the New Hampshire, New York, Vermont region due to a lack of pulping capacity and no likelihood of a new pulpwood, we have not conducted an analysis for this product.

Succinic Acid - Succinic acid is a C4 building block chemical. The majority of succinic acid production is currently petroleum-based, however, bio-based succinic acid production is expected to gain share as commercial production of bio-based succinic acid has emerged in recent years.

The appearance of succinic acid is colorless to white, crystal or powder and it is soluble in water. It offers broad application potential ranging from industrial markets, such as polyurethanes, resins and coatings to smaller, specialty markets, including personal care, flavors and food, as well as a precursor for other chemicals such as 1,4 butanediol (BDO).

1. Market – Bio-based succinic acid is identical in structure to petrol-based and can be directly substituted into a broad range of processes and applications. Bio-based succinic acid is cheaper to produce than its petrol-based counterpart. Succinic acid is versatile chemical and it offers broad application potential. It can be used in industrial markets, such as polyurethanes, resins and coatings (i.e., replaces mainly adipic acid) and in smaller, specialty markets, including personal care, flavors and food.

There is strong future demand growth potential for succinic acid and its derivatives, which is expected to be driven by BDO and polyurethanes. These two end uses are forecasted to account for over 60% of the total future consumption. Polybutyle succinate polymers as a new application can be used to replace conventional plastics, such as carrier bags, garbage bags, single-use food catering, packaging film or bottles.

2. Competition – BioAmber was a pioneer in bio-based succinic acid production but went bankrupt in 2018. Succinity is a joint venture between BASF and Corbion with a bio-based succinic acid plant in Spain (annual production capacity of 10 000 tons). The company is testing and validating the succinic acid value chain, one of the main drivers being development of complementary product, polybutyle succinate, for polylactic acid. Corbion announced in Nov 2017, that Succinity is minimizing current investment level until production route is optimized (key condition for positive market development).

Reverdia was a joint venture between DSM and Roquette that ended in 2019. It operated its bio-based succinic acid plant in Cassano, Italy (annual production capacity of 10,000 tons). Applications included alkyd paints, microcellular polyurethane foams for footwear and polybutyle succinate. Because of the new commercialization nature of this product manufacturing, producers are trying various methods to become profitable but it is still a nascent industry and more changes in manufacturers can be expect.

3. Barriers to Entry – With a projected annual growth demand for succinic acid at 5-6%, and with few producers in the market, there may be few barriers to entry from the market side. This product, like others discussed, is a small volume commodity product, making cost of production and competitive pricing key to success. The likeliest new producers would come from the few companies already producing the product who are looking to expand production with new manufacturing facilities.

4. Opportunities – With substantial growth projected as a non-fossil fuel derived product made from wood feedstock, the opportunities may be there to locate manufacturing in the northeast U.S., however the small size of the market relative to other opportunities such as pyrolysis oil and green diesel make succinic acid a poor cousin for the region.

5. Constraints – Constraints for succinic oil for the three-state region are that this product has a small international market not necessarily strong in the eastern seaboard focus, is a commodity product looking to grow based on lowest cost.

6. Labor/unit – As a fermentation type manufacturing process like many others discussed, the manufacturing plants tend to be small and labor/gallon of production not as positive as other possible wood manufacturing alternatives for the northeast that have larger scale facilities that take advantage of economies of scale.

7. Raw material – Any tree species that is growing in the three-state region is suitable for making succinic acid. Lower cost sources of feedstock, such as mill wood residuals given the loss of low-grade timber markets in the region, could be an attractive source of feedstock rather than forest-derived chips although the latter is suitable. Current bio-feedstocks are generally by-products of other processes such as bagasse or nut shells.

8. Ability to positively affect carbon equation – Succinic acid liquid fuel derived from woody feedstocks, especially wood manufacturing plant residues, will be very attractive as a fossil-fuel alternative acid relative to carbon.

White Pellets – Wood pellets made from raw wood feedstock used in combustion appliances for thermal applications in buildings. White pellets are compressed sawdust-like material produced in special press machines.

White pellets – i.e., conventional wood pellets – already have a strong manufacturing presence in the northeast U.S. and the three-state region in particular, with growth seen in the years immediately leading up to the COVID 19 pandemic. The domestic white pellet market is currently stable with slight growth and growth of production will come from within the current 15 wood pellet plants in the northeast. An important note is that the wood pellet (white pellet) plants in the northeast produce exclusively for the domestic building heating market – not the European bio-power market that southern US producers are in production for. There is little opportunity to expand white pellet production from the northeast for this off-shore power market because the southern U.S. plants have a very different cost structure (and slightly different product) making it impossible for northeastern plants to compete on price.

As a result of the above situation, we do not have a full analysis for this current strong product, just as we didn't provide one for sawn lumber.

Wood Plastic Composites (WPC) - WPC is composite material made from waste or virgin wood and plastic. In WPC, polyethylene, polyvinyl chloride, polypropylene and other types of plastic are most often combined with high-quality wood fiber/flour free of dirt and bark, or by-products of papermaking (e.g., bleached fiber by-products). Sometimes mineral fillers (e.g., calcium carbonate or talc) and coupling agents (e.g., maleated polyolefins, organosilanes, and acrylicmodified polytetrafluoroethylene) are also added to enhance the properties of WPCs. WPC are used in outdoor decking, benches, window/door frames, railings, fences, moldings, trim, cladding, siding, as well as some indoor furniture. There are capped and uncapped WPCs—capped WPCs have a resin layer which increases resistance to rot, mildew, mold, and splintering.

1. Market – North America is the largest producer and market for WPCs, especially composite decking and railings. In recent years, the main drivers for growth have been recovery of the residential market after the 2008-09 recession and growing demand for building products which require little maintenance. Asia-Pacific (especially China) is the second largest producer of WPCs accounting for about one-third of global production. U.S. and China make up nearly 80% of the worldwide market. Europe accounts for around 9%, with Germany the dominant producer, both in volume and number of manufacturers. Russia, Southeast Asia, South America, and India are the main emerging markets for WPCs.

Trade in WPC's is mainly domestic or regional (e.g., traded within North America or Europe) due to its relatively low unit value.

Decking is the main application for WPCs both in the United States and Europe, however the shares of other applications differ between these two regions. In

North America, the building and construction segment is the second strongest segment, while in Europe, (especially Germany) there is strong demand in the automobile industry (BMW, Opel, Audi, Volkswagen and other producers). In China, WPCs are used mainly in building/construction and the automobile industries.

2. Competition – The main producers of WPCs for decking and railing are: Trex Company Inc. (nearly 50% of the market), TimberTech and Azek, Fiberon LLC, and Advanced Environment Recycling Technologies Inc. Other players are Tamko Building Products, Fiber Composites LLC, Beologic N.V., and CertainTeed Corporation. Trex has several mills in the U.S., the nearest being in Virginia.

3. Barriers to Entry – The market is not large but stable and has grown since the 2008-09 recession. The major players in the market have a strong hold and are located near where high volumes of dry wood residue feedstock are available (see raw material below). Sourcing of dry wood feedstock is a major barrier to entry in the three-state region.

4. Opportunities – WPCs have many advantages over straight wood products including:

- Recycled materials,
- Low maintenance,
- More thermal stability than plastic,
- Dimensional stability,
- Low water absorption,
- Engineered profiles,
- Lower variability than wood,
- Does not warp or splinter,
- Tailored products,
- Lightweight.

As such, especially for outdoor decking and furniture and other exposed uses, WPCs have advantages over the traditional material – pressure treated wood.

5. Constraints – This is a limited market with mature producers. The most important constraint is sourcing large quantities of dry wood residue as feedstock to go along with the other WPC inputs that are petroleum-based.

6. Labor/unit – Labor is a modest input in WPC factories that are highly automated.

7. Raw material – WPC feedstock wood is from residues from furniture, cabinet and flooring manufacturers – very dry residues. As such, use of virgin

wood or sawmill residues are not the likeliest of sources and so WPC is less attractive as a forest product for the three-state region. Dry residues can be from any species. With only modest dry residue sources in the three-state region, WPC is not a strong candidate.

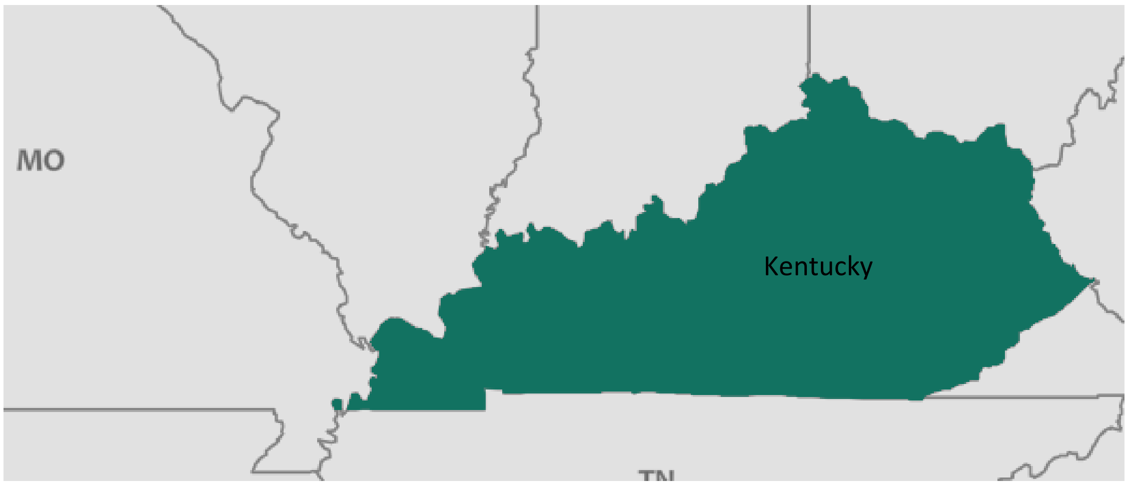
8. Ability to positively affect carbon equation – Since WPCs contain a high concentration of fossil-fuel based inputs in addition to the wood components, WPCs are low on the carbon scale as compared to the many other mostly or totally wood products discussed in this paper.

Appendix B

Benchmarking Analyses:

A. Benchmarking Analysis – Kentucky, Pennsylvania, Tennessee and West Virginia

Kentucky - Kentucky has a total area of 39,474.8 square miles, including 922.1 square miles of water, making it the 36th-largest state by area. Kentucky is bordered by Ohio, Indiana, Illinois, West Virginia, Missouri, Virginia, and Tennessee.



a. Raw material

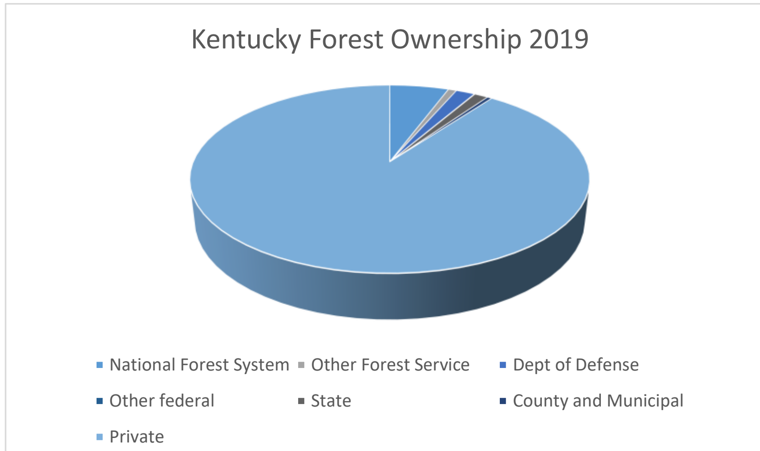
1. Forest Area and ownership

The Kentucky timberland[19] area covers 12,174,737 acres (Figure 15).

[19] Timberland: Forest land that is producing or is capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation. (Note: Areas qualifying as timberland are capable of producing in excess of 20 cubic feet per acre per year of industrial wood in natural stands. Currently inaccessible and inoperable areas are included.)

Figure 15 ***Kentucky Forest Area and Ownership***

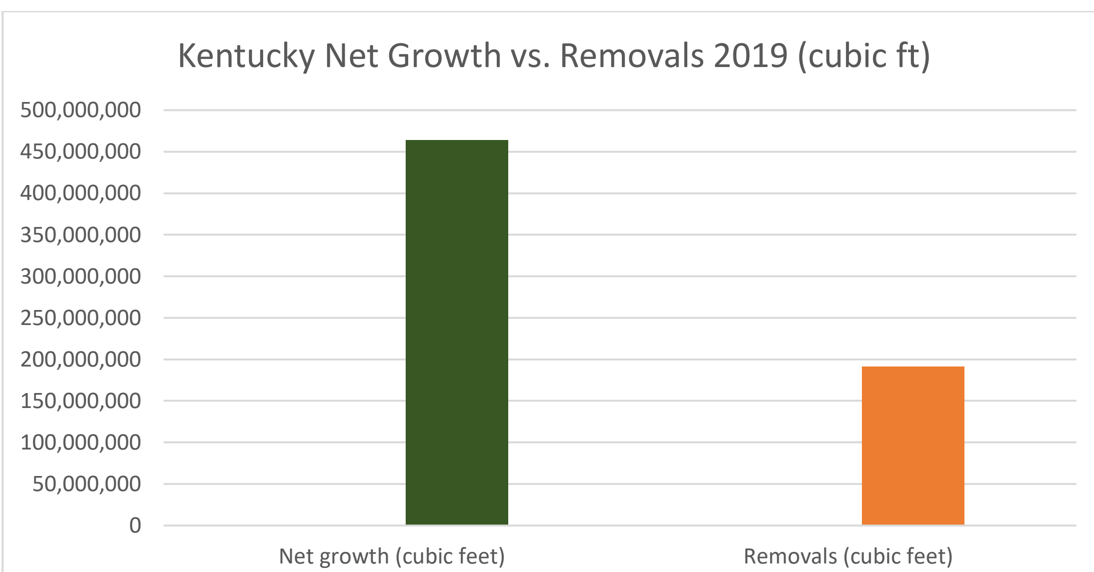
Owner Type	Acreage
National Forest System	692,643
Other Forest Service	97,103
Dept of Defense	223,228
Other federal	6,513
State	161,356
County and Municipal	55,835
Private	10,938,059
Total	12,174,737



Over 90% of those acres are owned privately while only 9.9 % is owned by the public sector. The federal government owns over 1.01 million acres while the State of Kentucky and local government owns just over 217,000 acres. Most of Kentucky's forests are mixed hardwood.

2. Harvest levels – From up-to-date data from the USDA Forest Inventory and Analysis dataset, the net growth to removals data for Kentucky looks positive (Figure 16).

Figure 16 ***Kentucky Timber Growth vs. Harvests 2019***



Source: USDA Forest Service FIA

The most recent FIA data shows that Kentucky has a 2.43 net growth to removal ratio for all timberland – meaning that each year, the State is growing 2.43 times more than it is removing from harvests and loss of timberland to other uses.

3. By-products – Kentucky timber by-products are primarily sawmill residues which are used mostly in the pulp and paper sector. Very little in-woods chipping is conducted as most timber harvesting is conducted with traditional chainsaw and skidder operations primarily designed to deliver sawlogs to the sawmills in the state. Secondary production of hardwood pulpwood occurs but is not a growth area. Some residues are used to generate electricity but little in stand-alone biomass electricity plants. Instead, most are through smaller generation facilities and combined heat power at mills – primarily in the forest products sector. According to the US Energy Information Agency less than 3% of energy used in Kentucky is from biomass sources.

4. Delivered wood cost – In Kentucky, hardwoods are the main species groups harvested (over 95%) and wood costs are competitive with other hardwood producing regions in the U.S. From State of Kentucky sources, at the beginning of 2020, delivered (to the sawmill) timber prices range from a low of $254/thousand board feet (Mbf) to $1,904/Mbf for Black Walnut with most in the mid-range. Increasing prices for white oak topped $1,000 per Mbf. This species has experienced increased local demand for the stave (wood barrel) market for the growing spirits sector for liquors, wine and beer.

   Low quality timber, which in this part of the country is hardwood pulpwood, is being sold, on average, for $45-50/ton delivered to the pulp mill.

5. Wood procurement practices

Most timber harvested in Kentucky comes from private land although a small volume of public timber is sold and harvested each year. Best Management Practices (BMPs) are practices that are required by Kentucky law (Kentucky Forest Conservation Act and Agriculture Water Quality Act) for timber harvesting activities. They are practices that are intended to protect water quality when dealing with agricultural and silvicultural operations.

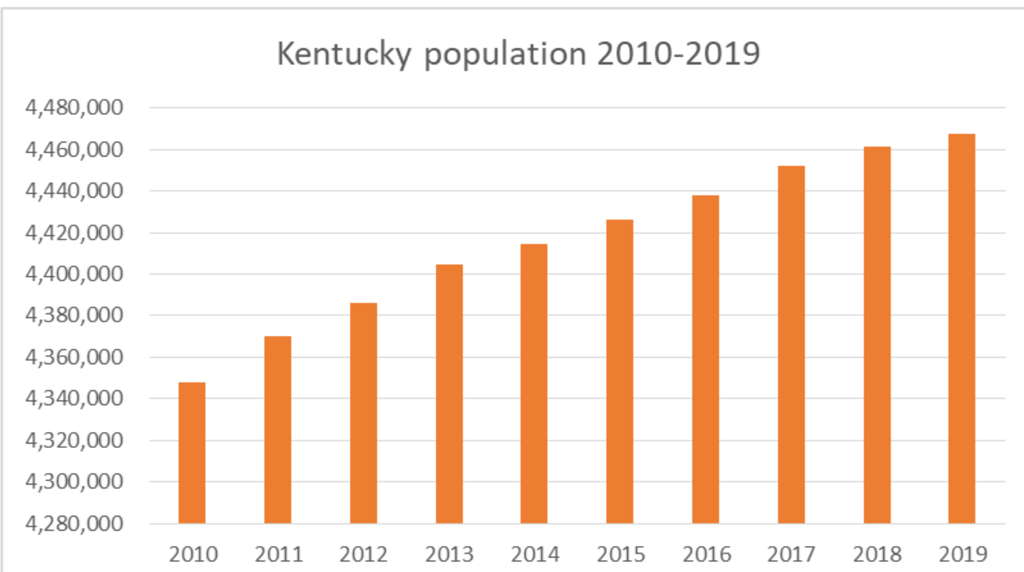
Timber harvesting is generally conducted with chainsaws and skidders along with bulldozers in the forests of Kentucky. A small number of timber harvesters employ mechanization using tracked feller bunchers and grapple skidders but most harvesting is done with chainsaws and skidders. Silvicultural practices used include clearcut, selections and shelterwood methods. Small clearcuts are often used as the land naturally regenerates the full range of hardwood species using this regeneration method. Logging is conducted year-round with stoppages during wet soil periods.

b. Workforce

1. Demographics

Kentucky's population in 2019 was 4,467,673 (Figure 17). The state has seen modest population growth since 2010 and ranks 26th in the US for population. It ranks 26th in the rate of growth from 2010-2019 among US states.

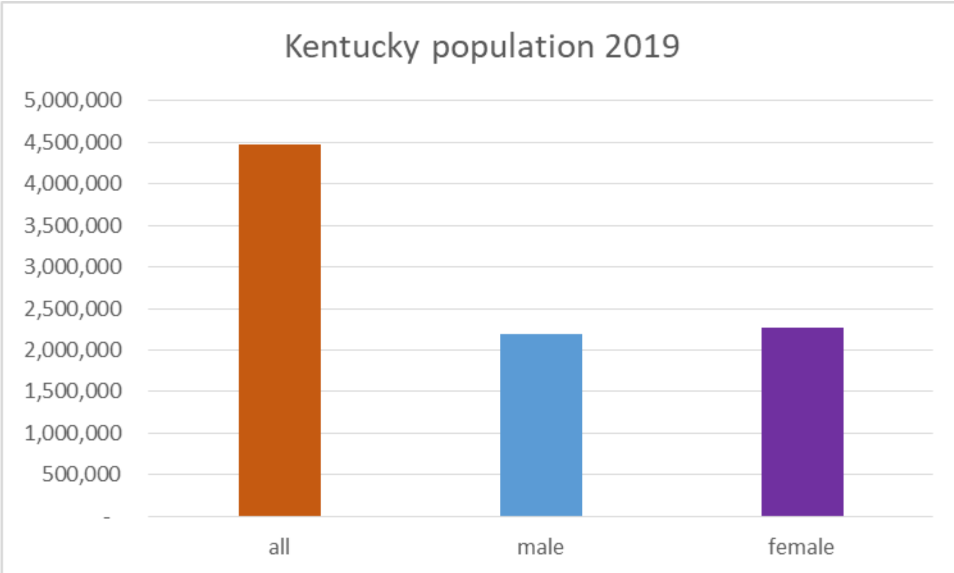
Figure 17 ***Kentucky Population 2010-19***



Source: US Census

Kentucky's population in 2019 was 51% female and 49% male (Figure 18). This is similar to most states in the US.

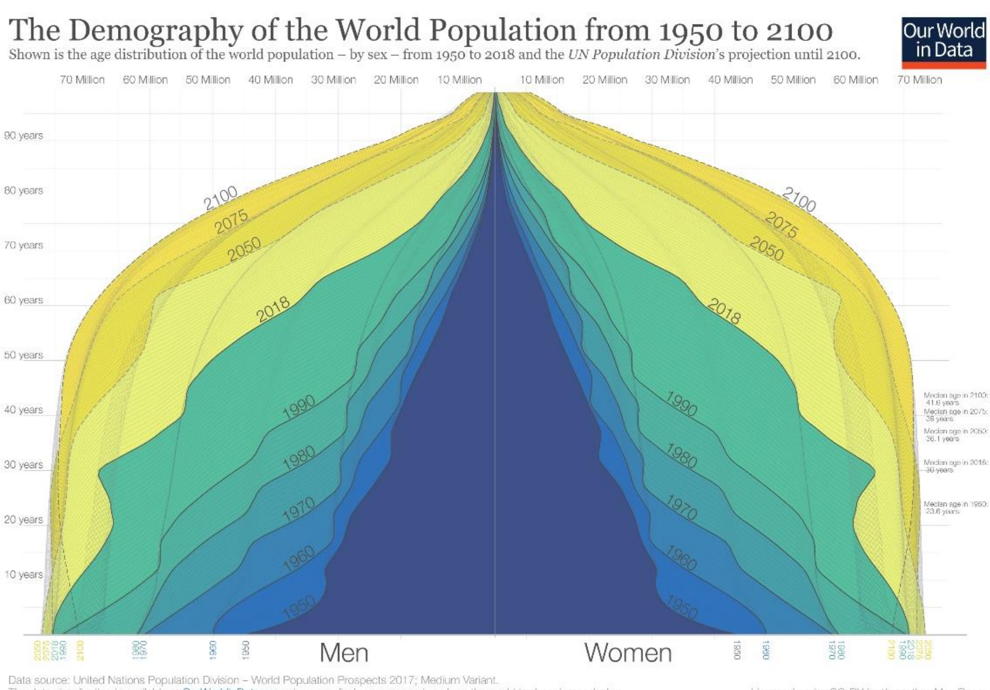
Figure 18 ***Kentucky Population Gender Distribution 2019***



Source: US Census

A more important and informative dataset on Kentucky population is found in Figure 20. Before digging into this Kentucky demographic information, some background on population dynamics is important to discuss. Figure 19 is from the United Nations and is a diagram that shows world population and its changes over time and projections into the future.

Figure 19 ***World Population Dynamics***



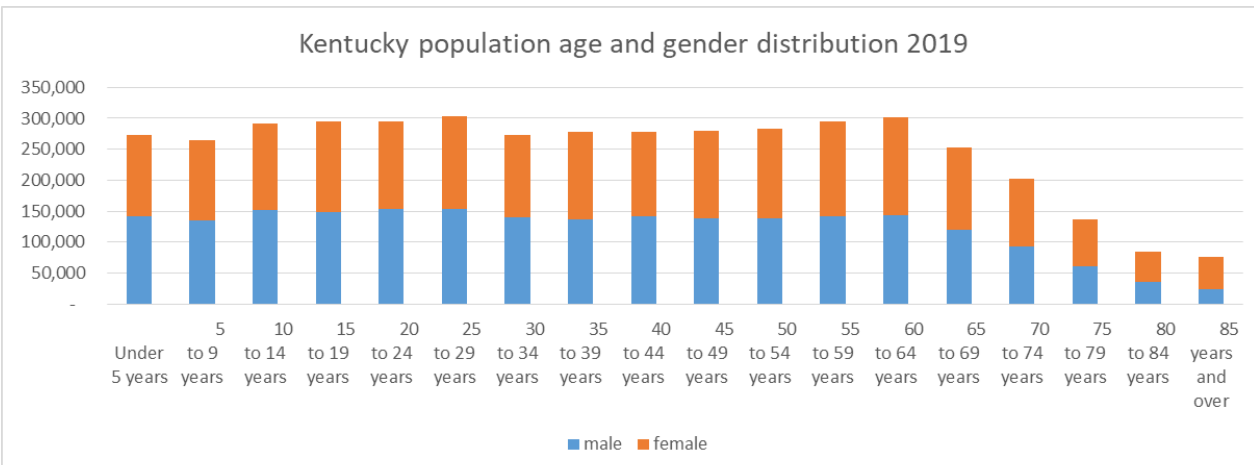
Source: United Nations

The figure shows world population from 1950 (2.5 billion people) to 2019 (7.7 billion) and projections to 2100 (11.2 billion). The most important finding from this figure is that age cohorts (10 years, 20 years etc) were dying at a much earlier age many decades ago compared to 2019. It simply means that infant mortality has reduced and average age at death has increased tremendously comparing 1950 to 2019. We are a healthier and older population today than we have ever been.

This is similar to what is occurring in Kentucky and all US states. From a labor perspective for the forest products industry, an increasing population in the working age cohorts from 20 to 50 represents good change. But an aging population is a concern in virtually all US states.

Kentucky's 2019 population shows a reasonable distribution across ages and genders (Figure 20).

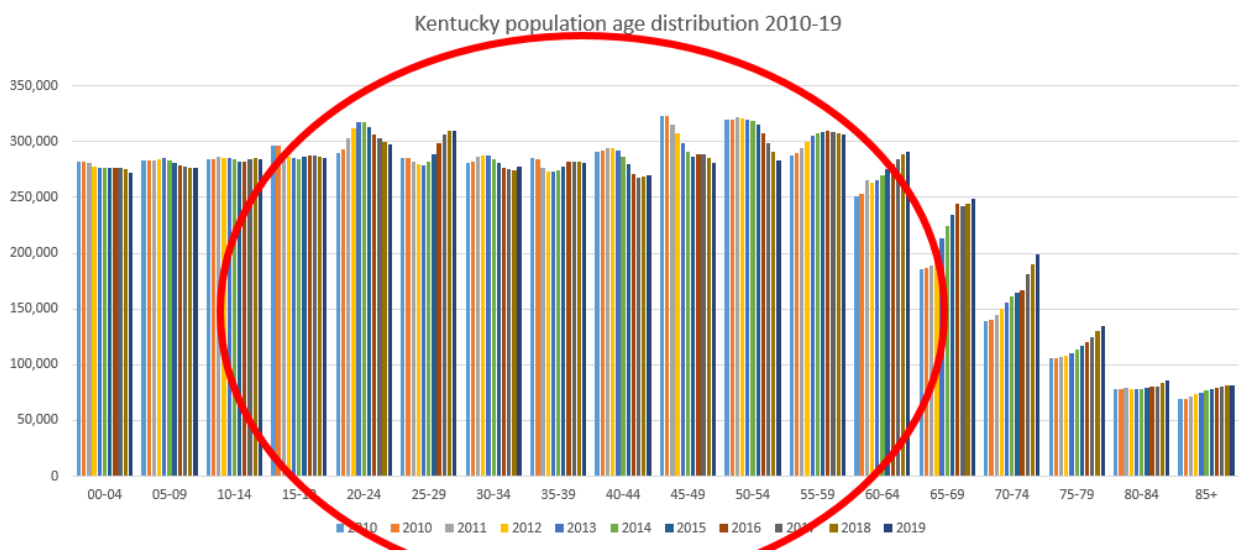
Figure 20 ***Kentucky Age and Gender Distribution 2019***



Source: US Census

Kentucky age distribution over time – from 2010 to 2019 – is probably more telling (Figure 21). Most of the critical labor age categories in the 20-54 age range are showing a declining population over time except for the 25-29 age class. The over 55 age classes all show increases over this period – a troubling sign of an aging population with fewer working age people available over time.

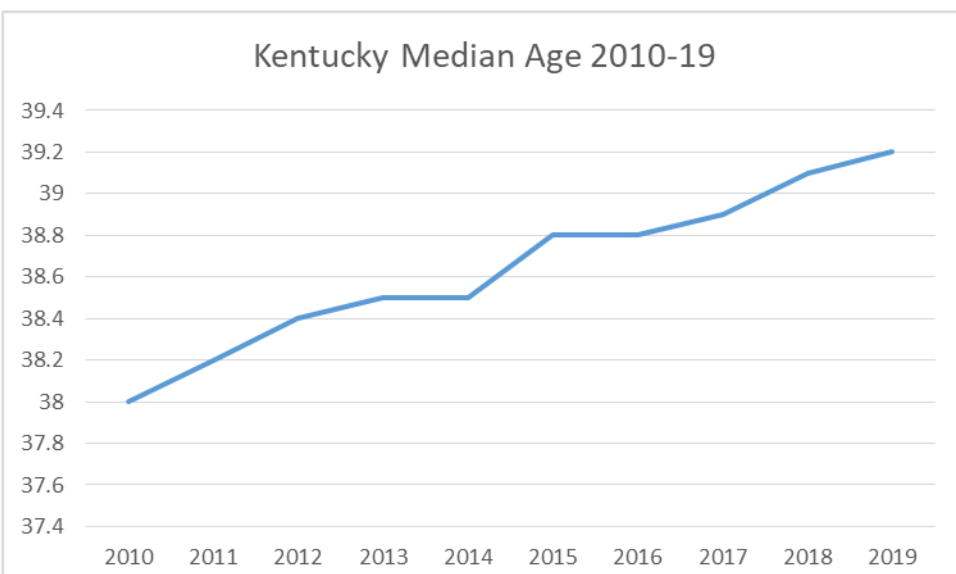
Figure 21 **Kentucky Age Distribution 2010-2019**



Source: US Census

Figure 22 further reinforces the aging workforce data with an increasing median age trend from 2010-2019.

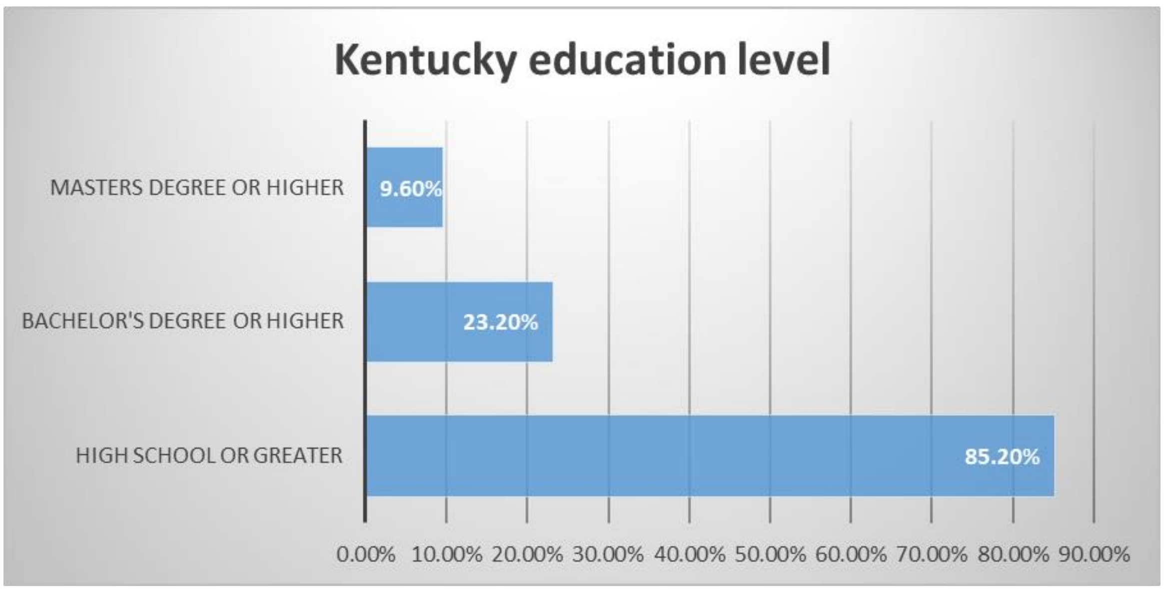
Figure 22 **Kentucky Median Age 2010-19**



Source: US Census

2. Level of education

Education level of a state's population is important workforce information. In Kentucky, 85.2% of the working-age population has at least a high school education. A bachelor's degree or higher is held by over 23.2% of the population and just under 10% of the population holds a masters degree or higher.

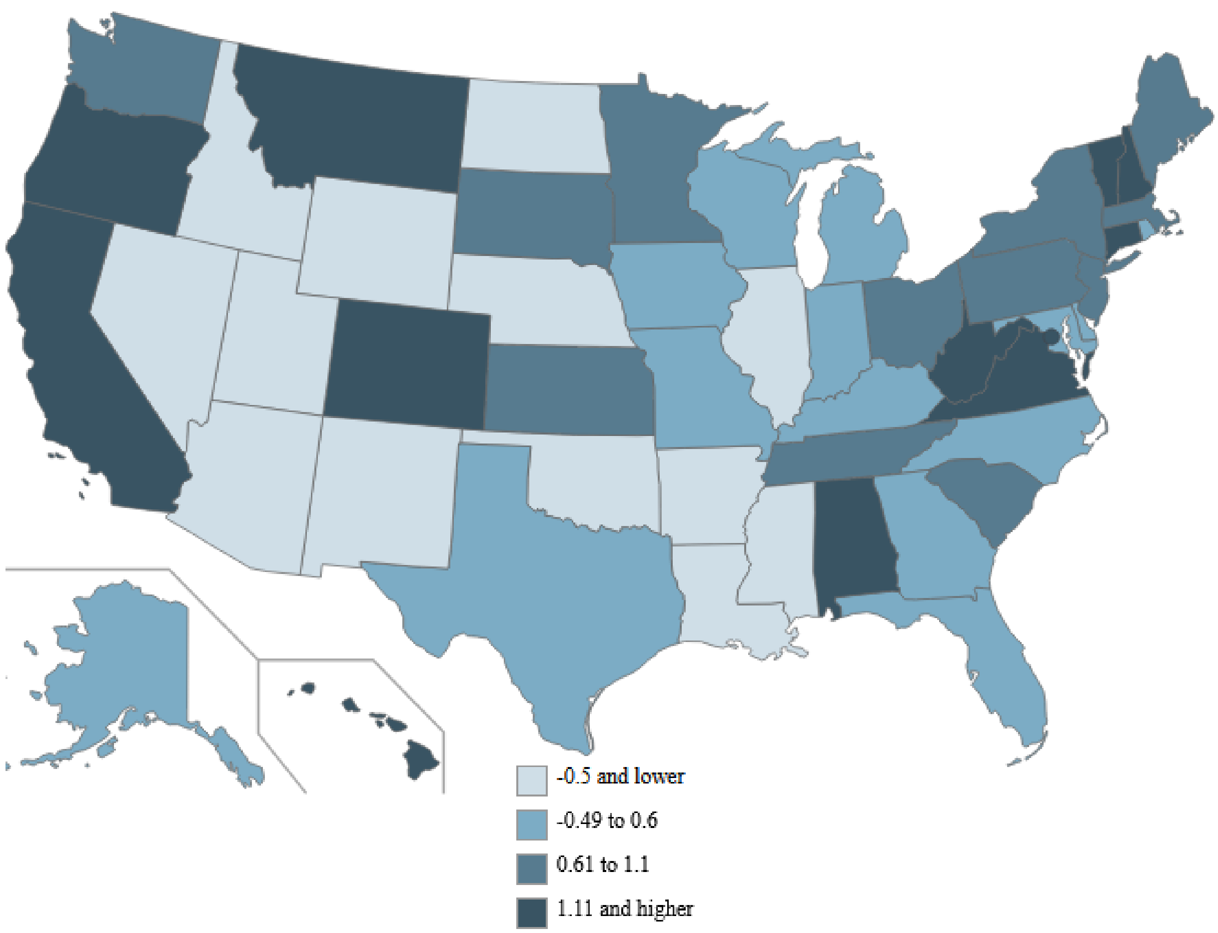


Source: US Census

3. Typical labor costs

In 2019 the US Department of Labor, Bureau of Labor Statistics for the first time published national statistics on labor productivity[20]. This data – focused on the 2007-2017 period provides insights into the differences in labor cost and productivity among the US states. Figure 23 shows changes in labor productivity in US states from 2016-17.

Figure 23 **US Labor Productivity Improvement 2016-17**

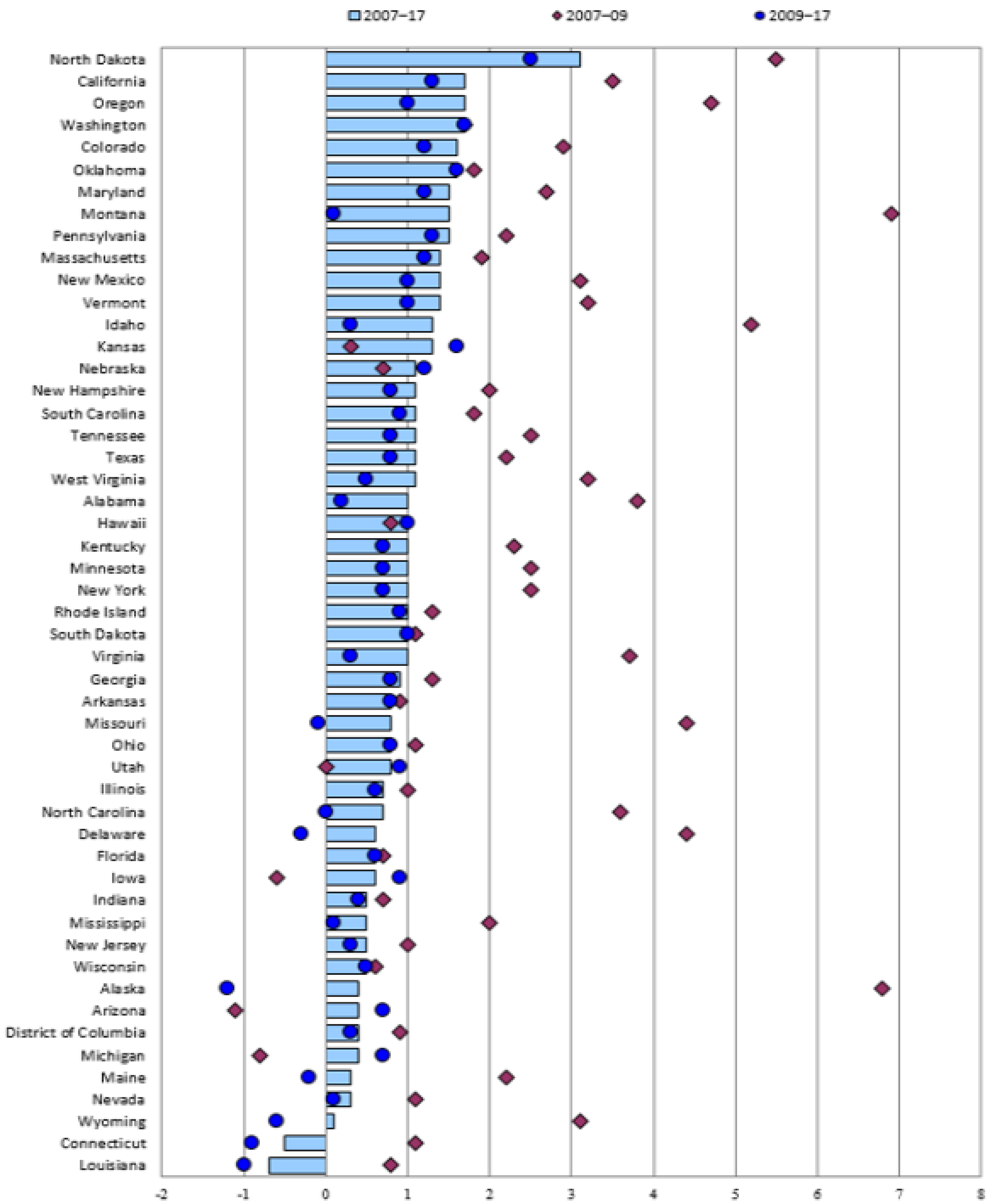


Source: US Department of Labor, Bureau of Labor Statistics

The map shows NH and VT among the most improved labor productivity states along with West Virginia in our benchmarked sample. Comparing the states nationwide for the 10-year 2007-2017 period (Figure 24) may be more useful.

[20] https://www.bls.gov/opub/mlr/2019/article/bls-publishes-experimental-state-level-labor-productivity-measures.htm

Figure 24 **US Labor Productivity Changes 2007-17**



Source: U.S. Bureau of Labor Statistics.

In this graph, the states we are focused on show the following (Figure 25) ranking:

Figure 25 **State rankings in worker productivity improvements 2007-2017**

	National labor productivity ranking 2007-17
Pennsylvania	9
Vermont	12
New Hampshire	16
Tennessee	18
West Virginia	20
Kentucky	23
New York	25

Source: US Dept of Labor, Bureau of Labor Statistics 2019

More specific labor cost and productivity data for Kentucky follows.

Kentucky had modest gains in worker productivity during the 2007-17 decade (Figure 26[21]). Unit labor costs were up 1.7 % during the period.

Figure 26 **Worker Productivity Changes 2007-2017**

Region and state	Labor productivity	Output per worker	Output	Hours	Employment	Real hourly compensation	Unit labor costs
New Hampshire	1.1	1.3	1.6	0.5	0.3	0.4	0.9
New York	1	0.8	1.8	0.8	1	–0.1	0.7
Vermont	1.4	1.3	1.1	–0.3	–0.1	0.6	1.1
Kentucky	1	0.5	0.7	–0.3	0.2	1.1	1.7
Pennsylvania	1.5	1.4	1.6	0.1	0.2	0.5	0.7
Tennessee	1.1	1.1	1.6	0.5	0.5	0.4	1
West Virginia	1.1	1.1	0.6	–0.4	–0.5	0.5	1.2

Source: US Dept of Labor, Bureau of Labor Statistics 2019

[21] The chart shows labor changes in % over the 2007-017 decade.

Unit labor costs for Kentucky were up more during the 2007-17 period than any of the other benchmarked states or the target states of NH, VT or NY.

c. Regulatory Climate

1. Relevant laws and regulation

There are two areas of relevant laws and regulations to benchmark for this effort: forestry/logging and business. **Forestry laws** relate to the requirements placed on harvesting of timber for forest industry manufacturing. Relevant business laws are important because they can help or hinder the advancement and expansion (or contraction) of forest industry. Only a few states in the US have comprehensive forest practices acts (California, Oregon, Washington, & a lesser extent Maine) although many that do not have comprehensive acts have laws that are often contained in the comprehensive acts. All states are covered by a series of laws not discussed here since they cover all states equally. The federal Clean Water Act is one such law that defers enforcement of the law's requirements for forestry to state regulatory agencies. The Lacey Act dealing in endangered species is another. This analysis will only cover state specific laws and regulations affecting forestry and logging.

For Kentucky, in 1998, the Kentucky Forest Conservation Act (KFCA) was signed into law. While the act places its primary responsibility on loggers, the law covers forestry operations on private forestland, which dominates the forest landscape.

Water quality is one of the most important aspects of KFCA (again, drawn from the federal Clean Water Act). KFCA requires loggers to use best management practices (BMPs) during tree harvesting and to correct any damage to land and water. Landowners also need to know about BMPs and water quality related to forestry operations as they are subject to the Agriculture Water Quality Act (KRS 224.71-100 to 224.71-140), which specifies that landowners will ensure that appropriate BMPs for various agricultural activities, including timber harvesting are implemented.

Although it is not required, landowners and loggers are encouraged to notify their local state field branch office of their commercial timber harvesting operations.

Lastly, the Act requires loggers to have a master logger (trained logger) or a temporary master logger on site and in charge of commercial timber harvests.

Business laws affecting the forest products industry in Kentucky are varied and include standard laws and regulations covered below.

Outside of taxation, which we covered later, there are 10 major business law areas that states and the federal government cover:

Employment and Labor Law

There are many government regulations on businesses that employ workers and independent contractors in the form of federal and state labor laws.

The most common labor laws are:

Wages and hours: According to the US Department of Labor, the Fair Labor Standards Act (FLSA) prescribes standards for wages and overtime pay. This act affects most private and public employment, and requires employers to pay covered employees at least the federal minimum wage and overtime pay of one-and-one-half-times the regular rate of pay (unless they are exempt employees).

Workplace safety and health: The Occupational Safety and Health Administration (OSHA) requires that employers, under the OSH Act, "provide their employees with work and a workplace free from recognized, serious hazards." The OSH Act is enforced through workplace inspections and investigations.

Equal opportunity: Most employers with at least 15 employees must comply with equal opportunity laws enforced by the Equal Employment Opportunity Commission (EEOC). The EEOC mandates that certain hiring practices, such as gender, race, religion, age, disability, and other elements are not allowed to influence hiring practices.

Non-US citizen workers: The federal government mandates that employers must verify that their employees have permission to work legally in the United States. There are several employment categories, each with different requirements, conditions, and authorized periods of stay (for employees who are not legal residents or citizens).

Employee benefit security: If your company offers pension or welfare benefit plans, you may be subject to a wide range of fiduciary, disclosure, and reporting requirements under the Employee Retirement Income Security Act.

Unions: If your business has union employees, you may need to file certain reports and handle relations with union members in specific ways. See the Office of Labor Management Standards' website for more information.

Family and medical leave: The Family and Medical Leave Act (FMLA) requires employers with 50 or more employees to provide 12 weeks of unpaid, job-protected leave to eligible employees for the birth or adoption of a child, or for the serious illness of the employee or a spouse, child, or parent.

Posters: Some Department of Labor states require notices to be shared or posted in the workplace for employees' view (for example, alcohol warnings and hand-washing reminders). Fortunately, the elaws Poster Advisor is an easy way to determine which posters you need, and you can use it to get free electronic and printed copies in multiple languages.

Antitrust Laws

Any time a company conspires with its competitors, third-party vendors, or other relevant parties, it may run afoul of antitrust laws. These are the issues antitrust laws strive to address, such as the following:

Conspiring to fix market prices: Discussing prices with competitors—even if it affects a small marketplace.

Price discrimination: Securing favorable product prices from buyers when other companies can't.

Conspiring to boycott: Conversations with other businesses regarding the potential boycott of another competitor or supplier.

Conspiring to allocate markets or customers: Agreements between competitors to divide up customers, territories, or markets are illegal. This provision applies even when the competitors do not dominate the particular market or industry.

Monopolization: Preserving a monopoly position through the acquisition of competitors, the exclusion of competitors to the given market, or the control of market prices.

Advertising

Rules and government regulations on advertising are generally to protect consumers so there must be care to be truthful in advertising. For example, claims in ads cannot be untruthful or purposely deceptive. Using testimonials in ads comes with additional regulations. Violating these rules can result in fines, which defeats the purpose of your advertising in the first place. There are also labeling laws for consumer products, meaning that they list out ingredients and chemicals within products.

Email Marketing

Closely related to advertising is email marketing. If the business engages in email marketing, there are separate regulations under the CAN-SPAM Act. There are several things that this Act regulates, but some of the main components are:

-Don't use false or misleading headers

-Don't use deceptive headlines

-Indicate that the message is an advertisement

-Include your business's name and address

-Show the customer how to opt out of emails, and honor the opt-out requests promptly

Each separate email violation is subject to hefty fines.

Environmental Regulations

Laws and regulations to protect water quality and air quality along with consumers are found at the federal and state level in all states. Most have permitting systems associated with activities that could affect air or water quality or consumer health.

Privacy

Businesses with staff and employees wind up amassing a large amount of sensitive personal information about their employees. As a result, there are a variety of rules and regulations about how employers must save and secure this data. Businesses cannot disclose an employee's private information, including Social Security number, address, name, health conditions, credit card, bank numbers, or personal history. And the Health Insurance Portability and Accountability Act (HIPAA) prohibits the release of health data without a patient's permission.

Licensing and Permits

Basic business licensing or registration is a requirement in all states, usually through the corporate division of the state's secretary of state office.

Insurance

As soon as an employee is hired, workers compensation insurance is required. All states, with the exception of Texas, require businesses with employees to purchase workers comp insurance.

Reporting Pay Data

If the business employs more than 100 people (or more than 50 as a federal contractor), there is a requirement to report how much each is paid, broken down by race/ethnicity, job category, and gender, to the Equal Employment Opportunity Commission each year.

Collecting Sales Tax

In many states, most businesses that sell physical goods must collect sales tax from customers and submit the tax to their state's revenue department. A few states do not collect sales tax. In general, the law specifies that a business must collect sales tax in any state with which it has a physical connection (known, in legal terms, as a "nexus"). That nexus might mean a physical retail shop, or hiring employees in the state. Even online sellers might have to collect sales tax in any state that they sell to.

If your business has a nexus, you need to collect sales tax except in Alaska, Delaware, Montana, New Hampshire, or Oregon where sales taxes are not law.

In Kentucky, there are no laws that affect business that are not covered in the listing above.

2. Taxation

For most small business owners, government regulation questions almost always begin with taxes. But there's more to taxes than merely paying them—knowing which business taxes to pay, when to pay them, and how to set up your business to account for future tax payments can spare you a ton of headaches when it comes time to write the government a check.

Every company registered within the United States has to pay federal taxes. Most companies will also have to pay state taxes, depending on the state in which the company is registered. These are unavoidable. Avoiding taxes—or deciding not to pay them outright—comes with hefty penalties and potential jail time.

But the kinds of taxes you'll pay depends on how you formed your business. In this regard, not all businesses are treated the same. Sole proprietorships pay taxes differently than, say, S-corporations. Here's a full rundown of the different taxes for business structures to help you determine what your business needs to file. Despite the differences between each kind of business, there are a few general terms you to know:

Income tax: Most businesses file an annual income tax return. Businesses must pay income tax as they earn and receive income, and then file a tax return at the end of the year.

Estimated tax: Estimated tax payments offer an alternative to paying income tax throughout the year as your company earns money. Sole proprietors, partners, and S-corporation shareholders must usually make estimated tax payments if they expect to owe $1,000 or more once they file their return. Note that corporations are usually required to make estimated tax payments if they expect to make more than $500 or more in income.

Employment tax: Companies that have employees are expected to pay taxes related to having staff on their payroll. These include Social Security and Medicare taxes, federal income tax withholding, and federal unemployment tax. For more information, see the IRS page on Employment Taxes for Small Businesses.

Excise taxes: Excise taxes are paid when your business makes purchases on specific goods, and are often included in the price of the product. One common example of excise tax is the purchase of gasoline, where applicable taxes are baked into the price per gallon rather than as a tally at the end of the transaction. You may be under certain excise tax law if you manufacture or sell certain goods, use various kinds of equipment, receive payment for certain kinds of services, and much more. For additional information, refer to the IRS guide on Excise Taxes.

Some businesses also have to collect sales tax, which we'll cover more in a bit.

Taxation of business operations is perhaps the most important of business laws and regulations to affect forestry industry operations.

In Kentucky, the major business taxes in addition to property taxes which are local are:

-Sales & Use Tax – applies to businesses operating as a wholesaler, retailer or seller in Kentucky.

Corporation Income Tax

Limited Liability Entity Tax

Consumer Use Tax

Withholding Tax

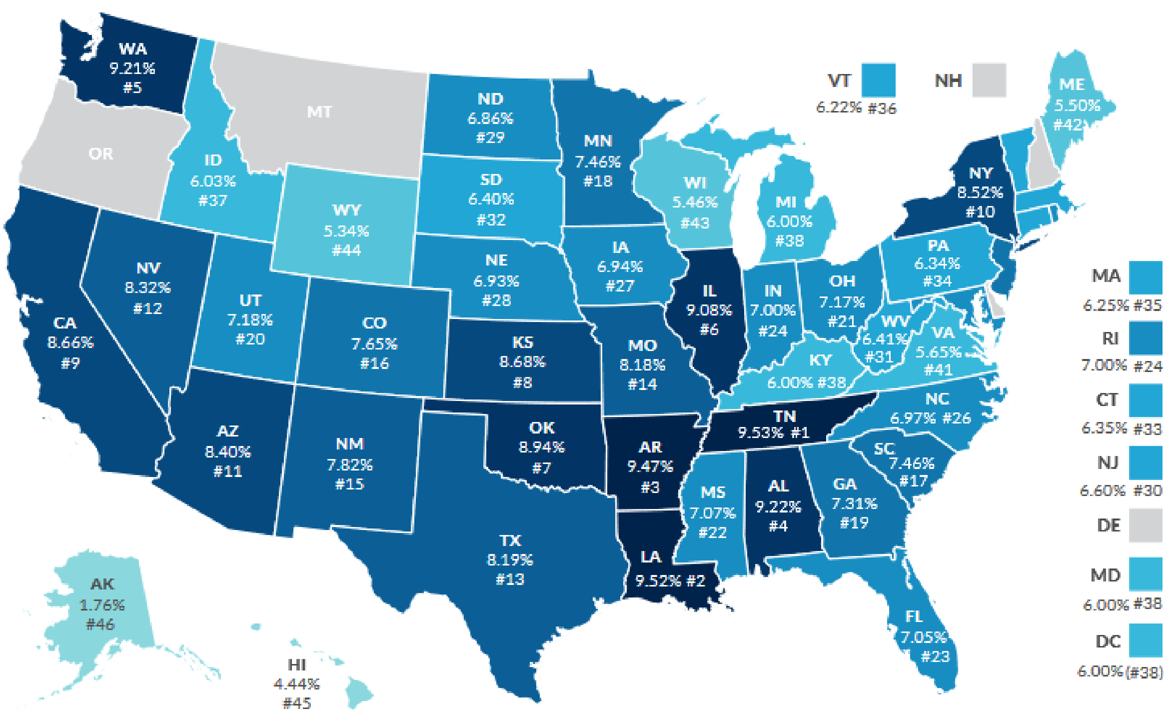
Telecommunication Tax

Utility Gross Receipts License Tax

Tangible Personal Property Tax

The major taxes to compare are the sales tax and corporate Income tax/Limited Liability Entity Tax. The sales tax rate for Kentucky is 6% and ranks it 38th in the country.

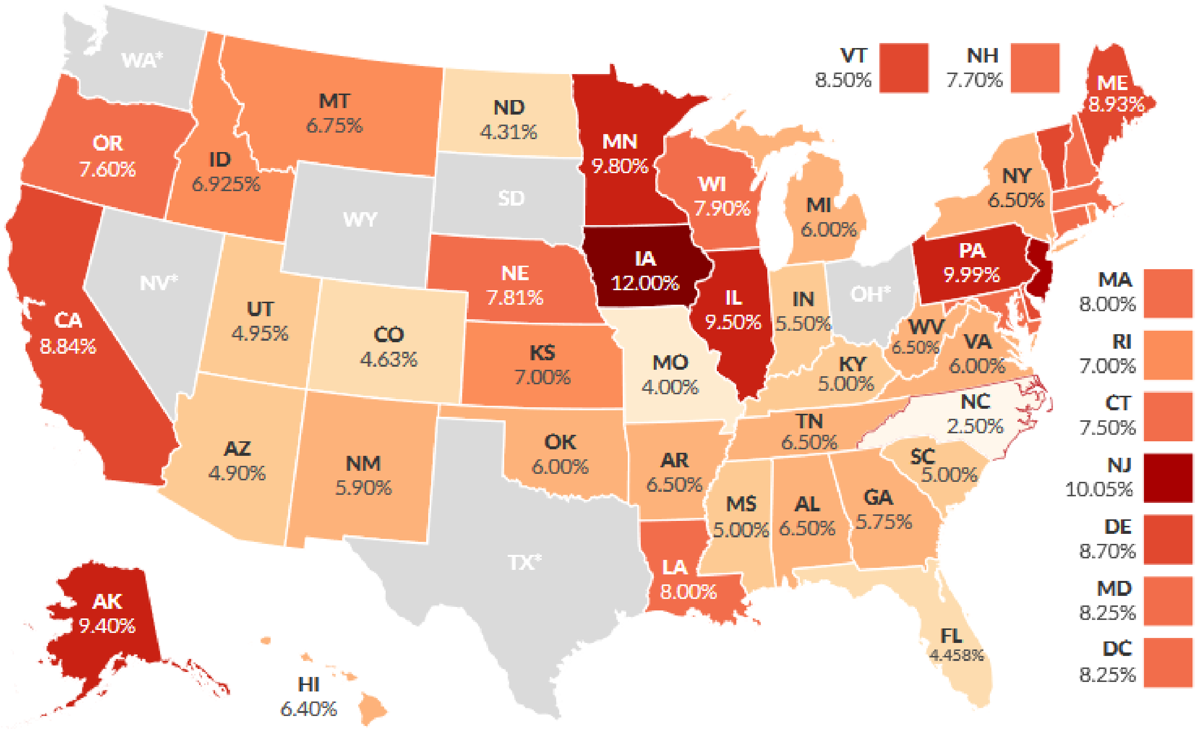
Figure 27 **Sales Tax Rates for US States 2020**



Source: Tax Foundation

For corporate and small business taxes, Figure 28 shows state rates. Kentucky's highest business tax rate is 5% ranking it in the middle with the highest rates at Iowa at 12%, 10.05% in New Jersey and Pennsylvania at 9.99% and the lowest with no business income tax in Ohio, Nevada, South Dakota, Texas, Washington and Wyoming. However, Ohio, Nevada, Texas, and Washington have business gross receipts taxes thought to be more problematic for business than corporate income taxes. South Dakota and Wyoming are the only states that do not levy either a business income or gross receipts tax.

Figure 28 **Business tax rates by US state 2020**



Source: Tax Foundation

d. Energy Costs

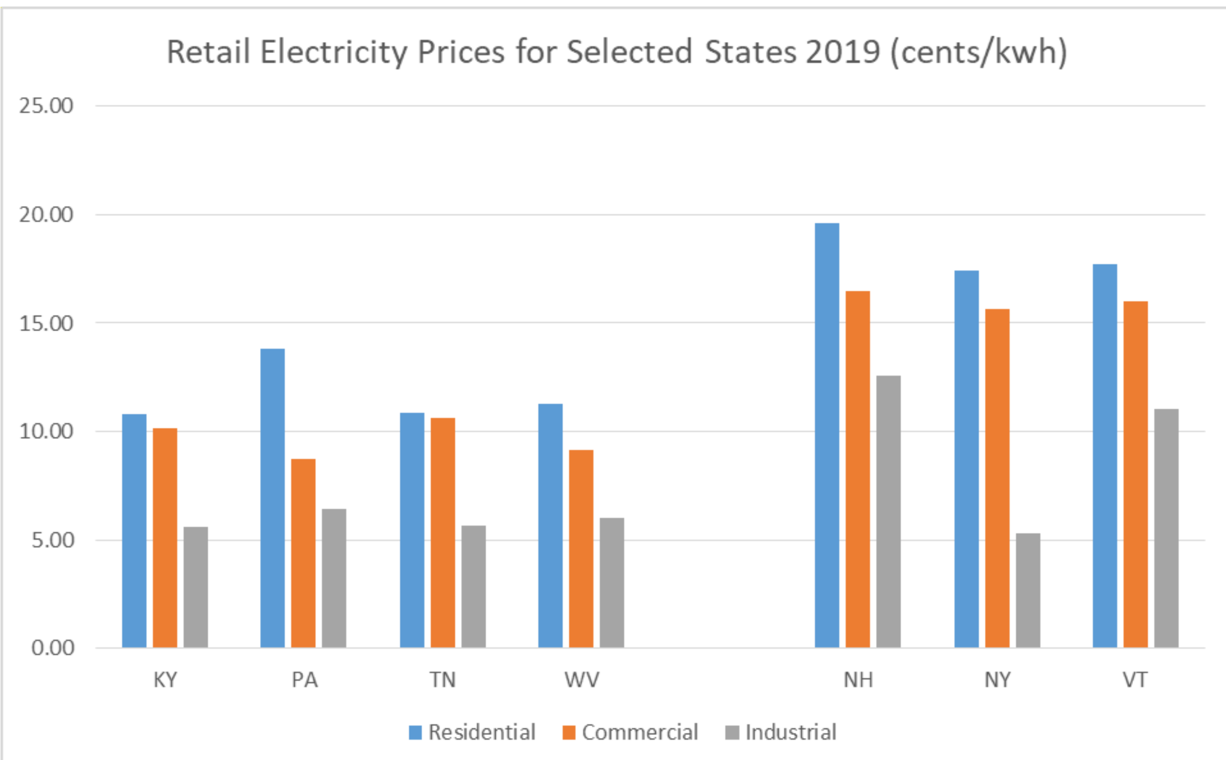
Of all the utilities associated with forest products manufacturing, electricity costs are the most critical to influence positive economics that allow for facilities to be built and operate successfully. Virtually all the machinery associated with forest products manufacturing runs on electricity.

Fossil fuel prices are important for the raw material supply chain infrastructure, but those prices generally do not vary much from state to state or region to region in the US and are based on world supply and demand. Because of the way electricity grids are operated, and the fact that the source of the power and the infrastructure to get it to customers is vastly different from state to state and region to region, electricity prices vary considerably.

Retail electricity costs in the three-state NH/VT/NY region are generally higher than national averages – particularly for residential customer rates and are certainly higher than our benchmarking states of Kentucky, Pennsylvania, Tennessee & West Virginia. The sector we are most interested in is for industrial retail electricity rates.

As we noted in the second report in this series[22] - within each state there are multiple electric utilities, each with a unique service territory and in some cases with competitive suppliers. Rates that a user pays for electricity may depend upon their utility service territory, competitive supplier, time of use and other factors. In other words, it is possible to get, and many large industrial power users do, a special deal that is lower than the average for that sector. The electricity cost comparisons below reflect that complexity and are average rates (Figure 29).

Figure 29 **Retail Electricity Prices for Selected States 2019**



Source: US Energy Information Administration

Kentucky's commercial and industrial retail electricity rates on average are 10.15 cents and 5.57 cents respectively, among the average and lower ranges in the benchmarked states but generally lower than the NH, NY and VT region except for NY's industrial rate.

[22] Northeast Wood Markets Retention and New Market Recruitment Initiative PHASE I, North East State Foresters Association, DRAFT REPORT Section 2: The unique regional attributes, weaknesses and opportunities for wood market maintenance and growth, October 14, 2020

e. Infrastructure and transportation

The most important infrastructure issue for the forest products industry is transportation. This generally refers to public road infrastructure for getting raw logs/timber feedstock to the mill for manufacturing and getting finished product to market. Virtually all feedstock procurement is truck traffic while finished product shipping usually starts out (and often is finished with) trucking and then sometimes uses rail access for long hauls and then shipping for overseas markets.

In Kentucky, commercial road issues are similar to other states in the east. Road freight is increasing on large trucks and the infrastructure of interstate, state and local road systems face shortages on funding, so critical issues like bridge upkeep and re-paving and maintenance are always chronic issues. The commercial road infrastructure – i.e. having adequate number of roads to access all geographies – is largely complete in Kentucky as with the other states in our study.

The TRIP report of 2019 which is a national report on commercial road issues in the US[23], highlights that commercial freight by road is increasing, and today, more freight (nearly 75% by value) travels to market through the nation's road system. They project that from 2016-2045 freight moved will increase by 104% by value and 44% by weight, and by trucks freight moved annually in the US, trucks is expected to increase by 91 percent in value (inflation-adjusted dollars) and 41 percent by weight. Clearly the road systems are critical to the forest products industry.

[23] America's Rolling Warehouses: Opportunities and Challenges with the Nation's Freight Delivery System, TRIP, 2019

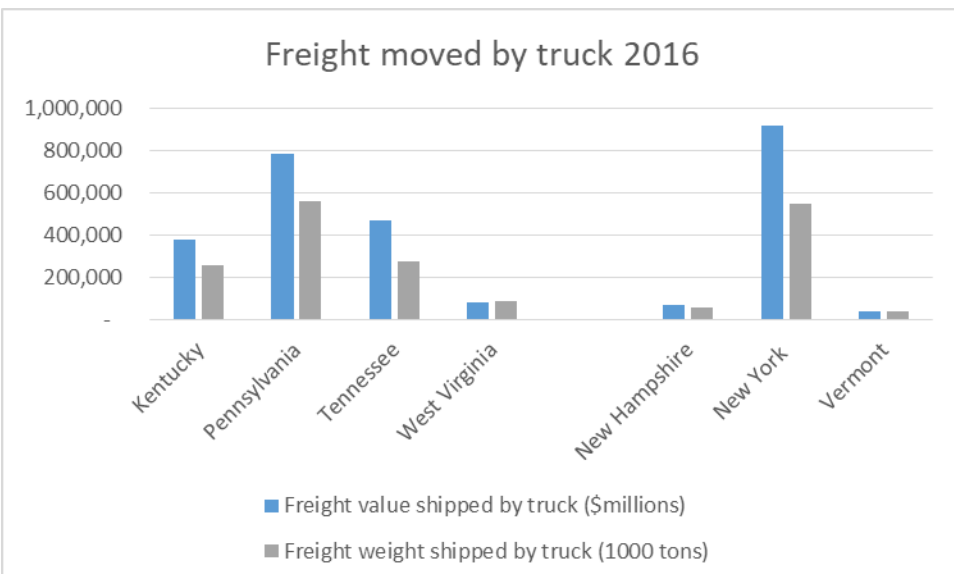
Figure 30 **Commercial Freight Method US**

Mode	By Value	By Weight
Truck	72%	66%
Rail	4%	10%
Water	2%	4%
Air	3%	0.03%
Multiple Modes	14%	3%
Pipeline	4%	16%

Source: TRIP Report, 2019

Of the seven states in our study, only Pennsylvania and New York are in the top 5 in the US in freight moved by truck.

Figure 31 **Freight moved by truck - selected states 2016**



Source: TRIP report 2019

Key bottlenecks in truck traffic (where traffic is slowed to much less than posted speed limits due to excess traffic amounts) shown in Figure 32 shows that Kentucky is not in the list of top 20 congested trucking routes in the US.

Figure 32 **Freight congestion US highways - top 20 bottlenecks**

RANK	STATE	Location Description	Average Speed	Average Speed During Peak Hours	Average Speed During Non-Peak Hours
1	New Jersey	Fort Lee: I-95 at SR 4	32	23	35
2	Georgia	Atlanta: I-285 at I-85 (North)	35	23	41
3	Georgia	Atlanta: I-75 at I-285 (North)	38	27	43
4	California	Los Angeles: SR 60 at SR 57	42	35	44
5	Texas	Houston: I-45 at I-69/US 59	34	24	38
6	Ohio	Cincinnati: I-71 at I-75	44	36	47
7	Illinois	Chicago: I-290 at I-90/I-94	24	18	27
8	Tennessee	Nashville: I-24/I-40 at I-440 (East)	41	28	48
9	Georgia	Atlanta: I-20 at I-285 (West)	45	38	47
10	California	Los Angeles: I-710 at I-105	38	27	43
11	Indiana	Gary: I-65 at I-80	47	45	48
12	Colorado	Denver: I-70 at I-25	38	30	42
13	Texas	Houston: I-10 at I-45	40	28	46
14	Connecticut	Hartford: I-84 at I-91	45	35	49
15	California	San Bernardino: I-10 at I-15	45	36	49
16	Texas	Dallas: I-45 at I-30	40	29	45
17	Illinois	Chicago: I-90 at I-94 (North)	31	17	37
18	Michigan	Detroit: I-94 at I-75	39	31	44
19	Louisiana	Baton Rouge: I-10 at I-110	37	29	41
20	New York	Brooklyn: I-278 at Belt Parkway	34	26	37

Source: TRIP Report 2019

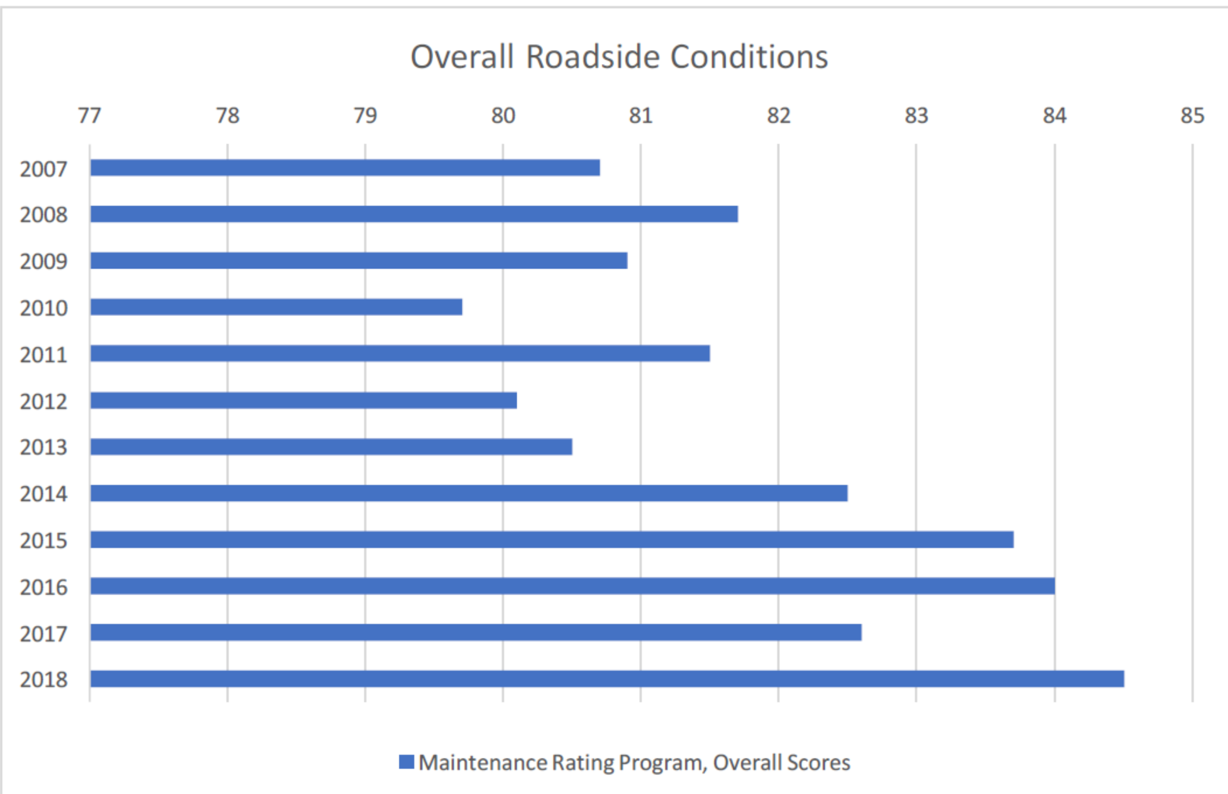
The American Society of Civil Engineers (ASCE) conducts a state by state analysis of infrastructure, including transportations systems. In their recent report for Kentucky, two key transportation infrastructure reviews were included for bridges and roads. For bridges, the report says:

> "The overall condition of Kentucky's bridges has improved in recent years. For example, the number of structurally deficient (SD) bridges in the state has steadily decreased. SD bridges are not unsafe, but they do require significant maintenance, rehabilitation, or replacement because critical load-carrying elements were found to be in poor condition due to deterioration or damage. In 2011, the Federal Highway Administration's (FHWA) National Bridge Inventory (NBI) reported that nearly 9.25 percent of all bridges in Kentucky were considered to be SD. However, in 2017 only 7.77 percent of Kentucky's bridges were SD, a reduction of 180 bridges."

For roads in Kentucky, the ASCE says:

"The state has recently acted to improve the roadway network by enacting a Highway Plan that will provide $8.5 billion for over 1,400 projects across the state over the next six years. The condition of the road systems is improving; the Kentucky Transportation Cabinet's (KYTC) performance score for all roads in 2018 was 84.5, which is well above the goal of 80 and is the highest score given to date. While this is encouraging, there continues to be inadequate funding for needed construction and safety initiatives. The KYTC recently identified $6 billion in unfunded construction projects, which would require an additional $490 million per year to address. In addition to current needs for road maintenance and safety initiatives, the state must also plan for future growth, as traffic volume has increased by 5 percent since 2013."

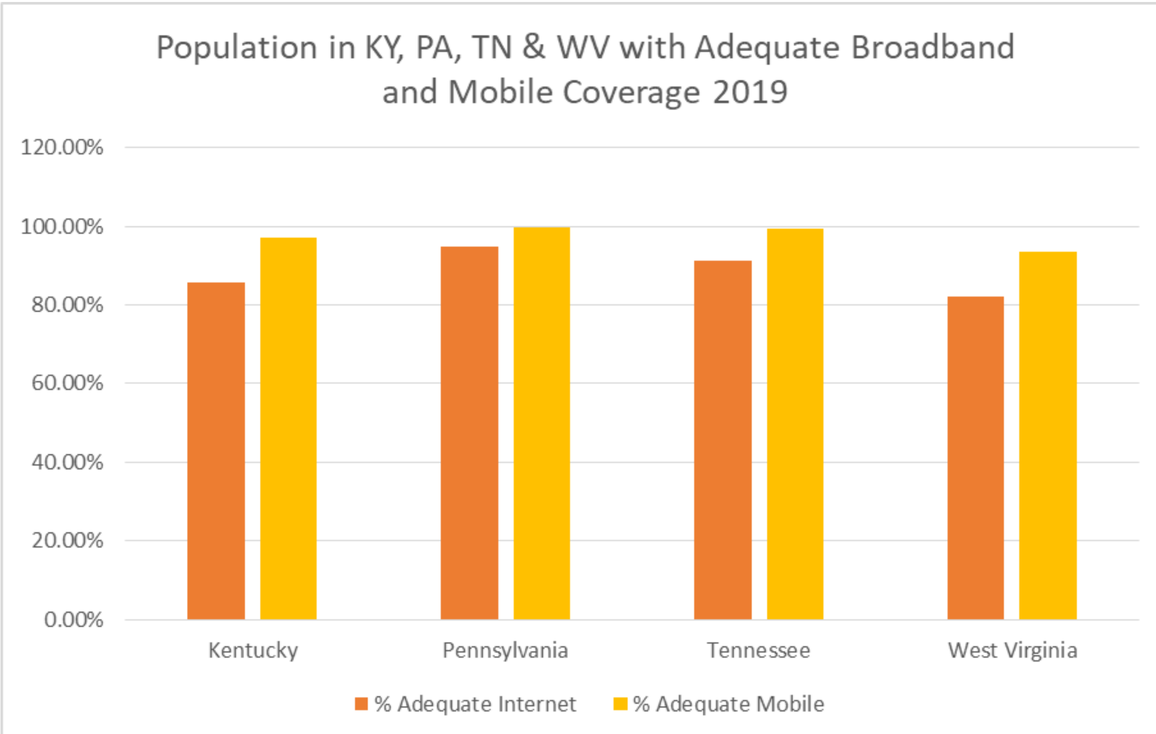
Figure 33 **Road conditions Kentucky 2007-18**



Source: ASCE Kentucky Infrastructure Report 2019

Another important infrastructure issue is access to fast broadband internet and mobile phone access. While improving each year, especially in rural areas, not all of the population in Kentucky has adequate broadband internet or mobile service (Figure 34).

Figure 34 **Broadband and Mobile Service in KY, PA, TN & WV 2019**



Source: broadbandnow.com

In Kentucky 85.8% of the population has adequate internet coverage while 97.1% has adequate mobile service.

f. Research and Development for Forest Products Manufacturing

Having in-state research and development activities in forest products and forest products manufacturing is very important to the future progress within the industry. In the past, many forest products companies did research and development in-house but with structural changes within the industry over the last 20 years, very little of that occurs today. University research cooperatives and industry trade group research has also dwindled. Other countries, most notably Canada and Finland have re-directed and re-energized their research and development efforts in the forest products industry.

In the U.S. today, most forest products research occurs in government or university labs. The USDA Forest Service has a series of forest products labs where research and development on forest products is conducted. The output from the labs is available for all in the public and private sector to use.

The Forest Products Laboratory (FPL) in Madison, Wis. is one of seven national Forest Service research facilities. FPL scientists focus their research around five areas:

Advanced Composites

Wood composite technologies have been used for decades to create building and home furnishing products. Composites are used for a number of structural and non-structural applications including interior paneling, sheathing, furniture, and support structures in many different types of buildings.

Advanced Structures

The FPL is a world leader in housing-related areas such as engineered wood products and structures, moisture control, material design and performance, coatings and finishes, adhesives, and wood preservation. Creating advanced technologies and alternative building methods can greatly enhance the value of wood in residential, non-residential, and transportation structures.

Forest Biorefinery

Trees are one of the best potential sources of biological fuel and chemicals. They grow in marginal soils unsuitable for agriculture; do not require fertilizer, herbicides, or pesticides; and accumulate biomass density for several years before incurring harvest costs. Converting wood resources into liquid fuels and chemical feedstock is becoming more cost competitive thanks in part to FPL research.

Nanotechnology

FPL scientists are conducting nanoscale research to learn more about the fundamental components of wood. Nanotechnology is a multi-disciplinary field of applied science and technology. Nanocellulose holds revolutionary potential for the forest products sector and is the economic key to accelerated forest restoration. Nanocellulose can be a cost-effective substitute for non-renewable resources in all manufacturing sectors.

Woody Biomass Utilization

U.S. forests contain a substantial amount of small-diameter, overstocked, and underutilized material. FPL scientists study small-diameter woody material, identify potential uses, and provide technology that can help rural-based communities create successful businesses from the by-products of forest management projects. FPL research explores the potential of small-diameter roundwood as a structural material for bridges, boardwalks, trail structures, picnic shelters, storage sheds, and other rustic buildings.

For in-state forest products research and development, the University of Kentucky, College of Agriculture, Food and Environment, the Robinson Center for Appalachian Resource Sustainability (RCARS) has two related research/tech transfer programs based at the UK Wood Utilization Center - a 14,000 square foot facility that contains an industrial hardwood furniture manufacturing laboratory, classrooms and computer laboratory.

The Wood Utilization Technical Training Series is technical training and education for the forest products industry. The second area of interest is the Entrepreneur Development in Wood Products effort. The Entrepreneur program goals are:

1. To develop a training program for Kentucky wood product entrepreneurs at the UK-RCARS Wood Utilization Center that includes product design & development, manufacturing, business management, one-on-one technical assistance, mentoring, and marketing.

2. Structure the use of the Wood Center to minimize the start-up risk to new entrepreneurs.

3. Potentially provide living space at a low cost to reduce travel expenditures for entrepreneurs living a long distance from Quicksand.

4. To work closely with financial lending institutions to identify and support promising new entrepreneurs.

The Entrepreneur program works like this:

An individual or group of individuals interested in designing and making wood products for marketing purposes can apply for the UK Wood Products Entrepreneur Program conducted at the RCARS Wood Utilization Center. New entrepreneurs selected for this program receive mentoring in product design, machinery operation, business planning, marketing and financing. Start-up risks for new entrepreneurs often include; initial capital outlay for space, equipment and utilities. Minimizing these cost allows the new entrepreneur an opportunity to invest limited resources into raw materials, labor and marketing. Once the entrepreneur's business has enough cash flow to secure its own space and equipment, the business graduates from the program and re-locates. The Advisory Committee will play a role in making this determination.

Pennsylvania

Pennsylvania - Pennsylvania has a total area of 44,730.5 square miles, including 1,311.2 square miles of water, making it the 32nd-largest state by area. Pennsylvania is bordered by Ohio, West Virginia, New Jersey, Maryland, New York, and Delaware.

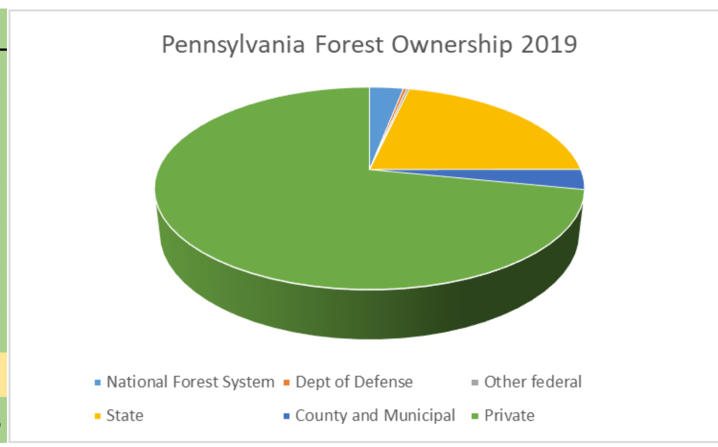
a. Raw material

1. Forest Area and Ownership

The Pennsylvania timberland area covers 15,982,555 acres (Figure 35).

Figure 35 ***Pennsylvania Forest Area and Ownership***

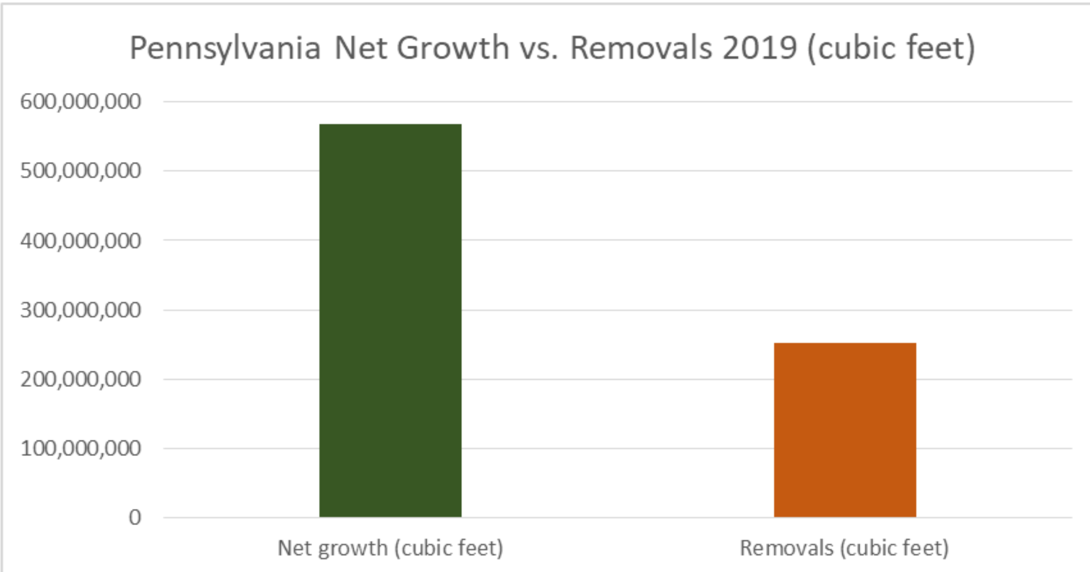
Owner Type	Acreage
National Forest System	485,444
Dept of Defense	49,468
Other federal	35,975
State	3,420,406
County and Municipal	511,140
Private	11,480,122
Total	15,982,555



Over 71% of those acres are owned privately while 29% is owned by the public sector. Pennsylvania state government owns over 3.42 million acres. The federal government owns 570,887 acres, the vast majority of which is in the National Forest system. Local government owns 511,140 acres. Most of Pennsylvania's forest are mixed hardwood. Only 4% of the lands are in softwood.

2. Harvest levels – From up-to-date data from the USDA Forest Inventory and Analysis dataset, the net growth to removals data for Pennsylvania looks positive (Figure 36).

Figure 36 ***Pennsylvania Net Growth vs. Removals***



Source: USDA Forest Service FIA

The most recent FIA data shows that Pennsylvania has a 2.25 net growth to removal ratio for all timberland – meaning that each year, the State is growing 2.25 times more than it is removing from harvests and loss of timberland to other uses.

3. By-products – Pennsylvania timber by-products are primarily sawmill residues which are used mostly in the pulp and paper sector. Some in-woods chipping is conducted but most timber harvesting is conducted with either cut-to-length harvesting systems or traditional chainsaw and skidder operations primarily designed to deliver sawlogs to the sawmills in the state. Secondary production of hardwood pulpwood occurs but is not a growth area. Some residues are used to generate electricity but little in stand-alone biomass electricity plants. Instead, most are through smaller generation facilities and combined heat power at mills – primarily in the forest products sector. According to the US Energy Information Agency less than 4% of energy used in Pennsylvania is from biomass sources.

4. Delivered wood cost – In Pennsylvania, hardwoods are the main species groups harvested (over 95%) and wood costs are competitive with other hardwood producing regions in the U.S. From State of Pennsylvania and Penn State sources, in 2020, delivered (to the sawmill) timber prices range from a low of $100/thousand board feet (Mbf) to over $1,000/Mbf for certain high quality sugar maple, red and white oak and black cherry sawlogs.

Low quality timber, which in this part of the country is hardwood pulpwood is being sold, on average, for $38-$42/ton delivered to the pulp mill.

5. Wood procurement practices

Most timber harvested in Pennsylvania comes from private land although a lesser but substantial volume of public timber is sold and harvested each year on both federal and state lands. Best Management Practices (BMPs) are practices that are voluntary but highly encouraged for timber harvesting activities in Pennsylvania. They are practices that are intended to protect water quality when dealing with agricultural and silvicultural operations.

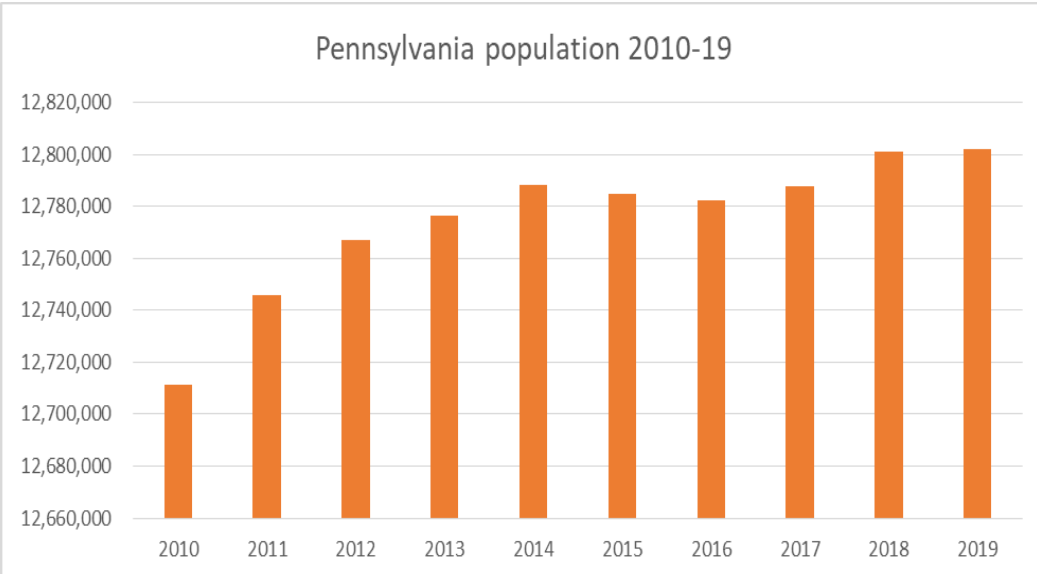
Timber harvesting is generally conducted with either feller bunchers and skidders, processors and forwarders or chainsaws and skidders in the forests of Pennsylvania. The trend is towards more mechanization in the woods of PA. Silvicultural practices used include clearcut, selections and shelterwood methods, though small clearcuts are often used as the land naturally regenerates the full range of hardwood species using this regeneration method. Logging is conducted year-round with stoppages during wet soil periods. Some harvesting is conducted on frozen ground when winter temperatures allow it.

b. Workforce

1. Demographics

Pennsylvania's population in 2019 was 12,801,989 (Figure 37). The state has seen modest population growth since 2010 and ranks 5th in the US for population. It ranks 5th in the rate of growth from 2010-2019 among US states.

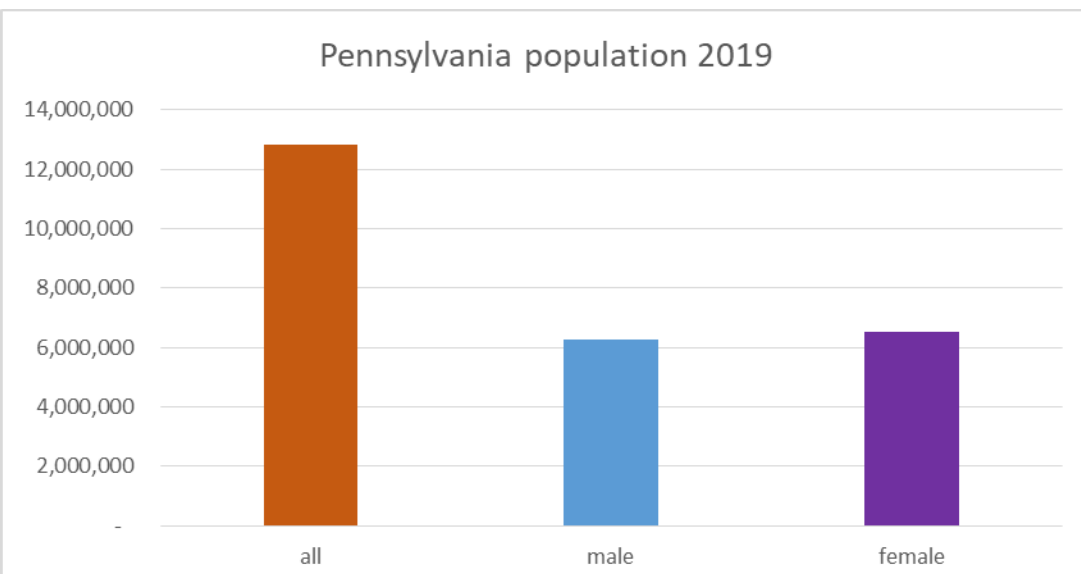
Figure 37 **Pennsylvania Population 2010-19**



Source: US Census

Pennsylvania's population in 2019 was 51% female and 49% male (Figure 38). This is similar to most states in the US.

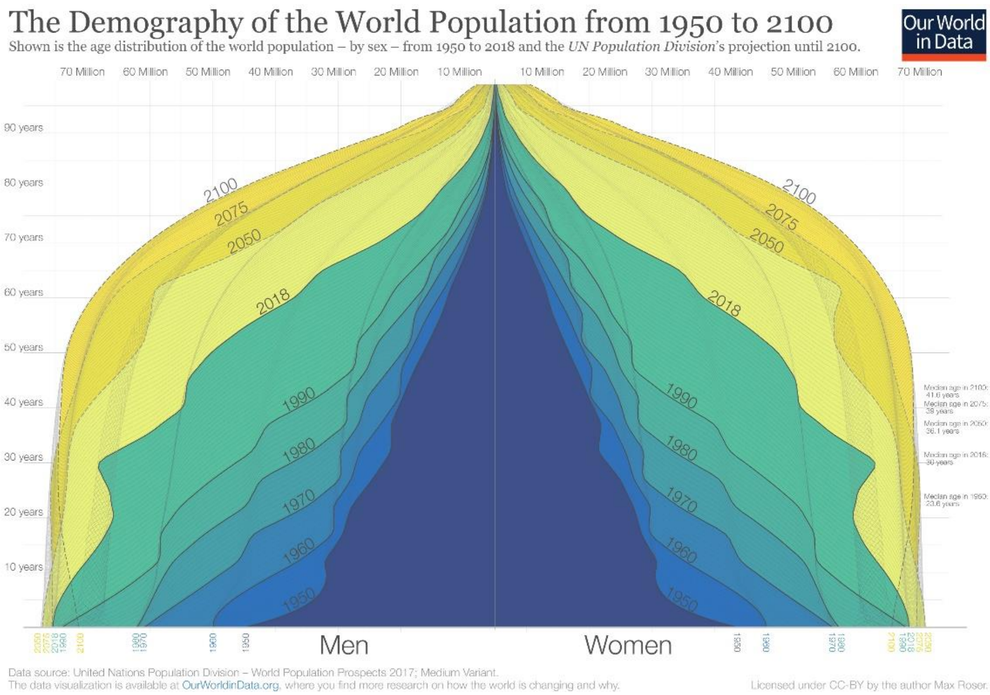
Figure 38 **Pennsylvania Population Gender Distribution 2019**



Source: US Census

A more important and informative dataset on Pennsylvania population is found in Figure 40. Before digging into this Pennsylvania demographic information, some background on population dynamics is important to discuss. Figure 39 is from the United Nations and is diagram that shows world population and its changes over time and projections into the future.

Figure 39 ***World Population Dynamics***

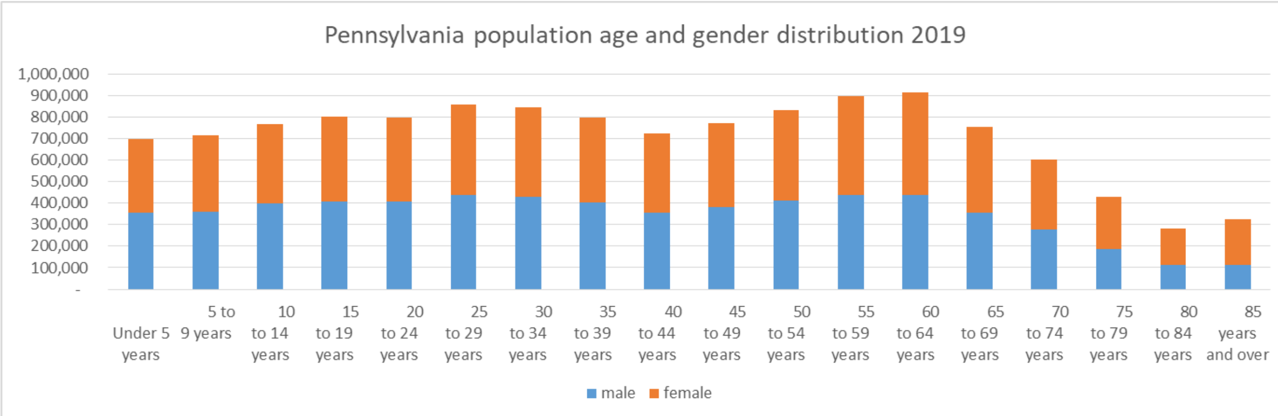


Source: United Nations

The figure shows world population from 1950 (2.5 billion people) to 2019 (7.7 billion) and projections to 2100 (11.2 billion). The most important finding from this figure is that age cohorts (10 years, 20 years etc) were dying at a much earlier age many decades ago compared to 2019. It simply means that infant mortality has reduced and average age at death has increased tremendously comparing 1950 to 2019. We are a healthier and older population today than we have ever been.

This is similar to what is occurring in Pennsylvania and all US states. From a labor perspective for the forest products industry, an increasing population in the working age cohorts from 20 to 50 represents good change. But an aging population is a concern in virtually all US states. Pennsylvania's 2019 population shows a reasonable distribution across ages and genders (Figure 40).

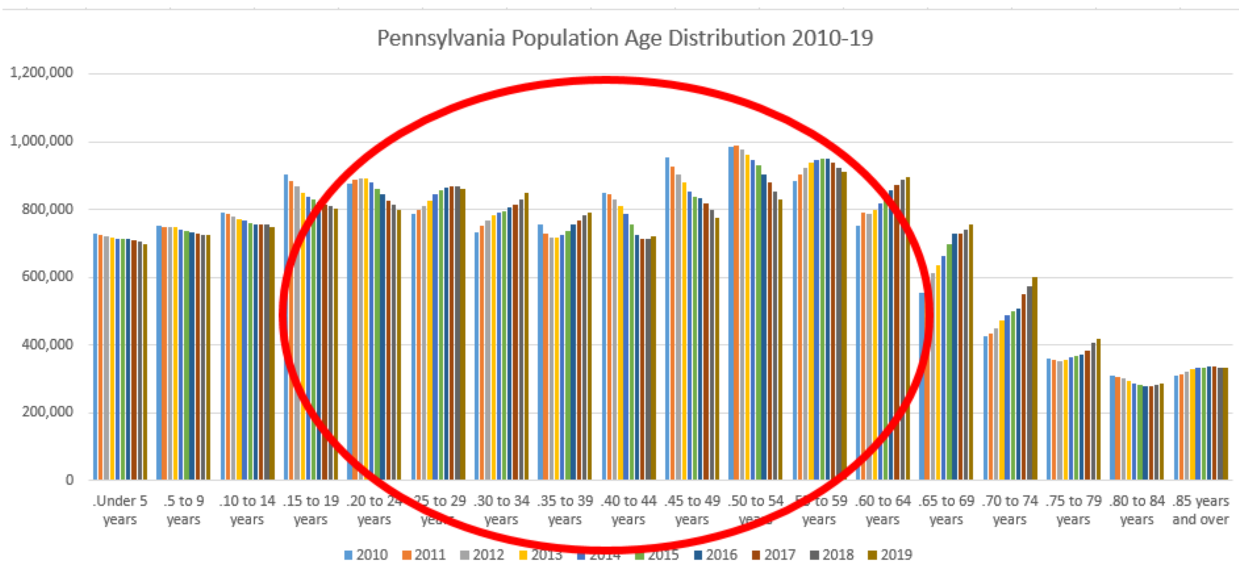
Figure 40 ***Pennsylvania Age and Gender Distribution 2019***



Source: US Census

Pennsylvania's age distribution over time – from 2010 to 2019 – is probably more telling (Figure 41). Most of the critical labor age categories in the 20-54 age range are showing a declining population over time except for the 25-29 age class. The over 55 age classes all show increases over this period – a troubling sign of an aging population with fewer working age people available over time.

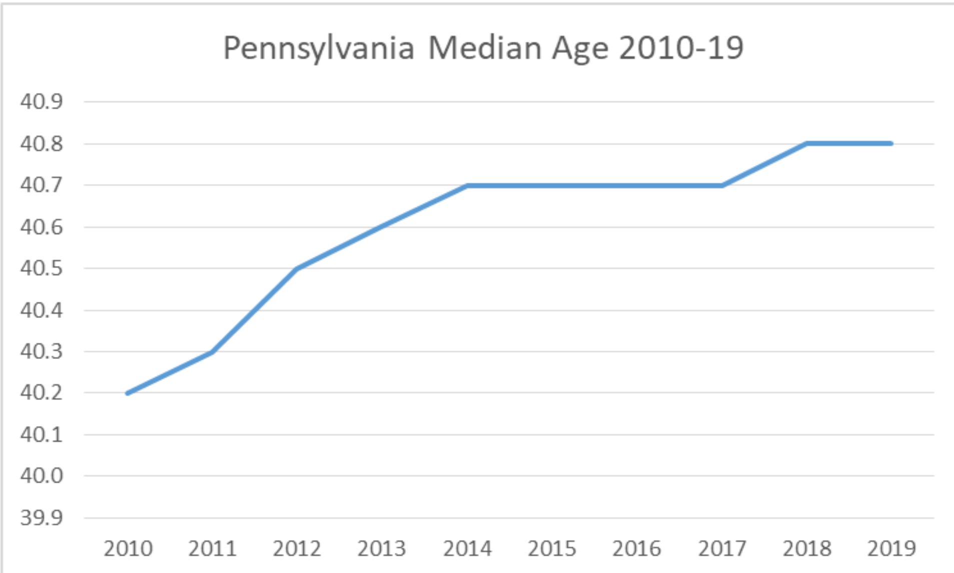
Figure 41 **Pennsylvania Age Distribution 2010-2019**



Source: US Census

Figure 42 further reinforces the aging workforce data with an increasing median age trend from 2010-2019.

Figure 42 **Pennsylvania Median Age 2010-19**

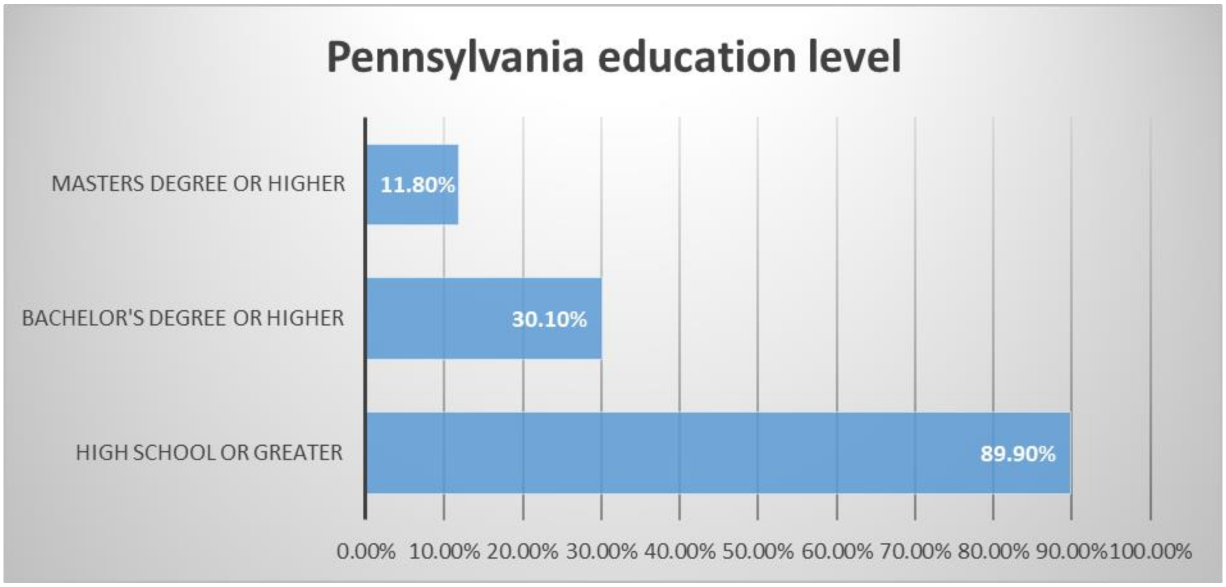


Source: US Census

2. Level of education

Education level of a state's population is important workforce information. In Pennsylvania, just under 90% of the working-age population has at least a high school education. A bachelor's degree or higher is held by over 30% of the population and 11.8% of the population holds a masters degree or higher.

Figure 43 **Pennsylvania Education Level**



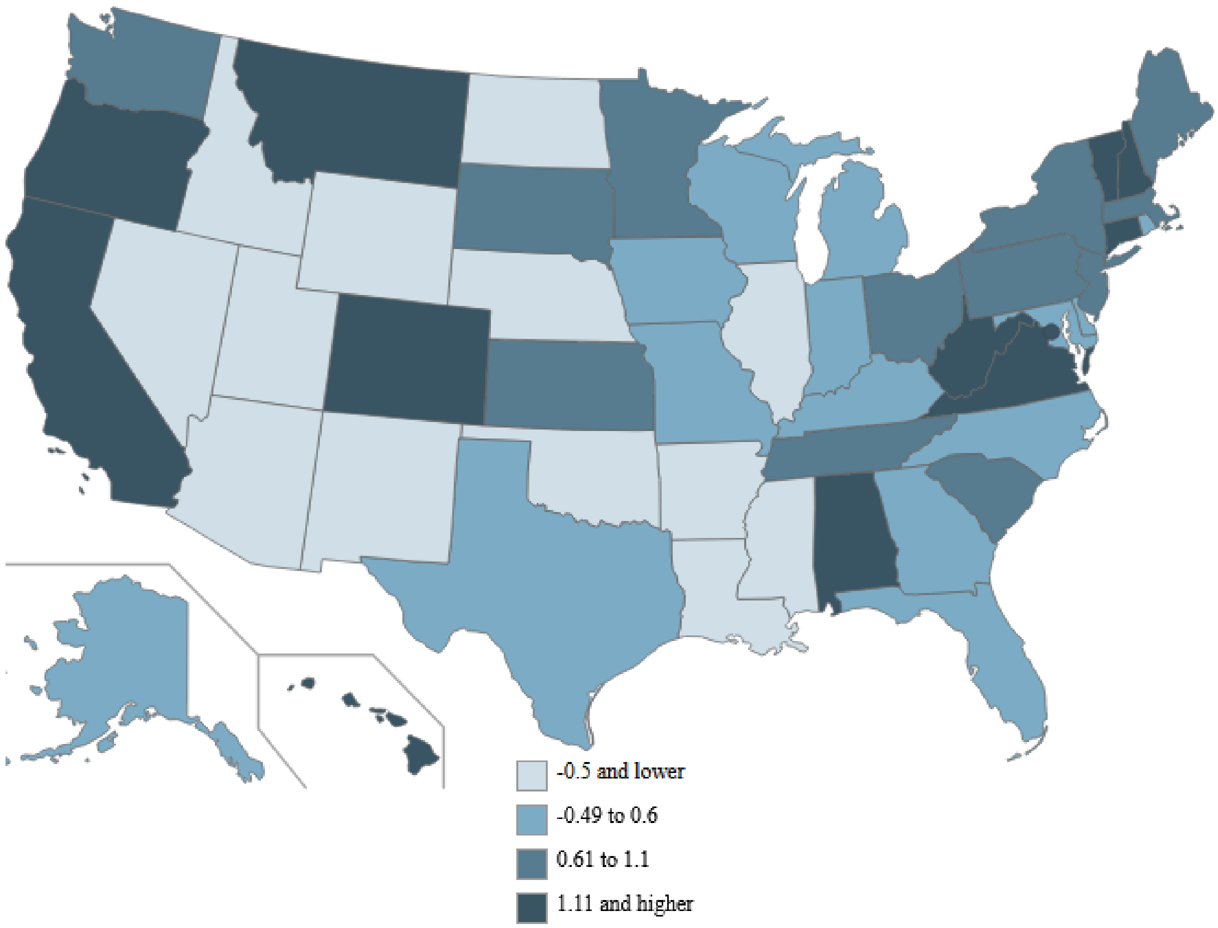
Source: US Census

3. Typical labor costs

In 2019 the US Department of Labor, Bureau of Labor Statistics for the first time published national statistics on labor productivity[24]. This data – focused on the 2007-2017 period provides insights into the differences in labor cost and productivity among the US state. Figure 44 shows changes in labor productivity in US states from 2016-17.

[24] https://www.bls.gov/opub/mlr/2019/article/bls-publishes-experimental-state-level-labor-productivity-measures.htm

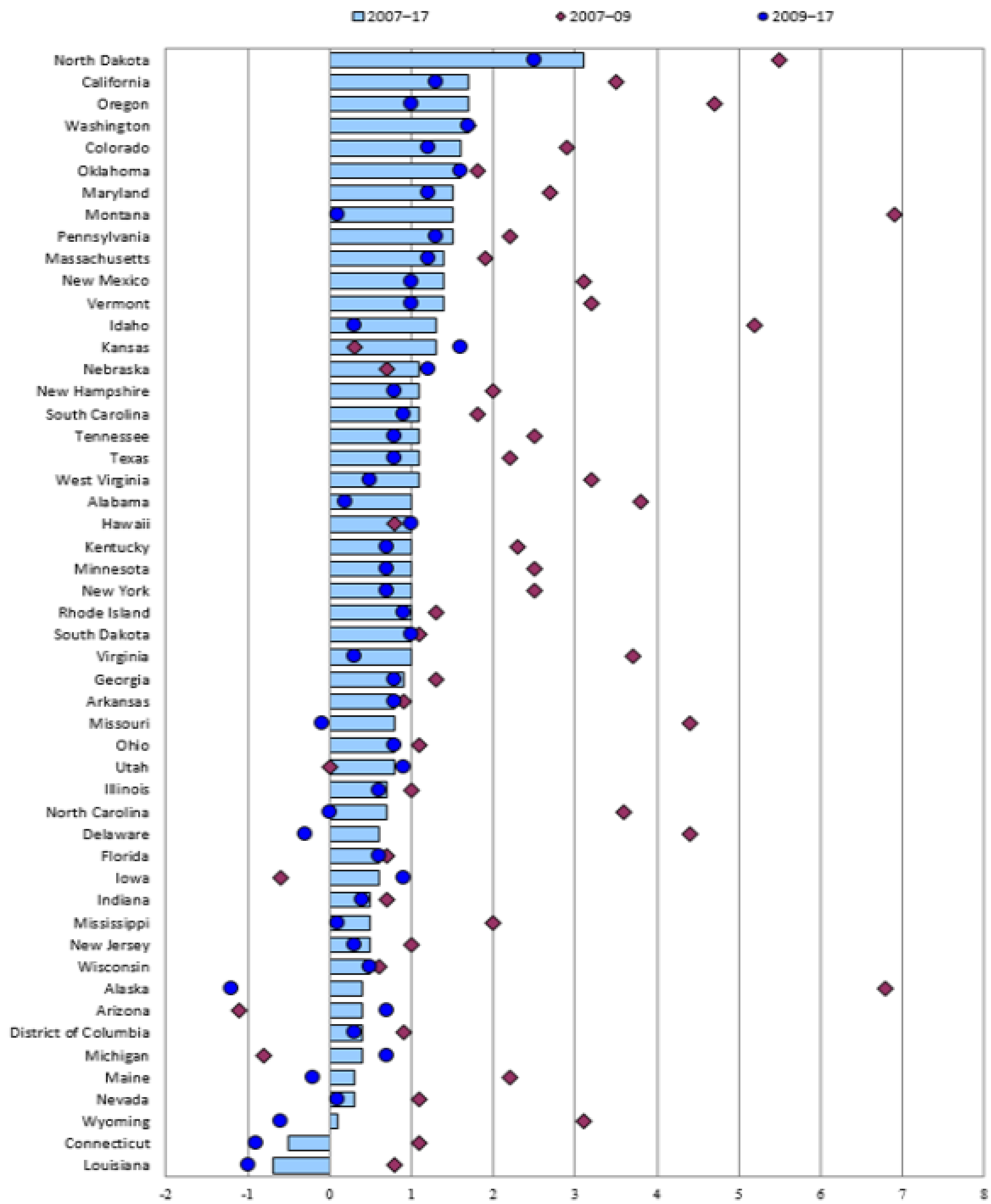
Figure 44 **US Labor Productivity Improvement 2016-17**



Source: US Department of Labor, Bureau of Labor Statistics

The map shows NH and VT among the most improved labor productivity states along with West Virginia in our benchmarked sample. Comparing the states nationwide for the 10-year 2007-2017 period (Figure 45) may be more useful.

Figure 45 **US Labor Productivity Changes 2007-17**



Source: U.S. Bureau of Labor Statistics.

In this graph, the states we are focused on show the following ranking:

Figure 46 **State rankings in worker productivity improvements 2007-2017**

	National labor productivity ranking 2007-17
Pennsylvania	9
Vermont	12
New Hampshire	16
Tennessee	18
West Virginia	20
Kentucky	23
New York	25

Source: US Dept of Labor, Bureau of Labor Statistics 2019

More specific labor cost and productivity data for Pennsylvania follows.

Pennsylvania had the highest gains in worker productivity during the 2007-17 decade (Figure 47) for the states in question. Unit labor costs were up 0.7 % during the period.

Figure 47 **Worker Productivity Changes 2007-2017**

Region and state	Labor productivity	Output per worker	Output	Hours	Employment	Real hourly compensation	Unit labor costs
New Hampshire	1.1	1.3	1.6	0.5	0.3	0.4	0.9
New York	1	0.8	1.8	0.8	1	–0.1	0.7
Vermont	1.4	1.3	1.1	–0.3	–0.1	0.6	1.1
Kentucky	1	0.5	0.7	–0.3	0.2	1.1	1.7
Pennsylvania	1.5	1.4	1.6	0.1	0.2	0.5	0.7
Tennessee	1.1	1.1	1.6	0.5	0.5	0.4	1
West Virginia	1.1	1.1	0.6	–0.4	–0.5	0.5	1.2

Source: US Dept of Labor, Bureau of Labor Statistics 2019

Unit labor costs for Pennsylvania were up more during the 2007-17 period but less than all other states of interest except for New York.

c. Regulatory Climate

1. Relevant laws and regulation

There are two areas of relevant laws and regulations to benchmark for this effort: forestry/logging and business. Forestry laws relate to the requirements placed on harvesting of timber for forest industry manufacturing. Relevant business laws are important because they can help or hinder the advancement and expansion (or contraction) of forest industry. Only a few states in the US have comprehensive forest practices acts (California, Oregon, Washington, & a lesser extent Maine) although many that do not have comprehensive acts have laws that are often contained in the comprehensive acts. All states are covered by a series of laws not discussed here since they cover all states equally. The federal Clean Water Act is one such law that defers enforcement of the law's requirements for forestry to state regulatory agencies. The Lacey Act dealing in endangered species is another. This analysis will only cover state specific laws and regulations affecting forestry and logging.

For Pennsylvania, state laws extensively regulate several aspects of timber harvesting. All timber harvesting operations in Pennsylvania must have a plan to control erosion and sedimentation. Operations that disturb 25 or more acres of land require an erosion and sedimentation control permit. State regulations (25 Pa. Code, Chapter 102) mandate (again from the Clean Water Act) that (1) the implementation and maintenance of erosion and sedimentation best management practices (BMPs) are required to minimize the potential for accelerated erosion and sedimentation; (2) all earth disturbance activities require the development and implementation of a written erosion and sedimentation plan; (3) the erosion and sedimentation plan shall be prepared by a person trained and experienced in erosion and sedimentation control methods and techniques applicable to the size and scope of the project being designed; (4) earth disturbance activities shall be planned and implemented to minimize the extent and duration of the earth disturbance, maximize protection of existing drainage features and vegetation, minimize soil compaction, and utilize other measures or controls that prevent or minimize the generation of increased stormwater runoff; (5) the erosion and sedimentation plan must contain drawings and narratives that consider such factors as topographic features, soils, volume and rate of runoff, sequence and maintenance program of BMPs, waste disposal, geologic formations, and thermal impacts to surface waters; and (6) the erosion and sedimentation plan must be available at the project site during all stages of the earth disturbance activity.

DEP is responsible for enforcing these regulations. County Conservation Districts (CCDs) may have delegated authority to enforce these regulations.

Business laws affecting the forest products industry in Pennsylvania are varied and include standard laws and regulations covered below.

Outside of taxation, which we covered later, there are 10 major business law areas that states and the federal government cover:

Employment and Labor Law

There are many government regulations on businesses that employ workers and independent contractors in the form of federal and state labor laws.

The most common labor laws are:

Wages and hours: According to the US Department of Labor, the Fair Labor Standards Act (FLSA) prescribes standards for wages and overtime pay. This act affects most private and public employment, and requires employers to pay covered employees at least the federal minimum wage and overtime pay of one-and-one-half-times the regular rate of pay (unless they are exempt employees).

Workplace safety and health: The Occupational Safety and Health Administration (OSHA) requires that employers, under the OSH Act, "provide their employees with work and a workplace free from recognized, serious hazards." The OSH Act is enforced through workplace inspections and investigations.

Equal opportunity: Most employers with at least 15 employees must comply with equal opportunity laws enforced by the Equal Employment Opportunity Commission (EEOC). The EEOC mandates that certain hiring practices, such as gender, race, religion, age, disability, and other elements are not allowed to influence hiring practices.

Non-US citizen workers: The federal government mandates that employers must verify that their employees have permission to work legally in the United States. There are several employment categories, each with different requirements, conditions, and authorized periods of stay (for employees who are not legal residents or citizens).

Employee benefit security: If your company offers pension or welfare benefit plans, you may be subject to a wide range of fiduciary, disclosure, and reporting requirements under the Employee Retirement Income Security Act.

Unions: If your business has union employees, you may need to file certain reports and handle relations with union members in specific ways. See the Office of Labor Management Standards' website for more information.

Family and medical leave: The Family and Medical Leave Act (FMLA) requires employers with 50 or more employees to provide 12 weeks of unpaid, job-protected leave to eligible employees for the birth or adoption of a child, or for the serious illness of the employee or a spouse, child, or parent.

Posters: Some Department of Labor states require notices to be shared or posted in the workplace for employees' view (for example, alcohol warnings and hand-washing reminders). Fortunately, the elaws Poster Advisor is an easy way to determine which posters you need, and you can use it to get free electronic and printed copies in multiple languages.

Antitrust Laws

Any time a company conspires with its competitors, third-party vendors, or other relevant parties, it may run afoul of antitrust laws. These are the issues antitrust laws strive to address, such as the following:

Conspiring to fix market prices: Discussing prices with competitors—even if it affects a small marketplace.

Price discrimination: Securing favorable product prices from buyers when other companies can't.

Conspiring to boycott: Conversations with other businesses regarding the potential boycott of another competitor or supplier.

Conspiring to allocate markets or customers: Agreements between competitors to divide up customers, territories, or markets are illegal. This provision applies even when the competitors do not dominate the particular market or industry.

Monopolization: Preserving a monopoly position through the acquisition of competitors, the exclusion of competitors to the given market, or the control of market prices.

Advertising

Rules and government regulations on advertising are generally to protect consumers so there must be care to be truthful in advertising. For example, claims in ads cannot be untruthful or purposely deceptive. Using testimonials in ads comes with additional regulations. Violating these rules can result in fines, which defeats the purpose of your advertising in the first place. There are also labeling laws for consumer products, meaning that they list out ingredients and chemicals within products.

Email Marketing

Closely related to advertising is email marketing. If the business engages in email marketing, there are separate regulations under the CAN-SPAM Act. There are several things that this Act regulates, but some of the main components are:

-Don't use false or misleading headers

-Don't use deceptive headlines

-Indicate that the message is an advertisement

-Include your business's name and address

-Show the customer how to opt out of emails, and honor the opt-out requests promptly

Each separate email violation is subject to hefty fines.

Environmental Regulations

Laws and regulations to protect water quality and air quality along with consumers are found at the federal and state level in all states. Most have permitting systems associated with activities that could affect air or water quality or consumer health.

Privacy

Businesses with staff and employees wind up amassing a large amount of sensitive personal information about their employees. As a result, there are a variety of rules and regulations about how employers must save and secure this data. Businesses cannot disclose an employee's private information, including Social Security number, address, name, health conditions, credit card, bank numbers, or personal history. And the Health Insurance Portability and Accountability Act (HIPAA) prohibits the release of health data without a patient's permission.

Licensing and Permits

Basic business licensing or registration is a requirement in all states, usually through the corporate division of the state's secretary of state office.

Insurance

As soon as an employee is hired, workers compensation insurance is required. All states, with the exception of Texas, require businesses with employees to purchase workers comp insurance.

Reporting Pay Data

If the business employs more than 100 people (or more than 50 as a federal contractor), there is a requirement to report how much each is paid, broken down by race/ethnicity, job category, and gender, to the Equal Employment Opportunity Commission each year.

Collecting Sales Tax

In many states, most businesses that sell physical goods must collect sales tax from customers and submit the tax to their state's revenue department. A few states do not collect sales tax. In general, the law specifies that a business must collect sales tax in any state with which it has a physical connection (known, in legal terms, as a "nexus"). That nexus might mean a physical retail shop, or hiring employees in the state. Even online sellers might have to collect sales tax in any state that they sell to.

If your business has a nexus, you need to collect sales tax except in Alaska, Delaware, Montana, New Hampshire, or Oregon where sales taxes are not law.

In Pennsylvania, there are no laws that affect business that are not covered in the listing above.

2. Taxation

For most small business owners, government regulation questions almost always begin with taxes. But there's more to taxes than merely paying them—knowing which business taxes to pay, when to pay them, and how to set up your business to account for future tax payments can spare you a ton of headaches when it comes time to write the government a check.

Every company registered within the United States has to pay federal taxes. Most companies will also have to pay state taxes, depending on the state in which the company is registered. These are unavoidable. Avoiding taxes—or deciding not to pay them outright—comes with hefty penalties and potential jail time.

But the kinds of taxes you'll pay depends on how you formed your business. In this regard, not all businesses are treated the same. Sole proprietorships pay taxes differently than, say, S-corporations. Here's a full rundown of the different taxes for business structures to help you determine what your business needs to file. Despite the differences between each kind of business, there are a few general terms you should know:

Income tax: Most businesses file an annual income tax return. Businesses must pay income tax as they earn and receive income, and then file a tax return at the end of the year.

Estimated tax: Estimated tax payments offer an alternative to paying income tax throughout the year as your company earns money. Sole proprietors, partners, and S-corporation shareholders must usually make estimated tax payments if they expect to owe $1,000 or more once they file their return. Note that corporations are usually required to make estimated tax payments if they expect to make more than $500 or more in income.

Employment tax: Companies that have employees are expected to pay taxes related to having staff on their payroll. These include Social Security and Medicare taxes, federal income tax withholding, and federal unemployment tax. For more information, see the IRS page on Employment Taxes for Small Businesses.

Excise taxes: Excise taxes are paid when your business makes purchases on specific goods, and are often included in the price of the product. One common example of excise tax is the purchase of gasoline, where applicable taxes are baked into the price per gallon rather than as a tally at the end of the transaction. You may be under certain excise tax law if you manufacture or sell certain goods, use various kinds of equipment, receive payment for certain kinds of services, and much more. For additional information, refer to the IRS guide on Excise Taxes.

Some businesses also have to collect sales tax, which we'll cover more in a bit.

Taxation of business operations is perhaps the most important of business laws and regulations to affect forestry industry operations.

In Pennsylvania, the major business taxes in addition to property taxes which are local are:

-Sales & Use Tax – applies to businesses operating as a wholesaler, retailer or seller in Pennsylvania.

Corporation/Small Business Income Tax

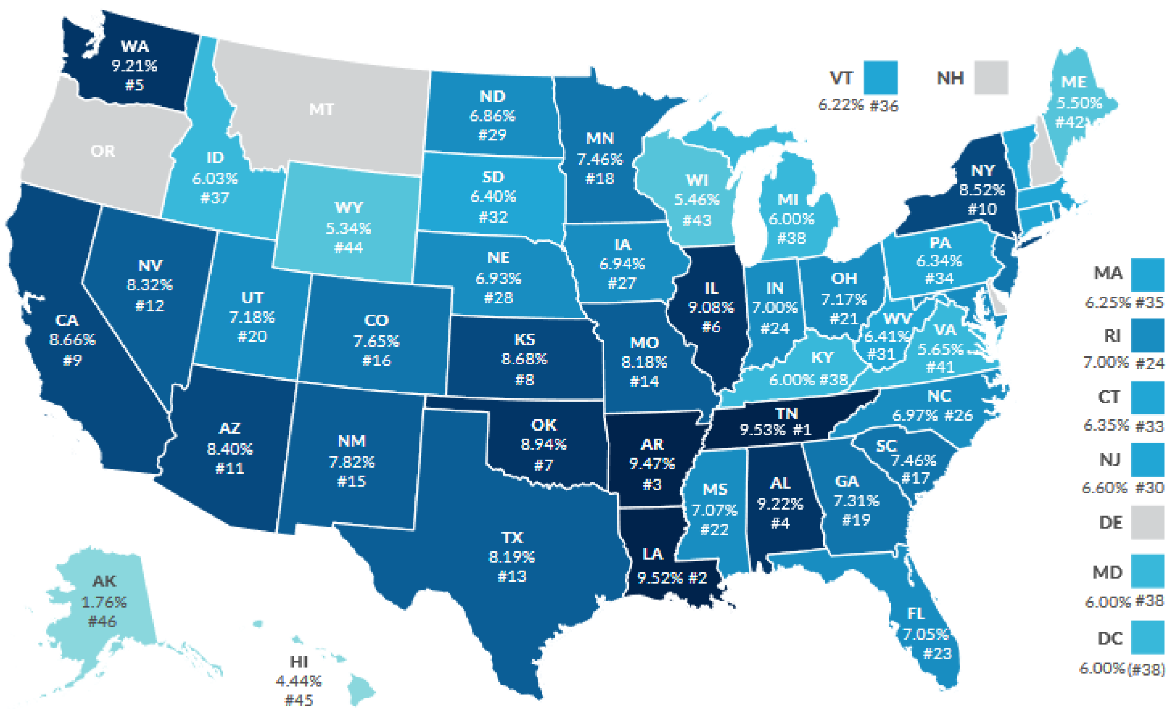
Gross Receipts Tax

Withholding Tax

Public Utility Realty Tax

The major taxes to compare are the sales tax and corporate and small business Income tax. The sales tax rate for Pennsylvania is 6.34% and ranks it 34th in the country.

Figure 48 **Sales Tax Rates for States in US 2020**

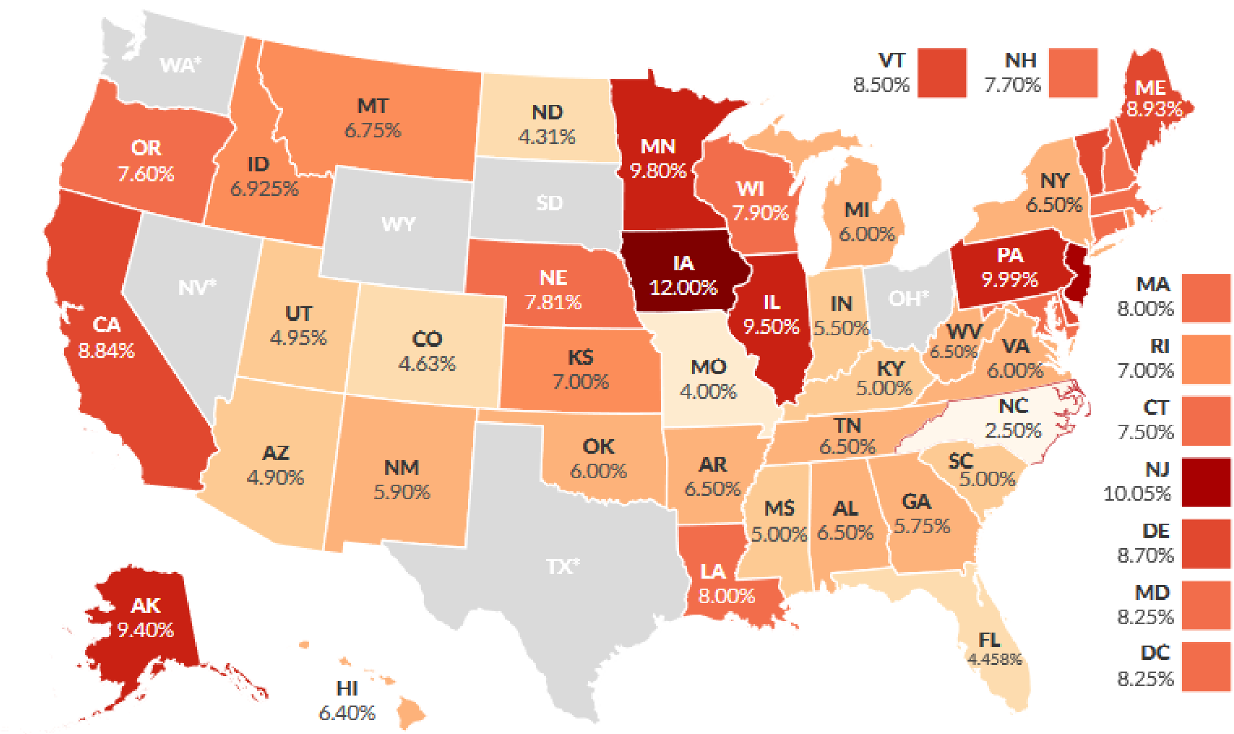


Source: Tax Foundation

For corporate and small business taxes, Figure 49 shows state rates.

Pennsylvania's highest business tax rate is 9.99% ranking it at the high end with the highest rates at Iowa at 12%, and 10.05% in New Jersey and the lowest with no business income tax in Ohio, Nevada, South Dakota, Texas, Washington and Wyoming. However, Ohio, Nevada, Texas, and Washington have business gross receipts taxes thought to be more problematic for business than corporate income taxes. South Dakota and Wyoming are the only states that do not levy either a business income or gross receipts tax.

Figure 49 **Business tax rates by US state 2020**



Source: Tax Foundation

d. Energy Costs

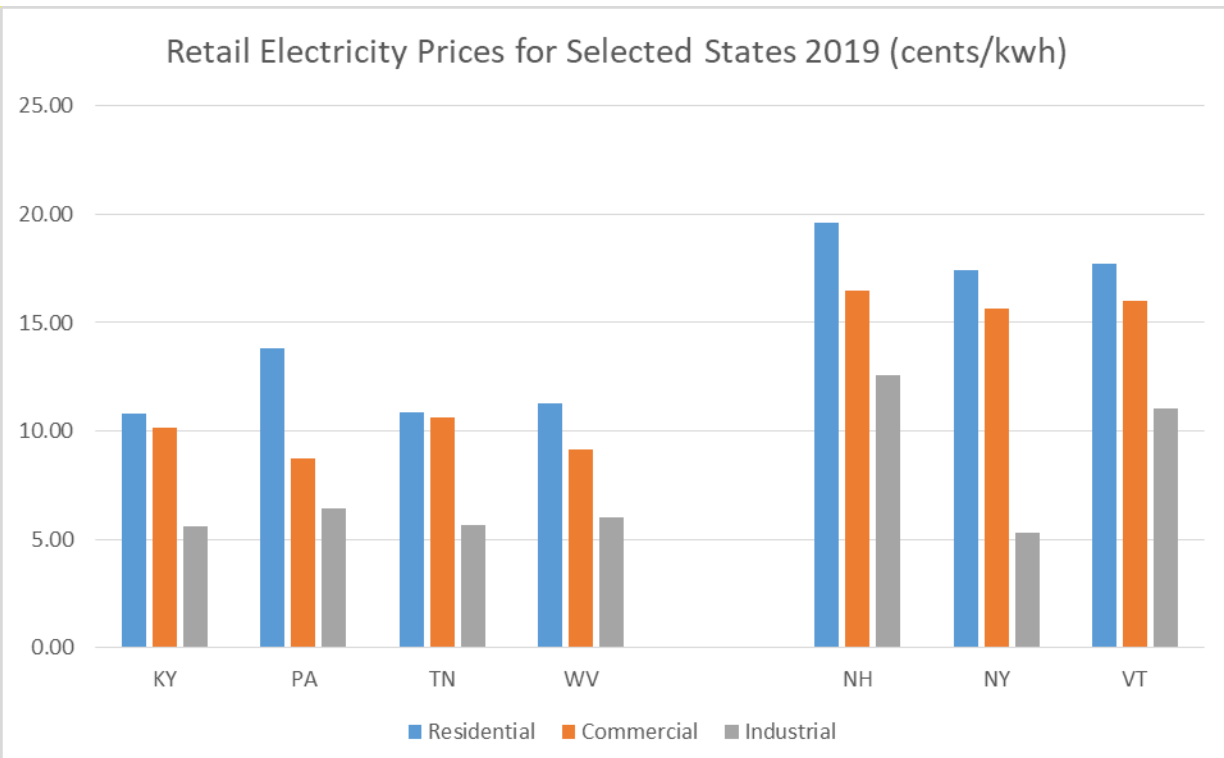
Of all the utilities associated with forest products manufacturing, electricity costs are the most critical to influence positive economics that allow for facilities to be built and operate successfully. Virtually all the machinery associated with forest products manufacturing runs on electricity.

Fossil fuel prices are important for the raw material supply chain infrastructure but those prices generally do not vary much from state to state or region to region in the US and are based on world supply and demand. Because of the way electricity grids are operated and the fact that the source of the power and the infrastructure to get it to customers is vastly different from state to state and region to region, electricity prices vary considerably.

Retail electricity costs in the three-state NH/VT/NY region are generally higher than national averages – particularly for residential customer rates and are certainly higher than our benchmarking states of Kentucky, Pennsylvania, Tennessee & West Virginia. The sector we are most interested in is for industrial retail electricity rates.

As we noted in the second report in this series - within each state there are multiple electric utilities, each with a unique service territory and in some cases with competitive suppliers. Rates that a user pays for electricity may depend upon their utility service territory, competitive supplier, time of use and other factors. In other words, it is possible to get, and many large industrial power users do, a special deal that is lower than the average for that sector. The electricity cost comparisons below reflect that complexity and are average rates (Figure 50).

Figure 50 **Retail Electricity Rates for Selected States 2019**



Source: US Energy Information Administration

Pennsylvania's commercial and industrial retail electricity rates on average are 8.71 cents and 6.41cents respectively, among the lower ranges in the benchmarked states but generally lower than the NH, NY and VT region except for NY's industrial rate.

e. Infrastructure and transportation

The most important infrastructure issue for the forest products industry is transportation. This generally refers to public road infrastructure for getting raw logs/timber feedstock to the mill for manufacturing and getting finished product to market. Virtually all feedstock procurement is truck traffic while finished product shipping usually starts out (and often is finished with) trucking and then sometimes uses rail access for long hauls and then shipping for overseas markets.

In Pennsylvania, commercial road issues are similar to other states in the east. Road freight is increasing on large trucks and the infrastructure of interstate, state and local road systems face shortages on funding, so critical issues like bridge upkeep and re-paving and maintenance are always chronic issues. The commercial road infrastructure – i.e. having adequate number of roads to access all geographies – is largely complete in Pennsylvania as with the other states in our study.

The TRIP report of 2019 which is a national report on commercial road issues in the US[25], highlights that commercial freight by road is increasing, and today, more freight (nearly 75% by value) travels to market through the nation's road system. They project that from 2016-2045 freight moved will increase by 104% by value and 44% by weight, and truck freight moved annually in the US, trucks is expected to increase by 91 percent in value (inflation-adjusted dollars) and 41 percent by weight. Clearly the road systems are critical to the forest products industry.

[25] America's Rolling Warehouses: Opportunities and Challenges with the Nation's Freight Delivery System, TRIP, 2019

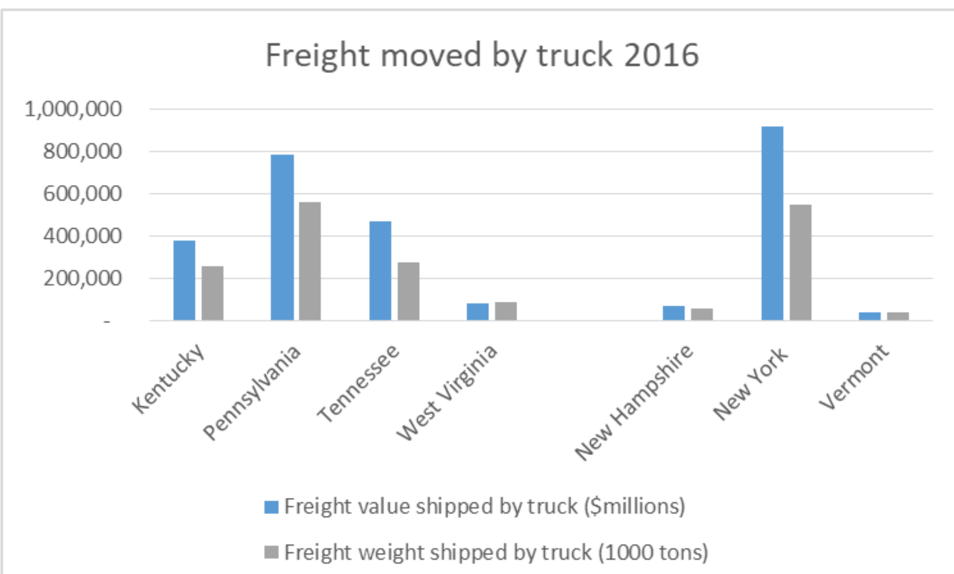
Figure 51 **Commercial Freight Method US**

Mode	By Value	By Weight
Truck	72%	66%
Rail	4%	10%
Water	2%	4%
Air	3%	0.03%
Multiple Modes	14%	3%
Pipeline	4%	16%

Source: TRIP Report, 2019

Of the seven states in our study, only Pennsylvania and New York are in the top 5 in the US in freight moved by truck.

Figure 52 **Freight moved by truck - selected states 2016**



Source: TRIP report 2019

Key bottlenecks in truck traffic (where traffic is slowed to much less than posted speed limits due to excess traffic amounts) shown in Figure 53 shows that Pennsylvania is not in the list of top 20 congested trucking routes in the US.

Figure 53 **Freight congestion US highways - top 20 bottlenecks**

RANK	STATE	Location Description	Average Speed	Average Speed During Peak Hours	Average Speed During Non-Peak Hours
1	New Jersey	Fort Lee: I-95 at SR 4	32	23	35
2	Georgia	Atlanta: I-285 at I-85 (North)	35	23	41
3	Georgia	Atlanta: I-75 at I-285 (North)	38	27	43
4	California	Los Angeles: SR 60 at SR 57	42	35	44
5	Texas	Houston: I-45 at I-69/US 59	34	24	38
6	Ohio	Cincinnati: I-71 at I-75	44	36	47
7	Illinois	Chicago: I-290 at I-90/I-94	24	18	27
8	Tennessee	Nashville: I-24/I-40 at I-440 (East)	41	28	48
9	Georgia	Atlanta: I-20 at I-285 (West)	45	38	47
10	California	Los Angeles: I-710 at I-105	38	27	43
11	Indiana	Gary: I-65 at I-80	47	45	48
12	Colorado	Denver: I-70 at I-25	38	30	42
13	Texas	Houston: I-10 at I-45	40	28	46
14	Connecticut	Hartford: I-84 at I-91	45	35	49
15	California	San Bernardino: I-10 at I-15	45	36	49
16	Texas	Dallas: I-45 at I-30	40	29	45
17	Illinois	Chicago: I-90 at I-94 (North)	31	17	37
18	Michigan	Detroit: I-94 at I-75	39	31	44
19	Louisiana	Baton Rouge: I-10 at I-110	37	29	41
20	New York	Brooklyn: I-278 at Belt Parkway	34	26	37

Source: TRIP Report 2019

The American Society of Civil Engineers (ASCE) conducts a state by state analysis of infrastructure, including transportations systems. In their recent report for Pennsylvania, two key transportation infrastructure reviews were included for bridges and roads. For bridges, the report says:

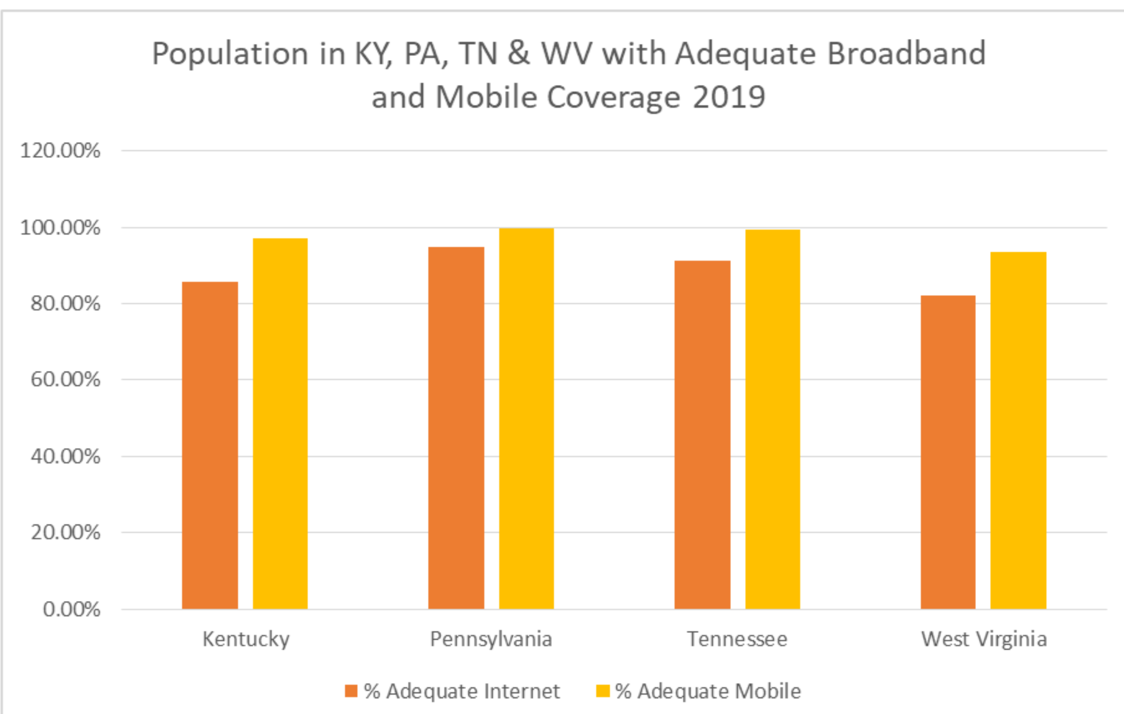
> "Of Pennsylvania's more than 22,779 highway bridges – the ninth largest inventory in the nation – 18.3% (4,173 bridges) are classified as being in poor condition, down from 24.4% in 2014. On average, Pennsylvania's bridges are 15 years older than the national average and continue to be in need of repair and modernization. The additional funding from Act 89 passed in November 2013 has brought much needed investment to the transportation system, but more work needs to be done. While there have been many improvements over the past four years, Pennsylvania's bridge asset managers still face several challenges, and Pennsylvania has more than double the national average of bridges rated in "poor" condition."

For roads in Pennsylvania, the ASCE says:

"In 2013, Act 89 provided significant improvement funding increases, resulting in 2,600 projects that are currently in progress or have been completed. Although these funds have contributed to the advancement of reconstruction, rehabilitation, new roadway, and intersection improvement projects, there is a significant roadway backlog that still requires attention, as seen by 43% of PennDOT owned roadways having a fair or poor pavement surface. For motorists statewide, traffic congestion results in over $3.7 billion per year in lost time and wasted fuel, and deficient roadway conditions cost the average motorist over $500 in operating and maintenance outlays. In FY 2019, Act 89 funding will hit its maximum funding level and plateau. Thus, as Pennsylvania's roadway infrastructure ages, needs for increased capacity rise, and fuel economy increases, the funding gap will grow unless additional or alternative funding sources are identified."

Another important infrastructure issue is access to fast broadband internet and mobile phone access. While improving each year, especially in rural areas, not all of the population in Pennsylvania has adequate broadband internet or mobile service (Figure 54).

Figure 54 **Broadband and Mobile Service in KY, PA,TN & WV 2019**



Source: broadbandnow.com

In Pennsylvania 94.9% of the population has adequate internet coverage while 99.80% has adequate mobile service.

f. Research and Development

Having in-state research and development activities in forest products and forest products manufacturing is very important to the future progress within the industry. In the past, many forest products companies did research and development in-house, but with structural changes within the industry over the last 20 years, very little of that occurs today. University research cooperatives and industry trade group research has also dwindled. Other countries, most notably Canada and Finland have re-directed and re-energized their research and development efforts in the forest products industry.

In the U.S. today, most forest products research occurs in government or university labs. The USDA Forest Service has a series of forest products labs where research and development on forest products is conducted. The output from the labs is available for all in the public and private sector to use.

The Forest Products Laboratory (FPL) in Madison, Wis. is one of seven national Forest Service research facilities. FPL scientists focus their research around five areas:

Advanced Composites

Wood composite technologies have been used for decades to create building and home furnishing products. Composites are used for a number of structural and non-structural applications including interior paneling, sheathing, furniture, and support structures in many different types of buildings.

Advanced Structures

The FPL is a world leader in housing-related areas such as engineered wood products and structures, moisture control, material design and performance, coatings and finishes, adhesives, and wood preservation. Creating advanced technologies and alternative building methods can greatly enhance the value of wood in residential, non-residential, and transportation structures.

Forest Biorefinery

Trees are one of the best potential sources of biological fuel and chemicals. They grow in marginal soils unsuitable for agriculture; do not require fertilizer, herbicides, or pesticides; and accumulate biomass density for several years before incurring harvest costs. Converting wood resources into liquid fuels and chemical feedstock is becoming more cost competitive thanks in part to FPL research.

Nanotechnology

FPL scientists are conducting nanoscale research to learn more about the fundamental components of wood. Nanotechnology is a multi-disciplinary field of applied science and technology. Nanocellulose holds revolutionary potential for the forest products sector and is the economic key to accelerated forest restoration. Nanocellulose can be a cost-effective substitute for non-renewable resources in all manufacturing sectors.

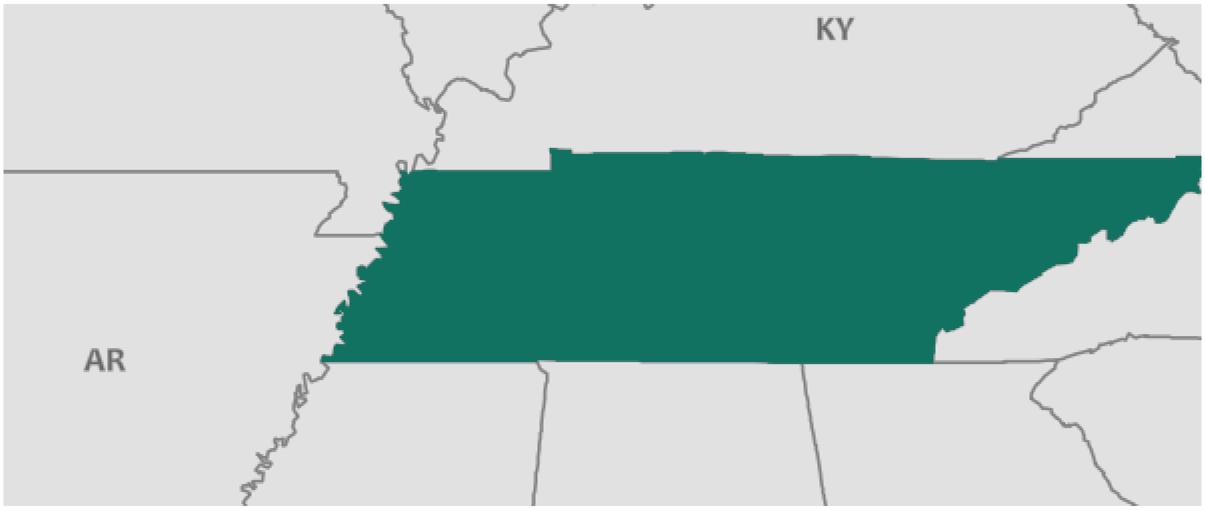
Woody Biomass Utilization

U.S. forests contain a substantial amount of small-diameter, overstocked, and underutilized material. FPL scientists study small-diameter woody material, identify potential uses, and provide technology that can help rural-based communities create successful businesses from the by-products of forest management projects. FPL research explores the potential of small-diameter roundwood as a structural material for bridges, boardwalks, trail structures, picnic shelters, storage sheds, and other rustic buildings.

Penn State University conducts research in areas of forest products and bio-energy. The focus of this work is through The Biomass Energy Center. The Center is relaunching as the "Center for Biorenewables", with an expanded mission to "build a greener future through innovation and education relating to biorenewable food, chemicals, pharmaceuticals, materials and energy". This transition occurred in for 2020, and will include a new and updated website, as well as new events and activities related to research and education on bioenergy and biorenewables.

Tennessee

Tennessee - Tennessee has a total area of 41,223.9 square miles, including 909.1 square miles of water, making it the 34th-largest state by area. Tennessee is bordered by North Carolina, Mississippi, Kentucky, Missouri, Georgia, Virginia, Alabama, and Arkansas.



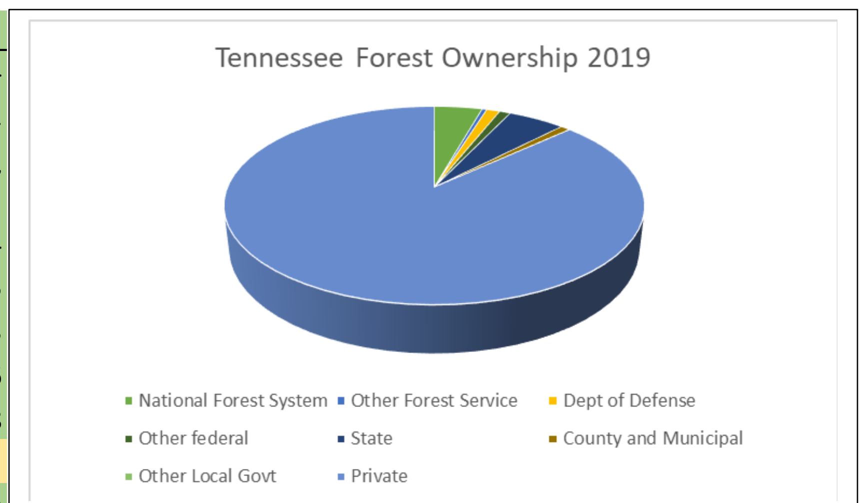
a. Raw Material

1. Forest Area and Ownership

   The Tennessee timberland area covers 13,288,919 acres (Figure 55).

Figure 55 ***Tennessee Forest Area and Ownership***

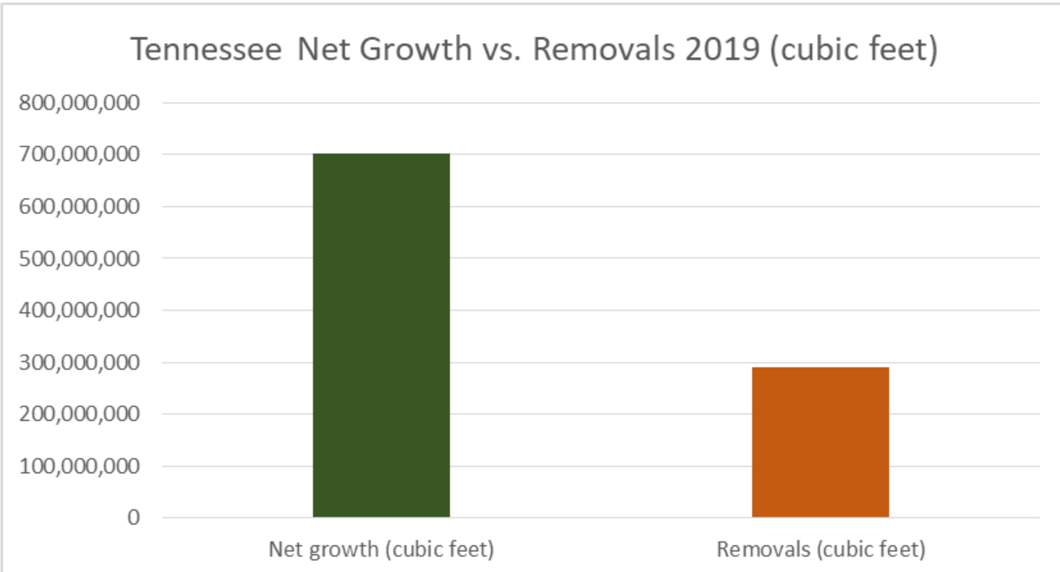
Owner Type	Acreage
National Forest System	584,104
Other Forest Service	57,592
Dept of Defense	161,147
Other federal	133,614
State	695,015
County and Municipal	114,893
Other Local Govt	6,076
Private	11,536,478
Total	13,288,919



Over 86% of those acres are owned privately while only 14% is owned by the public sector. The federal government owns just over 936,000 acres while the State of Tennessee and local government owns just nearly 816,000 acres. Most of Tennessee's forest are mixed hardwood.

2. Harvest levels – From up-to-date data from the USDA Forest Inventory and Analysis dataset, the net growth to removals data for Tennessee looks positive (Figure 56).

Figure 56 ***Tennessee Timber Growth vs. Harvests 2019***



Source: USDA Forest Service FIA

The most recent FIA data shows that Tennessee has a 2.43 net growth to removal ratio for all timberland – meaning that each year, the State is growing 2.43 times more than it is removing from harvests and loss of timberland to other uses.

3. By-products – Tennessee timber by-products are primarily sawmill residues which are used mostly in the pulp and paper sector. Very little in-woods chipping is conducted as most timber harvesting is conducted with traditional chainsaw and skidder operations primarily designed to deliver sawlogs to the sawmills in the state. Secondary production of hardwood pulpwood occurs but is not significant and not a growth area. Some residues are used to generate electricity but little in stand-alone biomass electricity plants. Instead, most are through smaller generation facilities and combined heat power at mills – primarily in the forest products sector. According to the US Energy Information Agency less than 6% of energy used in Tennnessee is from biomass sources.

4. Delivered wood cost – In Tennessee, hardwoods are the main species groups harvested (over 95%) and wood costs are competitive with other hardwood producing regions in the U.S. From various market sources, late 2020 delivered (to the sawmill) timber prices range from a low of $250/thousand board feet (Mbf) to over $1,000/Mbf for White oak, which has seen increasing demand for the barrel stave market for the growing spirits sector for liquors, wine and beer. There is good demand for hardwood sawlogs, the mainstay of Tennessee timber markets.

Low quality timber, which in this part of the country is hardwood pulpwood is being sold, on average, for $45-50/ton delivered to the pulp mill.

5. Wood procurement practices

The majority of timber harvested in Tennessee comes from private land although annually a relatively small amount public timber from state and National Forest land is sold and harvested each year. Best Management Practices (BMPs) are encouraged but not required by law for timber harvesting activities in Tennessee. They are practices that are intended to protect water quality when dealing with agricultural and silvicultural operations.

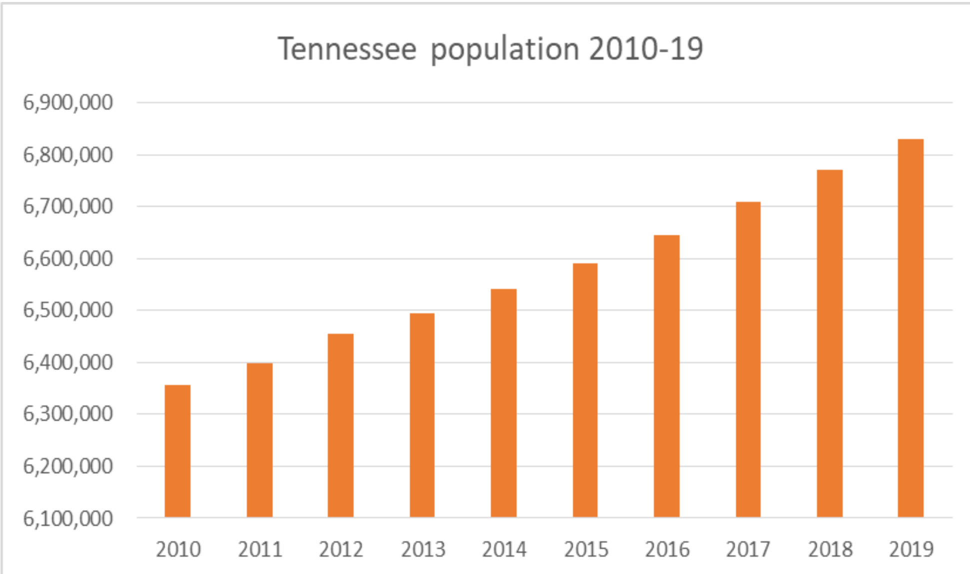
Timber harvesting is generally conducted with chainsaws and skidders along with bulldozers in the forests of Tennessee due to the mountainous nature of the landscape. A small number of timber harvesters employ mechanization using tracked feller bunchers and grapple skidders but most harvesting is done with chainsaws and skidders. Silvicultural practices used include clearcut, selections and shelterwood methods, though small clearcuts are often used as the land naturally regenerates the full range of hardwood species using this regeneration method. Logging is conducted year-round with stoppages during wet soil periods.

b. Workforce

1. Demographics

Tennessee's population in 2019 was 6,829,174 (Figure 57). The state has seen modest population growth since 2010 and ranks 16th in the US for population. It ranks 16th in the rate of growth from 2010-2019 among US states.

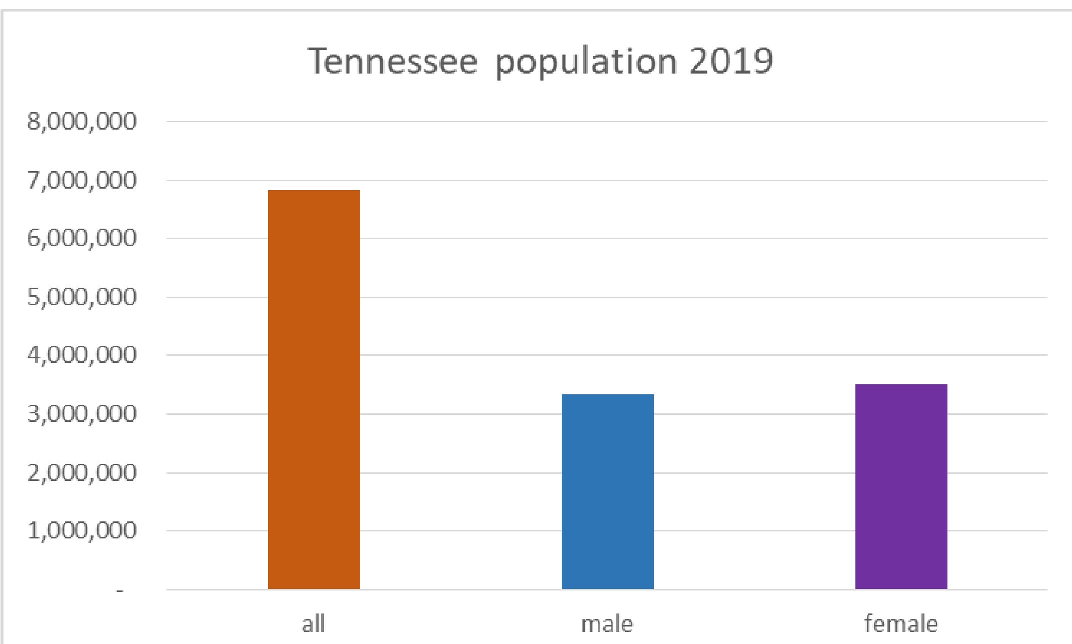
Figure 57 ***Tennessee Population 2010-19***



Source: US Census

Tennessee's population in 2019 was 51% female and 49% male (Figure 58). This is similar to most states in the US.

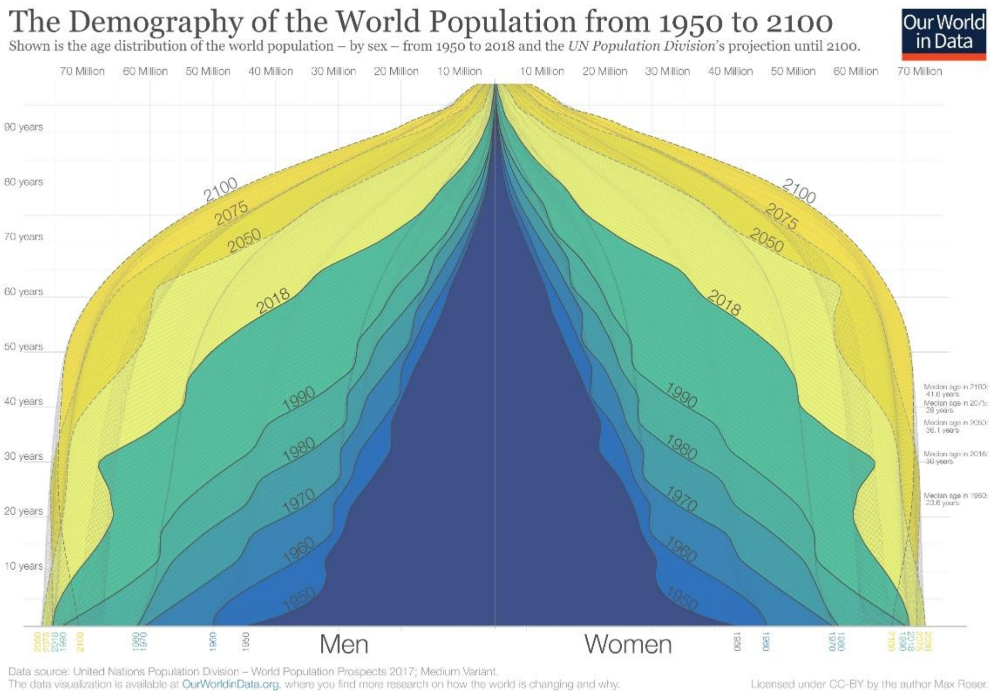
Figure 58 ***Tennessee Population Gender Distribution 2019***



Source: US Census

A more important and informative dataset on Tennessee population is found in Figure 60. Before digging into this Tennessee demographic information, some background on population dynamics is important to discuss. Figure 59 is from the United Nations and is diagram that shows world population and its changes over time and projections into the future.

Figure 59 ***World Population Dynamics***



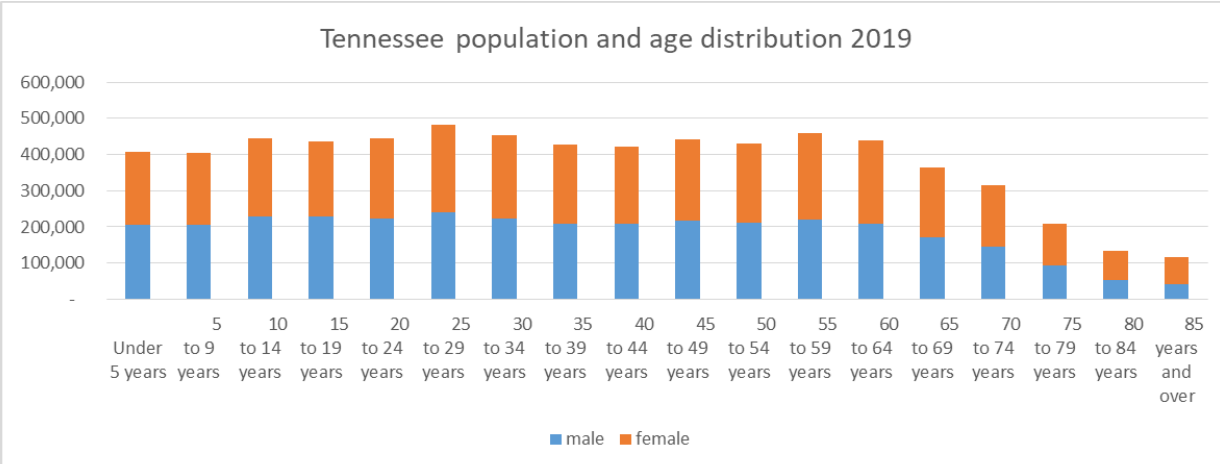
Source: United Nations

The figure shows world population from 1950 (2.5 billion people) to 2019 (7.7 billion) and projections to 2100 (11.2 billion). The most important finding from this figure is that age cohorts (10 years, 20 years etc) were dying at a much earlier age many decades ago compared to 2019. It simply means that infant mortality has reduced and average age at death has increased tremendously comparing 1950 to 2019. We are a healthier and older population today than we have ever been.

This is similar to what is occurring in Tennessee and all US states. From a labor perspective for the forest products industry, an increasing population in the working age cohorts from 20 to 50 represents good change. But an aging population is a concern in virtually all US states.

Tennessee's 2019 population shows a reasonable distribution across ages and genders (Figure 60).

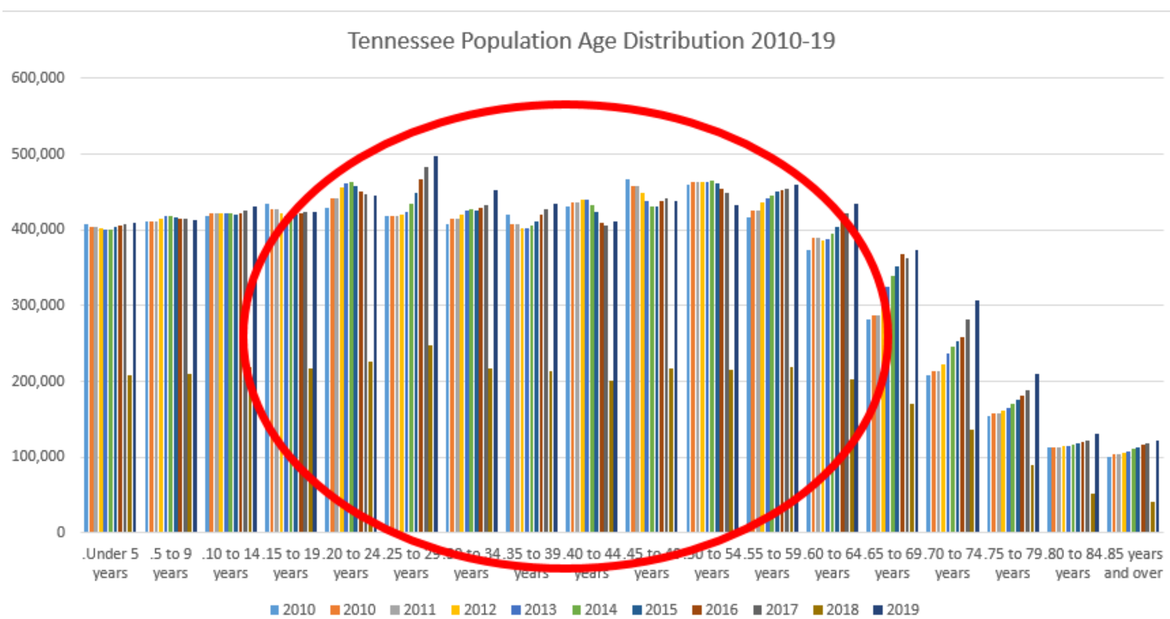
Figure 60 ***Tennessee Age and Gender Distribution 2019***



Source: US Census

Tennessee's age distribution over time – from 2010 to 2019 – is probably more telling (Figure 61). Some of the critical labor age categories in the 20-54 age range are showing a declining population over time but the 25-29, 30-34 & 35-39 age classes are showing increases. The over 55 age classes all show increases over this period – a troubling sign of an aging population with fewer working age people available over time.

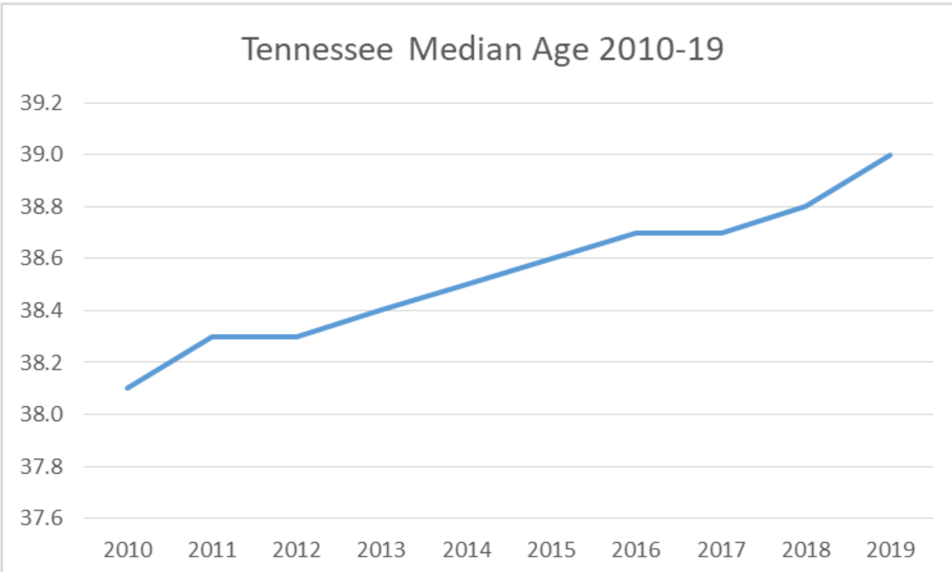
Figure 61 **Tennessee Age Distribution 2010-2019**



Source: US Census

Figure 62 further reinforces the aging workforce data with an increasing median age trend from 2010-2019.

Figure 62 **Tennessee Median Age 2010-19**

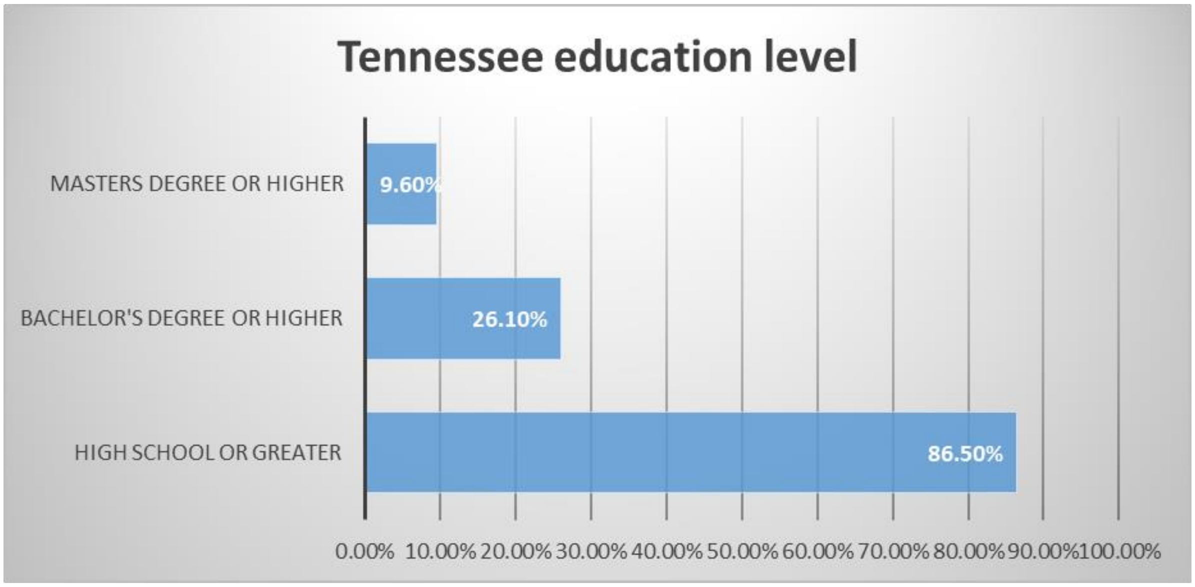


Source: US Census

2. Level of education

Education level of a state's population is important workforce information. In Tennessee, just over 86% of the working-age population has at least a high school education. A bachelor's degree or higher is held by over 26% of the population and 9.6% of the population holds a masters degree or higher.

Figure 63 **Tennessee Education Level**



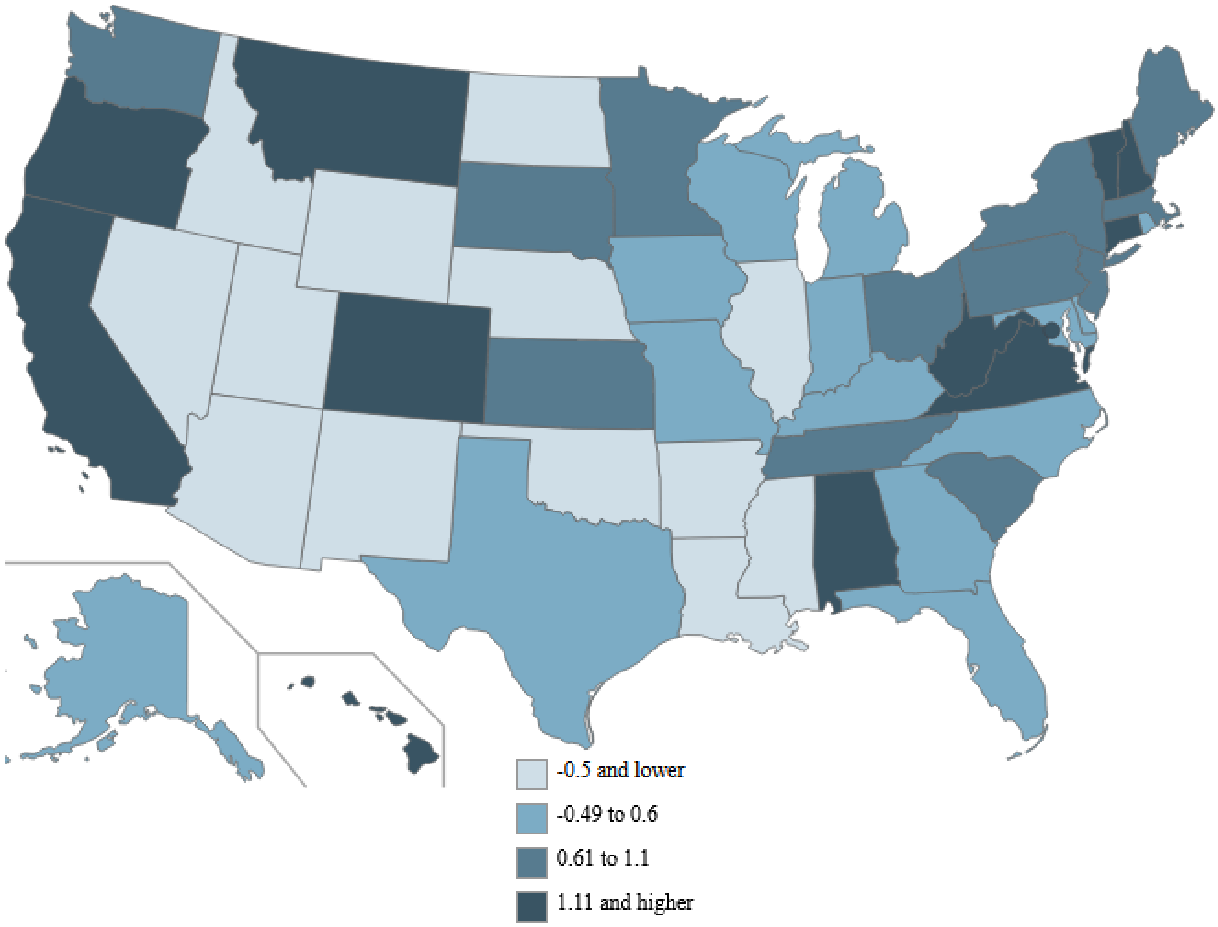
Source: US Census

3. Typical labor costs

In 2019 the US Department of Labor, Bureau of Labor Statistics for the first time published national statistics on labor productivity[26]. This data – focused on the 2007-2017 period provides insights into the differences in labor cost and productivity among the US state. Figure 64 shows changes in labor productivity in US states from 2016-17.

[26] https://www.bls.gov/opub/mlr/2019/article/bls-publishes-experimental-state-level-labor-productivity-measures.htm

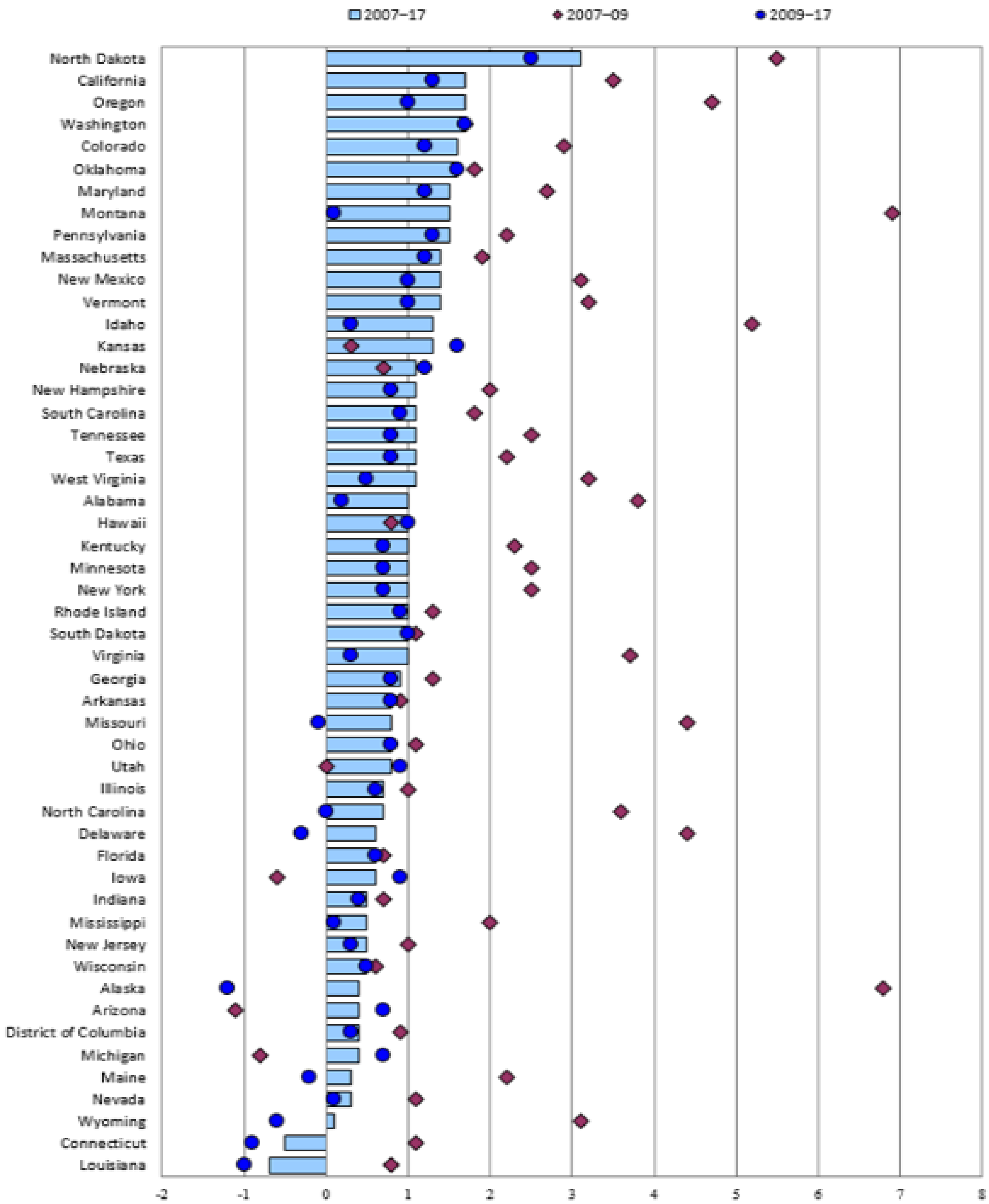
Figure 64 **US Labor Productivity Improvement 2016-17**



Source: US Department of Labor, Bureau of Labor Statistics

The map shows NH and VT among the most improved labor productivity states along with West Virginia in our benchmarked sample. Comparing the states nationwide for the 10-year 2007-2017 period (Figure 65) may be more useful.

Figure 65 **US Labor Productivity Changes 2007-17**



Source: U.S. Bureau of Labor Statistics.

In this graph, the states we are focused on show the following ranking:

Figure 66 **State rankings in worker productivity improvements 2007-2017**

	National labor productivity ranking 2007-17
Pennsylvania	9
Vermont	12
New Hampshire	16
Tennessee	18
West Virginia	20
Kentucky	23
New York	25

Source: US Dept of Labor, Bureau of Labor Statistics 2019

More specific labor cost and productivity data for Tennessee follows.

Tennessee had modest gains in worker productivity during the 2007-17 decade (Figure 67) for the states in question. Unit labor costs were up 1% during the period.

Figure 67 **Worker Productivity Changes 2007-2017**

Region and state	Labor productivity	Output per worker	Output	Hours	Employment	Real hourly compensation	Unit labor costs
New Hampshire	1.1	1.3	1.6	0.5	0.3	0.4	0.9
New York	1	0.8	1.8	0.8	1	–0.1	0.7
Vermont	1.4	1.3	1.1	–0.3	–0.1	0.6	1.1
Kentucky	1	0.5	0.7	–0.3	0.2	1.1	1.7
Pennsylvania	1.5	1.4	1.6	0.1	0.2	0.5	0.7
Tennessee	1.1	1.1	1.6	0.5	0.5	0.4	1
West Virginia	1.1	1.1	0.6	–0.4	–0.5	0.5	1.2

Source: US Dept of Labor, Bureau of Labor Statistics 2019

Unit labor costs for Tennessee were up during the 2007-17 period but less than Vermont, Kentucky and West Virginia.

c. **Regulatory Climate**

a. Relevant laws and regulation

There are two areas of relevant laws and regulations to benchmark for this effort: forestry/logging and business. Forestry laws relate to the requirements placed on harvesting of timber for forest industry manufacturing. Relevant business laws are important because they can help or hinder the advancement and expansion (or contraction) of forest industry. Only a few states in the US have comprehensive forest practices acts (California, Oregon, Washington, & a lesser extent Maine) although many that do not have comprehensive acts have laws that are often contained in the comprehensive acts. All states are covered by a series of laws not discussed here since they cover all states equally. The federal Clean Water Act is one such law that defers enforcement of the law's requirements for forestry to state regulatory agencies. The Lacey Act dealing in endangered species is another. This analysis will only cover state specific laws and regulations affecting forestry and logging.

There are no laws and regulations on timber cutting in Tennessee, but there are voluntary guidelines that Master Loggers – trained loggers – abide by to avoid water quality problems during harvesting operations. These Forestry Best Management Practices (BMPs) are, again, a result of the state's responsibilities under the Clean Water Act.

Business laws affecting the forest products industry in Tennessee are varied and include standard laws and regulations covered below.

Outside of taxation, which we covered later, there are 10 major business law areas that states and the federal government cover:

Employment and Labor Law

There are many government regulations on businesses that employ workers and independent contractors, in the form of federal and state labor laws.

The most common labor laws are:

Wages and hours: According to the US Department of Labor, the Fair Labor Standards Act (FLSA) prescribes standards for wages and overtime pay. This act affects most private and public employment, and requires employers to pay covered employees at least the federal minimum wage and overtime pay of one-and-one-half-times the regular rate of pay (unless they are exempt employees).

Workplace safety and health: The Occupational Safety and Health Administration (OSHA) requires that employers, under the OSH Act, "provide their employees with work and a workplace free from recognized, serious hazards." The OSH Act is enforced through workplace inspections and investigations.

Equal opportunity: Most employers with at least 15 employees must comply with equal opportunity laws enforced by the Equal Employment Opportunity Commission (EEOC). The EEOC mandates that certain hiring practices, such as gender, race, religion, age, disability, and other elements are not allowed to influence hiring practices.

Non-US citizen workers: The federal government mandates that employers must verify that their employees have permission to work legally in the United States. There are several employment categories, each with different requirements, conditions, and authorized periods of stay (for employees who are not legal residents or citizens).

Employee benefit security: If your company offers pension or welfare benefit plans, you may be subject to a wide range of fiduciary, disclosure, and reporting requirements under the Employee Retirement Income Security Act.

Unions: If your business has union employees, you may need to file certain reports and handle relations with union members in specific ways. See the Office of Labor Management Standards' website for more information.

Family and medical leave: The Family and Medical Leave Act (FMLA) requires employers with 50 or more employees to provide 12 weeks of unpaid, job-protected leave to eligible employees for the birth or adoption of a child, or for the serious illness of the employee or a spouse, child, or parent.

Posters: Some Department of Labor states require notices to be shared or posted in the workplace for employees' view (for example, alcohol warnings and hand-washing reminders). Fortunately, the elaws Poster Advisor is an easy way to determine which posters you need, and you can use it to get free electronic and printed copies in multiple languages.

Antitrust Laws

Any time a company conspires with its competitors, third-party vendors, or other relevant parties, it may run afoul of antitrust laws. These are the issues antitrust laws strive to address, such as the following:

Conspiring to fix market prices: Discussing prices with competitors—even if it affects a small marketplace.

Price discrimination: Securing favorable product prices from buyers when other companies can't.

Conspiring to boycott: Conversations with other businesses regarding the potential boycott of another competitor or supplier.

Conspiring to allocate markets or customers: Agreements between competitors to divide up customers, territories, or markets are illegal. This provision applies even when the competitors do not dominate the particular market or industry.

Monopolization: Preserving a monopoly position through the acquisition of competitors, the exclusion of competitors to the given market, or the control of market prices.

Advertising

Rules and government regulations on advertising are generally to protect consumers so there must be care to be truthful in advertising. For example, claims in ads cannot be untruthful or purposely deceptive. Using testimonials in ads comes with additional regulations. Violating these rules can result in fines, which defeats the purpose of your advertising in the first place. There are also labeling laws for consumer products, meaning that they list out ingredients and chemicals within products.

Email Marketing

Closely related to advertising is email marketing. If the business engages in email marketing, there are separate regulations under the CAN-SPAM Act. There are several things that this Act regulates, but some of the main components are:

-Don't use false or misleading headers

-Don't use deceptive headlines

-Indicate that the message is an advertisement

-Include your business's name and address

-Show the customer how to opt out of emails, and honor the opt-out requests promptly

Each separate email violation is subject to hefty fines.

Environmental Regulations

Laws and regulations to protect water quality and air quality along with consumers are found at the federal and state level in all states. Most have permitting systems associated with activities that could affect air or water quality or consumer health.

Privacy

Businesses with staff and employees wind up amassing a large amount of sensitive personal information about their employees. As a result, there are a variety of rules and regulations about how employers must save and secure this data. Businesses cannot disclose an employee's private information, including Social Security number, address, name, health conditions, credit card, bank numbers, or personal history. And the Health Insurance Portability and Accountability Act (HIPAA) prohibits the release of health data without a patient's permission.

Licensing and Permits

Basic business licensing or registration is a requirement in all states, usually through the corporate division of the state's secretary of state office.

Insurance

As soon as an employee is hired, workers compensation insurance is required. All states, with the exception of Texas, require businesses with employees to purchase workers comp insurance.

Reporting Pay Data

If the business employs more than 100 people (or more than 50 as a federal contractor), there is a requirement to report how much each is paid, broken down by race/ethnicity, job category, and gender, to the Equal Employment Opportunity Commission each year.

Collecting Sales Tax

In many states, most businesses that sell physical goods must collect sales tax from customers and submit the tax to their state's revenue department. A few states do not collect sales tax. In general, the law specifies that a business must collect sales tax in any state with which it has a physical connection (known, in legal terms, as a "nexus"). That nexus might mean a physical retail shop, or hiring employees in the state. Even online sellers might have to collect sales tax in any state that they sell to.

If your business has a nexus, you need to collect sales tax except in Alaska, Delaware, Montana, New Hampshire, or Oregon where sales taxes are not law.

In Tennessee, there are no laws that affect business that are not covered in the listing above.

b. Taxation

For most small business owners, government regulation questions almost always begin with taxes. But there's more to taxes than merely paying them—knowing which business taxes to pay, when to pay them, and how to set up your business to account for future tax payments can spare you a ton of headaches when it comes time to write the government a check.

Every company registered within the United States has to pay federal taxes. Most companies will also have to pay state taxes, depending on the state in which the company is registered. These are unavoidable. Avoiding taxes—or deciding not to pay them outright—comes with hefty penalties and potential jail time.

But the kinds of taxes you'll pay depends on how you formed your business. In this regard, not all businesses are treated the same. Sole proprietorships pay taxes differently than, say, S-corporations. Here's a full rundown of the different taxes for business structures to help you determine what your business needs to file. Despite the differences between each kind of business, there are a few general terms you should know:

Income tax: Most businesses file an annual income tax return. Businesses must pay income tax as they earn and receive income, and then file a tax return at the end of the year.

Estimated tax: Estimated tax payments offer an alternative to paying income tax throughout the year as your company earns money. Sole proprietors, partners, and S-corporation shareholders must usually make estimated tax payments if they expect to owe $1,000 or more once they file their return. Note that corporations are usually required to make estimated tax payments if they expect to make more than $500 or more in income.

Employment tax: Companies that have employees are expected to pay taxes related to having staff on their payroll. These include Social Security and Medicare taxes, federal income tax withholding, and federal unemployment tax. For more information, see the IRS page on Employment Taxes for Small Businesses.

Excise taxes: Excise taxes are paid when your business makes purchases on specific goods, and are often included in the price of the product. One common example of excise tax is the purchase of gasoline, where applicable taxes are baked into the price per gallon rather than as a tally at the end of the transaction. You may be under certain excise tax law if you manufacture or sell certain goods, use various kinds of equipment, receive payment for certain kinds of services, and much more. For additional information, refer to the IRS guide on Excise Taxes.

Some businesses also have to collect sales tax, which we'll cover more in a bit.

Taxation of business operations is perhaps the most important of business laws and regulations to affect forestry industry operations.

In Tennessee, the major business taxes in addition to property taxes which are local are:

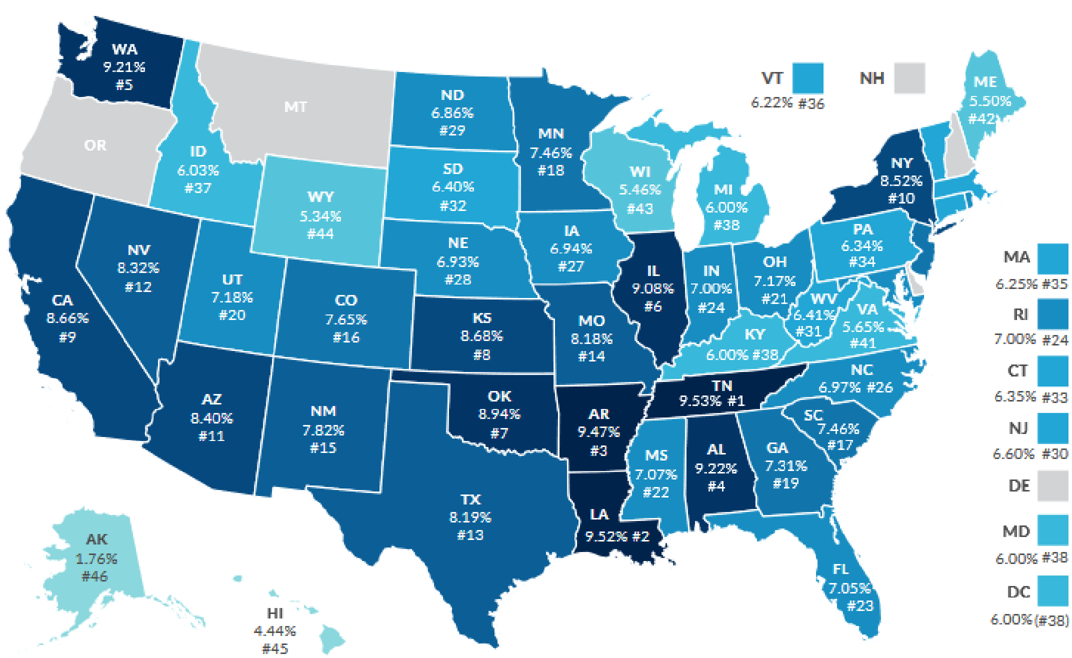
-Sales & Use Tax – applies to businesses operating as a wholesaler, retailer or seller in Pennsylvania.

Corporation/Small Business Income Tax

Gross Receipts Tax

The major taxes to compare are the sales tax and corporate and small business Income tax. The sales tax rate for Tennessee is 9.53% and ranks it 1th in the country (i.e. this is the highest sales tax rate in the nation).

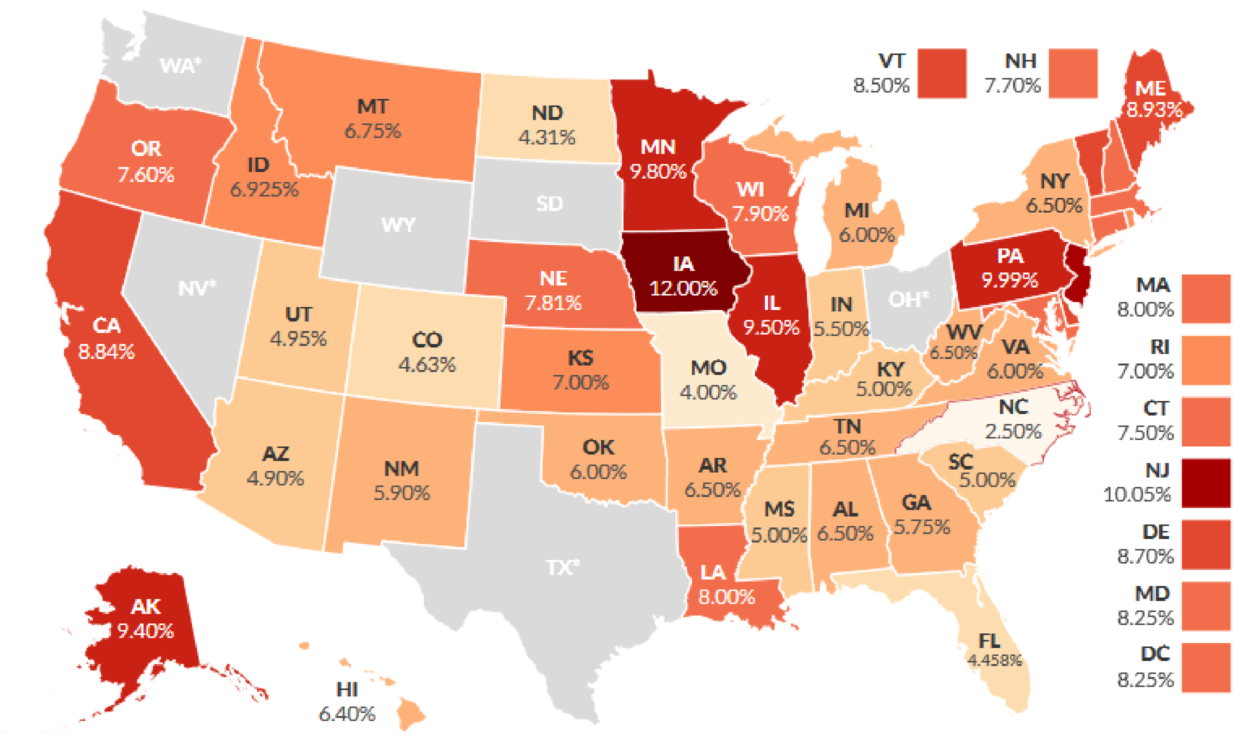
Figure 68 **Sales Tax Rates for States in the US**



Source: Tax Foundation

For corporate and small business taxes, Figure 69 shows state rates. Tennessee's highest business tax rate is 6.5% ranking it in the middle with the highest rates at Iowa at 12%, and 10.05% in New Jersey and the lowest with no business income tax in Ohio, Nevada, South Dakota, Texas, Washington and Wyoming. However, Ohio, Nevada, Texas, and Washington have business gross receipts taxes thought to be more problematic for business than corporate income taxes. South Dakota and Wyoming are the only states that do not levy either a business income or gross receipts tax.

Figure 69 **Business tax rates by US state 2020**



Source: Tax Foundation

d. Energy Costs

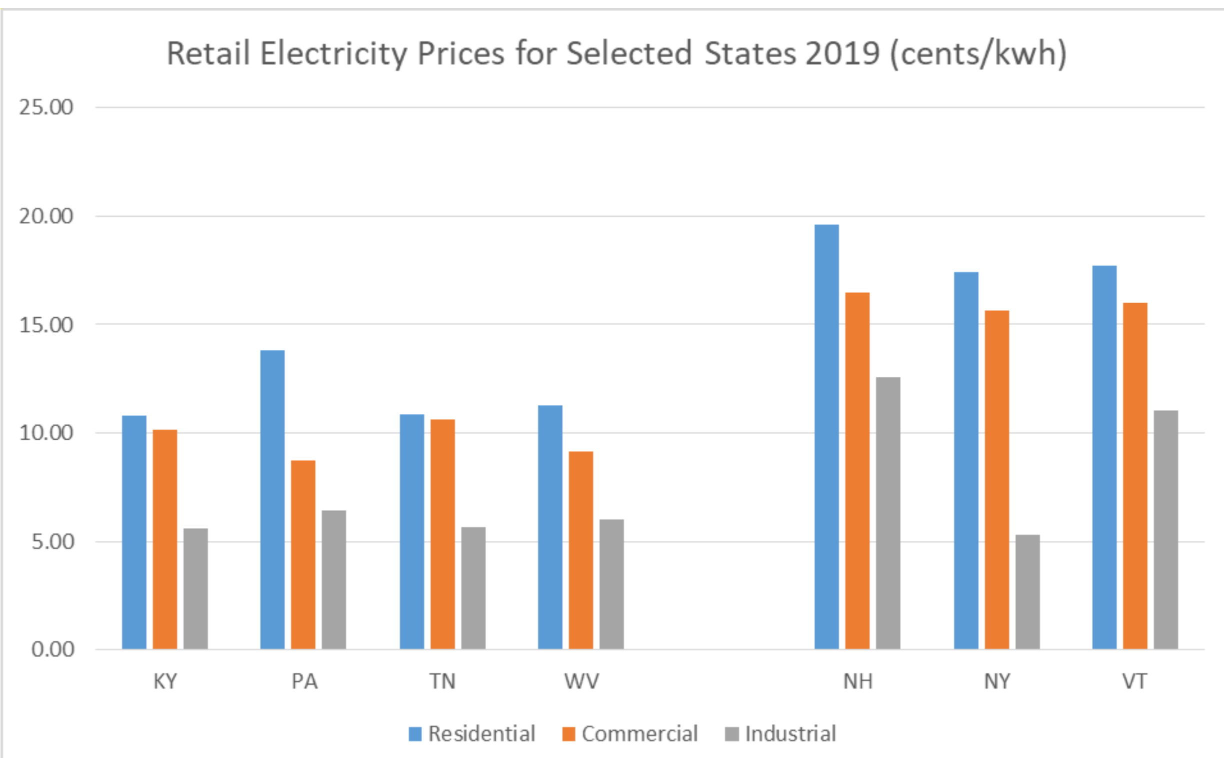
Of all the utilities associated with forest products manufacturing, electricity costs are the most critical to influence positive economics that allow for facilities to be built and operate successfully. Virtually all the machinery associated with forest products manufacturing runs on electricity.

Fossil fuel prices are important for the raw material supply chain infrastructure but those prices generally do not vary much from state to state or region to region in the US and are based on world supply and demand. Because of the way electricity grids are operated and the fact that the source of the power and the infrastructure to get it to customers is vastly different from state to state and region to region, electricity prices vary considerably.

Retail electricity costs in the three-state NH/VT/NY region are generally higher than national averages – particularly for residential customer rates and are certainly higher than our benchmarking states of Kentucky, Pennsylvania, Tennessee & West Virginia. The sector we are most interested in is for industrial retail electricity rates.

As we noted in the second report in this series - within each state there are multiple electric utilities, each with a unique service territory and in some cases with competitive suppliers. Rates that a user pays for electricity may depend upon their utility service territory, competitive supplier, time of use and other factors. In other words, it is possible to get, and many large industrial power users do, a special deal that is lower than the average for that sector. The electricity cost comparisons below reflect that complexity and are average rates (Figure 70).

Figure 70 **Retail Electricity Prices for Selected States 2019**



Source: US Energy Information Administration

Tennessee's commercial and industrial retail electricity rates on average are 10.65 cents and 5.68 cents respectively, among the lower ranges in the benchmarked states but generally lower than the NH, NY and VT region except for NY's industrial rate.

e. Infrastructure and transportation

The most important infrastructure issue for the forest products industry is transportation. This generally refers to public road infrastructure for getting raw logs/timber feedstock to the mill for manufacturing and getting finished product to market. Virtually all feedstock procurement is truck traffic while finished product shipping usually starts out (and often is finished with) trucking and then sometimes uses rail access for long hauls and then shipping for overseas markets.

In Tennessee, commercial road issues are similar to other states in the east. Road freight is increasing on large trucks and the infrastructure of interstate, state and local road systems face shortages on funding so critical issues like bridge upkeep and re-paving and maintenance are always chronic issues. The commercial road infrastructure – i.e. having adequate number of roads to access all geographies – is largely complete in Tennessee as with the other states in our study.

The TRIP report of 2019 which is a national report on commercial road issues in the US[27], highlights that commercial freight by road is increasing, and today, more freight (nearly 75% by value) travels to market through the nation's road system. They project that from 2016-2045 freight moved will increase by 104% by value and 44% by weight, and truck freight moved annually in the US, is expected to increase by 91 percent in value (inflation-adjusted dollars) and 41 percent by weight. Clearly the road systems are critical to the forest products industry.

[27] America's Rolling Warehouses: Opportunities and Challenges with the Nation's Freight Delivery System, TRIP, 2019

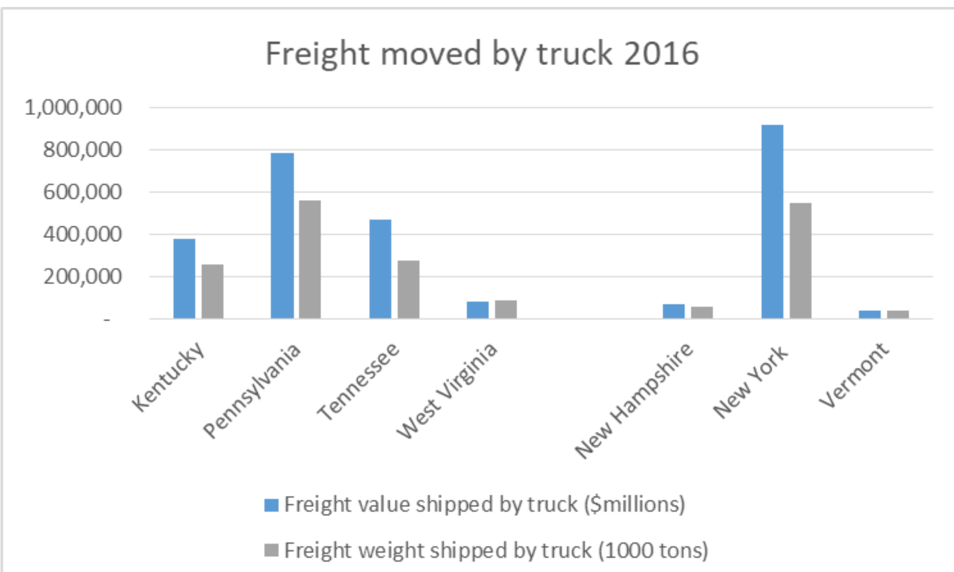
Figure 71 **Commercial Freight Method US**

Mode	By Value	By Weight
Truck	72%	66%
Rail	4%	10%
Water	2%	4%
Air	3%	0.03%
Multiple Modes	14%	3%
Pipeline	4%	16%

Source: TRIP Report, 2019

Of the seven states in our study, only Pennsylvania and New York are in the top 5 in the US in freight moved by truck.

Figure 72 **Freight moved by truck - selected states 2016**



Source: TRIP report 2019

Key bottlenecks in truck traffic (where traffic is slowed to much less than posted speed limits due to excess traffic amounts) shown in Figure 73 shows that Tennessee is in the list of top 20 congested trucking routes in the US for sections of interstate around Nashville.

Figure 73 **Freight congestion US highways - top 20 bottlenecks**

RANK	STATE	Location Description	Average Speed	Average Speed During Peak Hours	Average Speed During Non-Peak Hours
1	New Jersey	Fort Lee: I-95 at SR 4	32	23	35
2	Georgia	Atlanta: I-285 at I-85 (North)	35	23	41
3	Georgia	Atlanta: I-75 at I-285 (North)	38	27	43
4	California	Los Angeles: SR 60 at SR 57	42	35	44
5	Texas	Houston: I-45 at I-69/US 59	34	24	38
6	Ohio	Cincinnati: I-71 at I-75	44	36	47
7	Illinois	Chicago: I-290 at I-90/I-94	24	18	27
8	Tennessee	Nashville: I-24/I-40 at I-440 (East)	41	28	48
9	Georgia	Atlanta: I-20 at I-285 (West)	45	38	47
10	California	Los Angeles: I-710 at I-105	38	27	43
11	Indiana	Gary: I-65 at I-80	47	45	48
12	Colorado	Denver: I-70 at I-25	38	30	42
13	Texas	Houston: I-10 at I-45	40	28	46
14	Connecticut	Hartford: I-84 at I-91	45	35	49
15	California	San Bernardino: I-10 at I-15	45	36	49
16	Texas	Dallas: I-45 at I-30	40	29	45
17	Illinois	Chicago: I-90 at I-94 (North)	31	17	37
18	Michigan	Detroit: I-94 at I-75	39	31	44
19	Louisiana	Baton Rouge: I-10 at I-110	37	29	41
20	New York	Brooklyn: I-278 at Belt Parkway	34	26	37

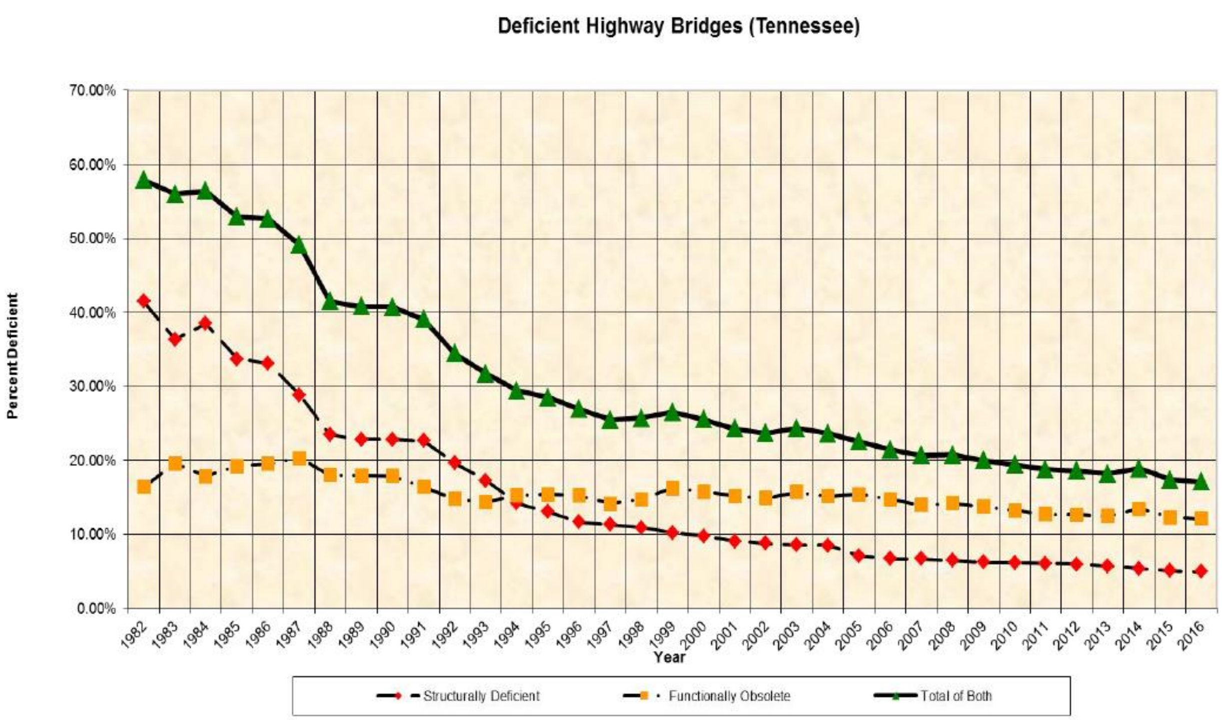
Source: TRIP Report 2019

The American Society of Civil Engineers (ASCE) conducts a state by state analysis of infrastructure, including transportations systems. In their recent report for Tennessee, two key transportation infrastructure reviews were included for bridges and roads. For bridges, the report says:

> "At the time of last reporting (spring of 2016), Tennessee had a total of 19,793 bridges on public roads with a length greater than 20 feet and not maintained by a Federal Agency. Of those bridges, 978, or 5%, are classified as structurally deficient (SD). This means one or more of the key bridge elements, such as the deck, superstructure or substructure, is considered to be in "poor" or worse condition. Another 2,407 bridges, or 12%, are classified as functionally obsolete (FO). This means the bridge does not meet design standards in line with current practice. While these bridges do not require replacement, their outdated designs mean they could use modernization to increase safety and improve traffic flow.

The graph in Figure 74 shows the history of Tennessee's SD and FO bridge percentage over time. When comparison numbers were last available (fall of 2015), Tennessee has the lowest number of combined SD and FO bridges of all the Southeastern States. Additionally, Tennessee ranked #7 (Nationwide) in terms of having the lowest combined SD and FO percentage. As demonstrated in the chart, the trend of structurally deficient bridges has been decreasing significantly from the 1980s to today, thanks to a concerted effort to repair or replace these bridges."

Figure 74 **Tennessee Highway Bridge Deficiency 1982-2016**



Source: ASCE Tennessee Infrastructure Report Card 2016

For roads in Tennessee, the ASCE says:

"Tennessee has over 90,000 miles of roadways and boasts superior roads when compared to neighboring and peer states. Tennessee consistently ranks in the top 5 states for overall roadway system quality since the poll in Overdrive magazine's annual survey of owner-operators' opinions began in 1996 (www.overdriveonline.com). However, due to inadequate funding levels, roads in Tennessee are beginning to exhibit some deterioration in performance. The efficiency of Tennessee's transportation system, particularly its highways, is critical to the health of the state's economy.

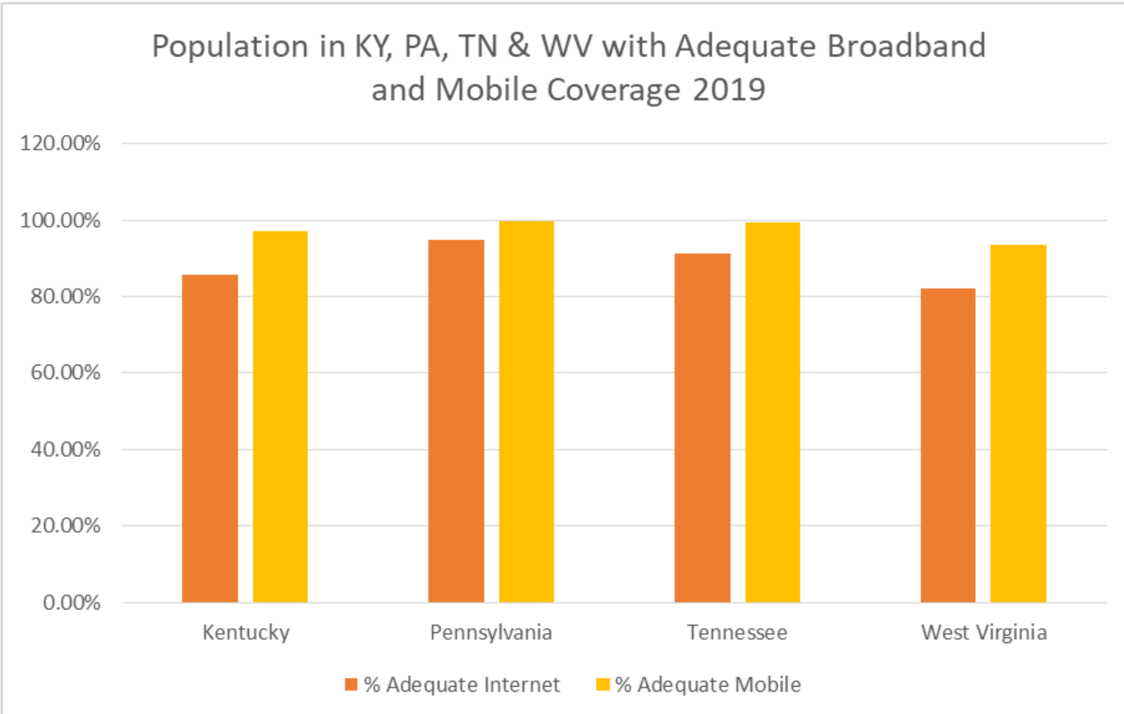
Annually, $433 billion in goods are shipped from sites in Tennessee and another $266 billion in goods are shipped to sites in Tennessee, mostly by truck. The Road Information Program (TRIP) (http://www.tripnet.org/docs/TN_Transportation_by_the_Numbers_TRIP_Report_Jan_2016.pdf) estimates that Tennessee roadways that lack some desirable safety features, have inadequate capacity to meet travel demands, or have poor pavement conditions cost the state's residents approximately $5.6 billion annually. These costs come in the form of additional vehicle operating costs (including accelerated vehicle depreciation, additional repair costs, and increased fuel consumption and tire wear), the cost of lost time and wasted fuel due to traffic congestion, and the financial cost of traffic crashes. Population increases and economic growth in Tennessee have resulted in an increase in the demand for mobility as well as an increase in vehicle miles of travel (VMT).

From 1990 to 2013, annual VMT in Tennessee increased by 52%, from 46.7 billion miles traveled annually to 71.1 billion miles traveled annually. Based on population and other lifestyle trends, TRIP estimates that travel on Tennessee's roads and highways will increase by another 30 percent by 2030. Since a large portion of the miles traveled are on TDOT (Tennessee Department of Transportation) maintained roads, and better records are available through TDOT, this study is primarily based on such roadways.

The condition of Tennessee roads is indicated by the quality of its pavement surfaces. TDOT's Pavement Management System, which was instituted in 1997, incorporates ride smoothness and distress data (cracking, rutting, patching, etc.). These are combined into a Pavement Quality Index (PQI), which is based on a scale of 0-5, with 5 being very good. More than 80% of TDOT-maintained roads are in the good to very good categories. However, locally maintained roads do not fare as well. When all roads in Tennessee are considered, 11 percent of Tennessee's major locally (those under city, town, and county jurisdictions) and state-maintained urban roads and highways have pavements in very poor to poor condition, while 29 percent are in fair condition and the remaining 60 percent are in good to very good condition."

Another important infrastructure issue is access to fast broadband internet and mobile phone access. While improving each year, especially in rural areas, not all of the population in Tennessee has adequate broadband internet or mobile service (Figure 75).

Figure 75 **Broadband and Mobile Service in KY, PA, TN & WV 2019**



Source: broadbandnow.com

In Tennessee 91.1% of the population has adequate internet coverage while 99.5% has adequate mobile service.

f. Research and Development

Having in-state research and development activities in forest products and forest products manufacturing is very important to the future progress within the industry. In the past, many forest products companies did research and development in-house but with structural changes within the industry over the last 20 years, very little of that occurs today. University research cooperatives and industry trade group research has also dwindled. Other countries, most notably Canada and Finland have re-directed and re-energized their research and development efforts in the forest products industry.

In the U.S. today, most forest products research occurs in government or university labs. The USDA Forest Service has a series of forest products labs where research and development on forest products is conducted. The output from the labs is available for all in the public and private sector to use.

The Forest Products Laboratory (FPL) in Madison, Wis. is one of seven national Forest Service research facilities. FPL scientists focus their research around five areas:

Advanced Composites

Wood composite technologies have been used for decades to create building and home furnishing products. Composites are used for a number of structural and non-structural applications including interior paneling, sheathing, furniture, and support structures in many different types of buildings.

Advanced Structures

The FPL is a world leader in housing-related areas such as engineered wood products and structures, moisture control, material design and performance, coatings and finishes, adhesives, and wood preservation. Creating advanced technologies and alternative building methods can greatly enhance the value of wood in residential, non-residential, and transportation structures.

Forest Biorefinery

Trees are one of the best potential sources of biological fuel and chemicals. They grow in marginal soils unsuitable for agriculture; do not require fertilizer, herbicides, or pesticides; and accumulate biomass density for several years before incurring harvest costs. Converting wood resources into liquid fuels and chemical feedstock is becoming more cost competitive thanks in part to FPL research.

Nanotechnology

FPL scientists are conducting nanoscale research to learn more about the fundamental components of wood. Nanotechnology is a multi-disciplinary field of applied science and technology. Nanocellulose holds revolutionary potential for the forest products sector and is the economic key to accelerated forest restoration. Nanocellulose can be a cost-effective substitute for non-renewable resources in all manufacturing sectors.

Woody Biomass Utilization

U.S. forests contain a substantial amount of small-diameter, overstocked, and underutilized material. FPL scientists study small-diameter woody material, identify potential uses, and provide technology that can help rural-based communities create successful businesses from the by-products of forest management projects. FPL research explores the potential of small-diameter roundwood as a structural material for bridges, boardwalks, trail structures, picnic shelters, storage sheds, and other rustic buildings.

In Tennessee, The Center for Renewable Carbon, at the University of Tennessee, Institute of Agriculture, develops new and/or improved bioenergy sources, biorefinery processes, bioproducts, and biomaterials that coordinates the science, knowledge transfer, and trains the workforce required to develop a sustainable and economically viable bioeconomy. The Center works in the research areas of materials, chemistry, fuels, power and manufacturing excellence.

West Virginia

West Virginia - West Virginia has a total area of 24,034.5 square miles, including 189.1 square miles of water, making it the 41st-largest state by area. West Virginia is bordered by Ohio, Pennsylvania, Kentucky, Maryland, and Virginia.

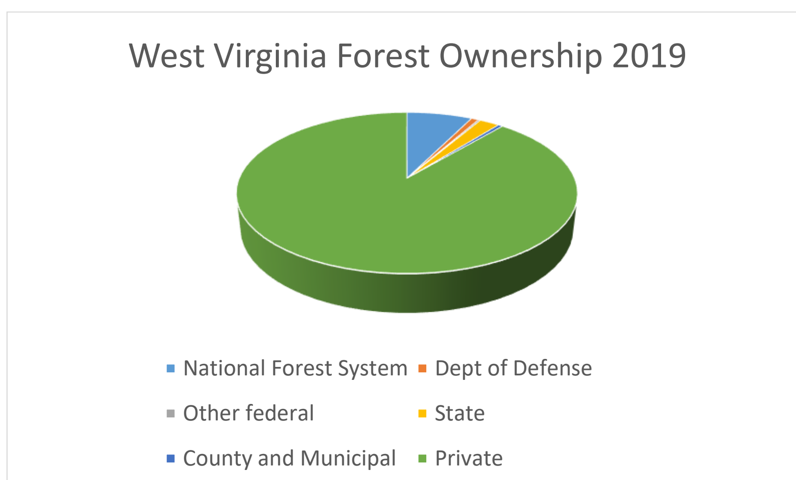
a. Raw Material

1. Forest Area and Ownership

   The West Virginia timberland area covers 11,708,830 acres (Figure 76).

Figure 76 ***West Virginia Forest Area and Ownership***

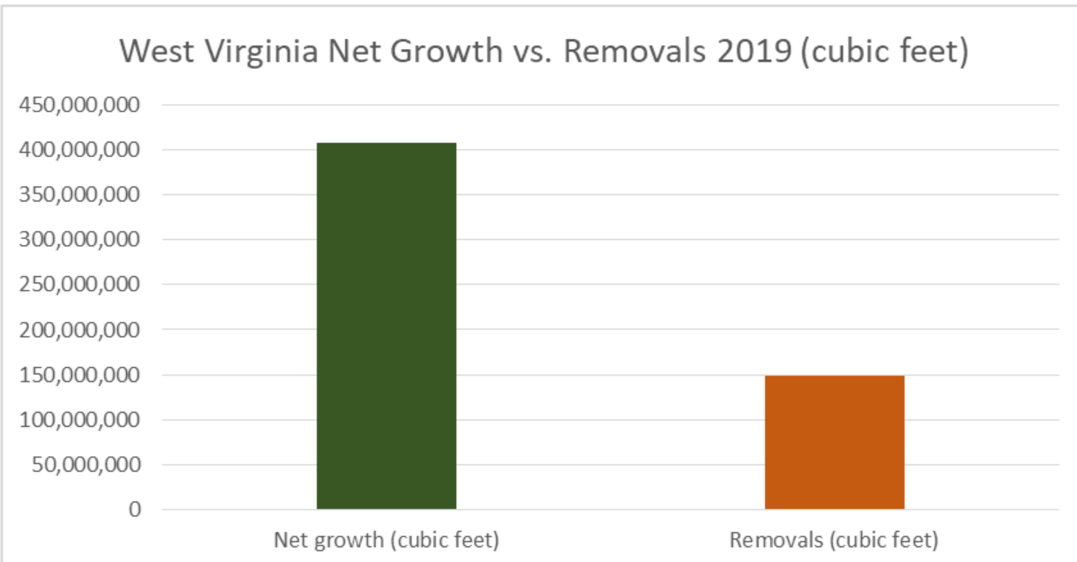
Owner Type	Acreage
National Forest System	866,313
Dept of Defense	96,622
Other federal	28,045
State	264,750
County and Municipal	61,133
Private	10,391,967
Total	11,708,830



Over 88% of those acres are owned privately while only 12% is owned by the public sector. The federal government owns just over 990,980 acres while the State of West Virginia and local government owns just 325,883 acres. Most of West Virginia's forest are mixed hardwood.

2. Harvest levels – From up-to-date data from the USDA Forest Inventory and Analysis dataset, the net growth to removals data for West Virginia looks positive (Figure 77).

Figure 77 ***West Virginia Timber Growth vs. Harvests 2019***



Source: USDA Forest Service FIA

The most recent FIA data shows that West Virginia has a 2.73 net growth to removal ratio for all timberland – meaning that each year, the State is growing 2.73 times more than it is removing from harvests and loss of timberland to other uses.

3. By-products – West Virginia timber by-products are primarily sawmill residues which are used mostly in the pulp and paper sector. Very little in-woods chipping is conducted as most timber harvesting is conducted with traditional chainsaw and skidder operations primarily designed to deliver sawlogs to the sawmills in the state. Secondary production of hardwood pulpwood occurs but is not significant and not a growth area. Some residues are used to generate electricity but little in stand-alone biomass electricity plants. Instead, most are through smaller generation facilities and combined heat power at mills – primarily in the forest products sector. According to the

US Energy Information Agency less than 2% of energy used in West Virginia is from biomass sources.

4. Delivered wood cost – In West Virginia, hardwoods are the main species groups harvested (over 95%) and wood costs are competitive with other hardwood producing regions in the U.S. From various market sources, late 2020 delivered (to the sawmill) timber prices range from a low of $200/thousand board feet (Mbf) to over $1,000/Mbf for White Oak and Black Walnut. White Oak has seen increasing demand for the barrel stave market for the growing spirits sector for liquors, wine and beer. There is good demand for hardwood sawlogs, the mainstay of West Virginia timber markets.

Low quality timber, which in this part of the country is hardwood pulpwood is being sold, on average, for $45-50/ton delivered to the pulp mill.

5. Wood procurement practices

The majority of timber harvested in West Virginia comes from private land although annually a relatively small amount public timber from state and National Forest land is sold and harvested each year. Best Management Practices (BMPs) are required by law (West Virginia Code 19-1B-7(g)) for timber harvesting activities in West Virginia. They are practices that are intended to protect water quality when dealing with agricultural and silvicultural operations.

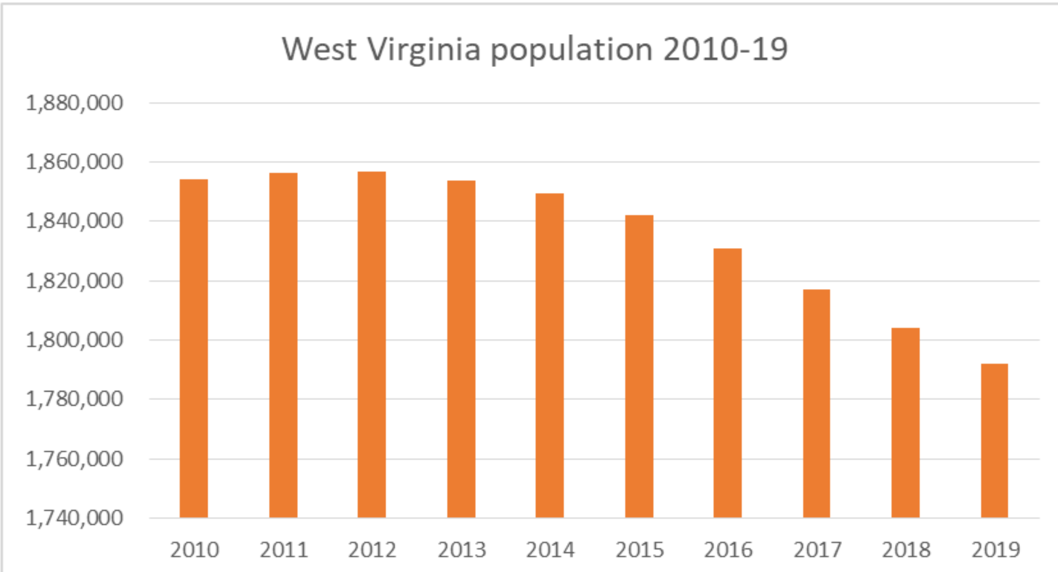
Timber harvesting is generally conducted with chainsaws and skidders along with bulldozers in the forests of West Virginia due to the mountainous nature of the landscape. A small number of timber harvesters employ mechanization using tracked feller bunchers and grapple skidders but most harvesting is done with chainsaws and skidders. Silvicultural practices used include clearcut, selections and shelterwood methods, though small clearcuts are often used as the land naturally regenerates the full range of hardwood species using this regeneration method. Logging is conducted year-round with stoppages during wet soil periods.

b. Workforce

1. Demographics

West Virginia's population in 2019 was 1,792,147 (Figure 78) and is the only state in this study with a declining population. West Virginia ranks 40th in the US for population. It ranks 40th in the rate of growth (loss) from 2010-2019 among US states.

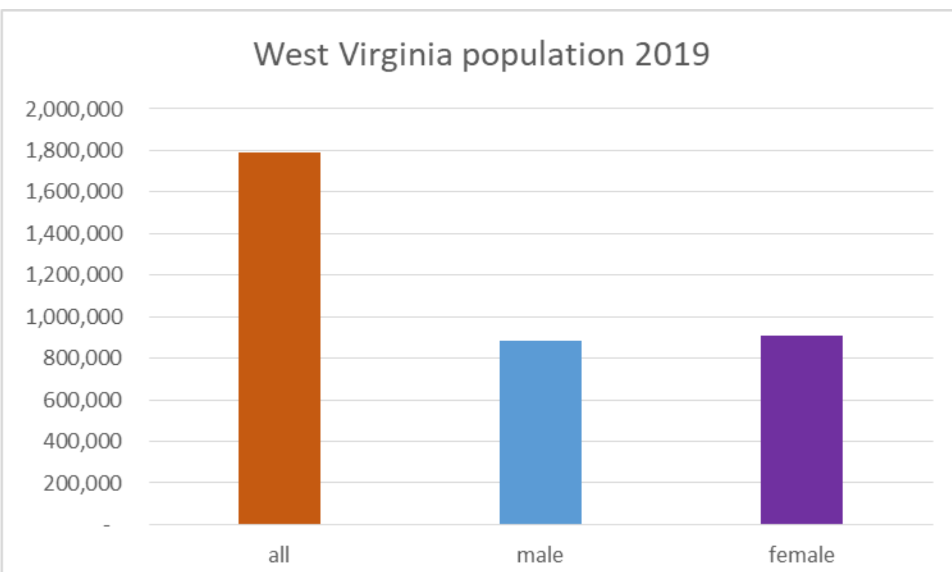
Figure 78 ***West Virginia Population 2010-19***



Source: US Census

West Virginia's population in 2019 was 51% female and 49% male (Figure 79). This is similar to most states in the US.

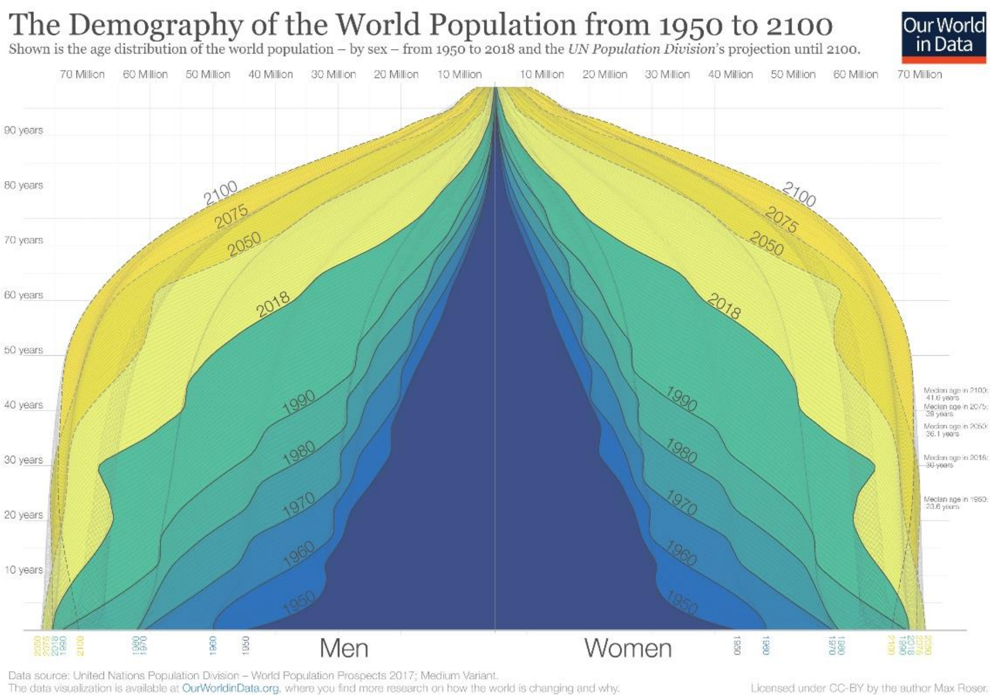
Figure 79 ***West Virginia Population Gender Distribution 2019***



Source: US Census

A more important and informative dataset on West Virginia population is found in Figure 81. Before digging into this West Virginia demographic information, some background on population dynamics is important to discuss. Figure 80 is from the United Nations and is diagram that shows world population and its changes over time and projections into the future.

Figure 80 ***World Population Dynamics***



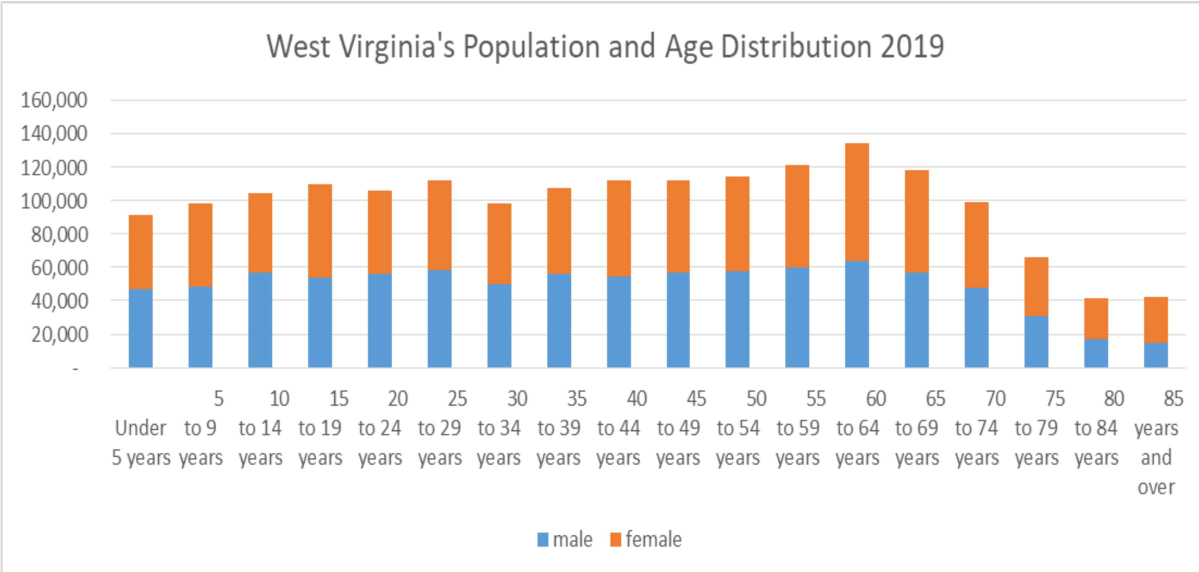
Source: United Nations

The figure shows world population from 1950 (2.5 billion people) to 2019 (7.7 billion) and projections to 2100 (11.2 billion). The most important finding from this figure is that age cohorts (10 years, 20 years etc) were dying at a much earlier age many decades ago compared to 2019. It simply means that infant mortality has reduced and average age at death has increased tremendously comparing 1950 to 2019. We are a healthier and older population today than we have ever been.

This is similar to what is occurring in West Virginia and all US states. From a labor perspective for the forest products industry, an increasing population in the working age cohorts from 20 to 50 represents good change. But an aging population is a concern in virtually all US states.

West Virginia's 2019 population shows a reasonable distribution across ages and genders (Figure 81).

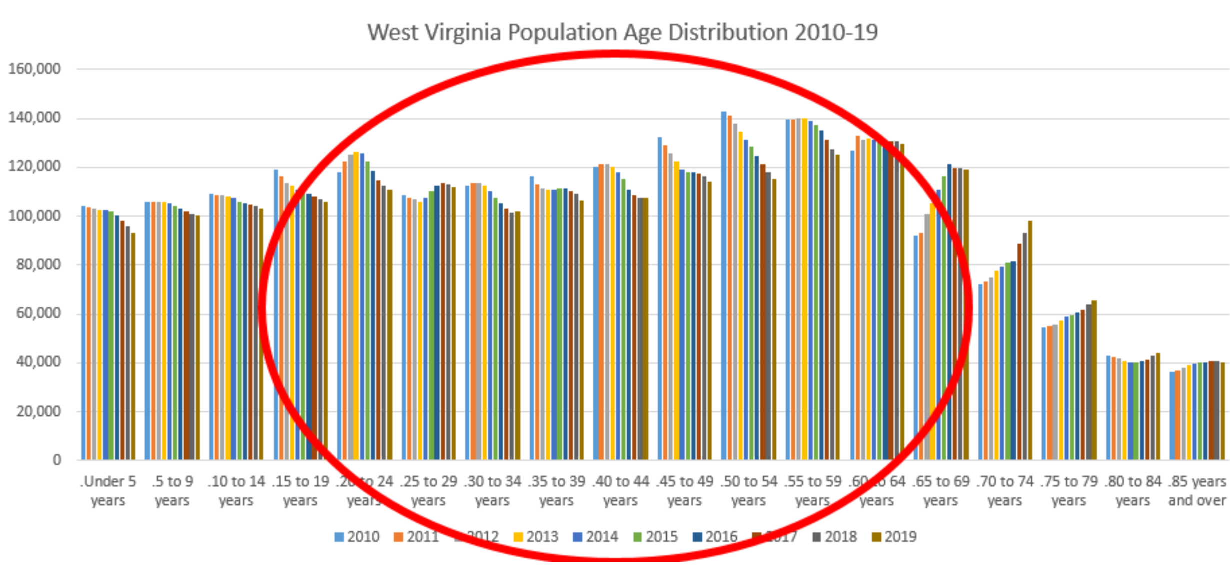
Figure 81 ***West Virginia Age and Gender Distribution 2019***



Source: US Census

West Virginia's age distribution over time – from 2010 to 2019 – is probably more telling (Figure 82). Most of the critical labor age categories in the 20-54 age range are showing a declining population over time except for the 25-29 age class. The over 55 age classes all show increases over this period – a troubling sign of an aging population with fewer working age people available over time.

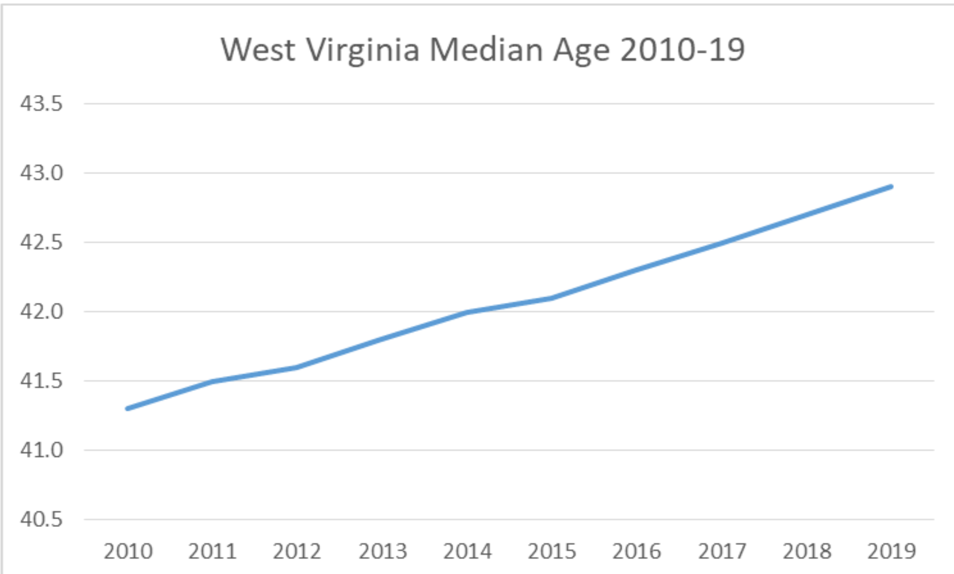
Figure 82 **West Virginia Age Distribution 2010-2019**



Source: US Census

Figure 83 further reinforces the aging workforce data with an increasing median age trend from 2010-2019.

Figure 83 **West Virginia Median Age 2010-19**

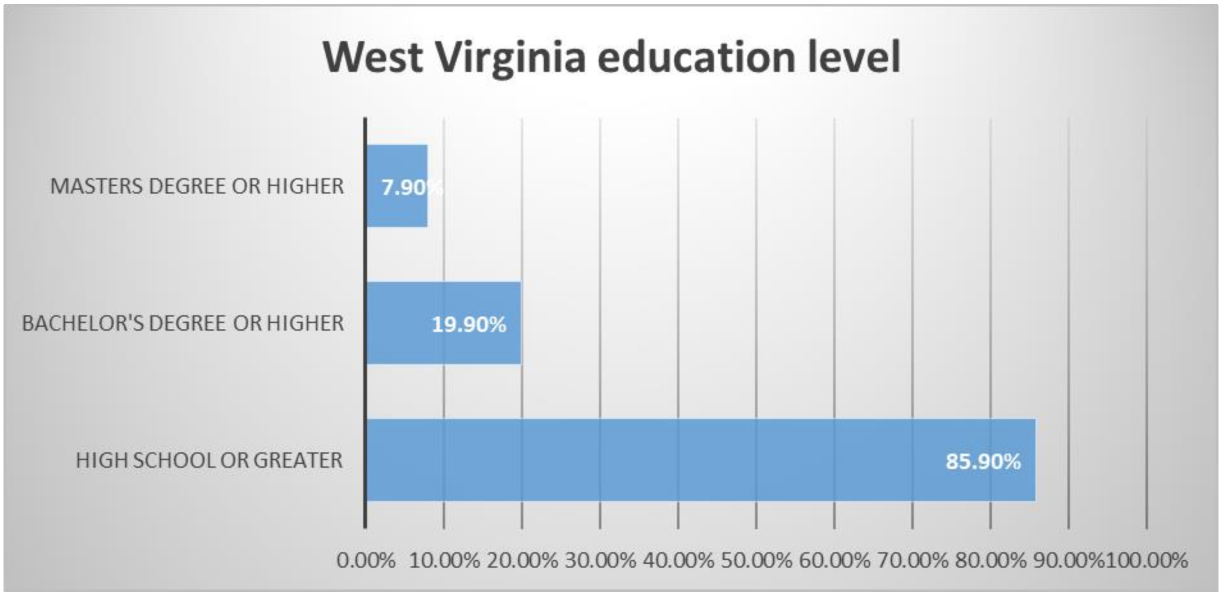


Source: US Census

2. Level of education

Education level of a state's population is important workforce information. In West Virginia, just under 86% of the working-age population has at least a high school education. A bachelor's degree or higher is held by just under 20% of the population and 7.9% of the population holds a masters degree or higher.

Figure 84 **West Virginia Education Level**



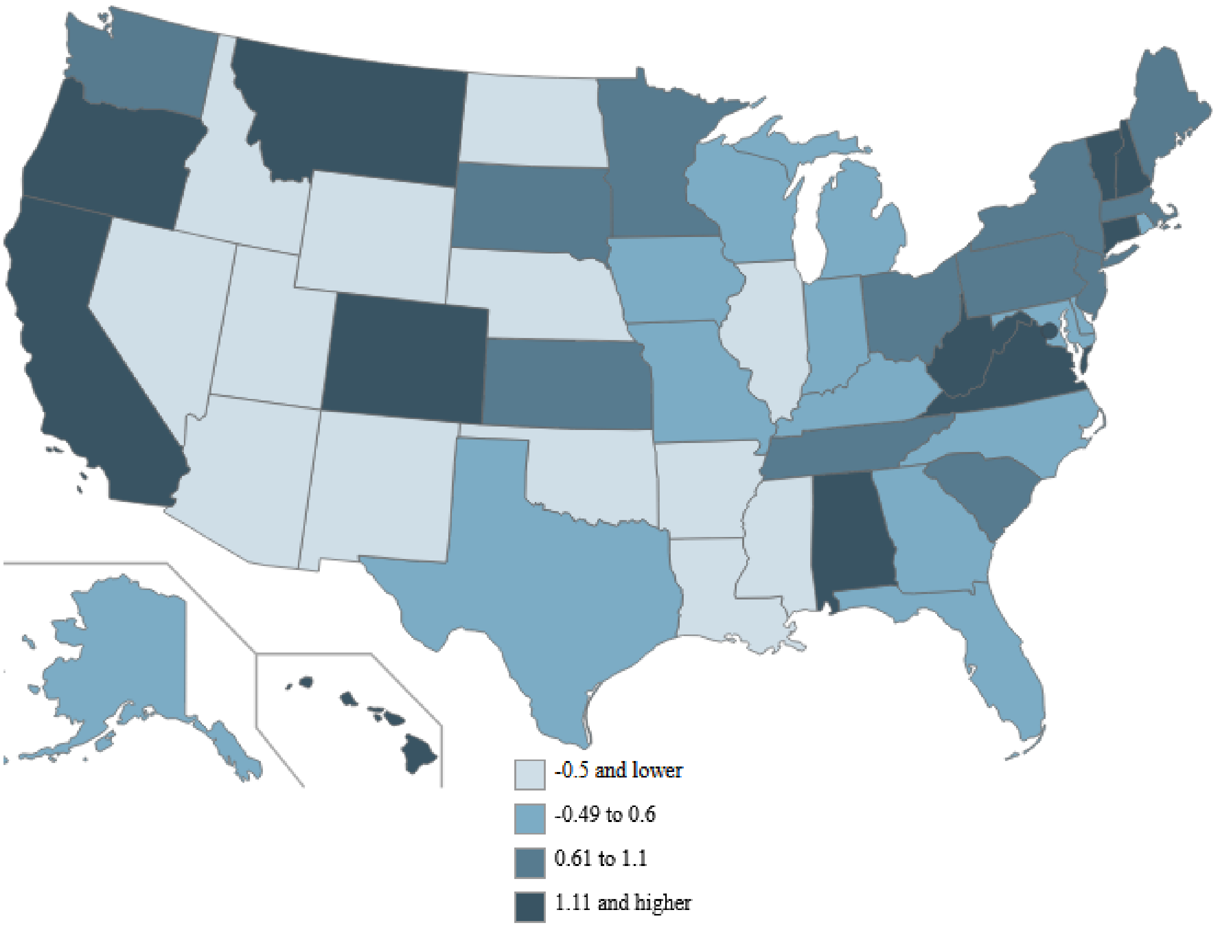
Source: US Census

3. Typical labor costs

In 2019 the US Department of Labor, Bureau of Labor Statistics for the first time published national statistics on labor productivity[28]. This data – focused on the 2007-2017 period provides insights into the differences in labor cost and productivity among the US state. Figure 85 shows changes in labor productivity in US states from 2016-17.

[28] https://www.bls.gov/opub/mlr/2019/article/bls-publishes-experimental-state-level-labor-productivity-measures.htm

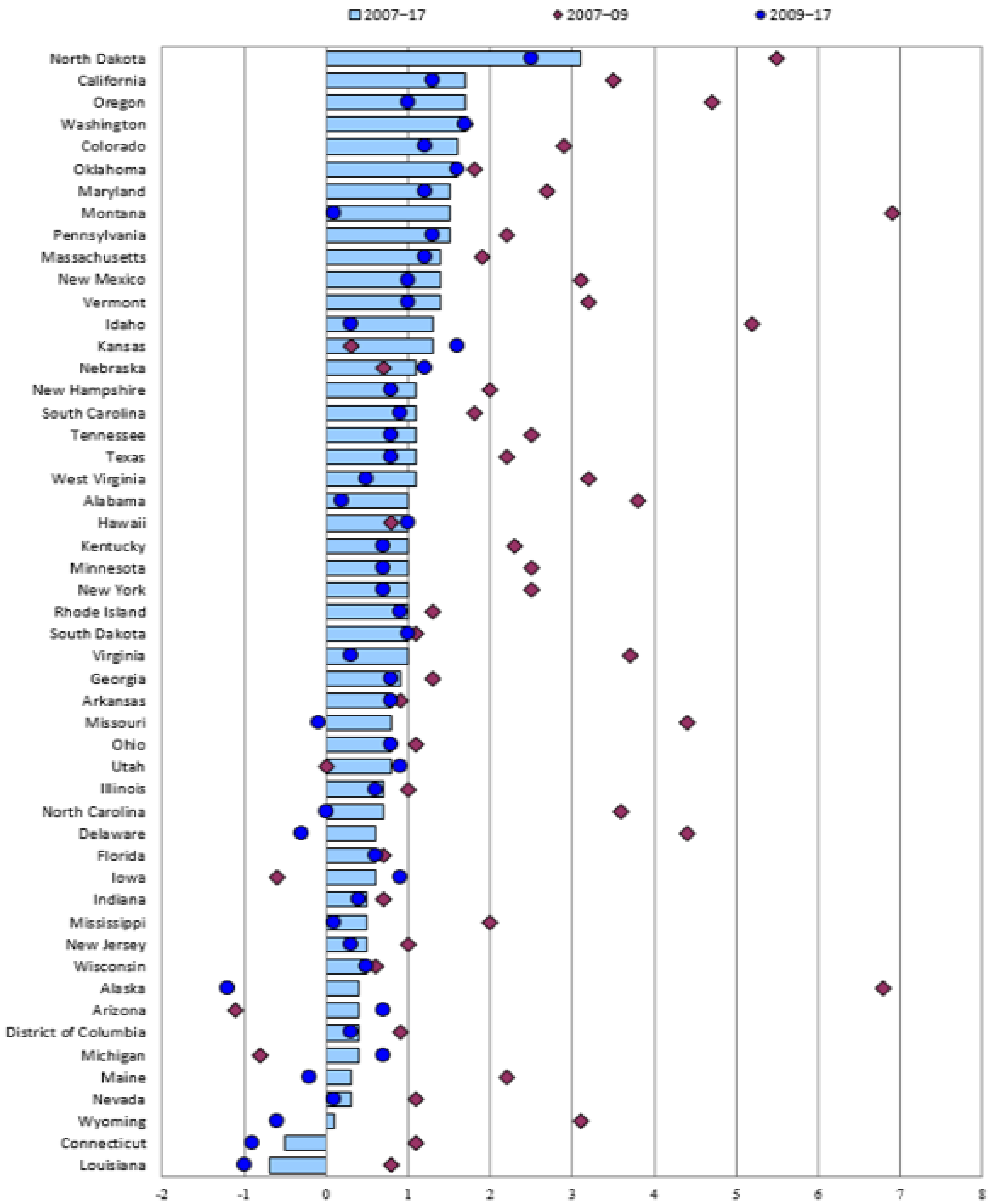
Figure 85 **US Labor Productivity Improvement 2016-17**



Source: US Department of Labor, Bureau of Labor Statistics

The map shows NH and VT among the most improved labor productivity states along with West Virginia in our benchmarked sample. Comparing the states nationwide for the 10-year 2007-2017 period (Figure 86) may be more useful.

Figure 86 **US Labor Productivity Changes 2007-17**



Source: U.S. Bureau of Labor Statistics.

In this graph, the states we are focused on show the following ranking:

Figure 87 **State rankings in worker productivity improvements 2007-2017**

	National labor productivity ranking 2007-17
Pennsylvania	9
Vermont	12
New Hampshire	16
Tennessee	18
West Virginia	20
Kentucky	23
New York	25

Source: US Dept of Labor, Bureau of Labor Statistics 2019

More specific labor cost and productivity data for West Virginia follows.

West Virginia had modest gains in worker productivity during the 2007-17 decade (Figure 88) for the states in question. Unit labor costs were up 1.2% during the period.

Figure 88 **Worker Productivity Changes 2007-2017**

Region and state	Labor productivity	Output per worker	Output	Hours	Employment	Real hourly compensation	Unit labor costs
New Hampshire	1.1	1.3	1.6	0.5	0.3	0.4	0.9
New York	1	0.8	1.8	0.8	1	–0.1	0.7
Vermont	1.4	1.3	1.1	–0.3	–0.1	0.6	1.1
Kentucky	1	0.5	0.7	–0.3	0.2	1.1	1.7
Pennsylvania	1.5	1.4	1.6	0.1	0.2	0.5	0.7
Tennessee	1.1	1.1	1.6	0.5	0.5	0.4	1
West Virginia	1.1	1.1	0.6	–0.4	–0.5	0.5	1.2

Source: US Dept of Labor, Bureau of Labor Statistics 2019

Unit labor costs for West Virginia were up during the 2007-17 period but only less than Kentucky.

c. **Regulatory Climate**
1. Relevant laws and regulation

There are two areas of relevant laws and regulations to benchmark for this effort: forestry/logging and business. Forestry laws relate to the requirements placed on harvesting of timber for forest industry manufacturing. Relevant business laws are important because they can help or hinder the advancement and expansion (or contraction) of forest industry. Only a few states in the US have comprehensive forest practices acts (California, Oregon, Washington, & a lesser extent Maine) although many that do not have comprehensive acts have laws that are often contained in the comprehensive acts. All states are covered by a series of laws not discussed here since they cover all states equally. The federal Clean Water Act is one such law that defers enforcement of the law's requirements for forestry to state regulatory agencies. The Lacey Act dealing in endangered species is another. This analysis will only cover state specific laws and regulations affecting forestry and logging.

Loggers in West Virginia are licensed by the State. The Timber Operator License requires the logger to be certified – meaning trained through the West Virginia logger training program. Every 2 years the logger must update their license and logger certification.

Best Management Practices for Logging are required of licensed loggers in the State. Further, all logging operations require a Timbering Operations Notification Form be filed with the West Virginia Division of Forestry. In the form, the logger certifies that they will follow Best Management Practices in their logging operation.

Business laws affecting the forest products industry in West Virginia are varied and include standard laws and regulations covered below.

Outside of taxation, which we covered later, there are 10 major business law areas that states and the federal government cover:

Employment and Labor Law

There are many government regulations on businesses that employ workers and independent contractors, in the form of federal and state labor laws.

The most common labor laws are:

Wages and hours: According to the US Department of Labor, the Fair Labor Standards Act (FLSA) prescribes standards for wages and overtime pay. This act affects most private and public employment, and requires employers to pay covered employees at least the federal minimum wage and overtime pay of one-and-one-half-times the regular rate of pay (unless they are exempt employees).

Workplace safety and health: The Occupational Safety and Health Administration (OSHA) requires that employers, under the OSH Act, "provide their employees with work and a workplace free from recognized, serious hazards." The OSH Act is enforced through workplace inspections and investigations.

Equal opportunity: Most employers with at least 15 employees must comply with equal opportunity laws enforced by the Equal Employment Opportunity Commission (EEOC). The EEOC mandates that certain hiring practices, such as gender, race, religion, age, disability, and other elements are not allowed to influence hiring practices.

Non-US citizen workers: The federal government mandates that employers must verify that their employees have permission to work legally in the United States. There are several employment categories, each with different requirements, conditions, and authorized periods of stay (for employees who are not legal residents or citizens).

Employee benefit security: If your company offers pension or welfare benefit plans, you may be subject to a wide range of fiduciary, disclosure, and reporting requirements under the Employee Retirement Income Security Act.

Unions: If your business has union employees, you may need to file certain reports and handle relations with union members in specific ways. See the Office of Labor Management Standards' website for more information.

Family and medical leave: The Family and Medical Leave Act (FMLA) requires employers with 50 or more employees to provide 12 weeks of unpaid, job-protected leave to eligible employees for the birth or adoption of a child, or for the serious illness of the employee or a spouse, child, or parent.

Posters: Some Department of Labor states require notices to be shared or posted in the workplace for employees' view (for example, alcohol warnings and hand-washing reminders). Fortunately, the elaws Poster Advisor is an easy way to determine which posters you need, and you can use it to get free electronic and printed copies in multiple languages.

Antitrust Laws

Any time a company conspires with its competitors, third-party vendors, or other relevant parties, it may run afoul of antitrust laws. These are the issues antitrust laws strive to address, such as the following:

Conspiring to fix market prices: Discussing prices with competitors—even if it affects a small marketplace.

Price discrimination: Securing favorable product prices from buyers when other companies can't.

Conspiring to boycott: Conversations with other businesses regarding the potential boycott of another competitor or supplier.

Conspiring to allocate markets or customers: Agreements between competitors to divide up customers, territories, or markets are illegal. This provision applies even when the competitors do not dominate the particular market or industry.

Monopolization: Preserving a monopoly position through the acquisition of competitors, the exclusion of competitors to the given market, or the control of market prices.

Advertising

Rules and government regulations on advertising are generally to protect consumers so there must be care to be truthful in advertising. For example, claims in ads cannot be untruthful or purposely deceptive. Using testimonials in ads comes with additional regulations. Violating these rules can result in fines, which defeats the purpose of your advertising in the first place. There are also labeling laws for consumer products, meaning that they list out ingredients and chemicals within products.

Email Marketing

Closely related to advertising is email marketing. If the business engages in email marketing, there are separate regulations under the CAN-SPAM Act. There are several things that this Act regulates, but some of the main components are:

-Don't use false or misleading headers

-Don't use deceptive headlines

-Indicate that the message is an advertisement

-Include your business's name and address

-Show the customer how to opt out of emails, and honor the opt-out requests promptly

Each separate email violation is subject to hefty fines.

Environmental Regulations

Laws and regulations to protect water quality and air quality along with consumers are found at the federal and state level in all states. Most have permitting systems associated with activities that could affect air or water quality or consumer health.

Privacy

Businesses with staff and employees wind up amassing a large amount of sensitive personal information about their employees. As a result, there are a variety of rules and regulations about how employers must save and secure this data. Businesses cannot disclose an employee's private information, including Social Security number, address, name, health conditions, credit card, bank numbers, or personal history. And the Health Insurance Portability and Accountability Act (HIPAA) prohibits the release of health data without a patient's permission.

Licensing and Permits

Basic business licensing or registration is a requirement in all states, usually through the corporate division of the state's secretary of state office.

Insurance

As soon as an employee is hired, workers compensation insurance is required. All states, with the exception of Texas, require businesses with employees to purchase workers comp insurance.

Reporting Pay Data

If the business employs more than 100 people (or more than 50 as a federal contractor), there is a requirement to report how much each is paid, broken down by race/ethnicity, job category, and gender, to the Equal Employment Opportunity Commission each year.

Collecting Sales Tax

In many states, most businesses that sell physical goods must collect sales tax from customers and submit the tax to their state's revenue department. A few states do not collect sales tax. In general, the law specifies that a business must collect sales tax in any state with which it has a physical connection (known, in legal terms, as a "nexus"). That nexus might mean a physical retail shop, or hiring employees in the state. Even online sellers might have to collect sales tax in any state that they sell to.

If your business has a nexus, you need to collect sales tax except in Alaska, Delaware, Montana, New Hampshire, or Oregon where sales taxes are not law.

In West Virginia, there are no laws that affect business that are not covered in the listing above.

2. Taxation

For most small business owners, government regulation questions almost always begin with taxes. But there's more to taxes than merely paying them—knowing which business taxes to pay, when to pay them, and how to set up your business to account for future tax payments can spare you a ton of headaches when it comes time to write the government a check.

Every company registered within the United States has to pay federal taxes. Most companies will also have to pay state taxes, depending on the state in which the company is registered. These are unavoidable. Avoiding taxes—or deciding not to pay them outright—comes with hefty penalties and potential jail time.

But the kinds of taxes you'll pay depends on how you formed your business. In this regard, not all businesses are treated the same. Sole proprietorships pay taxes differently than, say, S-corporations. Here's a full rundown of the different taxes for business structures to help you determine what your business needs to file. Despite the differences between each kind of business, there are a few general terms you should know:

Income tax: Most businesses file an annual income tax return. Businesses must pay income tax as they earn and receive income, and then file a tax return at the end of the year.

Estimated tax: Estimated tax payments offer an alternative to paying income tax throughout the year as your company earns money. Sole proprietors, partners, and S-corporation shareholders must usually make estimated tax payments if they expect to owe $1,000 or more once they file their return. Note that corporations are usually required to make estimated tax payments if they expect to make more than $500 or more in income.

Employment tax: Companies that have employees are expected to pay taxes related to having staff on their payroll. These include Social Security and Medicare taxes, federal income tax withholding, and federal unemployment tax. For more information, see the IRS page on Employment Taxes for Small Businesses.

Excise taxes: Excise taxes are paid when your business makes purchases on specific goods, and are often included in the price of the product. One common example of excise tax is the purchase of gasoline, where applicable taxes are baked into the price per gallon rather than as a tally at the end of the transaction. You may be under certain excise tax law if you manufacture or sell certain goods, use various kinds of equipment, receive payment for certain kinds of services, and much more. For additional information, refer to the IRS guide on Excise Taxes.

Some businesses also have to collect sales tax, which we'll cover more in a bit.

Taxation of business operations is perhaps the most important of business laws and regulations to affect forestry industry operations.

In West Virginia, the major business taxes in addition to property taxes which are local are:

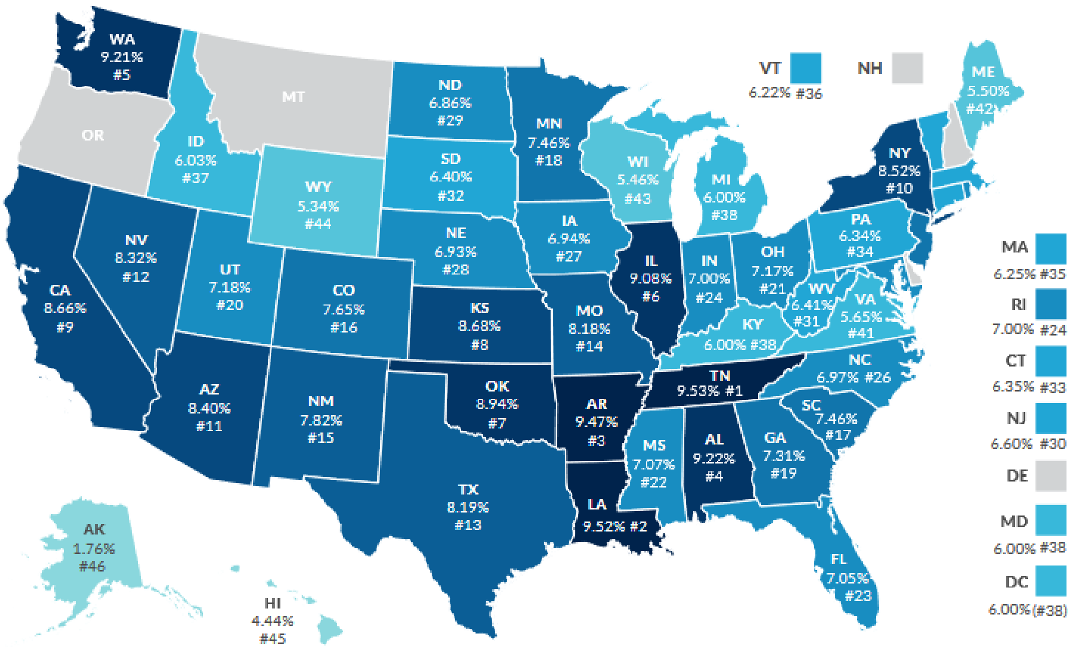
-Sales & Use Tax – applies to businesses operating as a wholesaler, retailer or seller in Pennsylvania.

Corporation/Small Business Income Tax

Business and Occupation Tax (public service or utility tax)

The major taxes to compare are the sales tax and corporate and small business Income tax. The sales tax rate for West Virginia is 6.41% and ranks it 31st in the country.

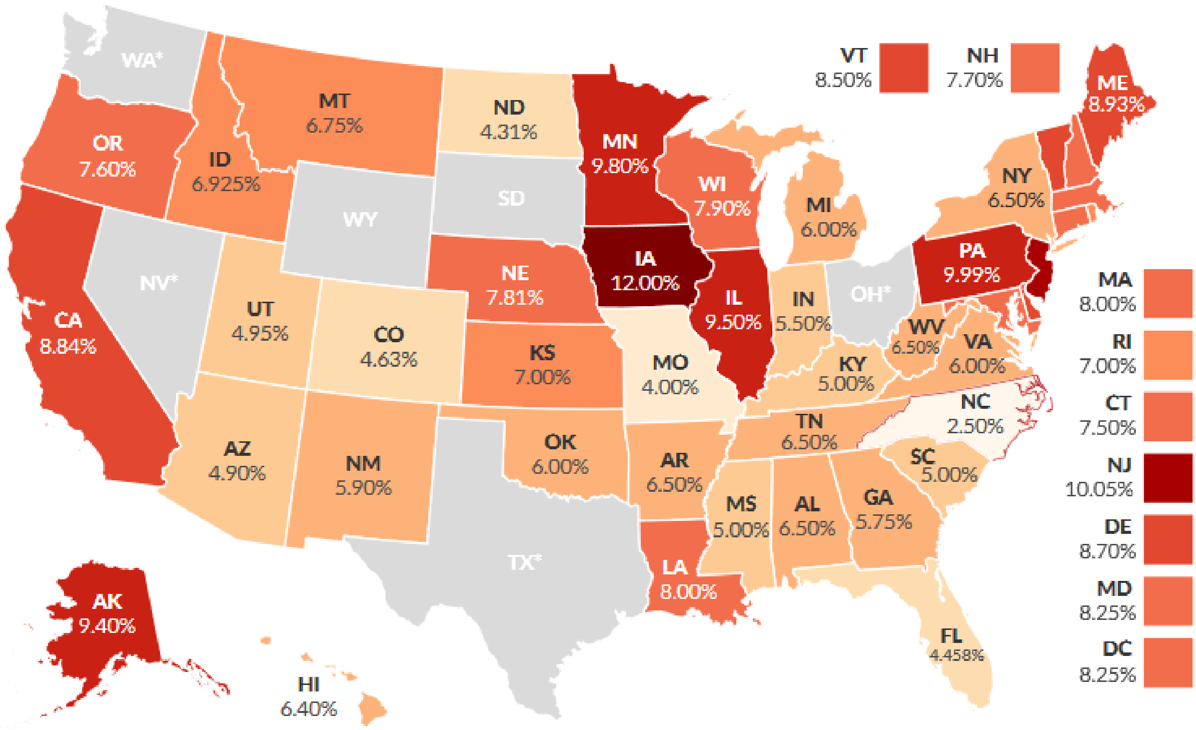
Figure 89 **Sales Tax Rates for States in the US**



Source: Tax Foundation

For corporate and small business taxes, Figure 90 shows state rates. West Virginia's highest business tax rate is 6.5% ranking it in the middle with the highest rates at Iowa at 12%, and 10.05% in New Jersey and the lowest with no business income tax in Ohio, Nevada, South Dakota, Texas, Washington and Wyoming. However, Ohio, Nevada, Texas, and Washington have business gross receipts taxes thought to be more problematic for business than corporate income taxes. South Dakota and Wyoming are the only states that do not levy either a business income or gross receipts tax.

Figure 90 **Business tax rates by US state 2020**



Source: Tax Foundation

d. Energy Costs

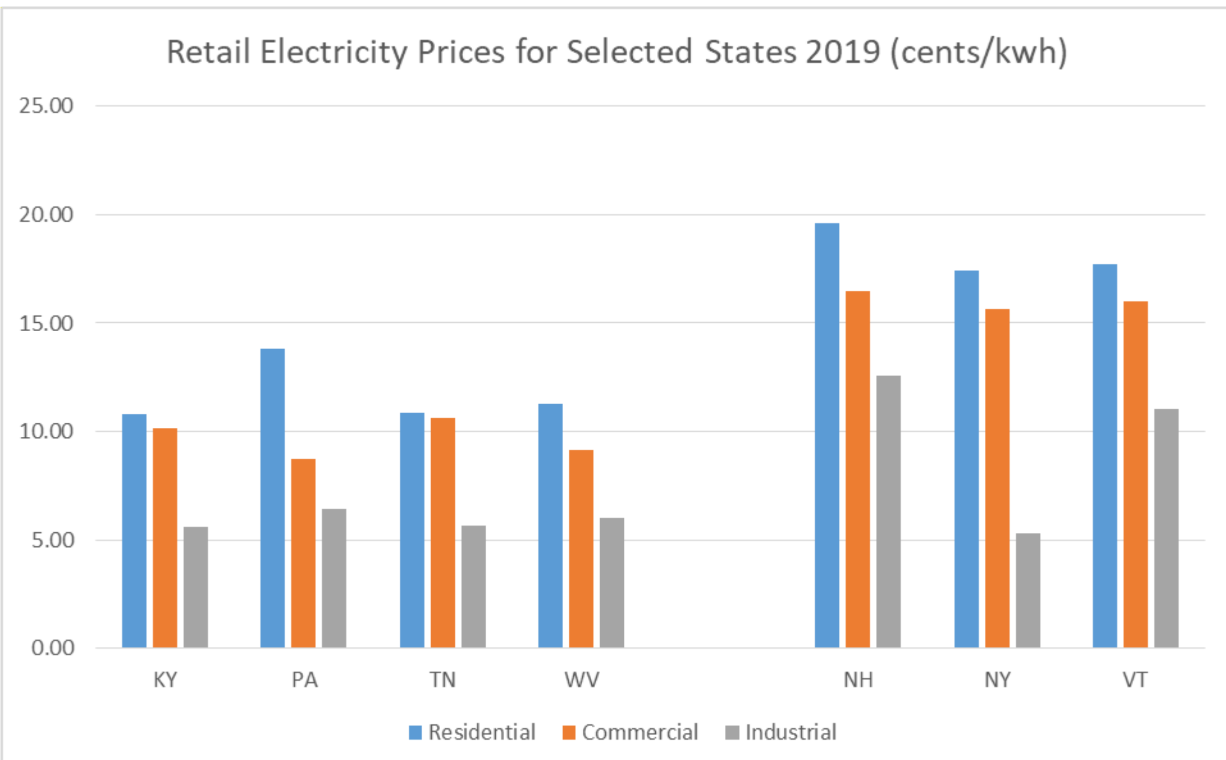
Of all the utilities associated with forest products manufacturing, electricity costs are the most critical to influence positive economics that allow for facilities to be built and operate successfully. Virtually all the machinery associated with forest products manufacturing runs on electricity.

Fossil fuel prices are important for the raw material supply chain infrastructure but those prices generally do not vary much from state to state or region to region in the US and are based on world supply and demand. Because of the way electricity grids are operated and the fact that the source of the power and the infrastructure to get it to customers is vastly different from state to state and region to region, electricity prices vary considerably.

Retail electricity costs in the three-state NH/VT/NY region are generally higher than national averages – particularly for residential customer rates and are certainly higher than our benchmarking states of Kentucky, Pennsylvania, Tennessee & West Virginia. The sector we are most interested in is for industrial retail electricity rates.

As we noted in the second report in this series - within each state there are multiple electric utilities, each with a unique service territory and in some cases with competitive suppliers. Rates that a user pays for electricity may depend upon their utility service territory, competitive supplier, time of use and other factors. In other words, it is possible to get, and many large industrial power users do, a special deal that is lower than the average for that sector. The electricity cost comparisons below reflect that complexity and are average rates (Figure 91).

Figure 91 **Retail Electricity Prices for Selected States 2019**



Source: US Energy Information Administration

West Virginia's commercial and industrial retail electricity rates on average are 9.16 cents 6.02 cents respectively, among the lower ranges in the benchmarked states but generally lower than the NH, NY and VT region except for NY's industrial rate.

e. Infrastructure and transportation

The most important infrastructure issue for the forest products industry is transportation. This generally refers to public road infrastructure for getting raw logs/timber feedstock to the mill for manufacturing and getting finished product to market. Virtually all feedstock procurement is truck traffic while finished product shipping usually starts out (and often is finished with) trucking and then sometimes uses rail access for long hauls and then shipping for overseas markets.

In West Virginia, commercial road issues are similar to other states in the east. Road freight is increasing on large trucks and the infrastructure of interstate, state and local road systems face shortages on funding, so critical issues like bridge upkeep and re-paving and maintenance are always chronic issues. The commercial road infrastructure – i.e. having adequate number of roads to access all geographies – is largely complete in West Virginia as with the other states in our study.

The TRIP report of 2019 which is a national report on commercial road issues in the US[29], highlights that commercial freight by road is increasing and, today, more freight (nearly 75% by value) travels to market through the nation's road system. They project that from 2016-2045 freight moved will increase by 104% by value and 44% by weight and truck freight moved annually in the US is expected to increase by 91 percent in value (inflation-adjusted dollars) and 41 percent by weight. Clearly the road systems are critical to the forest products industry.

Figure 92 **Commercial Freight Method US**

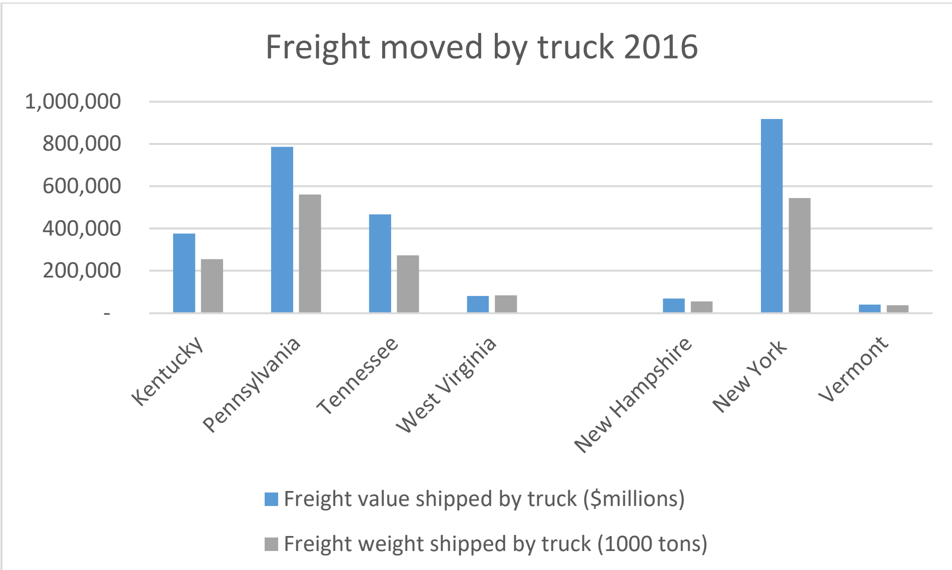
Mode	By Value	By Weight
Truck	72%	66%
Rail	4%	10%
Water	2%	4%
Air	3%	0.03%
Multiple Modes	14%	3%
Pipeline	4%	16%

Source: TRIP Report, 2019

[29] America's Rolling Warehouses: Opportunities and Challenges with the Nation's Freight Delivery System, TRIP, 2019

Of the seven states in our study, only Pennsylvania and New York are in the top 5 in the US in freight moved by truck.

Figure 93 **Freight moved by truck - selected states 2016**



Source: TRIP report 2019

Key bottlenecks in truck traffic (where traffic is slowed to much less than posted speed limits due to excess traffic amounts) shown in Figure 94 shows that West Virginia is not on the list of top 20 congested trucking routes in the US.

Figure 94 **Freight congestion US highways - top 20 bottlenecks**

RANK	STATE	Location Description	Average Speed	Average Speed During Peak Hours	Average Speed During Non-Peak Hours
1	New Jersey	Fort Lee: I-95 at SR 4	32	23	35
2	Georgia	Atlanta: I-285 at I-85 (North)	35	23	41
3	Georgia	Atlanta: I-75 at I-285 (North)	38	27	43
4	California	Los Angeles: SR 60 at SR 57	42	35	44
5	Texas	Houston: I-45 at I-69/US 59	34	24	38
6	Ohio	Cincinnati: I-71 at I-75	44	36	47
7	Illinois	Chicago: I-290 at I-90/I-94	24	18	27
8	Tennessee	Nashville: I-24/I-40 at I-440 (East)	41	28	48
9	Georgia	Atlanta: I-20 at I-285 (West)	45	38	47
10	California	Los Angeles: I-710 at I-105	38	27	43
11	Indiana	Gary: I-65 at I-80	47	45	48
12	Colorado	Denver: I-70 at I-25	38	30	42
13	Texas	Houston: I-10 at I-45	40	28	46
14	Connecticut	Hartford: I-84 at I-91	45	35	49
15	California	San Bernardino: I-10 at I-15	45	36	49
16	Texas	Dallas: I-45 at I-30	40	29	45
17	Illinois	Chicago: I-90 at I-94 (North)	31	17	37
18	Michigan	Detroit: I-94 at I-75	39	31	44
19	Louisiana	Baton Rouge: I-10 at I-110	37	29	41
20	New York	Brooklyn: I-278 at Belt Parkway	34	26	37

Source: TRIP Report 2019

The American Society of Civil Engineers (ASCE) conducts a state by state analysis of infrastructure, including transportations systems. In their recent report for Tennessee, two key transportation infrastructure reviews were included for bridges and roads. For bridges, the report says:

> "It is crucial for West Virginia to have an exceptional bridge network so that residents and visitors can enjoy the beautiful mountain ranges and scenic views the state's blessed with. Over 95% of the state's 7,291 bridges are maintained by the West Virginia Division of Highways (WVDOH). Of those bridges, 21% or 1,531 are structurally deficient, a much higher percentage than the national average of 7%. Replacing, widening, strengthening, or repairing efforts are estimated to cost the state around $2.9 billion. In 2017, to address this investment need, the state increased the gas tax by 3½ cents per gallon which generates an additional $750,000 per year in funding.

In that same year, the state also voted to fund The Roads to Prosperity initiative that includes funding measures that are expected to generate approximately $2.8 billion for highway and bridge construction over several years."

For roads in West Virginia, the ASCE says:

"West Virginia Division of Highways (WVDOH) maintains the sixth largest highway system in the nation with its purview extending across 93% of the state's 38,000 miles of roadways; 88% is rural and 12% urban. WVDOH is one of only four states that maintain both state and county roads, many over mountainous terrain which makes maintenance and safety challenging. In 2017, the fatality rate on West Virginia's rural roads was nearly three times higher than other roads in the state and almost double the national average.

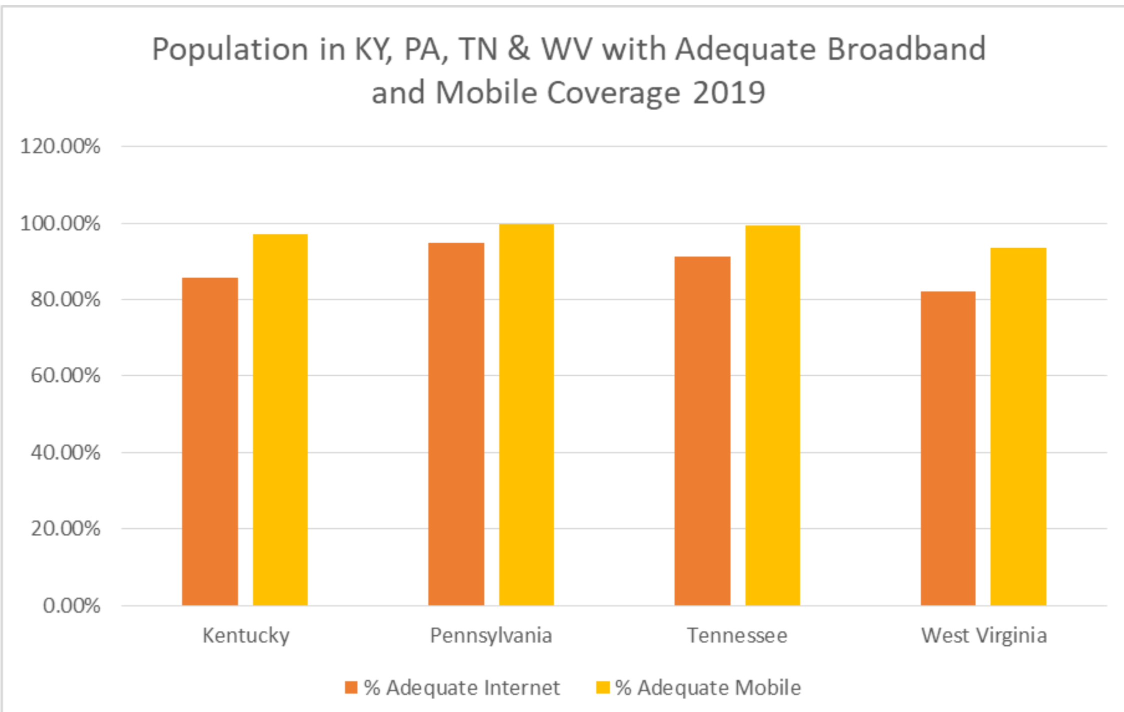
The projected cost of pavement maintenance is reaching $400 million annually, while near-term (2025) travel projections are expected to increase by 37%. Thankfully, the Roads to Prosperity Program, initiated by Governor Jim Justice in conjunction with the WVDOH, and the completion of a few capacity-adding projects are expected to enhance safety, support the state's economy, and improve overall road conditions.

In West Virginia, there are over 38,000 miles of public roadway. Roughly 36,000 miles are state owned and about 900 are federally owned, with 88% being rural and 12% urban. Unfortunately, 29% of major roads are in poor condition, while 55% are fair, and only 16% are in good condition. For comparison, 21 percent of the nation's roads are considered in poor condition.

Additionally, the repaving cycle for secondary roads is approaching a 33-year cycle, nearly two decades beyond the ideal 12-year cycle. This means that a secondary road, a road supplementing a main road, paved today will not be repaved for another 30 years. Driving on these rough roads is costing West Virginia motorists $758 million every year, which amounts to $647 per driver, in the form of increased Vehicle Operating Costs (VOC). In addition to VOC, traffic congestion throughout the state costs drivers an additional $225 million in the form of lost time and wasted fuel. By 2026, the state will need to add 142 miles of additional lanes to the interstate system in order to relieve the growing traffic congestion. To reflect this, Vehicle Miles Traveled (VMT) per person is expected to increase by 37% to 26 billion miles by 2025."

Another important infrastructure issue is access to fast broadband internet and mobile phone access. While improving each year, especially in rural areas, not all of the population in West Virginia has adequate broadband internet or mobile service (Figure 95).

Figure 95 **Broadband and Mobile Service in KY, PA, TN & WV 2019**



Source: broadbandnow.com

In West Virginia 82.20% of the population has adequate internet coverage while 93.40% has adequate mobile service.

f. Research and Development

Having in-state research and development activities in forest products and forest products manufacturing is very important to the future progress within the industry. In the past, many forest products companies did research and development in-house but with structural changes within the industry over the last 20 years, very little of that occurs today. University research cooperatives and industry trade group research has also dwindled. Other countries, most notably Canada and Finland have re-directed and re-energized their research and development efforts in the forest products industry.

In the U.S. today, most forest products research occurs in government or university labs. The USDA Forest Service has a series of forest products labs where research and development on forest products is conducted. The output from the labs is available for all in the public and private sector to use.

The Forest Products Laboratory (FPL) in Madison, Wis. is one of seven national Forest Service research facilities. FPL scientists focus their research around five areas:

Advanced Composites

Wood composite technologies have been used for decades to create building and home furnishing products. Composites are used for a number of structural and non-structural applications including interior paneling, sheathing, furniture, and support structures in many different types of buildings.

Advanced Structures

The FPL is a world leader in housing-related areas such as engineered wood products and structures, moisture control, material design and performance, coatings and finishes, adhesives, and wood preservation. Creating advanced technologies and alternative building methods can greatly enhance the value of wood in residential, non-residential, and transportation structures.

Forest Biorefinery

Trees are one of the best potential sources of biological fuel and chemicals. They grow in marginal soils unsuitable for agriculture; do not require fertilizer, herbicides, or pesticides; and accumulate biomass density for several years before incurring harvest costs. Converting wood resources into liquid fuels and chemical feedstock is becoming more cost competitive thanks in part to FPL research.

Nanotechnology

FPL scientists are conducting nanoscale research to learn more about the fundamental components of wood. Nanotechnology is a multi-disciplinary field of applied science and technology. Nanocellulose holds revolutionary potential for the forest products sector and is the economic key to accelerated forest restoration. Nanocellulose can be a cost-effective substitute for non-renewable resources in all manufacturing sectors.

Woody Biomass Utilization

U.S. forests contain a substantial amount of small-diameter, overstocked, and underutilized material. FPL scientists study small-diameter woody material, identify potential uses, and provide technology that can help rural-based communities create successful businesses from the by-products of forest management projects. FPL research explores the potential of small-diameter roundwood as a structural material for bridges, boardwalks, trail structures, picnic shelters, storage sheds, and other rustic buildings.

In West Virginia, West Virginia University has two forest products research-related programs:

The Appalachian Hardwood Center (AHC) is a jointly supported center of the WVU Extension Service and the WVU Davis College of Agriculture, Natural Resources, and Design.

The center was established in 1987 by the West Virginia Legislature to provide technical and research support for the state's growing wood products industry. The AHC is a center of excellence for outreach, extension and technology transfer, professional development, and applied research. The AHC serves sustainable natural resource-based businesses and communities as well as private forest landowners and natural resource professionals in the Appalachian forest region.

The Renewable Materials and Bioenergy Research Center researchers are exploring diverse ways to convert biomass into biofuels and bioproducts by improving feedstocks logistics and investigating methods to improve the efficiency of pretreatment and conversion.

The center promotes renewable bioproduct research and development, expanded education and outreach efforts, facilitated collaboration with regional university and industry experts, and enhances economic and workforce development by fostering the growth of a new regional industry in Appalachia. The primary objectives of the Renewable Materials and Bioenergy Research Center are two-fold:

(1) to provide research leadership to the renewable bioproducts sector, and

(2) to promote the success of the bioenergy products industry and economic development.

B. Indufor Benchmarking – Ontario and Minnesota

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FOR/Maine

Global Market Analysis and Benchmarking Study – Canada (East Coast, Ontario)

Final Report

Helsinki, Finland
June 29, 2018

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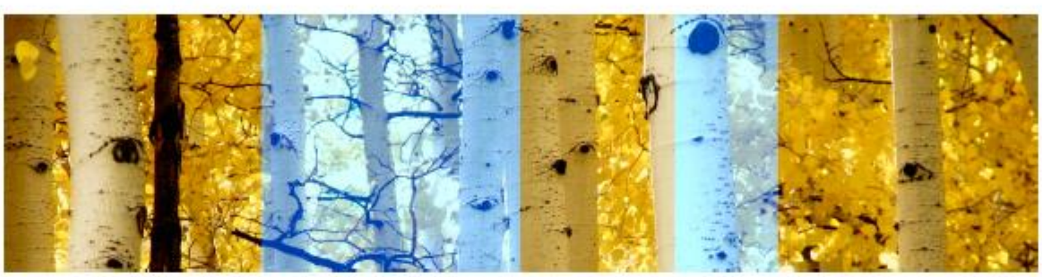
ID 122621



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1. TIER 1 – DETAILED ANALYSIS

1.1 Raw material

1.1.1 Harvest levels

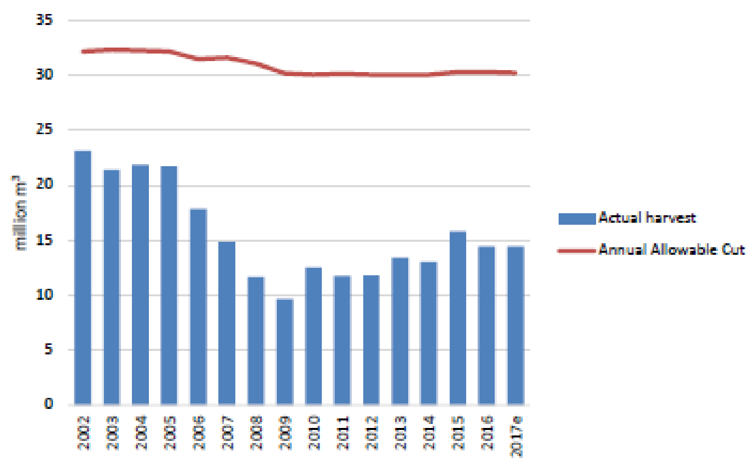
Annual harvests have decreased by over 5 million m³ since 2005 and levelled to around 15 million m³ in recent years. The annual allowable cut (AAC) level was decrease to approximately 30 million m³ in 2009 from an earlier level of about 32 million m³. The additional harvest potential is 16 million m³.

The decline in harvest volumes is a result from the decline of Ontario's forest industry. The entire forest industry suffered in Canada, first starting in 2005 and quickly increasing at the onset of the financial crisis. Additionally, the forest industry in Ontario faced multiple mill shutdowns prior to the global financial crisis. The forest industry in Ontario had made significant investments into processing technologies reducing dependency on workers, simultaneously increasing the energy consumption through automation. During this period, electricity costs increased rapidly and also the wood sourcing distance grew significantly beginning the downfall of Ontario's forest industry due to poor competitiveness in comparison to other regions. The decline of the forest industry was exacerbated by the global financial crisis in 2008 and 2009 reducing the annual harvest level below 10 million m³. In some forest management units, some of the reduction in the wood supply can also be attributed to uneven age class structure of the forests.

The majority of the sawmills are located in South Ontario, while other forest industry sectors are spread out in the rural areas throughout the province.

No significant investments have been announced to Ontario, except by International Wood Industries announcement to invest CAD 140 million in constructing a new sawmill with lines for value-added products as well as a pellet plant.

Figure 1.1 Harvest volumes and annual allowable cut (AAC) Ontario, 2002-2017e



Source: Ministry of Natural Resources and Forestry, National Forestry Database.

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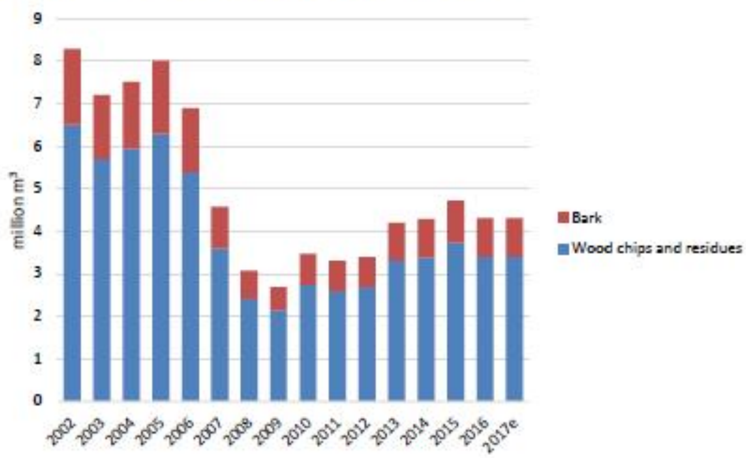
1.1.2 By-products

Based on the historical consumption of roundwood assortments by different industries, Indufor estimated the by-product production volumes in Ontario using Indufor's databases on by-product streams from different production operations. In the last five years the by-product production is estimated at around 4 million m³ (Figure 1.2). There are seven composite manufacturing plants, one manufacturing laminated strand lumber (LSL), four oriented strand board (OSB) plants, and one particle board and medium density fibreboard plant (MDF). Typical capacity of these plants is 200 000 m³, or a consumption of about 1 to 1.5 million m³ of by-products.

The pulp and paper mills in Ontario consume approximately 4 million m³ of pulpwood annually with a total pulp production capacity of 1.8 million m³. Considering an average roundwood to pulp conversion factor of 3.3 it can be deduced that the by-products are to large extent also utilized by the pulp mills. In addition, the annual recycled fibre consumption is some 100 000 metric tonnes. However, the pulp mills do not run at full capacity and have been reported to be reducing their production.

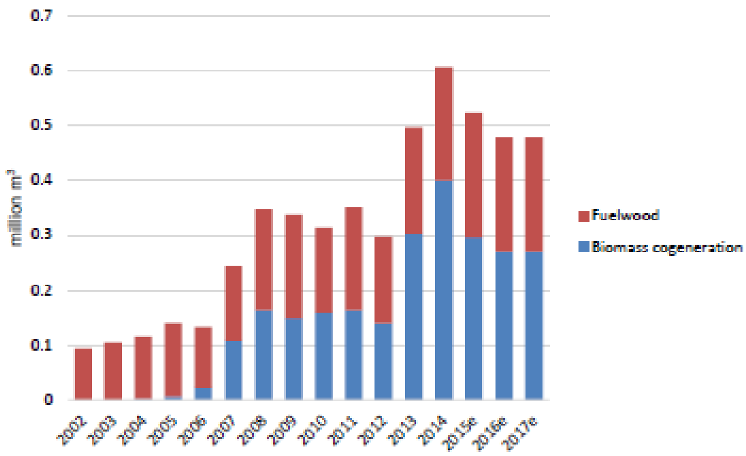
Figure 1.2 By-product volumes in Ontario, 2002-2017e



Source: National Forestry Database and Indufor analysis.

The use of by-products and fuelwood have increased significantly in the past 10 years in Ontario (Figure 1.3). The forest industry has made efforts to become more self-sufficient with regards to its power consumption and introduced new technologies to use the forest and other residues in combined heat and power, i.e. in cogeneration. Also, the *Ontario Green Energy Act* has encouraged industrial operators to phase out from fossil fuels and convert into using renewable energies such as biomass cogeneration.

Figure 1.3 Wood consumption in biomass cogeneration and fuelwood in Ontario, 2002-2017e



Source: National Forestry Database and Indufor analysis.

1.1.3 Forest ownership

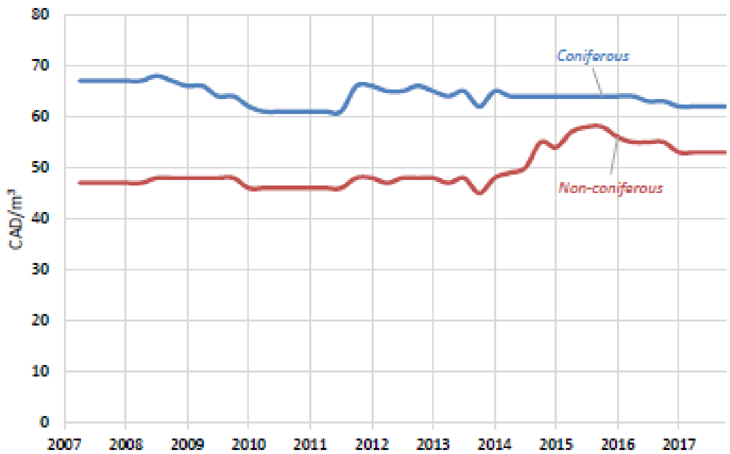
Ontario has 71 million hectares of forests. Government of Ontario, i.e. the Crown, owns 91% of the forests. The share of privately owned and owned by Federal government are 8% and 1%, respectively. Ontario Woodlot Association promotes the sustainable and profitable use of Ontario's privately-owned forests.

1.1.4 Delivered wood cost

Historically, the delivered wood cost in East Canada has been considered as the highest wood raw material cost in North America. In this case, East Canada constitutes of Ontario and Quebec. However, in the recent years the wood cost has started to decrease, and particularly the modest decrease of coniferous sawlog and wood chip prices have made the industry more competitive on the international markets. The pulpwood price has remained stable and non-coniferous pulpwood price even increased to above 50 CAD/m³ in 2014 (Figure 1.4).

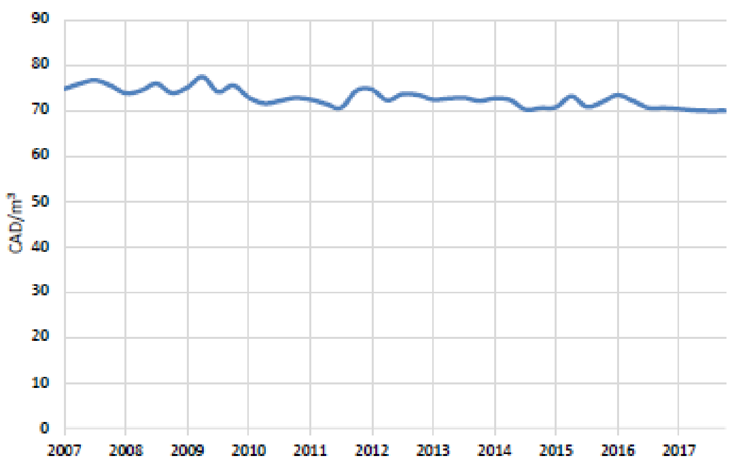
The pulp industry is shrinking in Ontario while the sawmilling industry is running at record levels, which has caused the wood chip price to decline (Figure 1.5). Despite the boost in sawmilling production the sawlog prices have remained at the historically low level of 55 CAD/m³ (Figure 1.6).

Figure 1.4 **Delivered quarterly pulpwood cost, 2007-2017**



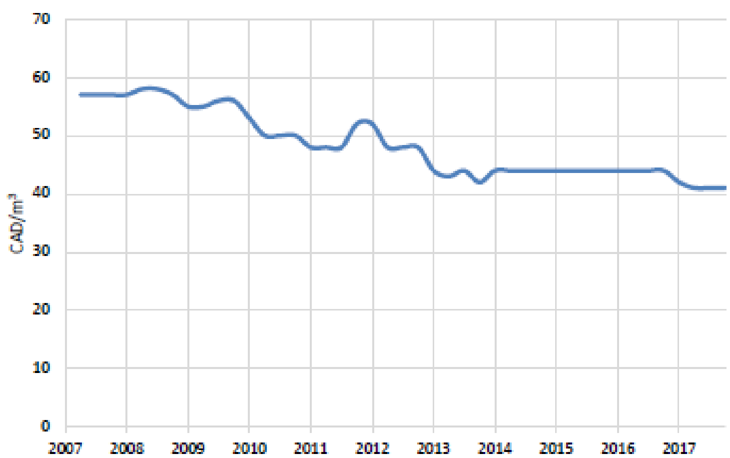
Source: Wood Resources Quarterly.

Figure 1.5 **Delivered quarterly coniferous sawlog cost, 2007-2017**



Source: Wood Resources Quarterly.

Figure 1.6 Delivered quarterly coniferous wood chip cost, 2007-2017



Source: Wood Resources Quarterly.

1.1.5 Wood procurement practice

The forest owner estimates the volume of the wood by assortment to be sold, after which they contact loggers to find interested parties in purchasing the wood. The contracted loggers, i.e. licenced harvesters, locate interested wood buyers and sell the different wood assortments.

Procuring wood from Crown forests for commercial purposes requires a Sustainable Forest Licence, Forest Resource Licence, and wood supply agreement from the Crown or an arrangement to buy trees from an existing licensed harvester. In wood supply agreements from the Crown, the commercial operator will secure a supply of wood to the mill, by obtaining the entire standing stock (with the potential of unwanted assortments). The public forest management units produce forest inventories, which offer wood supply information. The forest management units then notify the mills of the available supplies. The availability of supplies is updated along with procurement deals with mills.

1.2 Workforce

1.2.1 Demographics

The total population of Ontario is over 14 million people and 94% of the population lives in South Ontario (Table 1.1). People are continuing to migrate from the North of Ontario to South of Ontario. The overall population growth rate in Ontario was 1.6% in 2017 and is forecast by Ontario's Ministry of Finance to grow by 1.8% annually. The population is heavily urbanized and only 10% live in the rural areas. The unemployment rate is low to moderate, 5.5% of the total labour force. Employment grew by 2.5% (176 000 employees) in Ontario in 2017. The level of education is also relatively high, 65% of the total population has a higher education than secondary school diploma or equivalent.

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Table 1.1 Key demographic indicators

Indicator	Current situation
Total population (Jan. 2018)	14 318 800
Population growth rate (2017)	1.6%
Population urbanization, rural vs urban (2016)	10% vs 90%
Unemployment rate (2017)	5.5%
Level of education[1] (2016)	65.1%

[1] Ages 25 to 64, people with higher than secondary school diploma or equivalent.

Ontario has relatively high population growth rate compared to other developed countries (Figure 1.7). However, the population growth can be attributed to recent migrations. Ontario is projected to continue to have a strong net migration rate of 73% of all population growth over the 2016-2041 period.

Ontario has relatively uniform age-class structure, and the baby boomer generation of ages 45 to 59 does not stand out significantly (as is the case in many other regions). Unemployment rate has been low throughout the last decade and has continued to diminish. Urbanization has increased in the recent years, and already 90% of the population lives in urban centers. The Greater Toronto Area is the fastest growing region in the province and is expected to increase by 42% and to reach 9.6 million people by 2041.

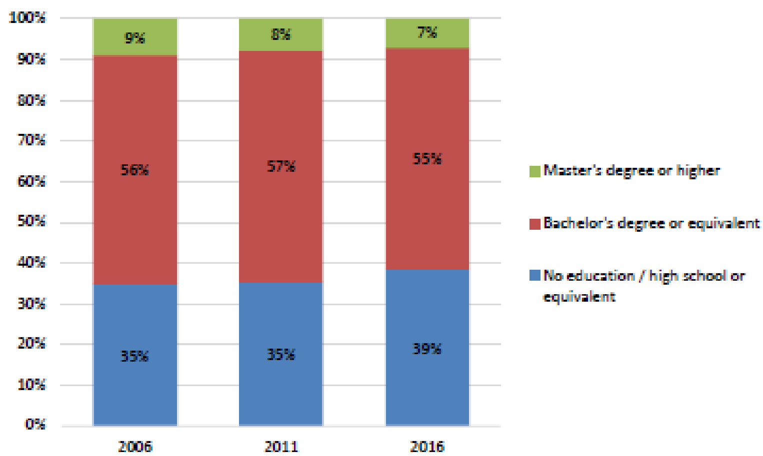
Figure 1.7 Historical demographic development

Source: Statistics Canada.

1.2.2 Level of education and the skill levels required

Ontario has highly educated population with 65% of population having at least secondary level education (Figure 1.8). Investments to modern nanocellulose, cellulosic sugars or pyrolysis oil bioproduct mills requires skilled labor with secondary and tertiary level education in biochemicals and relevant engineering. Investments in MDF and LVL would require labor mainly with secondary level education with a background from applied sciences in engineering. The aforementioned unemployment rate, urbanization particularly to Thunder Bay area and consequent lapse in labor availability is considered a more significant bottleneck than the level of education in Ontario.

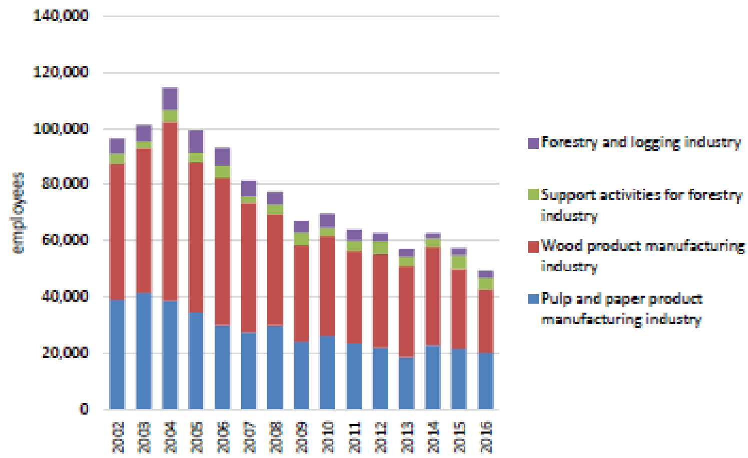
Figure 1.8 Level of education in Ontario, 2006-2016



Source: Natural Resources Canada, Labour Force Survey.

The forest sector labor force in Ontario has been diminishing drastically from over 110 000 jobs to just under 50 000 jobs from 2004 to 2016 (Figure 1.9). The decrease in jobs has been fastest in the wood product manufacturing and namely in sawmilling industry. Sawmill industry jobs are typically low-paid and do not require high education levels.

Figure 1.9 Forest sector direct employment in Ontario, 2002-2016

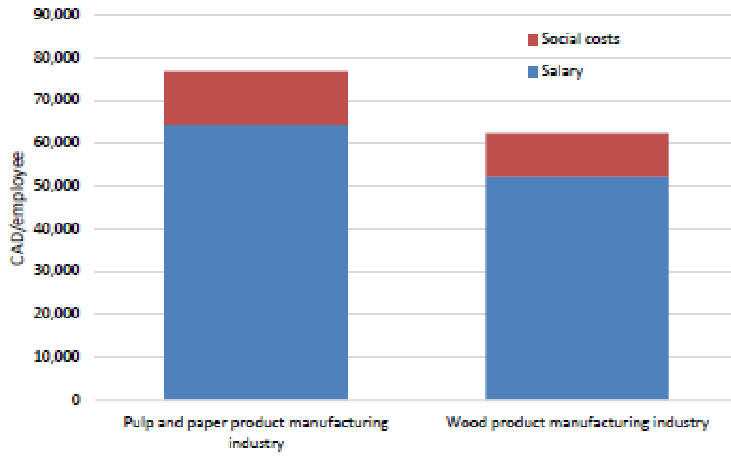


Source: Natural Resources Canada, Labour Force Survery.

1.2.3 Typical labor costs

The average labor cost in the pulp and paper manufacturing in Ontario is CAD 64 500 per employee. The labor cost is significantly lower in the wood product manufacturing industry, which comprises mainly of sawmills, where the average labor cost is CAD 28 400 per employee. According to the statistics for the whole of Canada, the social cost is 16.2% on top of the salaries in pulp and paper and wood product manufacturing industries.

Figure 1.10 Forest sector total salaries in Ontario



Source: Statistics Canada, Natural Resources Canada.

1.3 Regulatory climate

Regardless of number of regulatory acts influencing forestry and forest industry, the regulations can be perceived to have low negative impacts to the commercial operations. In fact, there are some bioeconomy policies that support the forest industry. As a result, the regulatory climate is considered neutral in Ontario.

1.3.1 Federal

Forests

Four percent of forest land in Canada is owned and regulated by federal government through the *Forestry Act*, while 90% of Canada's forest land is owned by provinces and territories and six percent is privately held. The *Forestry Act* aims to develop and research forests and provides timber regulations, including the cutting and removal of timber on federal lands. Under the Forestry Act, the Governor in Council is allowed to manage a forest experimental area on land that belongs to the State (Crown) or lands provided to the State (Crown) through an agreement with a province. Good forest management is promoted under the Forestry Act.

Although responsibility and authority regarding timber yield, rate of harvesting, and forest tenure and management are held by the provinces under the Constitution Act, with the except for First Nations reserve land and national parks, sustainable forest management principles have been adopted nationwide in 1992. Sustainable forest management refers to forest management that maintains the environmental, social, and economic values and benefits of forests over time.

While there are no federal laws regarding timber harvesting levels, the Canadian government measures and ensures that harvests remain below sustainable limits through an indicator that compares the amount of timber harvested with the wood supply, also known as the maximum sustainable harvest. The maximum sustainable harvest is referred to in this study as the annual allowable cut (AAC). The indicator is part of the Federal Sustainable Development Strategy (FSDS) aimed at establishing goals and targets, and identifying actions to achieve them. The 2016–2019 FSDS is the third strategy prepared, which promotes clean growth, ensures healthy ecosystems, and builds safe, secure and sustainable communities over the next three years. It includes the following targets regarding forests:

- By 2020, at least 17% of terrestrial areas and inland water are conserved through networks of protected areas and other effective area-based conservation measures.
- Between now and 2020, maintain Canada's annual timber harvest at or below sustainable wood supply levels.

Forest Operational Regulations

The following regulations are the most important for forestry operations:

- *Under the Fisheries Act*, The Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations the deposit of deleterious substances from pulp and paper mills into waters frequented by fish is managed. It requires that operators sample their effluents and it prohibits the release of chemicals. In addition, the regulation sets limits for the maximum quantities of biochemical oxygen demand matter (which consumes oxygen dissolved in water) and suspended solids that can be deposited from pulp and paper mills under prescribed conditions.
- Under the *Canadian Environmental Protection Act* (CEPA), regulations regarding formaldehyde emission standards for composite wood products help to reduce exposure to formaldehyde emissions from certain wood product, produced domestically or imported into Canada. In addition, it ensures that these regulations are aligned with those set out under Environmental Protection Agency (EPA) of the USA. Canadians will have the opportunity to provide comments on the regulatory proposal, which is anticipated to take place in fall 2018 and last 75 days.
  - As it stands, Formaldehyde was added to the List of Toxic Substances in Schedule 1 of CEPA 1999 and current controls focus on reducing formaldehyde emissions to outdoor air.
- Under the *Canadian Environmental Protection Act* (CEPA), the Code of Practice for management of air emissions from pulp and paper mills recommends and promotes best practices to facilitate and encourage ongoing improvements in the environmental performance of pulp and paper mills with respect to sulphur dioxide (SO2) and total particulate matter (TPM) air emissions from combustion sources.
- *The Regulatory Framework for Air Emissions* (2007) mandates reductions in emissions of greenhouse gases and air pollutants from the following industrial sectors: electricity generation produced by combustion, oil and gas, forest products (including pulp and paper and wood products), smelting and refining, iron and steel, iron ore pelletizing, potash, cement, lime, and chemicals production, including fertilizers.

Environmental and Forest Management Regulations

The following regulations refer to general environmental and conservation management practices for forestry operations:

- *Canadian Environmental Assessment Act* (2012) assesses the affect a project has on the environment and aims to protect the environment from adverse effects from human activities, as well as to promote cooperation with aboriginal communities, and to ensure public participation. The act applies to federal lands where the federal government is financially supporting activities. Under the Act the Canadian Environmental Assessment Agency, who assists the Minister of Environment, will assess if a project requires an Environmental Assessment (EA).
- *Species at Risk Act* (2002) aims to prevent wildlife species from extinction or from extirpation, which refers to "wildlife species that no longer exist in the wild of Canada, but exist elsewhere". Furthermore, it intends to recover those species that have been extirpated from an area or experienced severe declines from human activities, and to manage species of special concern. Forestry operations will have to consider if there are species at risks in the area of their operations and if there are species at risk in the

area of operations, it requires adjustment of activities and planning around these species.

- *Migratory Bird Convention Act* (1994) aims to protect and conserve migratory birds (as a population and individually) and their nests. There are general prohibitions under this Act and regulations that protect migratory birds and their nests and eggs; in addition, there are prohibitions on polluting areas and waters frequented by migratory birds with harmful substances.
- *Fisheries Act* (1985) concerns the managing of fish that are part of a commercial, recreational or Aboriginal fishery, or fish that support such a fishery. The Act prohibits the release of substances that could potentially degrade or alter the quality of water in ways that are harmful for fish. Industrial forestry operations have to manage the use and storage of chemicals and petroleum products in accord with this act.
- *Pest Control Products Act* (2002) manages chemicals that can be used in forest management, and is affected by the Canadian Environmental Protection Act.
- *First Nations Land Management Act* (1999) provides signatory First Nations the authority to make laws in relation to reserve lands, resources and the environment.
- *National Parks Act* (updated 2000) regulates protection of natural areas of national significance.
- *The Canada Water Act* contains provisions for formal consultation and agreements with the provinces and allows polluting contaminants to enter the water in low concentrations under some circumstance. The two goals of the federal government are to protect and enhance the quality of the water resources and to promote the wise and efficient management and use of water. All provinces and territories in Canada have pollution control regulations.

Bioeconomy

In 2015, the Canadian Council of Forest Ministers' (CCFM) committed to the Kenora Declaration of Forest to advance innovation and the bioeconomy in the forest sector. As part of their commitment, the CCFM developed a four-year Innovation Action Plan 2016-2020 aimed at implementing the three pillars of the declaration: 1) collaboration to accelerate and enhance sustainable, market drive investments to commercialize process, product and market innovation, with a focus on environmental excellence; 2) engage prospective partners and new entrants in non-traditional industries and academic fields, making concerted efforts to facilitate connections with the forest sector; and 3) mobilize the best talent and technologies to address the future needs of the forest sector.

The following regulations are of importance to bioeconomy:

- Greenhouse gas emissions: The government is committed to reducing Canada's total emissions of greenhouse gases, relative to 2005 levels, by 20% by 2020 and by 30% by 2030 under the Paris Agreement. As part of governmental commitment, in 2016 *The Clean Fuel Standard Regulations* was adopted try to achieve 30 Mt of annual reductions in GHG emissions by 2030, contributing to Canada's effort to achieve its overall GHG mitigation target of 30% emission reduction below 2005 levels by 2030. The design of the draft regulations will be published in late 2018. Furthermore, a Carbon Tax will be introduced in 2019, starting at CAD 20 per ton of emissions, climbing to CAD 50 per ton by 2022.
- Under *The Renewable Fuel Regulations* fuel producers and importers are required to have an average renewable fuel content of at least 5% based on the volume of gasoline that they produce or import into Canada (commencing December 15, 2010) and of at least 2% based on the volume of diesel fuel and heating distillate oil that they produce or import into Canada (Commencing July 1, 2011). A trading system was designed to enable primary suppliers to acquire compliance units from others, if needed, in order to meet their renewable fuel content requirement(s) under the Regulations.

- There are standards for 1) Solid Biomass Fuels, 2) Graded Wood Pellets, 3) Graded Wood Briquettes, 4) Graded Wood Chips, and 5) Graded Firewood.

1.3.2 Ontario

Forests

Most of Ontario's forest land is owned by the government of Ontario (the Crown). Only eight percent is privately-owned, and one percent belongs to the federal government. Different legislations apply for land owned by the government and privately held land.

Crown Land

The policy framework for sustainable forests governs forest land owned by Ontario (the Crown) and outlines the broad direction of forest policy and sustainable forest management. *The Crown Forest Sustainability Act* (CFSA) is at the center of this framework and regulates forest management planning, collection and reporting of forest management information, forest operations, compliance and enforcement, forest resource allocation and licensing, setting and payment of Crown charges, and independent forest audits. Under the CFSA, sustainable forest management became a legal requirement, which is implemented by CFSA's manuals and guidelines.

Other important legislations are the federal *Environmental Assessment Act* (1990), the *Environmental Bill of Rights* (1993), and the *Environmental Assessment Act* (EAA) among others. In addition, the *Ontario Forest Accord*, an agreement by government, industry, and conservation groups to a mutually acceptable approach to the establishment of new parks and protected areas while also ensuring the security of the forest industry, includes a commitment to streamline the forest management planning guides and regulations created under the *Crown Forest Sustainability Act*.

Private Land

The federal Forestry Act, the Trees Conservation Act, the Trees Act, and the Municipal Act may apply on some private lands, as well as the federal environmental legislation previously mentioned.

- The Forestry Act "gives the Minister of Natural Resources authority to enter into agreements with landowners such as municipalities or conservation authorities for forest management purposes. In addition, the Minister is given power under the Act to create programs to protect, manage, or establish woodlands and to encourage management that is consistent with good forestry practices."
- The Municipal Act allows all levels of municipalities in Ontario to pass forest conservation by-laws to regulate tree cutting.
- The Trees Conservation Act (1946), the Trees Act (1950) allow municipal councils to enact forest conservation by-laws.

However, in general, "forest management is not heavily regulated by the Government of Ontario. In some municipalities, municipal governments have passed tree cutting bylaws, under the Municipal Act, which may influence the harvest of timber on private lands. Otherwise, forest management is a voluntary activity on private land. To encourage good forest management, the Ontario government provides tax incentives to landowners who develop and commit to implement forest management plans."

Forest Management – Harvest

In general, Ontario does not determine an annual allowable cut on all the land, and timber agreements are allocated in three forms: supply agreements, sustainable forest licenses, and forest resources licenses.

Sustainable forest licensees are required to operate under a forest management plan, which is updated every 10 years, including an annual work schedule, with a validity for a 20-year term and a minimum of 160 years of strategic planning horizon. Every 5 to 7 years the license will be reviewed, which then can be extend for an additional 5 years. All forest management plans require an EA approval.

Harvest: Under the sustainable forest license, an allowable harvest level is determined, as well as renewal, access and maintenance activities. A maximum clearcut area of 49 hectares is allowed, while forest legislation restricts the size of clearance in state forests to 260 ha in Ontario (FPAC, 2015. Forest companies in Ontario pay Crown charges (stumpage) for every cubic meter of timber they harvest, within the Crown land.

Environmental: There are also buffer requirements (watercourse protection measures) in place for herbicide application of pesticides in forest to protect wildlife features under Ontario's Forest Management Guide for Conserving Biodiversity at the Stand and Site Scales (2010). Within set buffers, activities such as harvest and renewal are also constricted. To further conserve biodiversity, Ontario incorporates the coarse/fine filter approach, which focuses on conserving entire plant and animal communities (coarse), as well as individual species (filter), such as white-tailed deer and pine marten.

Forest Resource License are short-term (no longer than 5-years) licenses that authorize the harvest of timber in a smaller geographic area. Licensees are only responsible for operational activities, such as harvesting and the associated road construction.

Supply agreements: As stated by the government of Ontario, under supply agreements, the government makes a specific supply of Crown forest resources available to a licensed forest resource processing facility for a specified period. Supply agreements obligate the holder of a forest resource license (the harvester) to make forest resources available to the supply agreement holder.

Forestry Operations Regulations for Crown Land

Forest resource processing facilities are regulated under the CFSA, which requires licensing for all forest resource processing facilities (e.g. pulp and paper mills, sawmills) which consume more than 1 000 m^3 of forest resources per year. A forest resource processing facility license defines how a person can operate or construct a facility, increase the productive capacity of a facility or convert a facility to another type of facility. Before a facility license can be issued, the Ontario government must be satisfied the facility has a sufficient supply of forest resources to operate.

Bio Economy

Several Acts and Plans govern (renewable) energy strategies in Ontario.

- Under Ontario's Action Plan on Climate Change, Ontario is committed to reducing its greenhouse gas emissions to 6% below 1990 levels, and 15% by 2020.
- *Ontario Green Energy Act* aims to phase out coal-fired electricity and switch to renewable energy supplies. Renewable energy sources include biomass, biofuel and biogas. Key measures to facilitate development of renewable energy sources include the Feed-in Tariff program that guarantees specific rates for energy generated from renewable sources, streamlined energy approvals, and mandatory connection and priority access. Only stands identified in existing forest management plans are utilized (i.e., small stands that would not be conventionally logged are excluded), and in those stands any undesirable/unmerchantable trees can be taken, but green-tree retention guidelines still apply.
- Ontario's Long-Term Energy Plan lays out target plans of the province for clean, renewable energy (wind, solar, and bioenergy) of 10 700 MW by 2018. In 2015, Ontario's installed generation capacity totalled 36 945 MW, including over 5 000 MW of renewable energy as can be seen from Figure 1.11.

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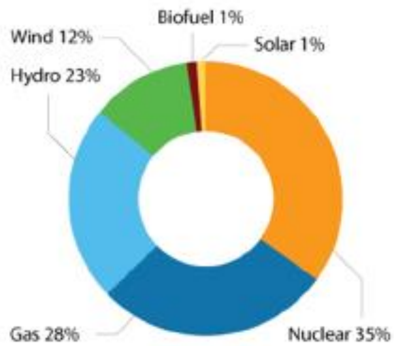
Figure 1.11 Ontario's installed power generation capacity



Nuclear	13,009 MW or 35%
Gas/Oil	10,277 MW or 28%
Hydro	8,472 MW or 23%
Wind	4,313 MW or 12%
Biofuel	495 MW or 1%
Solar	380 MW or 1%

Ontario's Integrated Power System Plan (Ontario Power Authority 2007) aims to double renewable energy capacity from 2007 to 2027, including a goal to add 800 MW of biomass-based power generation capacity.

Ontario's Forest Management Guide Conserving Biodiversity at the Stand and Site Scales outlines the regulations regarding biomass harvesting to ensure there will be sufficient retention of trees, downed woody material, soil protection, maintenance of understory, and protection of important wildlife features throughout forestry activities including biomass harvesting (Waito and Johnson 2010). Moreover, *Ontario Forest Biofibre Policy* aims to improve the utilization of forest products. The goal is to seek for forest residues that are underutilized. The policy does not apply to residual by-products of mill operations such as such as wood shavings, sawdust, bark, or wood chips. Ontario has clearly defined restrictions on what can and cannot be removed through forest harvesting.

Other applicable regulations

- The Environmental Bill of Rights, which aims to prevent, reduce, and eliminate the use, generation, and release of pollutants that are an unreasonable threat to the integrity of the environment among other things. For instance, biofuel production facilities require a certificate of approval for discharge into air and water. In addition, the Liquid Fuels Regulation, under the Technical Standards and Safety Act, applies to facilities, such as forestry operations, where gasoline or an associated product is handled, loaded, or dispensed to be used as a fuel in motor vehicles or as a fuel oil. These facilities require a license, registration, or certificate as outlined in the regulation.
- Ontario's Greener Diesel Regulation (2014) requires both a minimum volume of bio-based diesel (at least 4% of total diesel) to be blended into petroleum diesel as well as minimum reductions in lifecycle GHG intensity (70% reduction). Implementation of the regulation is being phased in over 3 years, with final requirements, which came into effect in 2017. Ontario's Ethanol in Gasoline Regulation (2007) requires at least 5% ethanol in gasoline and provides a regulatory incentive for cellulosic ethanol (1-liter cellulosic ethanol is equivalent to 2.5 liters of ethanol).

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1.4 Taxation

In Canada, taxation, deductions, exemptions, and credits can simultaneously be applied for the same service or product on federal, provincial, and county level.

Total corporate tax rate is 49.5% in Ontario, one of the highest within North America when no exemptions are in place. The corporate tax rate comprises of Federal basic rate of 38% and Ontario's provincial tax rate which is 11.5% for large businesses and 3.5% for smaller businesses. The basic rate is usually reduced by 10% to 28% through federal tax abatement or by 15% to 23% after general tax reductions. Consequently, the effective tax rate is 26.5% which is the lowest in North America.

Canada has a sales tax on both federal and provincial level. Ontario has a total sales tax rate of 13%, including the federal tax rate of 5% and provincial sales tax rate of 8%.

Canada has programs in place to reduce the corporate tax rate, such as deducting the entire cost of equipment purchases from a company's taxable income as well as reducing an employer's federal income tax liability when increasing employment. In Canada these programs are constructed to explicitly exempt biotechnology start-ups.

Ontario provides lower corporate income tax rate for manufacturers and small businesses, as well as offers numerous tax credits and incentives that can be used to reduce income tax to encourage scientific research and experimental development (SR&ED). The latter incentives make the after-tax-cost of SR&ED lower in Ontario than in many other jurisdictions, including the United States.

For corporations that derive at least 10% of their gross revenue for the year from manufacturing or processing goods in Canada for sale or lease, can claim the manufacturing and processing profits deduction (MPPD). The MPPD reduces the 38% tax with a rate of 13% on income that is not eligible for the small business deduction to 25%.

Ontario Tax Exemption for Commercialization: Newly established corporation, such as bioeconomy/clean technologies, may be eligible for a refund of the corporate income tax and corporate minimum tax for business paid in its first 10 taxation years.

Sale of standing and cut timber is taxed on a federal level in Canada. The sale of both standing and cut timber are taxed as ordinary income in Canada. Many costs related to the production of wood or growth of timber are eligible for a deduction or credit in Canada through the federal Common Reporting Standard (CRS). In Canada, the logging tax paid on a provincial level may be eligible for credits through the CRSs. Ontario has a provincial tax of 7.26 CAD/m^3 on Crown land, which comprises of Forestry Futures Trust Charge, Forest Renewal Trust Charge and Crown Stumpage Fee.

Ontario and Canada do not have trade tariffs on imports of sawnwood, wood pulp and waste paper, LVL, pyrolysis oil, nano cellulose or cellulosic sugars. However, there is a 6% tariff for MDF which exceeds in density 0.8g/cm^3.

In Ontario, regarding investments, a maximum of CAD 4 million tax credit can be obtained in addition to the federal credits. Also, the Ontario Innovation Tax Credit (OITC) is a 10% refundable tax credit on up to CAD 3 million of qualifying SR&ED expenditures of an associated group and is subject to phase-out limits.

Canada is in the process of developing a federal carbon taxing system, with carbon prices of min. 10 CAD/ton, while Ontario already introduced a cap-and-trade system. Ontario passed legislation introducing a cap-and-trade system in May 2016 and held its first carbon allowance auction in March 2017. Participation in the cap and trade program is not mandatory for facilities that generate less than 25 000 ton of greenhouse gas emissions per year.

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2. TIER 2 – GENERAL ANALYSIS

2.1 Policies

2.1.1 Incentives Canada Ontario

Incentives for the forestry sector are high in Canada on a federal level and medium for Ontario, while incentive for the bioeconomy are high in Ontario, but low on a federal level.

Forest Sector:

In reaction to the imposition by the US to impose duties on imports of certain Canadian softwood lumber, the Government of Canada formed a task forces and implemented immediate action, including CAD 867.5 million in funding over the coming years.

Ontario also responded to the US imposition, with direct funding of $30 million over three years. Although direct funding is lower, the government of Ontario will invest up to 50% of the costs of eligible forestry projects, as well as reduce electricity costs up to $20 million per year for forestry businesses in the northern part of Ontario.

Bioeconomy:

The Government of Canada mainly supports innovation and research through networks aimed at creating an enabling environment to develop Canada's bioeconomy, with an additional fund of CAD 500 million for biofuels.

Ontario on the other hand has a cumulative budget of CAD 1.1 billion over 10 years for technology funds, CAD 2.1 billion for green bonds and banks, and supports technology, research and energy efficiency projects anywhere between CAD 80 000 to CAD 10 million per project. In addition, Ontario supports its regional productivity, export and businesses with CAD 285 million in funds over 3 to 10 years.

2.1.2 Direct federal and provincial incentives in the forestry sector

The government of Canada has a history of supporting the forest economy. For instance, from 2009 to 2012, the government aimed to improve the environmental performance of Canada's pulp and paper mills, by providing a funding of CAD 1 billion. Moreover, in 2016, the federal government partnered with Quebec through the Transformative Technology Program to develop nano crystalline cellulose technology pilot plan, with CAD 32.4 million in funding. In the same year the federal government and Quebec provided respectively CAD 9 million and CAD 3.5 million in funding to install a plant to produce dissolving pulp from birch wood.

In 2017, the government pledged to invest CAD 867.5 million over a period of 2 to 4 years, in a reaction to the imposition by the US department of Commerce of duties on imports of certain Canadian softwood lumber products into the US.

Of the CAD 867.5 million, CAD 173 million (over three years) will go directly to research and development projects, supporting expanded use of wood in everything from innovative construction materials to biofuels. While, CAD 605 million will be in form of loans and loan guaranteed through the Business Development Bank of Canada, and CAD 99.5 million will go to help employment and community development, including helping employers avoid layoffs and retain skilled workers (CAD 9.5 million over 4 years) and assist provinces to help workers transition to new employment opportunities (CAD 80 million over two years).

On annual average, starting in 2018, the Canadian Government will directly fund the forestry sector with CAD 77.75 million. Although lower in direct funding, the province of Ontario funds the forestry sector with CAD 10 million on average per year through the Forestry Growth Fund as well as CAD 7.8 million through the Mass Timber Program. In addition to direct funding, Ontario will invest up to 50% of the costs of eligible forestry projects, as well as reduce electricity costs up to CAD 20 million per year for forestry businesses in the northern part of Ontario. Furthermore, businesses can find support through the Centre for Research and Innovation in the Bio-Economy, which is mandated to find new novel uses for forest biomass; to bring the forest industry beyond the traditional markets of newsprint, pulp and lumber.

Overall, the federal government supports innovation and research mainly indirectly through networks aimed at creating an enabling environment to develop Canada's bioeconomy. In addition to networks, the federal government implemented a CAD 500 million Next Generation BioFuel Fund to invest with the private sector in establishing large scale demonstration facilities to produce next-generation biofuels.

Ontario on the other hand provides many funds, (grants and loan) programs, which can be roughly categorized into the following buckets: forestry, technology, low carbon economy, research, regional economy, and trade.

2.2 Access to financing

Canada's banking system is stable and is considered one of the safest in the world. Canada's current credit rating is AAA stable/A-1+, which provides low interest rates. Although Moody downgraded the credit ratings of Canada's six largest banks in 2017, it noted that the country's banks remain among the highest rated globally.

As of May 2018, the Bank of Canada has kept the interest rate relatively low at 1.25%, due to slightly weaker economic performance. The Bank expressed their intention to hike rates gradually over the coming months. The Bank of Canada has struggled to maintain an inflation rate of 2%, as rates have recently increased. In 2017, the Inflation rate was 1.6%, while for 2018, it is expected to average between 2.2 to 2.3% and between 2.0 to 2.1% in 2019, according to the Focus Economics Consensus forest and the Bank of Canada respectively.

Overall the banking sector in Canada is favorable to large scale investments. The Government of Canada provides loans and loan guarantees. In 2017, the Government made commercial financing and risk management solutions, valued at CAD 500 million, available for forestry companies, through Export Development Canada (EDC). This move came as a reactionary measure to the United States government's introduction of import duties on certain Canadian softwood lumber. The Business Development Bank of Canada (BDC) additionally made CAD 105 million available in commercial financing to help forestry companies in the short and medium term.

In terms of private funding, in 2016, Canada ranked third in global attractiveness for private equity and capital venture. Although private equity investing and venture capital has soared in Canada in the recent years, these investments have primarily focused on sectors outside of forestry (ICT, Life Sciences, and Oil Gas).

In Ontario, the finance system is stable and offers a wide variety of potential finance sources from venture capital to commercial banks. Ontario's credit rating is Aa(2) N according to Moody's, which indicates a very low credit risk and subsequently a low interest rate. In 2017, the inflation rate based on the consumer price index was 1.7 percent.

The forestry sector largely benefits from the available financial sources in Ontario. According to the Government of Ontario, total annual investment in the forest industry averaged CAD 777.4 million over 2009-2013—down significantly from CAD 1 116.3 million in 2004-2008. Investment by the wood products industry averaged CAD 189 million annually over 2009-2013 (representing 15 percent of total amount invested in sector across Canada)—down from CAD 343 million in 2004-2008. Additionally, investment by the pulp and paper industry averaged CAD 568 million annually over 2009-2013 (representing 27 percent of total amount invested in sector across Canada)—down from CAD 690 million in 2004-2008. Investment amounts in Ontario indicate a favorable investment environment.

Ontario has created numerous government programs to fund environmentally minded projects and infrastructure. The government of Ontario offers a green bonds program, as part of its Climate Change Action Plan, aimed at reducing GHG by 80% compared to 1990. The program was launched in 2014 with CAD 500 million, quickly followed by other rounds of funding, with

CAD 750 million in 2016, CAD 800 million in 2017, and CAD 1 billion in 2018. Furthermore, in 2018, a Green Bank with CAD 1.1 billion in funding was established by the Government to support large commercial and industrial projects, by working with commercial banks to help aggregate projects to reduce risk.

Although the climate seems favourable to large scale investment, innovative early-stage companies, with limited profits and tangible assess, still find it difficult to secure financing from traditional sources. According to the government, venture capital and risk capital mechanisms are needed to fill the gap. To compensate the government offers programs, such as the Ontario Angel Network Program, the Ontario Venture Capital Fund, the NorthLeaf Venture Catalyst Fund, and the ScaleUP Ventures Fund. Additionally, Ontario Capital Growth Corporation (OCGC), which was established by the Ontario Capital Growth Corporation Act, 2008, manages Ontario's interests in venture capital funds to ensure that more high-potential technology companies have access to the capital required to grow and prosper. As a result, the venture capital market is flourishing in Ontario with many networks around the province, focused especially on innovation start-ups and regional economic development.

Conclusion:

Given that Canada's banking climate is stable, provides large loan guarantees focused on forest sector, and has an attractive private equity market, the score for financial access is high.

Given Ontario's many incentives and stable banking sector, the environment can be considered favourable to the forestry sector in general and innovative technologies specifically.

2.3 Logistic infrastructure and transportation costs

Holding 2% of the world's forests, Ontario is abundantly wealthy in wood resources. Due to the remote locations of most forest sites, publicly maintained forest access roads play a large role in cost efficiency of transport and overall market prices. The most recent forest access roads data available from 2013 indicates 26 618 km of roads were maintained, 3 915 km of roads were constructed, and 1 004 km were decommissioned by physical or natural means. The Ministry of Natural Resources and Forestry (MNRF) incurred costs of nearly USD 39 million for the construction, maintenance, and monitoring of primary and branch roads, as well as stream crossings. USD 32 million was spent on primary roads and USD 5.93 million on branch roads.

According to a study by Public Sector Digest Inc. in 2015, Ontario's infrastructure identified more than one third of roads and bridges as in poor or very poor condition. The nearly 40 000 km of highway lanes, built mainly in the 1990s, have struggled to deal with the harsh Ontario climate, leaving the provincial government with massive expenditures for annual maintenance. Issues with reliability and subsequent congestion of commercial transit for these roads in the Southern regions of Ontario have a significant impact on overall expenses—with estimates of USD 4.62 billion in costs to the regional economy (Greater Toronto and Hamilton Area). The United States accounts for more than 95% of all wood products from Ontario, with 71% utilizing trucks, 20% using railways, and a further 9% through marine and air transit.

Rail and marine transit, while less represented in Ontario, are a vital part of Canada's economy. Interprovince connections and access to the United States have broadened the reach of Canada's forest products industry beyond the Mid-West. Short line railways connected to the Canadian National Railway (CN) often suffer from similar inadequacies that are found in the United States (lack of track carrying capacity, double stack capabilities, or reach into forested regions). Nonetheless, the CN railways make a significant contribution to overall forest products exports. Marine transport through the Great Lakes region, specifically the Port of Hamilton at the West end of Lake Ontario, which captures 28% of all Great Lakes cargo.

Pulp, paper or allied products have a Canada/Mexico freight carload average rate of USD 6 379 below 180% RVC and an average of USD 9 191 above 180% RVC. Chemical or allied products have a Canada/Mexico freight carload average rate of USD 3 794 below 180% RVC and an average of USD 6 527 above 180% RVC. The estimated freight carload rate from Toronto to Los Angeles is USD 15 406 with a maximum weight capacity of 70 tonnes.

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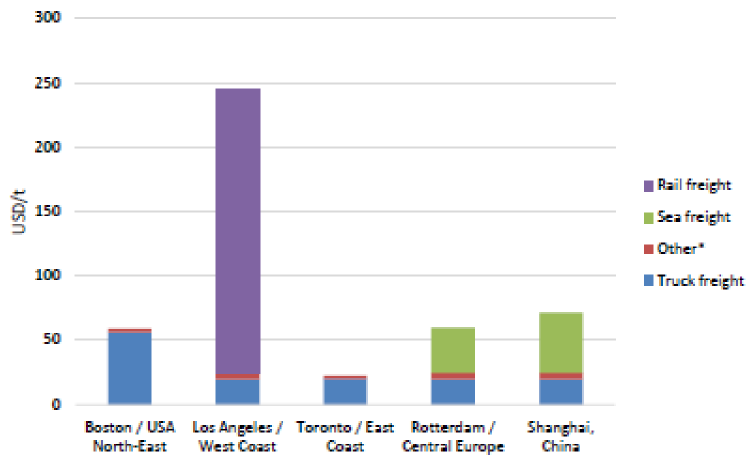
Using Greater Sudbury as a proxy the transportation cost to Toronto is reasonable at 20 USD/t (Figure 2.1). The market in Boston is within a distance that is relatively far using truck transportation, but too close for affordable train transportation. Consequently, shipping to Europe is equally attractive due to the relatively low sea freight rate.

Figure 2.1 Transportation costs



(*) Port costs, unloading and loading.

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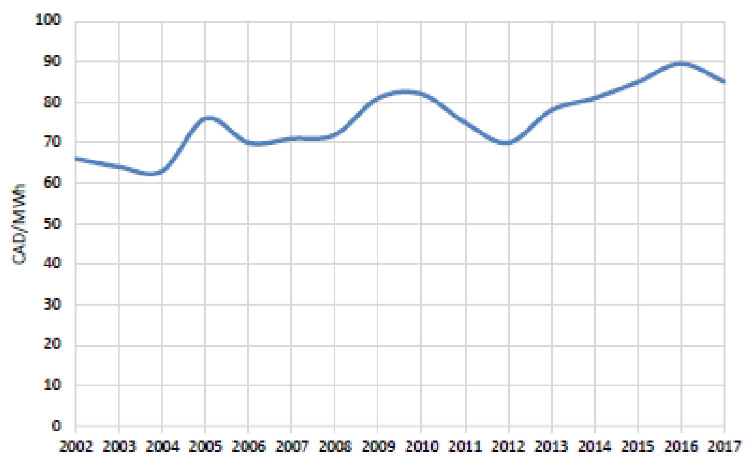
3. TIER 3 – HIGH LEVEL ANALYSIS

3.1 Energy

The transmission connected electricity price for industrial operators has been around 80 to 90 CAD/MWh in Ontario in the recent years (Figure 3.1). The distribution connected electricity price is about 10 CAD/MWh higher. The electricity prices are significantly higher in Ontario than in the neighbouring jurisdictions. The price level in Ontario is 25 CAD/MWh than in New Brunswick and over 40 CAD/MWh higher than in Quebec.

Figure 3.1 Delivered industry electricity price (Class A), 2002-2017

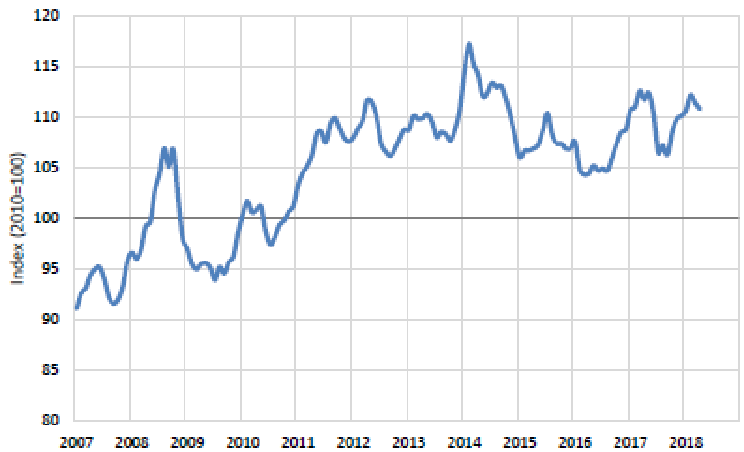


Source: Independent Electricity System Operator (IESO) of Ontario.

3.2 Key supplies

Ontario has Canada's largest chemical manufacturing sector with top-15 global chemical firms manufacturing in the province. There are nearly 700 chemical manufacturing establishments in Ontario. Consequently, supply of chemicals for forest industry is conveniently available from local sources. The chemical price index has remained stable during the last seven years indicating that the chemical prices have remained competitive during the economic boom of Canada (Figure 3.2). There are also a number of dedicated service providers for distribution of the wood waste towards end-users.

Figure 3.2 Chemicals and chemical product price index, 2007-2018



Source: Statistics Canada.

3.3 R&D

The investments into forest industry research and development declined severely during the global financial crisis in 2007 to 2009, but has increased notably since then. Ontario's forest industry has primarily invested into research and development (R&D) through FPInnovations, a Canadian non-profit member organization which conducts research and development for the Canadian forest industry. Ontario's forest industry investments to FPInnovations have been CAD 250 000 annually. The total annual investments are shown in Figure 3.3. FPInnovations and more specifically its wood products research division Forintek, focus on optimizing manufacturing process, developing higher value-added products and managing customer's expectations related to the end-products performance, durability and affordability.

In addition to investments into R&D through FPInnovations, Ontario's forest industry has research and development partnerships with universities, colleges and corporate partners. Private sector spending on R&D decreased significantly during the economic downturn in 2007 to 2009. The Ministry of Natural Resources and Forestry has started to prioritize its investments in science research under its Integrated Science Action Plan. The Ontario government is funding with CAD 5.8 million a pilot project to produce and commercialize biochemicals derived from wood at Resolute Forest Products' pulp and paper mill.

Ontario has also significant support in R&D in the biochemical sector and there are several ongoing R&D programs and establishments such as Bioindustrial Innovation Canada, Bioproducts Discovery and Development Centre, Centre for Research and Innovation in the Bio-Economy (CRIBE), GreenCentre Canada and MaRS Discovery District.

University of Guelph received CAD 6 million funding for bio-composites research in May 2018. This includes two initiatives researching ways to turn waste into new products and related technologies. The focus of the research will be to develop and commercialize technologies to produce sustainable plastic packaging from recycled and renewable plastics.

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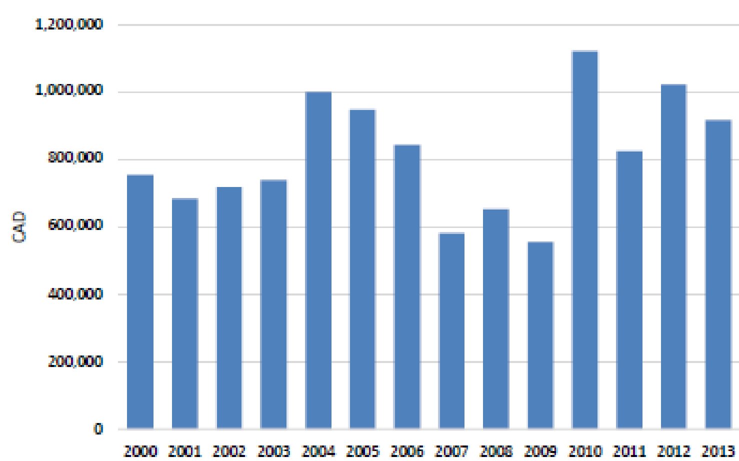
Ontario government is also spending CAD 6.7 million on pilot programs to help rural and indigenous communities to transition from fossil fuels to wood and pellet heating systems. The programs are launched through Green Ontario Fund (GreenON).

Ontario has a Wood Promotion Program which builds workforce capacity to support the industry in the future. It aims to connect the primary and secondary forest industries, federal and provincial governments and industry organizations. The program helps producers and their associations develop domestic opportunities for Ontario wood products and supports research and development for the next generation of forest products. The program provides technical advice to wood products producers to help them take advantage of new markets or enhance their productivity. Under the program, in most cases, Ontario invests up to 50% of a project's eligible costs.

Ontario also has the following programs to fund research:

- **New Directions Research Program** offers maximum of CAD 200 000 in funding for research that stimulates the sustainable growth and competitiveness of Ontario's agri-food, agri-business and rural sectors, with a focus on disruptive technologies.
- **Ontario's Alternative Renewable Fuels 'Plus' Research and Development Fund - Ontario Ministry of Agriculture, Food and Rural Affairs** (OMAFRA) funds CAD 200 000 max for exploration of new markets and uses for bioproducts, alternative renewable fuels and their co-products and contributes to the long-term sustainability of Ontario's agri-food, energy and rural sectors.
- **Ontario Ministry of Agriculture, Food and Rural Affairs and University of Guelph Research Agreement** funds research in seven theme areas that include: Bioeconomy-Industrial Uses with grants **between CAD 80 000 to 150 000 per project per year.**

Figure 3.3 Ontario forest industry investment, 2000-2013



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FOR/Maine

Global Market Analysis and Benchmarking Study – United States (Midwest, Minnesota)

Final Report

Helsinki, Finland
June 29, 2018

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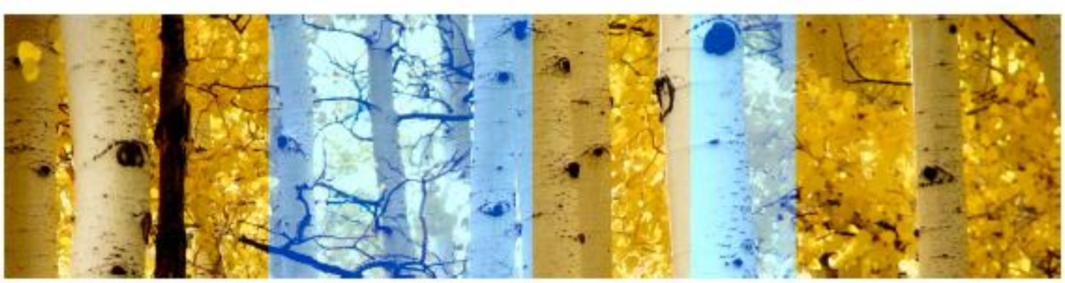
ID 122626



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1. TIER 1 – DETAILED ANALYSIS

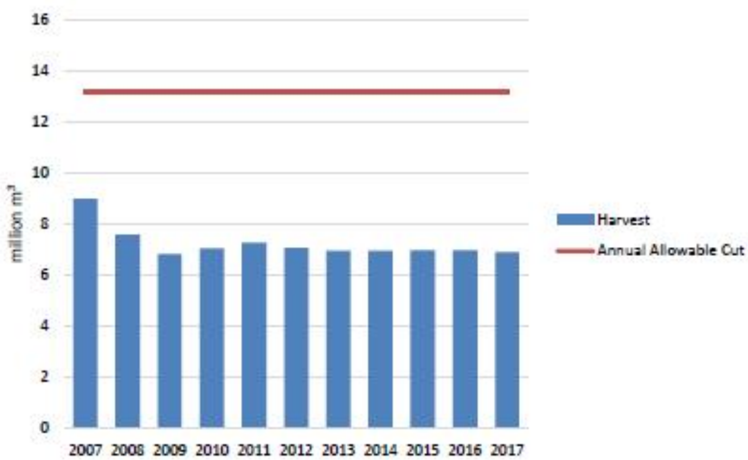
1.1 Raw material

1.1.1 Harvest levels

Harvest levels have decreased in Minnesota since 2005 due to downsizing in P&P sector. Current harvesting level is estimated 7 million m^3 a year (Figure 1.1). The total forest growth in 2017 was estimated at 25 million m^3 and annual mortality was 12 million m^3, which led to annual net growth of 13 million m^3. Annual sustainable harvesting level is estimated just above the annual net growth, due to potential substitution of some mortality with timely harvesting. Thus, there is biological potential to increase current harvesting levels by 6 million m^3 or relatively by 48% compared to net growth. Majority of the increased potential is in private forests.

However, the biological potential is limited by technical end economic restrictions. For example, protection areas, willingness to sell, forest accessibility, distance to mill and stand species composition can limit harvest levels. A realistic capture in short-term could be 9–10.5 million m^3, meaning potential to increase harvest by 2 – 3.5 million m^3. Collection of wood residues could be increased significantly.

Figure 1.1 Harvest and AAC in timberlands in Minnesota, 2007-2017e



Use unit conversion factor 1 cord = 2.4 m^3

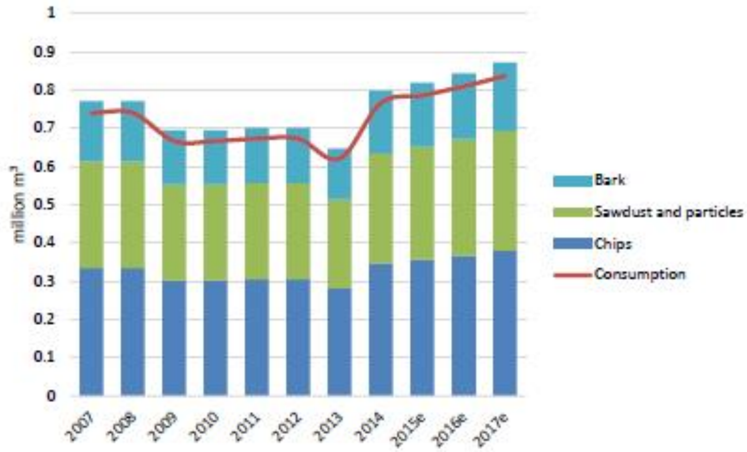
Source: Minnesota Department of Natural Resources, Forest Resources reports and Indufor analysis

Xcel Energy has announced its plans to close two wood using biomass plants in Minnesota, which would significantly impact the wood residue and energy wood demand in Minnesota. Furthermore, UPM shut a paper machine in Blandin Paper Mill in Grand Rapids in early 2018. The paper machine had a capacity of 128 000 tonnes. Together, the downsizing by Xcel Energy and UPM could decrease wood flows by 0.5 - 1 million m^3, further increasing harvesting potential in short-term for other products.

1.1.2 By-products

There is little potential (5%) to increase consumption of by-products (Figure 1.2). The majority of the by-products are chips that can be used for pulp production. Sawdust and particles and bark are mostly burned for energy. The production of by-products could double if all sustainably available saw logs would be harvested and processed.

Figure 1.2 Estimation of wood processing residues production and consumption, 2007-2017e



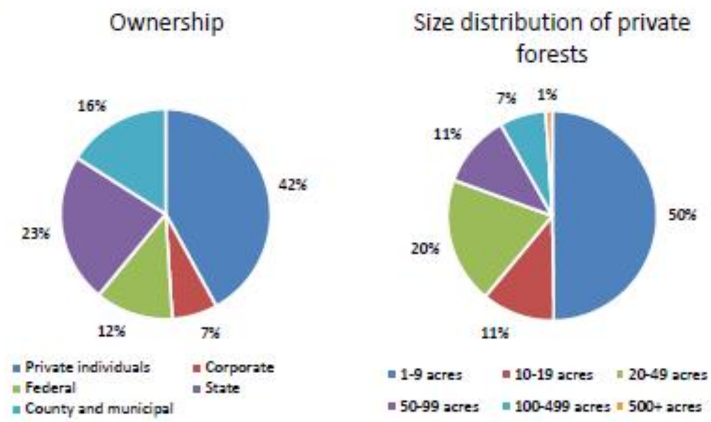
Source: Indufor estimation based on saw log consumption and experience from other geographies

1.1.3 Forest ownership

The total timberland area is approximately 17.4 million acres (7 million hectares). Approximately 49% of timberlands in Minnesota are privately owned – majority by private individuals (Figure 1.3) and 51% is public, with the state being the largest public owner followed by county and federal ownership. Minnesota is an important wood seller, selling stable timber permits from year to year, based on the forest authority's long-term forest management goals. The timber permits are sold transparently at auctions, where the location and details of the offered tracts are pronounced beforehand, and the results of the auctions are available afterwards.

Majority of the individual owners are smallholders. Half of the private individual forest owners in Minnesota own less than 9 acres (3.6 hectares) of timberland.

Figure 1.3 Timberland ownership in Minnesota



Source: Minnesota Department of Natural Resources and USDA.

1.1.4 Delivered wood cost

The delivered wood cost of pulpwood was estimated at 43 USD/m^3 in 2016 (Figure 1.4). Average stumpage cost for all species according to their share in pulpwood harvest was 10 USD/m^3 in 2016. Harvest and transportation costs were estimated based on costs in Lakes States area of US. The stumpage price varies greatly between species. Aspen and balm, followed by spruce species, are the most harvested species for pulpwood. Their stumpage prices can be double to other less harvested species.

Stumpage price of biomass sold for energy has varied between 0.8 and 1.1 USD/ton. Data is insufficient to estimate the delivered cost of biomass for energy. However, the delivered cost of fuelwood in the Lake States area is estimated at approximately 32 USD/ton, which could be close to the price of ton of biomass.

Delivered cost of residual chips in Minnesota was estimated based on average prices in the Lake States area. The average cost of residual chips was 46 USD/m^3 in 2016 (Figure 1.5).

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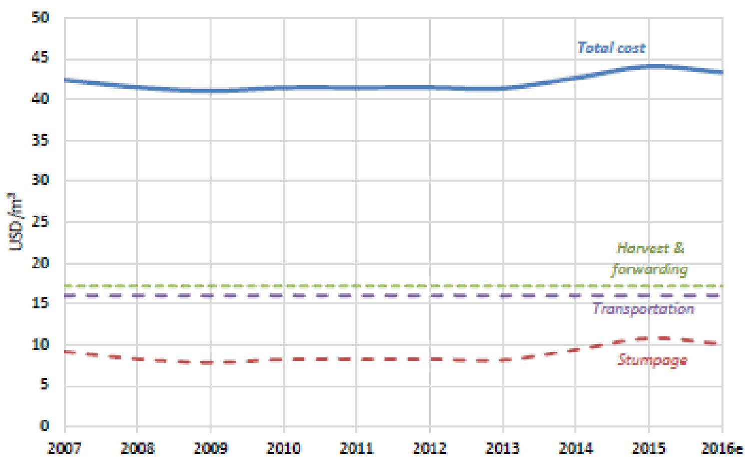
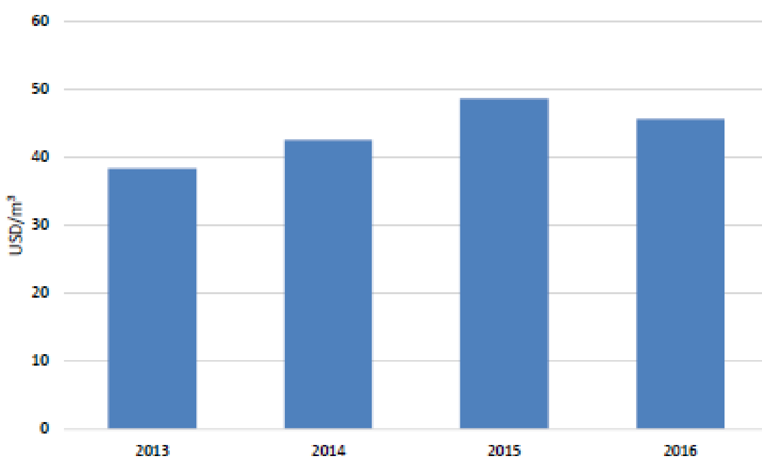
Figure 1.4 Estimated delivered pulpwood cost for Minnesota 2007-2016e



Used conversion factor 1 cord = 2.4 m³
Source: Minnesota Department of Natural Resources, Forest2Market, Indufor estimation

Figure 1.5 Estimated delivered cost of residual chips, 2013-2016



Source: Indufor database and analysis

1.1.5 Wood procurement practice

Approximately 30% of the wood is sourced from state forest. State sells timber permits through public auctions. Loggers and industry professionals often secure timber permits instead of business owners. Loggers need to follow *Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers* on best logging practices in state land. Standing sale is the common practice in private forest.

Various harvesting methods are used. Cutting is done either with a feller buncher or a cut to length harvester. Forwarding can be done either with a skidder or a forwarder. Harvesting may be done as group selection, clear cut or shelterwood harvest. Majority of the harvests are done in the winter due to restriction in soil and road carrying capacity in other seasons. Furthermore, long-distance trucks can carry limited loads in the winter.

1.2 Workforce

Table 1.1 1.2.1 Demographic comparisons

Indicator	Current situation
Total population (2017)	5 577 000
Population growth rate (2017)	0.9%
Population urbanization, rural vs urban (2017)	15% vs 85%
Unemployment rate (2017)	3.5%
Level of education[1] (2016)	11.7%

[1] Share of master's degree or higher in all population aged 25 and above

Total population of Minnesota is 5.6 million people. The population is increasing steadily by 0.7-0.9% annually. Post-war baby boom generation is still the largest age-class, but contrary to many other developed country populations, the size of younger age classes has remained constant (Figure 1.6).

Unemployment increased significantly after the recession of 2008. However, the increase was short-term. Currently, the unemployment is only 3.5%, which limits labour availability to new ventures.

The population is highly urbanized, and the share of urban population continues to increase. The driver for urbanization has not come from rural areas. Rather, the population increases faster in urban areas than in rural areas, which increases the relative share of urban dwellers.

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Figure 1.6 Historical development of demographics

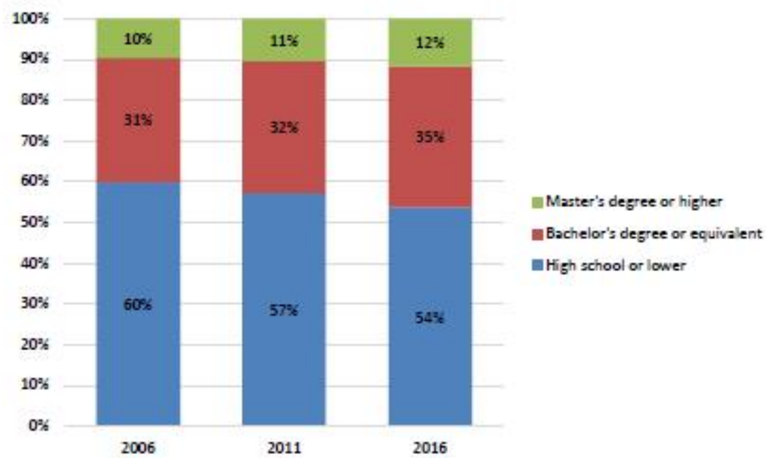
Source: The Minnesota Department of Administration, The Minnesota State Demographics Center; United States Census Bureau, American Fact Finder; The Minnesota Department of Employment and Economic Development, Greater Minnesota Refined & Revisited by Minnesota Department of Administration, Minnesota State Demographic Center; Indufor estimate based on United States Census Bureau, Decennial Census.

1.2.1 Level of education and the skill levels required

Approximately half of the people in Minnesota have at least a bachelor's degree or equivalent, which means that the labour force contains large-share of educated white-collar workers (Figure 1.7). Yet, only 12% of the population has at least a master's degree from university, which can be a limiting factor when it comes to new sophisticated wood products that require specific chemical and engineering knowledge. However, the number (12%) is an underestimation for the active labour force, because it includes all the population aged 25 and above, including retired people who have on average lower education level than the younger generations.

Manufacturing sector in Minnesota has had difficulties to find educated and experienced workforce. The unemployment rate is low, which means that there is little available workforce, and companies have to invest to obtain suitable workforce, either by rephrasing the calls for applications, training new employees more, increasing starting salaries or working with local educational institutions to modify curriculas to better answer to the sector's needs.

Figure 1.7 **Educational attainment of all population aged 25 and above**



Source: United States Census Bureau, American Fact Finder

1.2.2 Typical labor costs

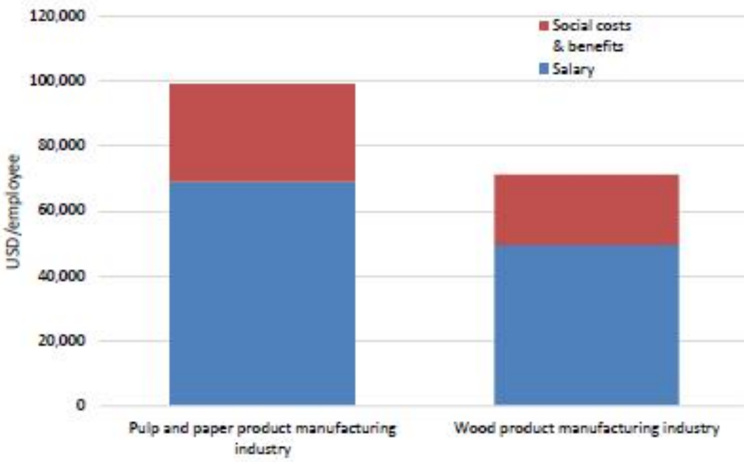
Average labor costs are high in P&P industry. Companies pay approximately 30% on top of the direct salaries. Different benefits include insurance costs, social costs, paid leaves and supplemental pays (Table 1.2). The average salary in P&P industry is almost 70 000 USD, which leads to a total average labor cost of almost 100 000 USD (Figure 1.8). The labor costs are much smaller in wood product manufacturing industry, where the average direct salary is just below 50 000 USD/year and the total labor cost approximately 70 000 USD/year.

Table 1.2 **Structure of labor costs in private industry in West North Central part of Midwest region, 2017**

Cost item	%
Wages and salaries	**69.7%**
Total benefits	**30.3%**
Paid leave	*6.6%*
Supplemental pay	*3.1%*
Insurance	*8.7%*
Retirement and savings	*3.9%*
Legally required benefits	*8%*

Source: United States Department of Labor, Bureau of Labor Statistics

Figure 1.8 Labor costs in P&P and wood product manufacturing industry, 2017



Source: The Minnesota Department of Employment and Economic Development and United States Department of Labor, Bureau of Labor Statistics

1.3 Regulatory climate

Raw material supply

There are no federal regulations on harvest levels or the conversion of natural forests to plantations. Other relevant regulations pertain to the protection of endangered species and the environment. The U.S. Fish and Wildlife Service administers *Endangered Species Act* criminalizes harming endangered species. The Environmental Protection Agency (EPA) regulates the use of insecticides in forestry under authority of the *Insecticide, Fungicide and Rodenticide Act*. The federal *Clean Water Act* obligates authorities to identify any non-point pollution sources in silviculture and sets forth procedures and methods (including land use requirements) to control to the extent possible such sources. The discharge of dredge or fill material from normal silvicultural activities (e.g., timber management) is not prohibited under this Act (with some exceptions). Control of nonpoint source pollution depends on the use of Best Management Practices, as well as the participation in a number of other voluntary incentive programs.

Minnesota Forest Resources Council (MFRC) develops policy recommendations to the Governor and federal, state, and local governments and to encourage the adoption of sustainable forest management policies and practices. The council operates under the Minnesota Sustainable Forest Resources Act and has published voluntary Forest Management Guidelines, which cover environmental protection and harvesting topics. The Minnesota Wetland Conservation Act (WCA) regulates work activity in non-public wetlands, but exempts forestry if the following conditions are met: impacts to hydrology and biology are limited in the wetland; no dikes, ditches, tile lines, or buildings are constructed; the wetland is not drained; and, the placement of fill is avoided when possible.

Environmental regulations for manufacturing

In the United States, federal and state authorities are responsible for regulating and enforcing environmental protections relevant to forestry products. Generally, the federal regulations apply, and enforcement responsibility is determined on a state-by-state basis. The EPA must authorize state agencies to regulate issues like water and air quality. States must, at a minimum, uphold the federal standards, but they can also pass more stringent regulations. The current administration has announced its intention to review or rescind many of the environmental regulations put in place by previous administrations, which the current administration claims are a hindrance to business. Nonetheless, air and water quality regulations are relevant to the production of the short-listed products in this study.

The *Clean Water Act* is the main federal law governing water pollution. The Act identifies point and nonpoint pollution sources, with manufacturing facilities for forest products considered point sources. Point sources require permits for any discharge into water bodies under the *National Pollutant Discharge Elimination System* (NPDES). State authorities can administer and enforce the permitting system if authorized by state laws and the EPA (all states in this study have been delegated such authority). NPDES permits must be reissued every five years. Sector-specific effluent guidelines set the standard for polluted runoff and are enforced by the NPDES permitting process. The *Pulp, Paper and Paperboard Effluent Guidelines* set the standards for permitting. Some trade groups claim that the guidelines are too strict and impose undue costs on the producers without commensurate impact on human health.

The *Clean Air Act* governs air pollution in the United States. The EPA has overall responsibility for the Act but states are mainly responsible for ensuring compliance and permitting. Permitting for stationary sources of pollution (volatile organic compounds) is required with renewal every five years. The standards used in the permitting process relevant to forestry products include the Kraft Pulp Mills: New Source Performance Standards (NSPS), *Plywood and Composite Wood Products Manufacture: National Emission Standards for Hazardous Air Pollutants, Pulp and Paper Production (MACT I & III): National Emissions Standards for Hazardous Air Pollutants (NESHAP) for Source Categories*, and *Compliance for Industrial, Commercial, and Institutional Area Source Boilers*. The Clean Air Act requires permits to build or add to major stationary sources of air pollution (the New Source Review (NSR)). Additionally, the production of ethanol requires on-site emissions control equipment to obtain a permit under the *National Emission Standards for Hazardous Air Pollutants (NESHAP) for Chemical Manufacturing Area Sources (CMAS)*.

Sulfur emission regulation

Ocean-going vessels and large ships traditionally used "bunker fuel" with sulfur levels as high as 5%, or 50,000 ppm, sulfur. Bunker fuel burned on these ships was a large source of harmful air pollution in the U.S. An international treaty designated two Emission Control Areas (ECA) covering U.S. waters. The North America ECA extends 200 miles from the shores of North America, and the U.S. Caribbean Sea ECA covers waters around Puerto Rico and the U.S. Virgin Islands. The sulfur content of the fuel used in marine vessels operating in these ECAs may not exceed 0.10 weight percent (1000 ppm).

EPA's national ambient air quality standards for SO2 are designed to protect against exposure to the entire group of sulfur oxides (SO_x). National Ambient Air Quality Standards (NAAQS) for SO_2 specify maximum amounts of sulfur dioxide to be present in outdoor air. Limiting SO_2 in the air protects human health and the environment. The sulfur content of gasoline is limited to a maximum of 10ppm beginning in 2017.

Emission markets

EPA's Clean Air Markets Division (CAMD) runs programs that reduce air pollution from power plants to address several environmental problems, including acid rain, ozone and particle pollution, and interstate transport of air pollution. CAMD programs include the Acid Rain Program (ARP), the Cross-State Air Pollution Rule (CSAPR), and the CSAPR Update.

Each year, EPA holds an auction for SO_2 emissions allowances set aside in an Auction Allowance Reserve to let interested parties such as electric power plant owners, environmental groups, emissions brokers and others acquire up to 125,000 tons of emissions allowances under

Phase II of Title IV of the Clean Air Act Amendments. This program provides a source of allowances beyond those initially allocated and facilitates price discovery.

SO_2 allowances are then allocated to affected units serving generators greater than 25 megawatts. All new units based on their historic fuel consumption and specific emission rates. Each allowance permits a unit to emit one ton of SO_2. Sources may choose among several options to reduce emissions. Sources may sell or bank (save) excess allowances if they reduce emissions and have more than they need, or purchase allowances if they are unable to keep emissions below their allocated level. At the end of the year, each source must hold sufficient allowances to cover its SO_2 emissions (each allowance represents one ton of emissions). In 2018, the price for SO_2 was 0.06 USD per ton.

The NO_x program embodies many of the same principles of the SO_2 trading program, in that it also has a results-oriented approach, flexibility in the method to achieve emission reductions, and program integrity through measurement of the emissions. However, it does not "cap" NO_x emissions as the SO_2 program does, nor does it utilize an allowance trading system.

The Minnesota Pollution Control Agency is responsible for permitting facilities that emit pollutants, which adheres to the federal Kraft Pulp Mill NSPS. Minnesota's environmental quality standards align with the federal Clean Water Act and Clean Air Act.

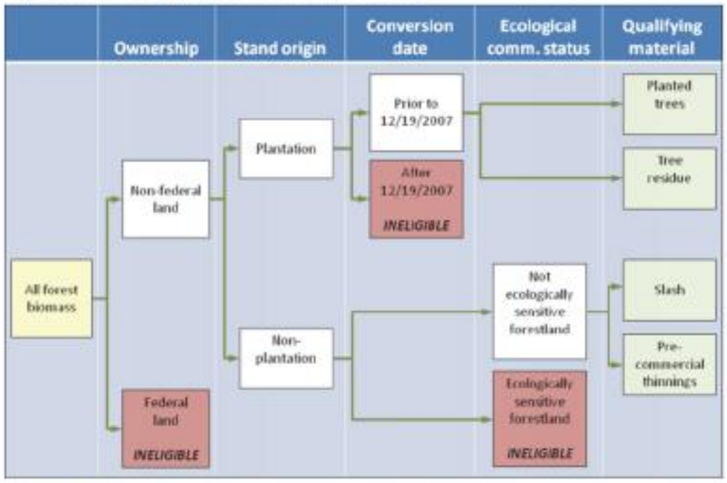
Market access

Key market access regulations related to the short-listed products relate to formaldehyde standards and the use of cellulosic ethanol in renewable fuels standards.

Specific to MDF, CARB2 and the Formaldehyde Standards for Composite Wood Products Act apply only to interior use products such as hardwood plywood, medium density fiberboard, and particleboard. The formaldehyde emissions standards go into effect beginning on December 12, 2018. Products used in the construction of a building's frame are exempt from emission requirements. There are no small entity exemptions and there is no de minimis standard based on the size of smaller panel producers.

Administered by the EPA, the Renewable Fuel Standard requires transportation fuel sold in the United States to contain a minimum volume of renewable fuels. Under the standard, Cellulosic bio-fuel is its own category and is considered an Advanced Biofuel. Advanced biofuels are required to meet stricter air pollution requirements than regular corn-based ethanol. Cellulosic biofuel must be produced from cellulose, hemicellulose, or lignin and must meet a 60% lifecycle GHG reduction. The minimum volume determinations are subject to change year-to-year, which provides uncertainty to supply market. For 2018, the EPA set a volume requirement of 288 million ethanol-equivalent gallons, which is lower than the 2018 target of 7 billion gallons set by the *Energy Independence and Security Act* of 2007. The lower requirement is due to the limited supply of cellulosic biofuels on the market. To qualify as renewable cellulosic biofuels used for liquid transportation fuels, the fuel must be produced from logging residues, "pre-commercial" thinning materials, or biomass originating from forest plantations established before 2007 (Figure 1.9). These criteria require the producer to maintain records and proof of plantation establishment.

Figure 1.9 Categories of renewable biomass



In April 2018, the EPA Administrator announced a policy making clear that future regulatory actions on biomass from managed forests will be treated as carbon neutral when used for energy production at stationary sources.

Minnesota passed a statute in 2013 that bans products for children that intentionally contains formaldehyde.

Voluntary actions for sustainable forest management

Minnesota has a large number of certified forests. In 2012, the total certified area was 8.5 million acres (3.4 million hectares), but 7.5 million acres are public and less than 1 million acres are private, and most of those are corporate owned forests. FSC® and SFI® are the most common certification schemes.

Conclusion

Minnesota's regulatory climate is neutral, with forest management driven by more than just commercial harvesting concerns and water and air quality regulations meeting federal standards.

1.4 Taxation

The main taxes in Minnesota are the corporate tax (30.8%) and the sales tax (6.875%), wood sales tax (varies) and property tax (1% of the market value).

Within North America, the USA has programs in place to reduce the corporate tax rate, such as deducting the entire cost of equipment purchases from a company's taxable income as well as reducing an employer's federal income tax liability when increasing employment. Minnesota provides a variety of incentives and financial assistance to help companies startup, expand, and relocate in Minnesota. However, none of these incentives reduce the corporate tax rate, while some reduce the sales tax, including materials used or consumed to produce a product. Manufacturers can be exempted from paying sales tax on electricity.

The Greater Minnesota Job Expansion Program provides sales tax benefits to businesses located in Greater Minnesota that increase employment. Qualifying businesses that meet job-growth goals may receive sales tax refunds for purchases made during a seven-year period.

Th Border-Cities Enterprise Zone Program provides sales tax credit on construction equipment and materials, while materials used or consumed to produce a product may qualify for the industrial production sales exemption.

Electricity, gas or steam used or consumed in agricultural or industrial production is exempt from sales and use tax. Exemption does not apply to space heating, lighting or water used or consumed in non-production areas such as office or administrative areas.

Sale of standing and cut timber is taxed on a federal level in USA, with the sale of standing timber taxed as capital gain, while the sale of cut timber is taxes ad ordinary income. The tax for standing timber can be 0% - 15% - 20%. In addition to a tax on the sale of timber, all US states have some sort of tax on the harvest of timber. In Minnesota, standing timber is to be defined as real property and when it is sold a deed tax must be paid.

Many costs related to the production of wood or growth of timber are eligible for a deduction or credit within the USA through the federal IRS or CRS.

Property tax for (forest)land is applied on a state level as ad valorem in Minnesota. It taxes the value of the land as it is currently being used. The property tax is ad valorem, with net rate of 1% of the market value. Property taxes can be lowered in all states when a landowner adopts a sustainable forest management plan, resulting in 35% decrease in Minnesota.

Environmental taxes are applied on both federal and state level in USA. The tax for diesel and gas is 0.53 and 0.47 cents per gallon respectively.

2. TIER 2 – GENERAL ANALYSIS

2.1 Policies

Federal

In the USA, the Wood Innovation Grant is the most important mechanism to expand and accelerate wood products and wood energy markets, with 8 million USD in funding in 2018. In total, the Forest Products Program has 359 million USD budgeted in 2018. In addition, the Forest Stewardship Program helps to create jobs in rural communities by sustaining local forest products markets and increasing demand for qualified private forestry consultants. The 2018 budget provides 20.5 million USD in support of this program.

Under the Obama administration, the USA set a renewable energy target of 20% of renewables on electricity use for all agencies, the largest energy consumer in the country. However, states have been adopting and increasing renewable energy standards (RET). As part of these standards, utilities are required to sell specific amount of renewable electricity, which can be designated only for investor-owned utilities (IOUs) or incorporate government run utilities.

Utilization of biobased products in US is encouraged with several programs. The BioPreferred Program aims to increase the consumption of biobased products by setting a mandatory purchasing requirement for federal agencies and their contractors, but also by a voluntary labelling initiative. With a label granted by United States Department of Agriculture, the consumer is provided information about the bio content of the product. Biorefinery, Renewable Chemical, and Biobased Product Manufacturing Assistance Program may provide a loan guarantee up to 250 million USD for projects that use emerging technologies to convert outputs of biorefineries or biobased product manufacturing facilities into end user-products. However, the program is part of Farm Bill 2014 agreement that will be renewed in 2018, but most likely in smaller scale.

Use of biomass as an energy source is supported by the federal government with a variety of programs. From the point of view of forest biomass, some of the relevant programs are BioEnergy Engineering for Products Synthesis, Process Development for Advanced Biofuels and Biopower and State Energy Loan Program. The Renewable Fuel Standard set by the Environmental Protection Agency requires transportation fuel sold in the US to contain a minimum volume of renewable fuels, for example fuel derived from cellulosic biofuel.

Minnesota

Similar to Maine and Oregon, Minnesota has set renewable energy standards and GHG emission targets, with the aim to have 26.5% of electricity produced by renewable energy sources by 2025, and to reduce GHG emissions by 30% by 2025. In addition to these targets, Minnesota requires utilities to invest 1.5% of their annual income in conservation programs under the Conservation Improvement Program (CIP), which may include promoting the startup, expansion, and attraction of renewable energy projects. Because of the CIP program, Xcel Energy, one of Minnesota's utility facilities, developed the Renewable Energy Fund, which provided 100.9 million USD for legislatively-mandated projects and programs, since its inception in 2002, predominately focused on solar energy.

Minnesota also has programs to stimulate the production of advanced biodiesel. As of May 1, 2018, Minnesota requires all #2 diesel to contain 20% biodiesel, between May 1 to September 31, and to contain 5% biodiesel, between October and March. 1# diesel is exempted from the biodiesel requirement. Furthermore, eligible production facilities may receive financial incentives to produce biodiesel from cellulosic biomass ($2.1053 per MMBtu), to produce chemicals which have at least a 51% biobased content ($0.06 per pound), and to produce thermal energy from biomass combustion, gasification, or anaerobic digestion ($5.00 per MMBtu).

In terms of forest programs, Minnesota offers federal programs, such as the Forest Legacy Program, The Forest Stewardship Program, and the Healthy Forests Reserve Program. In addition, Under the Sustainable Forest Incentive Act (SFIA) landowners are encouraged to no develop forests. Overall the aim of the programs is to preserve and maintain forest land. The forestry industry does not seem to benefit directly from these programs.

The forest industry may benefit from the presence of the forest products management development institute. As current forest policies do not go above and beyond federal policies or similar state policies on sustainable forest management, the policy environment can therefore be considered medium. However, as Minnesota's policy environment is high for the development of (clean) technology-driven economy by offering grants, loans, and other incentives, with a focus on biofuels (produced from cellulosic biomass), the policy environment can be considered high. Minnesota has a renewable energy standard (2007) of 26.5% by 2025 (IOUS) and 25% by 2025; In addition, Excel Energy Xcel Energy has a separate requirement of 31.5% by 2020; 25 percent must be from wind or solar. Solar: 1.5% by 2020 (other IOUs); Statewide goal of 10% by 2030.

The Community Energy Efficiency & Renewable Energy Loan Program, also known as the "Rev It Up" Program, is a revolving loan program that allows up to 100 million USD in revenue bonds to be issued for low-cost loans to local units of government, industrial and commercial businesses.

Green Business Loan Program: This revolving loan program provides low-interest loans to Minnesota businesses seeking financing to install energy retrofits. Loan amounts range from 20,000—300,000 USD.

Small Business Environmental Assistance Program provides low-interest loans up to 50,000 USD to qualified small businesses to finance environmental projects such as capital equipment upgrades that meet or exceed environmental regulations, including idle reduction technologies.

Grants are available to biofuel producers for up to 2.1053 USD per million British Thermal Unit (MMbtu) for advanced biofuel produced from cellulosic biomass. Total payments to all producers are limited by statute to the equivalent of 17,100,000 MMBtu of advanced biofuel. The Minnesota Department of Agriculture offer funding assistance to fuel retailers for the installation of equipment to dispense ethanol fuel blends ranging from E15 through E85.

Renewable Chemical Production Incentive Program: Chemicals must have content that is at least 51% biobased to be eligible for the production incentive. Materials may be from agricultural, forestry, or solid waste sources. The subsidy is 0.06 USD per pound of production from cellulosic biomass.

The Conservation Improvement Program (CIP), requires utilities to invest 1.5% of their annual income in conservation programs. For instance, thee Renewable Development Fund promotes the startup, expansion, and attraction of renewable energy projects and companies across Minnesota and Wisconsin.

RDF Grant Program has provided over 276 million USD for renewable energy initiatives including 90.6 million USD for Renewable Energy Production Incentive (REPI) payments, 100.9 million USD for legislatively-mandated projects and programs, and 2.3 million USD for general program support. Mandated programs have included the appropriation of 25 million USD to the University of Minnesota for the Initiative for Renewable Energy and Environment (IREE), 21 million USD for the Minnesota Bonus Solar Rebate Program, 25 million USD for the Solar Energy Incentive Program, and 120 million USD for the Made In Minnesota Solar Energy Production Incentive Account.

The forest industry may benefit from the presence of the forest products management development institute. As current forest policies do not go above and beyond federal policies or similar state policies on sustainable forest management, the policy environment can therefore be considered neutral. However, as Minnesota's policy environment is high for the development of (clean) technology-driven economy by offering grants, loans, and other incentives, with a focus on biofuels (produced from cellulosic biomass), the policy environment can be considered beneficial.

2.2 Access to financing

Overall, the banking sector is stable and favorable to investment in the United States. Investment spending should remain strong and cost of capital low. The credit rating is AA+/Stable/A-1+, enabling low interest rates. There is an abundance of private equity investors in the United States, both domestic and foreign. The United States ranks first for private funding in attractiveness for private equity and capital venture. The current federal funds rate is 1.75%, although the Federal Reserve signaled it will raise rates to 2% in 2018, 2.5% in 2019 and 3% in 2020. Inflation was on average 2.1% in 2017.

Many options exist for loan guarantees for investments; the USDA's Business and Industry (B&I) Guaranteed Loan Program provided guarantees of 60, 70 or 80 percent (depending on loan size) to a variety of business purposes, including forestry projects.

Minnesota's banking system is stable and the credit rating AAA/Aa1. Minnesota offers several funds and loans, with a focus on developing small businesses, creating opportunities for Native Americans, and to a lesser extent developing (small) manufacturers. Through its State Small Business Credit Initiative, Minnesota stimulates private sector lending and improves access to capital (up to USD 15.4 million) for small businesses and manufacturers. In addition, small businesses may benefit from low interest-loans (up to 50 000) to finance environmental projects, such as capital equipment upgrades that meet or exceed environmental regulations, including idle reduction technologies. Moreover, the Growth Acceleration Program, provides grants up to USD 50,000 and consulting service to help small manufacturers become more efficient. As for larger businesses, Minnesota offers Renewable Energy Loan and Green Business Loan Programs, which respectively allows up to 100 million in revenue bonds to be issued for low-cost loans to industrial and commercial businesses. It also provides the Federal Business and Industry Loan Guarantee Program with an upper limit of USD 10 million, in line with other states.

Private equity and capital venture investment opportunities are present in Minnesota, albeit in lower quantities than other states.

Ease of access to financing provides an advantage over many other countries that do not have substantial private investment, however, the United States lacks substantial national level forestry incentives and green capital incentives that are found in the EU and Canada. Although Minnesota enjoys a stable banking environment and access to Government backed finance is aimed at small businesses (of which some may be manufacturers)—the state lacks forest-based financial incentives. Additionally, there is a major shortage in early financial backers or strong venture capital interest. Therefore, access to finance can be defined as low to neutral in relation to forest industry investments.

2.3 Logistic infrastructure and transportation costs

As a Great Lakes state, Minnesota is centrally situated to access Canadian and Central United States markets. 56% of forestland is held by the public, while the remaining 44% is held by private individuals, companies or organizations. Minnesota's forest products industry is almost entirely based on exports within the continent (just under 7% is transported internationally with the overwhelming majority to Canadian markets). The lack of open water ports has shifted Minnesota's forest products economy to neighboring states of Wisconsin, Illinois, and Michigan. Transportation of products has primarily relied on trucking (2.71 billion commercial miles on Minnesota state highways) and rail shipments (248 million tons). An additional 58.4 million tons traveled through ports on Lake Superior, and 9.2 million tons through river ports on the Mississippi River.

The relatively high level of privately held remote forest land, requires a significant forest road network to reach the state and national transport networks. While accurate statistics are not available, it is likely that forest roads are used in a similar capacity as other highly forested states. Using Annual Highway Construction costs, Minnesota ranks as the thirtieth most expensive state for road construction ($24 190 per lane mile). General forest road construction costs and maintenance are likely higher than average due to the harsher winter climate, 2 million USD. Investors may receive a 45% tax credit on their investment, up to 112 500 USD per year, when investing in innovative business located in the Minnesota border cities of Breckenridge, Dilworth, East Grand Forks, Moorhead, and Ortonville. The credit is non-refundable and may be carried forward up to four years.

Much of the private and public research is done in conjunction with the University of Minnesota. The University provides academic careers in e.g. Bioproducts and Biosystem's Engineering that offer studies related to production of bioenergy and biobased products.

The Industrial Partnership for Research in Interfacial and Materials Engineering (IPRIME) at the University of Minnesota researches interfacial and materials science. The Initiative for Renewable Energy and the Environment (IREE) researches bio-based and other renewable energy resources and processes. IREE has a state funding of 5 million USD annually.

R&D in relation to forestry sector is at medium level in Minnesota, lacking R&D in the private sector.

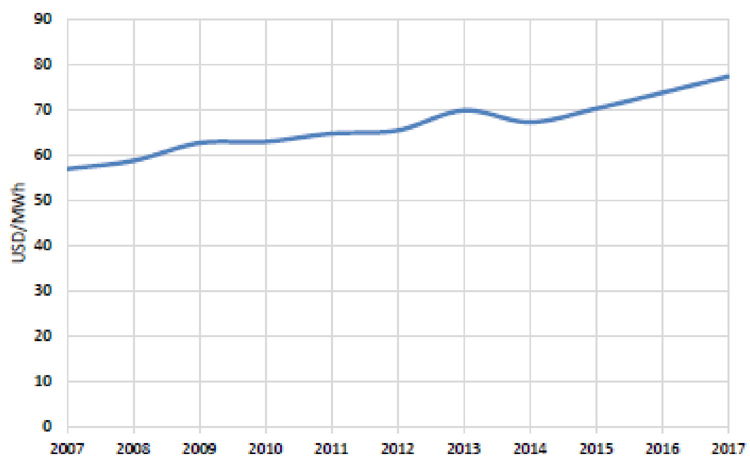
3. TIER 3 – HIGH LEVEL ANALYSIS

3.1 Energy

The nominal price of electricity has increased steadily from 2007 to 2017, and the trend seems to continue. The power cost less than 60 USD/MWh in 2007, but now the price is closing to 80 USD/MWh (Figure 3.1). The residential price of electricity is 70% higher than the industrial price.

Industrial electricity costs more in Minnesota than in US on average. However, the price is competitive in the Mid-West Region. The electricity costs less in Iowa to the South, approximately the same in Wisconsin to the East, but more in both North and South Dakota to the West.

Figure 3.1 Nominal retail price of electricity for industry, 2007-2017



Source: U.S. Energy Information Administration

3.2 Key supplies

Minnesota has lots of machinery and chemical products manufacturing. It is home to many multinational conglomerates that produce wide variety of products, such as 3M. Costs of machinery and chemical products can be higher in Minnesota than for example Oregon and Maine. However, the central location of Minnesota permits to import key supplies from Canada or domestically from other states, but as mentioned, the cost can be higher in Minnesota than in other states.

Key supplies are neither a hindering nor a benefiting factor in Minnesota.

3.3 R&D

While overall private R&D funding has declined, the US Forest Service, universities and other public-private partnerships contribute to the advancement of forestry innovation.

Expenses on research and development or investment may be eligible for tax credit. In Minnesota, the credit is 10% up to the first 2 million USD, and 2.5% for eligible expenses above

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especially in the Northeast where forests are concentrated. Public roads in Minnesota are ranked twenty-fifth in overall quality and ROPAs in poor condition are ranked thirtieth (1.41%). Overall road infrastructure in Minnesota therefore slightly worse than the national average, although urban interstates and congestion impacts are significantly worse than national levels. The maximum total gross weight (97 000 lb) for Minnesota is relatively lower than the average allotted weight for forest trucking, driving up transport costs.

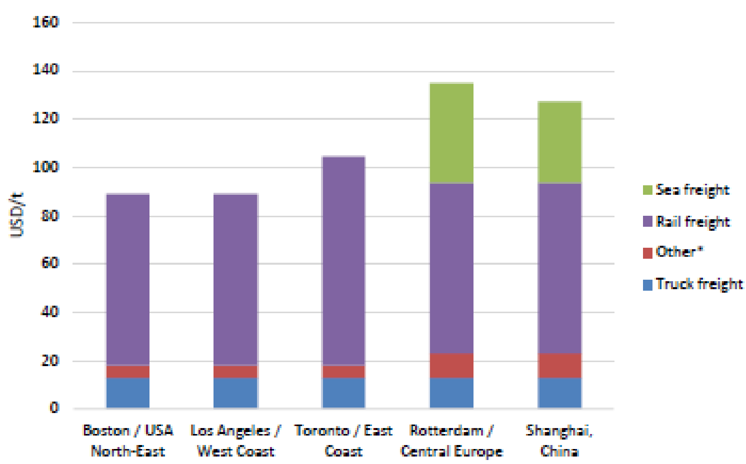
However, Minnesota experiences harsh winters and frost, which enables harvesting using less developed forest roads in the winter, when the frost supports heavy machinery. Therefore, forest roads for winter harvesting can be constructed lightly. Additionally, the region is rather flat, which decreases road construction costs to for example Oregon.

There are four class I railroads in Minnesota, comprising over 80% of all railroad track (3 623 miles) while class II, III and private railroads make up the remaining 821 miles. Rail is a key mode of transportation for shipping paper and wood products in Minnesota, however, much of this traffic is due to construction lumber imports into the state. There is minimal short line rail connection between forests and manufacturing plants in the Northeast, leaving the majority of forestry transit to short- and long-haul trucking. The rail networks provide a continued link between the continental United States and Canada, as well as access to ports on Lake Superior.

Pulp, paper or allied products have an Upper Mid-West freight carload average rate of USD 4 017 below 180% RVC and an average of USD 6 452 above 180% RVC. Chemical or allied products have an Upper Mid-West freight carload average rate of USD 2 906 below 180% RVC and an average of USD 4 454 above 180% RVC.

Minnesota's rail freight costs to the selected North American markets are moderate estimated at USD 4 961 per freight carload to both West Coast and East Coast U.S with a maximum carload of 70 tonnes (Figure 2.1). Assuming access to international markets through Boston the transportation costs from Minnesota are high.

Figure 2.1 Transportation costs



(*) Port costs, unloading and loading.

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