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Forest Opportunity Roadmap/Maine: Forest Products Best Practices

Prepared For:
Maine Forest Products Council

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Executive Summary

With the restructuring of the global forest products industry, many of Maine's pulp and/or paper mills have closed. While recent investments indicate the forest products industry in Maine is rebounding, it must evolve and innovate to remain competitive. This study focuses on potential evolution in one area of the forest products supply chain—transportation. It examines the role that targeted transportation investments and operational policies can play in increasing the efficiency of Maine's forest products industry to allow the industry to remain competitive in the regional and global marketplace.

The study evaluated six primary tasks:

- Integration of Rail and Port with Truck Infrastructure
- Operational Efficiency of Transporting Forest Products
- Improved Truck Coordination
- Comparison of Wheel Configuration and Weight Limits
- Comparison of Vehicle Load Size
- Comparison of Seasonal Weight Limits

Integration of Rail and Port with Truck Infrastructure

Rail can be cost-competitive with trucking when shipping high-volume, low-cost bulk cargos over medium to long-haul distances. Estimates for the minimum shipping distance required for rail to be cost-effective range from 125 to 210 miles. While many forest products are high volume, low-cost bulk cargos, the average truck haul distance from Manie's woodlands to the processing facility for raw forest products is approximately 60 miles, less than half of the minimum distance considered to be cost-effective. In addition, Maine's existing rail infrastructure presents barriers to shipping both raw and finished forest products, such as a fragmented network, service and capacity constraints, and limited access to larger markets. While railroads have been actively working to improve service and capacity throughout Maine, additional investments in Maine's rail network are required before a significant modal transfer to rail is feasible.

Competitive ports are critical to maintaining strong position in foreign markets. While several market opportunities for the export of forest products were identified, few forest products are exported from Maine's ports.

Market opportunities exist in Asia, but Maine's forest products industry faces several comparative disadvantages against competitors in western states, including increased shipping costs and reduced load rates due to smaller logs size. The recent trend towards an increasing degree of containerization provides an opportunity to reduce costs. Due to the container trade imbalance, containerizing forest products may increase the efficiency when shipping abroad.

It is recommended that ports make specialized capital investments in infrastructure to expand handling capabilities and efficiency of loading forest products to increase competitiveness. Existing studies should be reviewed and additional site studies should be completed to consider the existing infrastructure, land, availability of forest products, and market potential to determine the most appropriate investments at specific port facilities.

Operational Efficiency of Transporting Forest Products

Outreach with stakeholders and a review of literature identified the following obstacles that inhibit the efficient transportation and handling of forest products:

- Dispersed locations of Maine's forest products industry
- Lack of back-hauls, resulting in empty return trips
- Shortage of skilled drivers and operators
- Difficult geography, road conditions, and climate
- Variations in the design, maintenance, and fuel efficiency of trucks and trailers
- Inefficiencies in handling of raw forest products at processing facilities

Processing facilities are scattered across Maine, which results in longer travel distances for raw material to reach the point of use, though not long enough for rail to be cost-effective, directly impacting transportation costs. The long distances are not unique to Maine as the hauling distance for softwood logs and pulpwood was found to be highest in northern states, increasing the price of forest products compared to other regions of the United States.

There are no direct solutions to the challenges associated with the dispersed locations of processing facilities across Maine. Measures identified to overcome these challenges include subsidies to get the closed processing facilities running again and government intervention to incentivize a more concentrated cluster of processing facilities.

The rate of young labor entering the forest products industry is not enough to replace the many retiring truck drivers and loggers in Maine, resulting in a strain on labor in the state's forest products sector. The shortage of truck drivers is impacting both the movement of raw products to mills and the distribution of finished product to customers. Labor shortages have also impacted loggers. With fewer loggers to harvest the wood, processing facilities must obtain raw materials from farther away, increasing transportation costs. Given the high cost of entering the logging industry and the uncertainty surrounding it, the shortage of loggers is not anticipated to change.

Among strategies to address labor force issues, the following should be considered:

- Increasing compensation could help attract and retain skilled drivers and operators.
- De-coupling trucking from logging through outsourcing trucking to independent contractors would put downward pressure on trucking costs so long as there is enough competition in the newly created market.
- Outsourcing the transportation sector of the forest products industry provides opportunity to restructure the cost-structure from salary-based to invoice-based, making economies of scale possible.

The cost of road construction and selection of appropriate trucks and trailer types is mainly affected by the geographic condition and types of terrain of harvesting and stocking sites. Resultantly, the forest trucking sector experiences a wide variation in road conditions, as drivers must navigate roads ranging from the lowest standard private logging roads near the landing sites to the highest standard public roads. The variation in road conditions statewide limits the availability of trucks suitable to maneuver the gradient over the truck haul. Direct opportunities to alter the geographic conditions surrounding Maine's forest products industry are limited and unlikely feasible.

The trucks and trailers used in the transportation of raw forest products have their own characteristics and must be adaptable to meet different road conditions and requirements at mills (e.g., different bunk spacing). The lack of standard unloading equipment and the inability to use specialized trucks/trailers creates inefficiencies and increases costs. The following strategies were identified to increase the efficiency of trucks:

- Increase use of training programs for trucking companies, which have been shown to lower operating costs (e.g., smartDriver for Highway Trucking program designed by Natural Resources Canada).
- Use of automatic control for tire pressure allows log trucks increased access to steep logging roads, even in bad weather.
- Upgrading the truck fleet could increase the loading capacity (i.e., lighter trucks allows for increased load size) and use of modern technology.
- Use of integrated scale systems in truck reduces potential load loss because without it, the operators do not know if they have a full authorized load.
- Use of integrated fuel consumption control system to reduce excessive fuel consumption.
- Use of a trucking simulator to optimize the combination of vehicle characteristics and route planning.
- Appropriate alignment of vehicle characteristics, such as engine, design, number of axles, trailer types, and length can improve overall performance of trucks.

Long turnaround times for trucks at the processing facility are another source of inefficiency in the industry. Reasons for long turnaround times include the inconsistent arrival of trucks at processing facilities and different requirements and specifications for delivering and offloading wood via truck or rail at different mills. Reducing idling at processing facilities presents an opportunity for efficiency gains through reduced truck turn times. The following measures have been identified to reduce truck turn times:

- Improved scheduling and coordination of deliveries to avoid peak surges in the arrival of raw materials at processing facilities.
- Utilize self-loading trucks to reduce congestion in space-constrained landing sites.
- Use more unloading cranes or other systems such as frontend loaders with grapples at the processing facilities.
- Improve communication and coordination between different processing facilities in the same area when dispatching and procuring materials.

- Widen and adequately space paved roads at the landing to reduce congestion and facilitate more efficient traffic passage.
- Optimizing yard design can also reduce inefficiencies.

Improved Truck Coordination

Operational optimization involves better planning and coordination of the fleet, either company-wide or region-wide. Several approaches were reviewed to improve operational efficiency:

- Central dispatch model (CDM)
- Consolidation yards
- Truck reservation systems
- Decision support systems
- Collaborative logistics

A CDM is an open-platform logistical model that operates on a common system for all truckers covering a defined geographic area. With regards to Maine's forest products industry, the CDM could either cover all logging and trucking companies in Maine for all processing facilities in operation or be scaled to cover a region of Maine. The CDM would allow trucks to increase utilization by making spare haulage capacity available to logging crews that may be short on trucks. One centralized operation could distribute orders in a way that minimizes travel distances and transportation costs.

A consolidation yard serves as a landing area to store logs somewhere between the logging site in the woods and the processing facility destination, which could be viewed as a middle ground between CDM and the current operational model of each trucking firm operating independently. The consolidation yard allows for collecting and sorting lots by logger, size, species, and processing facility, and could improve logistics for truckers and loggers through better use of equipment, especially in remote areas of Maine.

Truck reservation systems at mills offer another path for greater industry logistics efficiency. In providing advanced lead time for loggers and truckers, a truck reservation system would reduce the reactive environment suppliers work and minimize unnecessary truck movements. While the use of truck reservation systems in the forest industry were not identified, many ports have successfully implemented truck reservations systems, which have been beneficial for both truck operators and the ports.

As the size of the work areas increase, the use of more expensive computer-assisted planning methods becomes justified. These methods are based on problem solving algorithms incorporating decision support systems. However, their use is rather limited, notably due to the lack of precision of the information available on the road network, or the need to use standards, for example for weight and volume units.

Comparison of Wheel Configuration and Weight Limits

Maine falls within the typical range of maximum allowable loads per axle and has the same unpermitted maximum gross vehicle weight of 80,000 pounds as its peers in neighboring New England states (except for Connecticut, which has maximum gross vehicle weight of 73,000 pounds). The peers also have several exceptions and variations of the allowable loads based on routes, axle numbers, distance between axles, and vehicle types. In addition, some peers allow a 5 to 10 percent variance on the weight restrictions. Maine appears to be the only state to waive overweight fines in January and February on interstates, and the weight limit of up to 137,700 pounds for certain cross-border shipments is among the highest weights allowed by the peers; only Michigan and Wisconsin allow higher weight limits.

Comparison of Vehicle Load Size

Maine's maximum load size is 8½ feet, consistent with all other peer states and Canadian provinces. In addition, exemptions for certain vehicle types, such as snow plows or logging trucks, are not unusual and restricted travel on routes, time of day, and weekends or holidays are also common among the peers. Overall, Maine is on par with its peers with regards to vehicle load size.

Comparison of Seasonal Weight Limits

Maine's posted weight limit during the spring thaw is contrasts with the other northeastern states and Canadian provinces vary their limits based on routes and vehicle classes. Only Minnesota and Wisconsin also set maximum posted limits, but they can also vary. Maine's maximum falls between Minnesota's and Wisconsin's. None of the southeastern or pacific northwestern states have weight restrictions given the differences in climate compared to Maine, the northeast, and the upper Midwest.

Recommendations

Of the possible recommendations and improvements that could be made, several were identified as being the most actionable:

- Implementing a truck reservation system is appropriate for Maine and has proven to be beneficial in reducing inefficiencies. Both truckers and mill operators would benefit.
- Standardize unloading equipment across facilities to improve interoperability for shippers at each facility. The State could support this by incentivizing facilities to follow standard guidelines when recapitalizing old equipment.
- Optimize yard design at processing facilities to maximize unloading efficiency and minimize truck turn times.
- Offer incentives for truckers to replace old equipment with new equipment, which will increase operating efficiency and load size.
- Conduct training programs for trucking companies that focus on routing and lowering operating costs.

- Use consolidation (stockage) yards to maximize truck loads on forest roads. Consolidation yards could be operated by a single logging or processing company or could be shared among multiple companies to reduce costs.
- Perform holistic analyses on potential infrastructure investments to avoid expensive expenditures that do not prove to be cost-beneficial.

Though not directly related to logistics, another challenge identified was a lack of coordination across the forest product industry when responding to inquiries from abroad. A potential buyer from abroad does not have a central point of contact in Maine that can direct them to the proper resources (e.g., what mills produce pulp, which ports can handle woodchips). The lack of a central coordinating entity makes it difficult for the buyer to understand which options are available. It is recommended that a central coordinating entity be established that could distribute inquiries to the proper resources within Maine to help facilitate connections and business development opportunities.

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1 Introduction

The global forest products industry is restructuring as technological changes, shifting product demand, and continued cost pressures alter the competitive landscape. Maine's industry is not immune to the change. Maine had 12 pulp and/or paper mills operating in 2010; by 2017 only six remained (Crandall et al., 2017). The effects of these closures have been particularly acute in rural areas, and mill closures have been concentrated in central Maine. While there are many smaller processing facilities (i.e., sawmills) across Maine, the closure of the large pulp and paper mills greatly reduced the demand for raw forest products. Furthermore, the remaining pulp and paper mills are dispersed across the state, increasing the likelihood that raw forest products will have to be transported greater distances.

Recent investments indicate a rebound in the forest products industry statewide. ND Paper, a Chinese-based company, announced plans to invest in two mills in Maine. The company intends to invest $110 million to upgrade the former Catalyst Paper Mill in Rumford, and another $40 million for the mill in Old Town (Valigra, 2019).

While the forest products industry in Maine is rebounding, the global forest products industry is restructuring. Technology and changing demands are transforming the global market for forest products, with the consequence that Maine's industry must evolve and innovate to remain competitive.

1.1 Purpose of Study

The purpose of this study is to examine the role that targeted transportation investments and operational policies can play in increasing the efficiency of Maine's forest products industry to allow the industry to remain competitive in the regional and global marketplace. This study focuses on identifying best practices for movement of wood from the harvest landing to the processor and the movement of finished products to market.

1.2 Organization of Report

This report is organized by task as presented in the Request for Proposal issued for the study:

Task 1: Integration of Rail and Port with Truck Infrastructure
Task 2: Operational Efficiency of Transporting Forest Products
Task 3: Improved Truck Coordination
Task 4: Comparison of Wheel Configuration and Weight Limits
Task 5: Comparison of Vehicle Load Size
Task 6: Comparison of Seasonal Weight Limits

2 Task 1: Integration of Rail and Port with Truck Infrastructure

Maine has 1,100 miles of rail and four primary maritime ports. Integration of these assets into the movement of forest products is critical for decreasing costs and increasing efficiency. Task 1 comprises two components: identifying obstacles to the use of rail and a competitive analysis of Maine's ports.

2.1 Obstacles to the Use of Rail

Many raw forest products are high-volume, low-value, which provides the potential for rail freight to be cost-competitive with other modes. However, there are barriers to shipping forest products by rail in Maine.

Maine's rail freight network includes 1,100 route miles of seven Class II and III railroads (Cambridge Systematics, Inc., 2017; American Association of Railroads, 2017).[1] Table 1 compares the length of Maine's rail infrastructure, by total rail miles, to its primary competitor states, displayed by region. The table also includes a comparison of forested land in the state. Although Maine ranks 1st in the United States for percent of forested land and 19th for total forested land, it ranks 40th in total rail miles.

Table 1: Comparison of Rail Infrastructure and Forested Land

State	Rail Miles (rank)	Forested Land – thousand acres (rank)	Percent Forest Land (rank)
Northeastern United States			
Maine	1,100 (40)	17,700 (19)	89 (1)
Massachusetts	1,100 (41)	3,000 (39)	61 (11)
New Hampshire	400 (47)	4,800 (36)	84 (2)
Vermont	600 (44)	4,600 (38)	78 (4)
Upper Midwest United States			
Minnesota	4,300 (8)	17,400 (21)	34 (30)
Wisconsin	3,000 (17)	17,000 (22)	49 (23)
Pacific Northwest United States			
Oregon	2,400 (30)	29,800 (4)	49 (24)
Washington	3,000 (22)	22,400 (10)	53 (20)
Southeastern United States			
Alabama	3,300 (16)	22,900 (8)	71 (5)
Arkansas	2,500 (27)	18,800 (15)	56 (14)
Louisiana	2,900 (23)	14,700 (26)	53 (18)
Mississippi	2,500 (28)	19,500 (13)	65 (8)
North Carolina	3,200 (18)	18,600 (17)	63 (10)
South Carolina	2,300 (31)	13,100 (28)	68 (6)
Texas	10,500 (1)	62,400 (2)	37 (29)

Sources: American Association of Railroads, 2017; U.S. Department of Agriculture, 2019; AECOM Analysis.

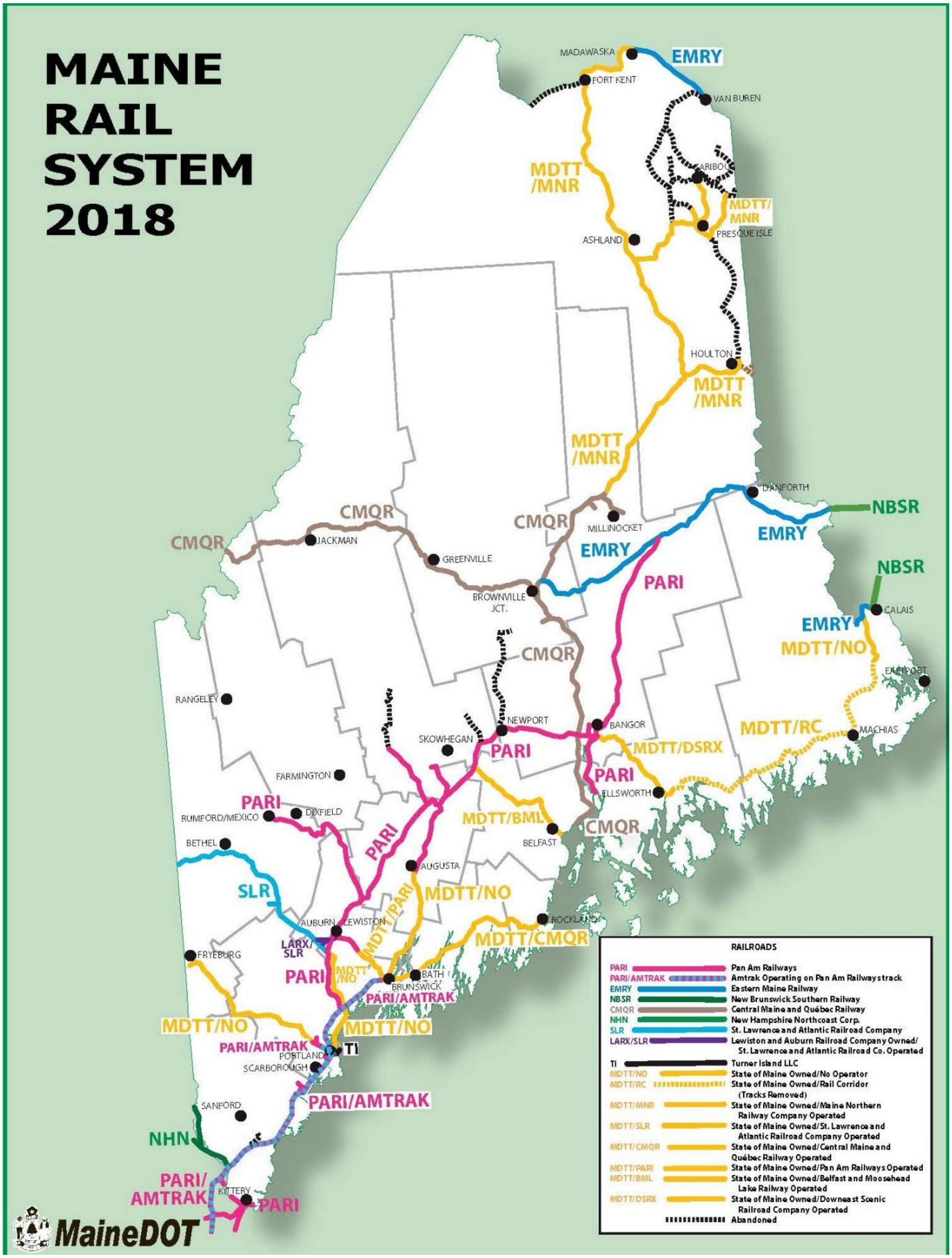
The forest products industry is the primary customer base for the railroad network in Maine, accounting for 42 percent of carloads originating in Maine in 2015, though that share has been decreasing (Cambridge Systematics, Inc., 2017; Maine Department of Transportation, 2014). Multiple obstacles exist that limit the ability of the forest products industry to increase utilization of rail for the shipment of both raw and finished forest products. The primary obstacles identified are limited access to larger markets, fragmented network, and service and capacity constraints. These challenges reduce the viability of rail freight for the forest products industry.

[1] An analysis of geographic data found there are 816 miles of main line active railroads with an operator in Maine (Maine Department of Transportation, 2019).

2.1.1 Limited Access to Larger Markets

Maine's rail network was built to connect Maine and its ports to Montreal and the Great Lakes; as a result, the state's rail infrastructure is predominantly east-west oriented (Maine State Rail Plan, 2014). The east-west orientation of the state's rail infrastructure limits direct rail access between Maine and the larger markets in the northeastern United States (Figure 1), with only Pam Am Railways providing access to northeastern markets. Furthermore, the two rail routes with double-stack clearance for containers connect to Canadian provinces and do not directly connect Maine to the contiguous U.S. rail network. The only portions of Maine's rail network with double-stack clearance are the Central Maine and Quebec Railway (CMQR) from Searsport to Montreal and the Saint Lawrence and Atlantic Railroad (SLR) from Auburn to Montreal, which ultimately has access to states in the Midwest and the Port of Vancouver, Canada, via CN (also referred to as Canadian National) (Maine Department of Transportation, 2014). These issues limit direct rail access to larger markets in the northeast United States.

Figure 1. Maine's Rail Network



Source: MaineDOT

2.1.2 Fragmentation

The fragmented nature of Maine's rail network means moving freight (finished or raw) in Maine by rail often requires multiple railroad handling operations. Transferring freight among rail operators adds time and costs to shipping via rail freight. Representatives from multiple processing facilities stated it can take weeks to ship via rail compared to days to ship via truck. Due in part to their remote geographic location, much of Maine's logging forests lack rail connection. To be transported to the processing facility via rail requires truck drayage from the landing site to an adequate rail yard. Virtually all Maine wood is moved by trucks, even wood moved by rail leaves the woods on trucks (Professional Logging Contractors of Maine, 2014). The sparse network of large forest products processing facilities (i.e., pulp and paper mills) across Maine coupled with the state's fragmented rail network limits the viability of transporting raw products from the landing sites to the processing facilities by rail.

2.1.3 Service and Capacity Constraints

The limited capacity of Maine's rail network inhibits the efficiency and competitiveness of rail freight statewide. The industry standard is for the design load of railroad lines to be able to accommodate loaded railcars that weigh 286,000 pounds or greater (Association of American Railroads Standard S-259), but significant portions of the rail network in Maine can only accommodate 263,000-pound rail cars (Maine Department of Transportation, 2014). Businesses in Maine that are restricted to the lighter railcar loads may be subject to delays in transit and additional costs in transloading (Maine Department of Transportation, 2014). Infrastructure investments necessary to expand capacity beyond 263,000 pounds per railcar can be cost prohibitive for the smaller short line and regional railroads that operate in Maine. To assist in addressing these capacity constraints, the State of Maine has applied for and been successful in leveraging Federal discretionary funding matched by the private railroad operators. Recent grant awards to the Maine Department of Transportation include:

- Federal Transportation Investment Generating Economic Recovery (TIGER) grant for $20 million awarded in 2017 was partially matched by CMQR and the New Brunswick and Maine Railways. The $37.5 million investment was used to improve rail lines in central and northern Maine.
- Fostering Advancements In Shipping And Transportation For The Long-Term Achievement Of National Efficiencies (FASTLANE) grant for $7.8 million awarded in 2018 was matched by Maine Northern Railway and State funds. The $15.6 million investment was used to upgrade 22 bridges to meet 286,000-pound rail capacity.
- Consolidated Rail Infrastructure and Safety Improvements (CRISI) grant for $17.4 million awarded in 2019 will be matched by Pan Am Railways and State funds. The $35 million investment will be used to modernize 75 miles of mainline track in central Maine.

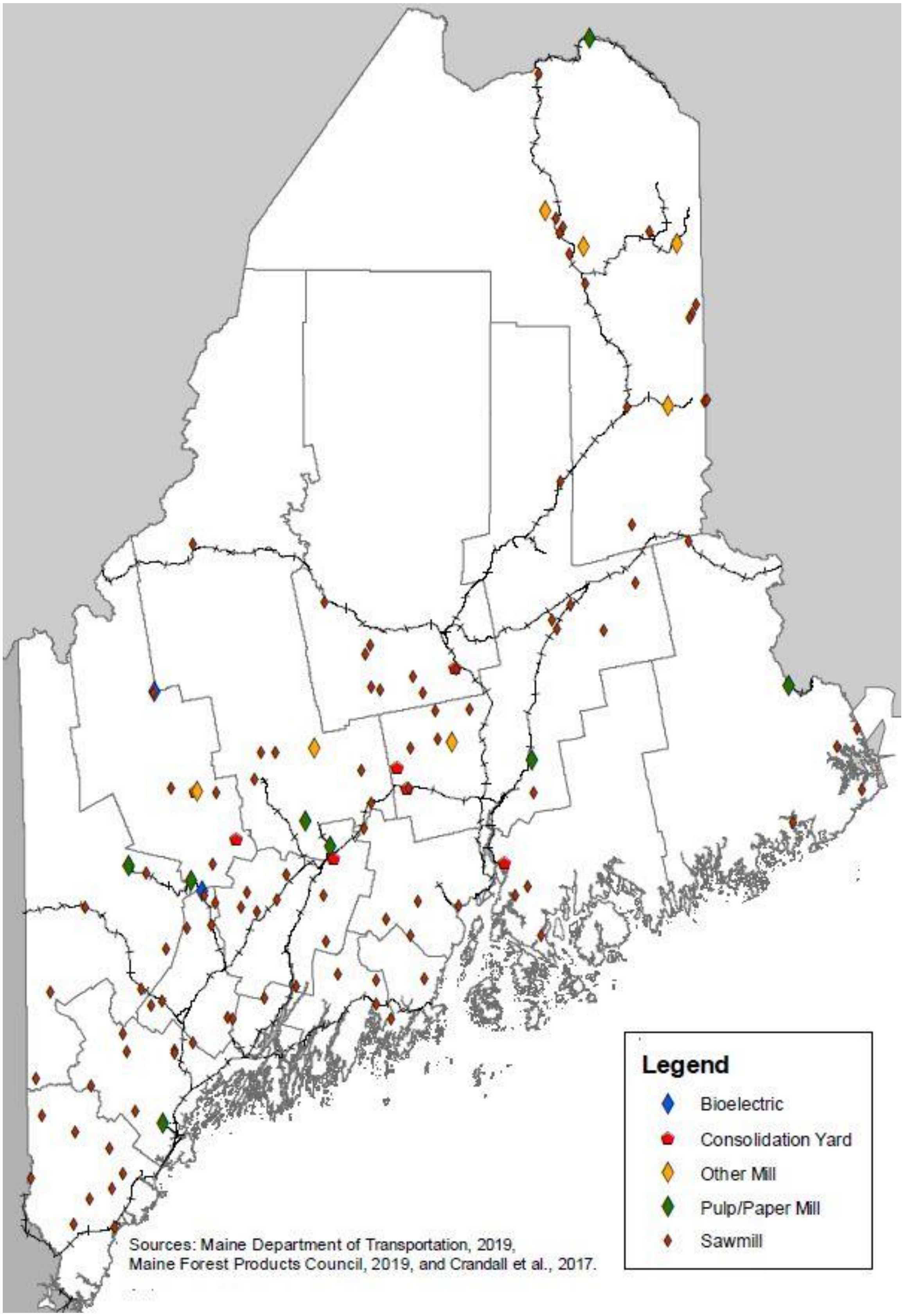
As previously described, the vertical clearance restrictions in Maine and throughout New England limit the ability to double-stack containers, which impacts the ability to cost-effectively ship finished forest products. Many tracks in Maine also need investments to bring their conditions to a state of good repair. Without such investments, the track conditions result in slow travel speeds. Finally, rail access can be cut off to certain facilities during the spring flood season, further reducing capacity and service accessibility.

From the perspective of rail operators, there are multiple obstacles that reduce the viability of shipping raw forest products by rail. Operators have said that there is a shortage of rail cars available to transport raw forest product. Rail operators also stated that they would be willing to purchase or lease the appropriate rail cars if there was a guarantee of a long-term contract for the use of the cars. However, given the uncertainty in the market and inconsistent demand, small rail operators cannot afford to obtain the rail cars. A rail operator in Maine recommended that the State of Maine or another entity purchase rail cars and make them available for lease on Maine's rail network.

Rail operators confirmed that the closure of large pulp and paper mills, particularly along the Penobscot River, has significantly cut into volumes shipped. Reducing rail volumes decreases revenues of the rail operators and reduces the economies of scale that would help make rail freight more cost competitive for the forest products industry. In addition, the time it takes for rail operators to assemble a full train reduces the viability of shipping forest products.

A map of Maine's rail infrastructure overlain on pulp and paper facilities, bioelectric facilities, and sawmills is provided in Figure 2. While most of the large pulp and paper mills have rail access or are located near a rail line, most of the sawmills are not located near a rail line.

Figure 2. Forest Products Facilities and Maine's Rail Infrastructure



Shippers and facility operators identified several concerns with the use of rail to transport raw material and/or finished products. Concerns include:

- Rail is not cost-competitive for shorter haul distances.
- Transit time takes longer than is acceptable (multiple facility operators stated that shipments [raw or finished] can be in transit for weeks).
- Limited options exist for shipping finished forest products from Maine to points south and west.
- Rail operators prefer to haul longer trains, resulting in smaller loads (e.g., a few rail cars) being parked in a rail yard until a sufficient number of rail cars is reached.
- Tracking product (raw or finished) that is in transit is difficult.
- Competition is limited, so facility operators are not able to negotiate a better rate.
- Because of limited trucking capacity, facility operators are reluctant to experiment much with rail in case it does not work, as they may not be able to easily go back to trucking (i.e., trucking companies may establish contracts with other companies).
- Because raw products must be transloaded from truck to rail, and potentially back to truck, there is a loss of product (estimated to be 2 to 3 percent for each time raw product is handled).
- Railroads can be difficult to work with.
- Representatives from processing facilities expressed concern of having inventory tied up in rail cars for as long as it takes to move product.
- Periodic flooding can result in line closures, particularly during the spring flood season.
- While the dispersed nature of processing facilities (as described in Section 3.1.2) results in long truck-haul distances and deadhead miles, a representative from a processing facility explained that forest products do not typically travel long distances by rail standards.

2.1.4 Analysis and Recommendations for the Use of Rail

Rail freight is cost-competitive when shipping high-volume, low-cost bulk cargos, which include many raw forest products. However, Maine's existing rail infrastructure presents barriers to shipping forest products by rail. The primary obstacles identified are limited access to larger markets for finished products, a fragmented network, and service and capacity constraints. The lack of adequate and consistent rail service in Maine was identified by stakeholders as a major factor in the limited use of rail and the low rail mode share.

Because Maine's rail network is predominantly east-west oriented, rail freight has limited access to larger markets in the northeastern United States for finished forested products. Only one railroad (Pan Am Railways) has direct access to and/or connections to the consumer markets in the northeast. In addition, vertical clearance restrictions in Maine and throughout New England limit the ability to double-stack containers, which further restricts capacity for shipping finished products.

With many rail operators but a small number of rail-miles, Maine has a fragmented rail network. The fragmented network leads to frequent switching of railcars between rail operators, which adds time and cost. In addition, the limited number of rail miles means that there are few transfer sites (e.g., sidings) located close to the harvest landing site, resulting in longer truck distances to get from landing site to where raw products can be transferred to rail. For processing facilities without direct access to rail infrastructure, raw and finished forest products must be drayed by truck in and out of the facilities, adding freight costs for each truck move. To assist, Maine Department of Transportation's Industrial Rail Access Program[2] provides matching grants to shippers to improve access to the rail system.

Although expanding use of rail for shipping forest products provides the potential for cost savings, much work needs to be done to the rail network in Maine before a significant modal transfer to rail is feasible. While improvements are being made to the rail network through grants and by some operators (e.g., Irving), the State should continue to build on the work of the 2014 Maine State Rail Plan to improve the overall freight rail network. The State Rail Plan recommended the following:

- Continue a strategy for investment in railroad infrastructure to improve the rail network to a state of good repair (SOGR) to enable rail to be a viable and sustainable transportation mode for Maine-based shippers/consignees.
- Continue coordination with the railroads to accommodate heavier rail cars (286,000 pound) and double-stack clearances in corridors as may be warranted by market conditions.
- Direct state investments in rail infrastructure toward intermodal hubs such as the intermodal facilities at Auburn, Mack Point at the Port of Searsport, Estes Head terminal at the Port of Eastport, the Presque Isle Commerce Center, the Auburn area distribution center, and the Port of Portland.
- Continue cooperative efforts with railroads, shippers, and regional planning agencies to identify underused rail served facilities and sites that may be developed to grow rail market opportunities (Cambridge Systematics, Inc., 2017).

For railroads, the ability to make investments in rail corridors and to improve service is dependent upon volumes shipped. In 2018, CN invested $10 million in Nova Scotia and $30 million of private funding in New Brunswick. The investments included 350 new railcars for forest products and 350 roundwood cars. CN has also invested in new central support cars for the transportation of round timber, which is safer and can maximize transportation load (286,000 pounds) (CN, 2018). CN's recent investments in its rail infrastructure were supported by the fact that the forest products industry is the third most important rail shipper in Canada (after coal and chemicals products). Railroads in Maine have expressed a willingness to invest in infrastructure if they can be assured of a consistent volume of business.

Independent of infrastructure investment, the decision by processing facilities to use rail for either delivering raw materials or shipping product must be appropriate for their needs. In Maine, as elsewhere, the use of rail must be justified considering:

- The distance to the client (buyer or user) or to the next optimal transportation system (e.g. truck)
- The volume to ship
- The nature, form and specifications of the product

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[2] More information on Maine's Industrial Rail Access Program can be found at: http://www.maine.gov/mdot/ofbs/irap/.

- The delivery schedule (delay to respect)
- The stockage capacity
- The handling equipment availability and capacity

The shipping distance for forest products significantly determines whether shipping by rail is cost-effective. Some studies have estimated that the use of rail becomes cost-effective only beyond 210 miles, while other studies estimate that rail becomes cost-effective at 125 miles (Gonzalez et al., 2013).

Optimization models can be used to support efficiency gains in the transportation sector, by considering parameters such as hauling distance, type of forest products, and fuel costs to select the best option for shipping materials. A study in Michigan and Wisconsin revealed that 20 percent of transit ton-miles truck could have been more cost-effectively moved through the multi-modal use of truck and rail freight, which would have reduced transportation costs by 3.8 percent (Journal of Forestry, July 2013).

The following factors should be taken into consideration when reviewing the shipment of specific forest products and potential investment:

Railway Logs or Tree Lengths Transportation

- For most of the raw forest products transported in Maine, the use of rail is unlikely to be cost-effective (the average truck haul distance in Maine is about 60 miles[3], whereas more than 125 miles is typically considered the minimum for rail to be cost-effective).
- It could be cost-effective for logs to be delivered to ports on a multi-modal truck-rail option. However, considering the limits of Maine's rail infrastructure, the lack of stocking and handling system, and the light volume, it is unlikely.
- There may be limited demand to ship a volume of logs to other countries due to the trend to process logs locally prior to shipment.
- Before considering any significant investment, an analysis of the volume (and specifications) to be shipped (actually or in a medium or long term), the origin, destination, and delivery time frame should be completed.

Railway Lumber or Pulp & Paper Products Transportation

- Continue important investments in the rail infrastructure to increase service and capacity, such as upgrading rail to 286,000 pounds (9 percent increase over 263,000) and eliminating the clearance restrictions (bridges, electricity lines, etc.) to allow for double-stacking of containers.
- Secure more rail cars, after assessing the type of railcars that are most likely to be shipped via rail on needs.
- An analysis should be performed to identify priorities, as all forest product types could travel long distances within the United States, potentially representing a large volume.

[3] See Table 2. Average Travel Distance by Forest Product Type in Section 3.1.2.

Railway Biomass and Pellet Transportation

- Because most pellet products are likely destined for export, an analysis should be done to determine the specific needs (volume involved, delivery schedule and duration, stocking capacity, transportation mean (container or bulk), pellet type (torrefied or not) of manufacturing plants.
- Specialized equipment for stocking and handling of biomass and pellets are well known and should be reviewed to ensure that loading and unloading rates are acceptable.

2.2 Competitive Analysis of Ports

Maine has four main maritime ports located in Portland, Searsport, Eastport, and Bucksport (Figure 3). While the Maine Port Authority works with the respective port authorities and operators, it has direct oversight of operations at the International Marine Terminal in Portland. This section describes the four ports and how the ports handle raw or finished forest products. A discussion of non-Maine ports and how those ports have made investments in handling forest products follows the port descriptions.

Figure 3. Location of Maine's Ports

Source: AECOM

2.2.1 Portland

Source: Maine Port Authority, https://www.maineports.com/ports.

Supported by the development of the Grand Trunk Railway in 1853, the Port of Portland emerged as a major grain port of entry for the entire northeast (City of Portland, 2017). Forest products have long been important to Maine and the Port of Portland has contributed to the industry through the import and export of paper, pulp, lumber, and logs. In addition to forest products, the Port of Portland handles petroleum, liquid bulk cargo, project cargo, containers, and passengers. Petroleum products are the primary products handled at seven of the Port's nine terminals, but bulk and break bulk are also handled at the Sprague Portland Harbor Terminals and Citgo/Turners Island terminals. Rail access is available via Pan Am Railways.

Recent investments have substantially expanded the Port's International Marine Terminal and increased its container capacity. A 2016 grant awarded to the Port through the U.S. Department of Transportation's FASTLANE program helped double the capacity of the International Marine Terminal from 25,000 to 50,000 containers a year to support the port's rapid growth. In 2012, the Port of Portland handled 200 containers, whereas the port is on track to handle over 30,000 containers in 2019 (McGuire, 2019). Major exports from the Port of Portland include semiconductor devices, prepared cranberries, firearm cartridges, paperboard, frozen scallops, medical instruments, and industrial machinery (McGuire, 2019).

The Sprague Portland terminal, purchased from the Merrill family in 2004, primarily handles bulk, break bulk, and project cargos. Prior to selling the terminal in 2004, Merrill spent $1.7 million on a 56,000-square-foot warehouse that allowed them to maintain the newsprint business (Amory, 2005). In 2006 Sprague invested $3 million to erect a second 60,000 square foot building to further strengthen its ability to handle both newsprint and wood pulp.

Turners Island is a private terminal handling bulk cargo with direct rail to marine connections. The terminal also has 14 acres of open storage, with an additional 84 acres of rail-accessible open storage available in Scarborough, and 9,000 square feet of dry warehouse space. MCM Forest Products has shipped by rail through the terminal (Turners Island, LLC., ND).

2.2.2 Searsport

Source: Maine Ports Authority, https://www.maineports.com/ports.

Searsport has rail access serviced by Central Maine & Quebec Railway (CMQR), which has connections to Pan Am Railways, Canadian Pacific Railway, CN, Eastern Maine Railroad, and Maine Northern Railway. CMQR and the connections provide access to markets to the north, south, and west. The track connecting Searsport and Montreal has the capacity to handle 286,000-pound rail cars and can accommodate double-stack intermodal freight (Maine Department of Transportation, 2014).

Searsport handles a wide variety of products, ranging from liquid fuels, liquid and dry bulk commodities, heavy lift project cargo and breakbulk cargos, including forest products. The port can handle containers, and there is room for expansion as Searsport has available land for an industrial park or container yard nearby (HDR, 2017). The Port also has the potential to handle export logs, lumber, wood pellets and wood chips. Each of these commodities have unique handling characteristics from inbound transportation to storage and ship loading. The Port has improved on its ability to safely and efficiently handle new commodities through a combination of public and private investment. In 2017, Sprague and the Maine Department of Transportation completed a Front-End Engineering Design (FEED) plan to erect two utility-scale pellet domes on Mack Point with automated rail offloading and automated high capacity ship loader. It is estimated that the facility would cost approximately $35 million to build and could accommodate 600,000 metric tons a year in exports.

In 2003, the port underwent a $20 million reconstruction effort, in collaboration with the Maine Port Authority, to replace the old bulk and breakbulk pier with the new Mack Point cargo pier. Sprague completed a maintenance dredge of both their liquid and bulk dock berths in 2018 and is currently anticipating approval for a maintenance dredge of the approaches and turning basin off Mack Point.

2.2.3 Eastport

Source: Maine Ports Authority, https://www.maineports.com/ports.

Eastport, the easternmost city in the United States, is a small port with two berths and no rail access. The naturally deep water approaches 100 feet and has a mean low water depth of 65 feet, making it the deepest natural seaport in the continental U.S (Port of Eastport, ND). The port terminal at Estes Head is primarily set up to handle dry bulk, neo-bulk, and break-bulk cargos (HDR, 2017 (2)). A $10 million warehouse storage and bulk handling system was constructed in 2013 capable of loading 1,000 tons per hour, depending on product density. The terminal has 140 acres of land available for development (HDR, 2017 (2)). The naturally deep water, availability of developable land, and geographic proximity to Europe account for some of the Port of Eastport's largest competitive advantages. However, the lack of on-site rail access has been identified as the primary challenge the Port faces (HDR, 2017(2)), as it could take upwards of 1,000 truck moves to fully load or unload a 40,000-deadweight-ton vessel. In addition, the ports distance from larger markets in North America limits it's use.

Maine's forest products industry accounts for a large share of the Port's exports, as chemically processed wood pulp and wood in the rough were the second and third highest exports between January and October in 2016 (HDR, 2017(2)). The Woodland Pulp & Paper company, less than 40 miles away in Baileyville, Maine, is an existing partner with the Port as its geographic proximity to the mill allows it to keep its trucking costs lower than other processing facilities farther away from the coast (Trotter, 2016). Other primary opportunities identified for business development include biomass products and processed forest products (HDR, 2017(2)).

The Port of Eastport is actively pursuing markets for forest products. The Quoddy Tides reported the Eastport Port Authority is looking into the possibility of shipping biomass to Canada and a "smaller volume log deal to the port," (Mainebiz, March 27, 2019). In addition, Chris Gardner, Executive Director of the Eastport Port Authority, identified the following possibilities at the Port Authority's March 2019 board meeting:

- Shipping woodchips to the Danish firm Verdo, which supplies biomass to European power plants.
- Exporting low-quality biomass to South America. Gardner reported the Port Authority is working with the Brazilian company Duferco on the biomass shipments, which would not require heat treatment as shipments to Europe require.

Discussion with stakeholders have identified several concerns/challenges that prevent the forest products industry from fully utilizing the port, including:

- Lack of rail access limits the ability to cost effectively deliver bulk products, such as woodchips.
- It is unlikely that rail access to the port will ever be re-established.
- There is local opposition to an increase in the number of trucks that would be needed to support a bulk operation.
- Because of the presence of forest products facilities in the region, the cost of raw fiber is more expensive than other parts of Maine (i.e., there is more local demand for the raw fiber).

2.2.4 Bucksport

Bucksport has rail access that was previously used by loggers. It has a depth of 35 feet at low tide. The major port tenant until 2014 was Verso Paper Mill. Following the mill's closure in 2014, the mill was scrapped and hauled away by American Iron & Metal. In 2017, Maine Woods Biomass Exports, LLC was using available port property to prepare containers of hemlock for export to China, with the containers being trucked to larger east coast ports for shipping.

There is room for new investment at Bucksport, as indicated by the February 2018 announcement that Whole Oceans Aquaculture would purchase land from American Iron & Metal, a previous tenant, for a land-based Atlantic Salmon production center.

2.2.5 Wood Handling Investments at Competing Peer Ports

Several ports outside of Maine have made announcements of capital investments in infrastructure such as warehouses, storage facilities, or handling equipment like cranes for the purposes of improving the handling of forest products. This section discusses peer ports and their investments.

Port of Wilmington

- The Port of Wilmington in North Carolina has two wood storage pellet domes established by the wood pellet manufacturer Enviva (Figure 4). Enviva invested $35 million on the terminal domes but the Port of Wilmington still owns the property (O’Neal, 2017). The domes have a capacity of 45,000 metric tons each and are reinforced for hurricanes and earthquakes. The domes have been in operation since December 2016 with pellets sourced from Enviva’s Sampson, North Carolina, plant (Enviva, 2019). Wood pellet deliveries can be made at the port by rail and truck, with the rail link able to handle approximately 50 percent of the total volume (North Carolina Ports, 2016).

Figure 4. Wood Pellet Storage Dome at the Port of Wilmington, North Carolina

Source: Enviva, http://www.envivabiomass.com/enviva-assets/port-of-wilmington-nc/.

Port of Morehead City

In 2013, the North Carolina Council of State approved a deal to expand the Port of Morehead City’s profile in the wood pellets industry. An agreement was made between the port and WoodFuels, LLC of Raleigh, North Carolina, to construct a $25 million export facility. The facility was to receive, store, load, and ship pellets to Europe to be used as a source of renewable energy (Wood Bioenergy, 2013), but to date has not been constructed. The port does handle other forest products, including lumber and woodchips. Approximately 170,000 tons of woodchips are exported by Yildiz Entegre (Yildiz Entegre, 2019).

Port of Savannah

In September 2018, Fram Renewable Fuels, LLC, a supplier of wood pellets to the European Union, announced it was investing $15 million in a wood pellet plant in Nahunta, Georgia (Williams, 2018).

Port of Boston

In 2018, a $45 million investment was announced for three ship-to-shore cranes at Conley Terminal at the Port of Boston, where containerized cargo includes logs and lumber (Journal of Commerce, 2018).

Other Infrastructure Investments

In addition to the investments previously described, the following capital infrastructure investments have recently been made or announced:

- In 2018, Enviva Partners announced it would invest over $75 million to expand its wood pellet production facility in Southampton County, Virginia (Augusta Free Press, 2018). Enviva Partners broke ground for its existing 454,000-metric-ton manufacturing facility in 2012 (Enviva, ND).
- In 2017, Electro Source leased 3 acres at the Port of Portsmouth, New Hampshire, to store and ship woodchips (McMenemy, 2017).
- CN invested $30 million in New Brunswick in 2018 to strengthen the company's rail network across the province, improving safety and supporting client services. CN's New Brunswick rail network spans the province to Moncton and reaches the ports of Saint John and Belledune (CN, 2018).
- The Québec government has granted $6,847,000 in financial assistance to Barrette-Chapais for the construction of two dry material storage domes and a conveyor at the Grande-Anse marine terminal in the Port of Saguenay. The project, whose total cost is estimated at $17 million, will create nearly 25 jobs. The project to build two storage domes and a conveyor is an essential link in the logistics of transporting wood pellets. (QWEB, January 2019).
- The Port of Prince Rupert and CN are partnering on a $122 million project – $60.6 million of which is coming from NTCF (National Trade Corridors Fund - Transport Canada) – to construct a new double track bridge across the Zanardi Rapids, rehabilitate the existing single track Zanardi Bridge and expansion of the causeway between the Zanardi Bridge and Ridley Island, to reduce operational conflict (The Northern View, September, 2019).
- Clallam County, WA, plans to invest $2.4 million to upgrade the cofferdam barge facility at manage by the Port of Port Angeles. This investment is aimed at bolstering the Port's ability to provide reliable supply chain services for the wood-products industry. Markets for woodchips and hog fuel are growing, and wood mills are increasingly using barges to move wood to markets (#BuildWA, April 2019).
- The Port of Tacoma Commission approved a $12.5 million settlement with Weyerhaeuser Company, allowing the Port to move ahead with its plans to widen the Blair Waterway for safe navigation of marine terminal traffic. Weyerhaeuser has operated a 25-acre woodchip facility, located on the Blair Waterway, since 1973 (JOC.com, October 2019).
- The Port of Bellingham announced that it had signed a lease with GrandCamp International LLC to export logs to Asia through the Bellingham Shipping Terminal. This represents a major investment. The 5-year lease includes 5 acres of property and up to 7 acres of optional water area near the shipping terminal (Bellingham Herald, January 2017).

2.2.6 Analysis and Recommendations for Use of Ports

All of Maine's ports share a competitive advantage in their geographic proximity to Europe compared to other U.S. ports on the eastern seaboard. However, a port on the periphery must work harder to develop a competitive advantage than those that are centrally located near maritime and other transportation networks or large domestic markets. Proximity to a strong transportation network, good facilities, and infrastructure connections are not always enough. Competitive advantages can also be found in the following (Brooks and al., 2010):

- A better performing inland transport network
- A more customized client approach
- An adaptable and resilient business environment, and
- Increased reliability from availability of assets.

Some of the barriers that have been identified at Maine's ports include:

- Lack of warehouses
- Lack of specialized handling equipment
- Lack of land adjacent to the terminals
- Lack of rail access (Port of Eastport)

China's inability to source enough wood domestically or from the West Coast of the United States presents business opportunities for Maine's ports and for the state's forest products industry. Although Maine is twice the distance from the West Coast, the volume of forest products has garnered China's interest. Hemlock log deliveries for export to China were made to the same site where trucks once pulled up to deliver wood to the former Verso paper mill in Bucksport for paper production (Turkel, 2017), though this ended in 2017. The hemlock logs were trucked to Boston for export, though the long-term goal is to ship directly from Maine.

There are comparative disadvantages that Maine's forest products industry faces regarding shipping commodities to China that give competitors in western states an advantage. From conversations with port operators, it is understood that trees harvested in Maine are smaller than those harvested in western states, and the smaller size of logs reduces the load rates at port facilities. Competing with the more efficient load rates of ports in western states is difficult for Maine's ports.

Shipping forest products from Maine to markets in China and other parts of Asia through the Panama Canal adds substantial shipping costs compared to competitors in states along the Pacific Coast. Despite the geographic obstacles when shipping across the Pacific Ocean, opportunities to export to markets in Asia should be pursued. However, it is recommended that Maine ports look to specialize in products that have the greatest opportunity to be exported to Europe, the Middle East, and South and Central America.

Another challenge identified by a port operator is a lack of coordination across the forest product industry when responding to inquiries from abroad. It was noted that a potential buyer from abroad does not have one central point of contact in Maine that can direct them to the proper resources (e.g., what mills produce pulp, which ports can handle woodchips). The lack of a central coordinating entity makes it difficult for the buyer to understand which options are available. A recommendation made to establish a central coordinating entity that could distribute inquiries to the proper resources within Maine to help facilitate connections and business development opportunities.

A notable recent trend has been an increasing degree of containerization, with approximately 50 percent of all timber shipped via containers. This trend provides opportunities for ports to export forest products. In Sweden alone, the timber sector is set to continue as profitable for ports, as they expected to see further growth and higher containerization, and thus better opportunities for Swedish timber to reach its customers in an even faster and more cost-effective way (PortStrategy, January 30, 2018). While Maine has exported containerized forest products, the containers were trucked to larger ports outside of Maine.

As with rail, it is recommended that ports make capital investments in infrastructure to improve the handling of forest products, including warehouses or storage facilities, such as wood storage pellet domes or handling equipment like cranes or large capacity conveyors. Site specific studies that consider the existing infrastructure, land, and availability of forest products (volume, nature, stocking and handling requirements, delivery schedules, etc.) should be completed to determine the most appropriate investments at specific port facilities.

3 Task 2: Operational Efficiency of Transporting Forest Products

Transportation accounts for approximately half of production costs in the forest supply chain in Maine (Kizha, 2016). The purpose of Task 2 was to identify obstacles that exist and solutions that are available to improve the operational efficiency of transporting forest products. The subsection that follows identifies existing obstacles to the efficient transportation of forest products. The subsequent subsection identifies best practices used in the industry.

3.1 Obstacles to Efficient Forest Products Transportation

A literature review of the forest products trucking industry in Maine and discussions with stakeholders identified the following obstacles faced by stakeholders to the efficient transportation and handling of forest products:

- Dispersed locations of Maine’s forest products industry
- Long haul distances and lack of back-hauls
- Shortage of skilled drivers and operators
- Difficult geography, road conditions, and climate
- Variations in the design, maintenance, and fuel efficiency of trucks and trailers
- Inefficiencies in wood handling at processing facilities

3.1.1 Dispersed Locations of Maine's Forest Products Industry

Transportation costs are directly related to the locations of the wood supply areas and the processing facilities, and from the processing facilities to the markets for the products. In Maine, the processing facilities are scattered across the state, resulting in long travel distances for raw material to reach the point of use (see Figure 2). Recent mill closures have exacerbated the situation, resulting in increased hauling distances (Koirala et al., 2017(1)). However, the long distances are not unique to Maine, the hauling distance for softwood logs and pulpwood was found to be highest in northern states, which increases the price of forest products compared to other regions of the United States (Kizha, 2016).

3.1.2 Long Haul Distances and Lack of Back-hauls

As previously described, the dispersed nature of Maine's forest products industry results in long travel distances, particularly from the forest harvesting site to the processing facility, which directly affects transportation costs. The average one-way distance for forest products from Maine's woodlands to the processing facility is about 60 miles (Koirala et al., 2017 (3)), although one mill representative said their company's average was 100 miles. When broken down by individual forest products, pulpwood had the longest average one-way travel distance at 68 miles, and woodchips had the shortest average one-way travel distance at 58 miles (Koirala et al., 2017 (3)). Table 2 provides the average travel distance by forest product type. Efforts to reduce travel distances could result in significant efficiency gains in the state's forest products industry.

Table 2: Average Travel Distance by Forest Product Type

Forest Product	Average One-way Travel Distance (miles)
Sawlogs	59
Pulpwood	68
Hog fuels	58
Woodchips	58

Source: Koirala et al., 2017 (3)
Note: Additional detail not available in report.

When transporting raw forest products, truckers typically transport a single load and return empty, resulting in significant deadhead miles (Koirala, et al., 2017(3)). Transportation efficiency decreases by almost half when trucks travel empty from the mill to harvesting sites. Utilizing empty trucks to haul other loads while returning to the harvesting site, also known as back-hauling, could substantially improve transportation efficiency. However, back-hauling can be difficult to accomplish because equipment is specialized for specific tasks. As of 2017, only vertically integrated companies that own multiple portions of the forest products supply chain, such as owning timberland, a railway system, and mills (pulp and paper and/or sawmills) had practiced back-hauling in Maine (Koirala et al., 2017(3)).

While not unique to Maine, traditional business practices coupled with the uncertainty surrounding the forest and logging industries creates a planning process in the forest products supply process that is largely reactive, rather than proactive (Fallas-Valverde et al., 2018). The reactive environment caused by delayed, poor, or limited information on expected demand results in inefficient transportation planning and transportation rates agreements which increases transportation costs and limits back-hauls.

When transporting finished forest products, significant deadhead miles are less of a concern since other products/commodities can more easily be hauled on the return trip. For finished products, truckers face many of the same challenges with back-hauls as when hauling other commodities.

3.1.3 Shortage of Skilled Drivers and Operators

Recent studies suggest a shortage of truck drivers in Maine, and the situation worsened in the 5 to 10 years prior to 2017 (Koirala et al., 2017 (3)). However, the labor shortage is unique neither to Maine's forest transportation sector, nor the forest trucking sector nationwide. Maine has experienced a trend of shrinking labor force in every employment sector over the last 20 years, and the American Trucking Association estimated the shortage overall is greater than 35,000 drivers nationwide (Koirala et al., 2017 (3); Kizha, 2016). If not addressed, the shortage of skilled drivers and operators could become critical in the coming years.

As with truckers, labor shortages have also impacted loggers and the ability of mills to source raw material from wood lots close to the mill. Many loggers left the profession when the mills closed, and demand decreased. Although demand has been increasing, there are fewer loggers to harvest the wood, so mills must obtain raw materials from farther away. Given the high cost of entering the logging industry, the uncertainty of the logging industry, and the general lack of labor across the state, the shortage of loggers is not anticipated to change.

3.1.4 Geography, Road Conditions, and Climate

The cost of road construction and selection of appropriate trucks and trailer types is mainly affected by the geographic condition and types of terrain of harvesting and stocking sites. Narrow road conditions and rough terrain directly affect transportation costs by increasing the time it takes drivers to maneuver through treacherous terrain and wait for passing trucks. Climate also affects the condition of the roads, as logging roads in Maine are particularly susceptible to damage during Maine's wet spring season. The winter season is the preferred time to harvest in Maine because of the hard and frozen conditions, which prevents soil displacement. However, winter harvesting presents additional challenges associated with maintenance, including snow removal and anti-slip measures.

The forest trucking sector experiences a wide variation in road conditions, as drivers must navigate roads ranging from the lowest standard private logging roads near the landing sites to the highest standard public roads. Transportation of forest products is unique among other transportation sectors in that it relies on both private road networks with limited regulations that must be constructed and maintained and public road networks, where shippers must comply with regulations. The variation in road conditions statewide limits the availability of trucks suitable to maneuver the gradient over the truck haul.

3.1.5 Design, Maintenance, and Fuel Efficiency of Trucks and Trailers

As described under geography, road conditions, and climate, the availability of trucks suitable to maneuver the gradient over the truck haul is limited by the variation in road conditions, making the selection of truck and trailer designs logistically challenging.

Trucks used in forest products transportation have their own characteristics. For instance, mills have different requirements for bunk spacing when unloading log trucks. Variations in bunk spacing on log trucks allowed by processing facilities requires shippers to reconfigure the bunks on their trucks/trailers between loads or mills (Cambridge Systematics, Inc., 2017). It also limits availability of trucks/trailers to those that have the required bunk spacing or can be reconfigured. Further variation exists within the types of trucking fleets that exist to move specific products, such as tractor trailers to haul logs, woodchips, pellets, biomass materials, and pulp.

In addition, the fuel efficiency was identified as a communal problem in the sector. Fuel efficiency is of concern in the forest products industry as most log trucks are older than other long haulage trucks. The average age of a log truck is 9.7 years compared to the average age of 3.9 years for all other trucks (Dowling, 2010). More recent information on the age of log truck fleets is not available for Maine or the United States at large. However, the mean vehicle age of a logging truck was found to be 9.5 years in Georgia, whereas the mean vehicle age in the trucking industry at large was found to be 5.5 in 2015 (Conrad and Langdale, 2017). An analysis conducted by Domtar (Domtar 2015) in Quebec estimated 70 percent of trailers and 26 percent of trucks were over 15 years old, indicating the use of outdated technology (see Section 3.2.5). These findings indicate that the aging of log truck fleets may be a challenge endemic to the industry. Many long haulage trucks currently utilized in the forest products industry were modified from their original use, further contributing to the challenges regarding truck selection and fuel efficiency.

3.1.6 Wood Handling at Processing Facilities

Long turnaround times for trucks at the receiving facility is another source of inefficiency in the industry. Studies have found that trucks idle 27 percent of the time at mill facilities and 32 percent of the time at harvesting locations for loading and unloading (Dowling, 2010).

Part of the reason for long turnaround times is the inconsistent arrival of trucks at plant facilities, with mills reporting that most trucks arrive in the early morning. The arrival of many trucks often exceeds the unloading capacity of the facility, leading to queue of trucks. Time spent at the processing facilities waiting for trucks to be unloaded is a major source of long truck turnaround times.

In addition, different mills have different requirements and specifications for delivering and offloading wood via truck or rail. Offloading equipment varies operationally and in terms of efficiency at Maine mills, leading to longer wait times for unloading and greater haul distances because the truck closest to the facility may not have the appropriate trailer specifications. The inconsistencies in the handling abilities of equipment create inefficiencies, thus increasing costs and lowering profitability in the forest products industry.

3.2 Best Practices and Recommendations

This section identifies best practices and makes recommendations to overcome obstacles in the transportation sector of Maine's forest products industry.

3.2.1 Dispersed Locations of Maine's Forest Products Industry

There are no direct solutions to the challenges associated with the dispersed locations of processing facilities across Maine. Measures identified to overcome these challenges include subsidies to get the closed processing facilities running again and government intervention to incentivize a more concentrated cluster of processing facilities (Koirala, et al., 2017(3)). Because of the business and political climates that exist in Maine, these strategies would not likely move forward.

Because the dispersed locations of Maine's forest products industry results in long travel distances, strategies to mitigate the challenge are accounted for under best practices to reduce hauling costs and empty travel distances.

A suggested area for further study would be to analyze a potential redistribution of the wood supply areas allocated to each processing facility in order to reduce the individual hauling distance. Many parameters would have to be considered, such as wood species and size, topographic conditions, investments required, and private lands and value. Although a reallocation of the wood supply sector could not be enforced, the results of the study could be used to encourage facility operators to work together for the benefit of all.

It is unlikely the use of rail to transport raw forest products could be utilized to mitigate the impacts of the dispersed locations of Maine's forest products industry, as the remote nature of Maine's logging forests restricts rail access. Wood that is shipped by rail still leaves the woods on trucks. To transport raw products to the processing facility would require a modal transfer, adding time and costs to transport (Professional Logging Contractors of Maine, 2014).

3.2.2 Long Haul Distances and Lack of Back-hauls

Long hauls from the harvesting sites to processing facility, coupled with empty return trips from the processing facility back to the harvesting site present substantial opportunities for cost savings. In addition to the recommendations presented in Section 3.2.1, the following measures have been identified to reduce unnecessary transportation and, thereby, travel distances:

- Extend the planning horizon at processing facilities and improve formal communication between processing facilities and loggers to reduce the reactive environment of the supply chain.
- Increase notice on order changes so that loggers can be made aware and adjust in a reasonable time frame.
- Develop a model that uses metrics from core suppliers, including location, volume, type of system to harvest, and seasonable operability window that allows processing facilities to allocate quota according to capacity.
- Implement a system that allocates quota according to capacity.

There are obstacles to the successful implementation of back-hauling in the forest products industry because the trucks used to transport shipments of raw forest products often have unique characteristics based on the products they carry (Kizha, 2016). The following recommendations have been identified to reduce the movement of empty trucks hauling raw forest products:

- Improve planning and coordination among loggers, processing facilities, and shippers to reduce the frequency of empty return trips.
- Identify convenient transportation routes that are conducive to back-hauling.
- Create more concentrated landing sites or develop consolidation yards (Koirala, et al., 2017(1); Keefe et al, 2014).
- Develop networking and communication strategies between processing facilities from different regions (Koirala, et al., 2017(1)).
- Use trucks and trailers that are capable of dynamic configurations that can accommodate a wider range of forest products (Koirala, et al., 2017(1)).
- Better tracking of trucks in real time using embedded devices or cellular applications.

3.2.3 Shortage of Skilled Drivers and Operators:

Not enough young drivers and operators are entering the forest product industry to replace retiring drivers and operators. The shortage of skilled drivers and operators statewide puts increasing pressure on the state's forest products sector. Among strategies, the following should be considered:

- Increasing compensation could help attract and retain skilled drivers and operators transporting raw and finished forest products, though those increased costs would ultimately be reflected in increased costs if efficiency gains are not made elsewhere in the supply chain.
- Independent contract schemes for labor, combined with ownership sharing protocols for equipment could reduce barriers to enter the industry, and resultantly, help alleviate the constrain on labor (Koirala, et al, 2017(3)).
- De-coupling trucking from logging through outsourcing trucking to independent contractors would put downward pressure on trucking costs so long as there is enough competition in the newly created market. Similarly, outsourcing trucking to independent contractors when shipping finished forest products could also reduce transportation costs.
- Outsourcing the transportation sector of the forest products industry provides opportunity to restructure the cost-structure from salary-based to invoice-based (Palander et al., 2012). Invoice-based entrepreneurship makes economies of scale possible (Palander et al., 2012). The efficiency gains created from economies of scale can mitigate the challenges to the industry that result from a lack of skilled truck drivers.

Although increasing compensation and incentives could assist with driver shortage in the short-term, automated vehicles and platooning (linking two or more trucks in a convoy using connectivity technology) could alleviate the constraint on labor and reduce shipping costs in the long-term.

3.2.4 Geography, Road Conditions, and Climate

Like the challenges associated with the dispersed locations of Maine's forest products industry, direct opportunities to alter the geographic conditions surrounding Maine's forest products industry are limited. Although designing roads to avoid rough terrain and steep slopes would reduce transportation costs, it's not always feasible because of the natural geography of logging forests. Road forest design that connects every landing within one harvest operation can also improve the efficiency of transporting forest products to the processing facility, mitigating the geographic challenges (Koirala, et al, 2017(3)). Upgrading forest roads can also improve the performance of logging trucks, lowering supply chain costs (Koirala, et al, 2017(3)).

Similarly, climatic conditions cannot be avoided. Although there are safety concerns associated with winter harvesting operations, it is the preferred season as the hard, frozen conditions help minimize soil displacement. Alberta recently made a policy change to extend its winter weight premium (WWP) policy, which extends the season in which trucks can carry heavier loads. However, the applicability of implementing such a policy in Maine could be limited pending the effects of climate change.

It should be noted that Maine has extensive private road networks with over 10,000 miles of road in contiguous sections in Maine. In many cases these networks feed directly into processing facilities. When operating on these networks, specialized truck can often operate with less restrictions.

3.2.5 Design, Maintenance, and Fuel Efficiency of Trucks and Trailers

This section discusses several general ideas for addressing the variations in design, maintenance, and fuel efficiency, as well as specific ideas that have been implemented elsewhere. General measures to consider include:

- Appropriate alignment of vehicle characteristics, such as engine, design, number of axles, trailer types, and length can improve overall performance of trucks (Kizha, 2016).
- Improving conditions of logging roads can increase the performance of logging trucks and improve the fuel efficiency of trucks.
- Because fuel consumption is highest during acceleration, planning transportation routes that avoid frequent stops and turns, traffic lights, and gradient changes can increase fuel efficiency (Koirala, et al, 2017(3)).
- The optimal combination of vehicle characteristics and route planning can be determined using a trucking simulator (Kizha, 2016).

Other specific ideas include:

- Conduct training programs for trucking companies to lower operating costs. For example, Natural Resources Canada has redesigned the online smartDriver for Highway Trucking program to help the trucking industry reduce operating costs while decreasing greenhouse gas emissions (The Working Forest, Winter #1, 2018).

- In Quebec, a government program subsidizes companies (mills and contractors) to support workers training, including equipment drivers like truckers; demands are initiated by companies (mills owners).
- Use automatic control for tire pressure. Weyerhaeuser's Grande Prairie, Alberta, timberlands operation is phasing in more tire pressure-controlled equipped log trucks, allowing them to increase their access on steep logging roads, even in bad weather (Logging and Sawmilling, 2016).

As part of a larger transportation study, Domtar (Domtar, 2015) evaluated 184 trucks and trailers in Quebec. The following findings are applicable to Maine's forest products industry:

- Upgrading the truck fleet could increase the loading capacity by over 11 percent.
- 70 percent of trailers and 26 percent of trucks are over 15 years old, indicating the use of outdated technology.
- 11 percent of trailers have fixed axles, 71 percent have retractable axles and only 18 percent are equipped with the contemporary auto turning axles, indicating a potential important load loss.
- 85 percent of trucks had a weight of at least 42,900 pounds, while modern trucks have a weight of 39,600 pounds, indicating a load loss of over 3,300 pounds.
- Only 20 percent have an integrated scale system, resulting in another potential load loss because the operators do not know if they have a full authorized load.
- Only 22 percent get an integrated fuel consumption control system, resulting in excessive fuel consumption.

3.2.6 Wood Handling at Processing Facilities

There are significant opportunities to increase efficiency at forest products processing facilities given the size of log yards in the industry, the complexity of their material flow, the variety of stored geometries and vehicles required, and the seasonality of the raw material inflow. Further, due to the volatility of the industry, which affects supply, demand, products and technologies, a continuous improvement cycle is mandated. The focus of future work should be on the analysis and implementation of routing and dispatch systems in the log yard as these have the greatest potential to improve efficiency. In addition, new transport systems and automation of the log yard should be considered in order to bring the next industrial revolution to the log yard (Huka M.A., Gronalt M., 2018).

The time trucks spend idling at processing facilities presents an opportunity for efficiency gains through reduced truck turn times. The following measures have been identified to reduce truck turn times:

- Improved scheduling and coordination of deliveries to avoid peak surges in the arrival of raw materials at processing facilities.
- Utilize self-loading trucks to reduce congestion in space-constrained landing sites.
- Use more unloading cranes or other systems such as frontend loaders with grapples at the processing facilities.

- Improve communication and coordination between different processing facilities in the same area when dispatching and procuring materials.
- Widen and adequately space paved roads at the landing to reduce congestion and facilitate more efficient traffic passage.
- Standardize unloading equipment across facilities to improve interoperability for shippers at each facility. The State could support this by incentivizing facilities to follow standard guidelines when recapitalizing old equipment.

A detailed analysis was done by FORAC at 38 Quebec sawmills log yards with the objective of identifying measures to reduce the handling cost and the return to the scale cycle time (between the entry on the site and the exit (scale to scale). The results estimated:

- Only 8 percent of the yards were operating at 100 percent efficiency, 33 percent were operating at an efficiency rate below 50 percent.
- Upgrading the yards design and operations could reduce the overall needs in site area by 17 percent, the amount of equipment by 20 percent, and labor needs by 14 percent;
- In the best yards, 90 percent of the wood was going directly to the mill infeed deck and 60 percent during the peak delivering period.

Measures were identified that could reduce the scale to scale cycle time by up to 25 percent, including:

- Optimizing the yard design to reduce the transportation distance of forest products from the landing site to the consolidation yard/processing facility.
- Using a hard area surface, a plane and a well-drained surface to reduce transportation times and wear and tear on equipment.
- Use of modern handing equipment that reduces mechanical problems and provides more flexibility for and is adapted to the needs of the processing facilities.
- Technical assistance on yard design and how to operate and maintain equipment.

In addition, on-line tool can be used to shows how many trucks are waiting in line, see in real time how long the line is, and distribute messages if there is an offset or if there is something going on. Conversations with a representative from a wood processing facility indicate such a tool may could change how the yards are operated.

4 Task 3: Improved Truck Coordination

Operational optimization involves better planning and coordination of the fleet, either company-wide or region-wide. The purpose of Task 3 was to identify how a central dispatch model (CDM) or alternative concept could improve the coordination of trucking and move wood more efficiently by realizing shorter haul distances, greater back-haul potential, and enhanced productivity for truckers. Several approaches were reviewed to improve operational efficiency:

- Central dispatch model (CDM)
- Consolidation yards

- Truck reservation systems
- Decision support systems
- Collaborative logistics
- Mathematical and computer modeling

4.1 Central Dispatch Model

As noted in literature and through stakeholder discussions, transportation costs account for as much as 50 percent of total delivered cost of a timber harvesting operation (Dowling, 2010; Kizha, 2016). A large contributor to costs for hauling raw forest products is the empty back-haul after delivery (deadhead miles). It is possible for individual trucks to achieve efficiency gains, but the major gains would come from managing the fleet of multiple loading locations and customer destinations (U.S. Endowment for Forestry and Communities, 2019). Increasing productivity requires a procurement mechanism that is more responsive to demand and more efficient routing that takes less time and results in fewer empty miles. To increase productivity, daily harvesting production and loads hauled must align with fluctuating timber demand. It is logistically challenging to match logging crews, trucking companies, and processing facilities in a manner that maximizes efficiency without central coordination. The purpose of a CDM is to be the coordinating body that aligns harvesting production and loads hauled with demand.

A CDM is an open-platform logistical model that operates on a common system for all truckers covering a defined geographic area. With regards to Maine's forest products industry, the CDM could cover all logging and trucking companies in Maine for all processing facilities in operation or it could be scaled to cover a large region covering many processing facilities and harvesting areas. The CDM would allow trucks to increase utilization by making spare haulage capacity available to logging crews that may be short on trucks. The CDM has been suggested to consolidate the operations of many individual companies into one centralized operation that could more efficiently serve a larger geographic area and ensure that orders are distributed to truckers evenly and more appropriately in accordance with their origins and destinations.

Therefore, the end goal of CDM is to reduce overall costs by ensuring a steady flow of product to meet the demand of the processing facilities by fully utilizing trucks and minimizing empty back-hauls by managing the individual loads over a network. CDM would contribute to higher margins on products and result in fewer trucks on the road. Computerized simulations of CDM generally show that fewer miles and hours are needed for the same delivered loads than normal field operations, saving truckers on fuel and labor costs from reduced hours and miles (Mendell and Sydor, 2006).

To implement a successful CDM, all truckers, loggers, and processing facilities would need to cooperate by sharing the supply and demand sides of their businesses. In addition, the platform under which the system would operate needs to be established and coordinated by a neutral third-party entity to encourage participation and avoid the perception of favoritism in routes and bookings.

Using a CDM offers several benefits and challenges. The benefits of a CDM model include:

- The ability to match truck capacity to wood supply
- Improved communication and transparency of quotas set by processing facilities, enabling supply to match demand
- Expanded planning horizons for processing facilities and longer-term forecasts
- A reduction in empty miles driven by trucking companies
- A reduction in trucks needed to haul forest products
- Overall reductions in transportation costs

Although there are obvious benefits to the CDM, there are also important challenges to overcome. These challenges include:

- Substantial upfront personnel investments to change existing operations, expand hauling networks, and train and commit all participating bodies to the objectives of the model
- A commitment of adequate resources dedicated to planning and dispatching by each company that implements a centralized logistics management system
- Achieving employee buy-in of logging crews and trucking companies so that their concerns of being tracked are placated
- Facilitating trust among participating bodies so that individual stakeholders will not sub-optimize one component of the supply chain, compromising gains in the industry
- An increased reliance on outside trucks
- An expectation that all trucks provide equal service to loggers

Examples of successful implementation of CDM are limited because of the challenges. However, the U.S. Endowment for Forestry and Communities initiated a pilot program that investigated the benefits and challenges of CDM (U.S. Endowment for Forestry and Communities, 2019). The pilot study findings include (U.S. Endowment for Forestry and Communities, 2019):

- Gains of over 12 percent in calculated hours at greater than 50 hours per week were achieved when individual trucks fully participated.
- A fleet’s delivered log-haul costs can be reduced by up to 13 percent using real-time central dispatching.
- There is potential for efficiency gains at both mills and log loading sites.
- Mill delivery delays drastically lower fleet and truck productivity.
- Drivers are reluctant to use GPS software and to load from unfamiliar harvesting crews.
- Industry culture may present the greatest challenge as truckers and loggers like to do things as they have always been done.

Although full-scale experience with CDM is limited, trucking companies often employ a smaller-scale model when they dispatch their fleet from a central location. This report does not recognize a coordinated dispatching system within a single company as CDM. Nonetheless, various companies liken their operations to CDM, including:

- Sun Chasers of Creswell, Oregon – with between six and 20 drivers
- Harvest Haul of Magnolia, Mississippi – with 40 trucks operated for Weyerhaeuser sawmills
- Metsaliitoo Group of Finland

In addition, private companies are offering forest logistics services. Trimble Forestry is a privately-operated company that specializes in forest products logistics. A component of the company's Connected Forest Logistics services is the Wood Supply Execution (WSX) System, a logging supply, plan, execution, and dispatch system. The product allows users to manage log supply plans and set up scheduling for loggers and truckers. WSX specifically notes that it is equipped for managing dispatch of the logging industry considering the remote sites, rugged conditions, and uncertain production processes (Trimble, 2019).

4.2 Consolidation Yard

Similar in function to a warehouse, a consolidation yard could be a middle ground between CDM and the current operational model of each trucking firm operating independently. A consolidation yard could improve logistics for truckers and loggers, especially in the remote areas of Maine. It is also similar in function to how grain elevators rely on "satellite" locations to store and aggregate grain before shipping larger quantities to a mainline terminal.

In short, a consolidation yard serves as a landing area to store logs somewhere between the logging site in the woods and the processing facility destination. The site allows for collecting and sorting lots by logger, size, species, and processing facility. It could be a partnership among several loggers who can combine loads to make sure all truck trips to the processing facility are full. Storage at the consolidation yard moves the raw product from the landing site and can be short-term or long-term, depending on the processing facility demand. Potential benefits of this operating model include:

- More efficiently packed trucks
- Limiting road-haul mileage of off-road trucks, and use of road-configured trucks to the processing facilities
- Shorter empty back-hauls
- More truck turns per day
- Reduced congestion at the processing facilities
- Better management and monitoring of processing facility quotas
- Potential decoupling of logging and trucking
- Potential for the transfer to rail, particularly in northern Maine
- Potential flexibility in consolidation yard locations and use

Like the CDM, there are potential drawbacks and challenges associated with the consolidation yard:

- Adds one more stop in the forest products transportation model, which adds handling costs
- Requires cooperation among the competing loggers and truckers
- Requires coordination on how to monitor the handling of payment and handoffs
- May require a willing party to share valuable real estate with competitors

- Requires agreements be made regarding the equipment to be used at the site and who runs the operation
- Potentially increases damage to product and loss of product (estimated to be 2 to 3 percent for each time raw product is handled) through increased handling
- May result in decreases of revenue when value of product is based on weight (i.e. logs will dry out while being stored)

The consolidation yard model is already being used by individual loggers and truckers. Perhaps due to a lack of incentives to work together on a common site, the so-called “log yard” model has typically not expanded to be used by multiple operators. In addition to several companies in Quebec (e.g., Domtar, Windsor), the following companies use log yards in Maine:

- Nicols Brothers
- Prentiss & Carlisle has a log yard in East Newport
- Madden Timberlands has a log yard in Passadumkeag
- Timber Resource Group has log yards across Maine, New Hampshire, and Vermont

Domtar in Quebec evaluated the efficiency improvements of consolidation yards (Domtar, 2015). Their evaluation identified several advantages:

- Transportation off public roads allows for increased truck loads.
- Operators can take advantage of more specialized forest transportation trucks and trailers that are designed to operate more efficiently on certain road types.
- If wood stays on a yard for months, the wood moisture level decreases (6 percent or more); therefore, the volume per load can be increased for transportation to the processing facility. This moisture level advantage offsets the unloading and reloading cost at the yard.
- With a consolidation yard, the B-Train trailer can be used for additional load capacity of over 10 percent or 8,800 pounds; moreover, the fuel consumption can be reduced by 5 percent (higher load/truck and truck more energy efficient).
- During forest operations, trucks can be concentrated in the forest (shorter transportation distance).
- The log yard at the processing facility can be reduced in size.
- Because of access to the public roads, the raw material is transported to the processing facilities on a more consistent and regular basis throughout the year (i.e., public roads may be cleared of snow quickly).
- Because of the increased load size and greater consistency, the number of trucks processed per day can be reduced, which reduces the “scale to scale” cycle at the processing facility.
- The yard can be used to service more than one processing facility and for different products (e.g., sawlogs, pulp logs, biomass).

Domtar determined that the ideal location for the consolidation yard is off a private road and adjacent to a public road, where the timbers can be transported to the yard on private roads for transfer, and then distributed to the processing facilities on public roads. The volume of the yards and the distance to the processing facilities was quite high (around 150 miles) for Domtar’s evaluation. Therefore, there was a greater advantage/efficiency to using a truck and trailer configuration designed for highway use to transport forest products over this distance, as opposed to a configuration designed for off-road use.

4.3 Truck Reservation System

A truck reservation system could improve the efficiency of transportation in Maine's forest products industry. In providing advanced lead time for loggers and truckers, a truck reservation system would reduce the reactive environment suppliers work in, reducing time spent by trucks waiting to unload at processing facilities, and in the process, truck turn times. Additionally, a truck reservation system would give logging and trucking companies the opportunity to coordinate their operations in a cost-effective manner by eliminating the incentive of trucker/loggers to rush to the processing facilities before the facility meets its quota. In reducing the reactive environment suppliers work in, a truck reservation system would minimize unnecessary truck movements by reducing the likelihood that a truck would need to be redirected because a processing facility has met its quota.

Although no forest product processing facilities that use a truck reservation system were identified, truck reservation systems are used at several ports both in the United States and internationally. Ports implemented truck reservation systems because congestion caused long lines that disrupted port operations and traffic on nearby roads. In addition, excessive idling caused pollution and drove up truck costs due to unproductive working hours and vehicle costs. The goal of the systems was to alleviate congestion on and off the ports during peak truck drop-off and pick-up times by mandating that truckers reserve a time to be on the port property.

Domestic ports that have implemented truck reservation systems include the Port of Virginia (2018), terminals at Port of Los Angeles (2018), Port of Oakland (2016), Port of Tacoma (2017), and Port of New York New Jersey's Global Terminal Center (2017). International ports of Hamburg (2017) and Vancouver (2013) also use these systems. This list is not intended to be exhaustive, but rather to illustrate that these systems have become increasingly prevalent in recent years.

The systems are commonly implemented through an app on a driver's phone. Trucks or drivers are registered and authorized through the port to set up reservations in real-time and alerts and updates are pushed to users' phones. Some ports require reservations for certain movements or times of day:

- Import container pick-ups (Tacoma, Oakland) (Northwest Seaport Alliance, 2017 and Port of Oakland, 2016)
- Certain hours (opening through 2pm at Port of Virginia,6 to 9am GCT Bayonne) (Gillis, 2019; Port of Virginia, 2019; and NJ.com, 2017)
- All trucks (Hamburg) (HHLA)

Typically, truckers must register and reserve their time slot a few days in advance, and if the window they prefer is not available, the system will offer the next available time. Most systems provide a reservation window of an hour, with flexibility of 15 to 30 minutes on either side of the window. Priority is given to trucks delivering during their reserved window; trucks arriving outside of the window are worked-in if possible, but no charge or penalty is given for missing a reservation window. However, reservation capabilities may be revoked for repeated offenses (HHLA, and Northwest Seaport Alliance, 2017).

The Port of Virginia has seen an improvement in truck turn time after implementing the reservation system. Between March 2018 and March 2019, with about 765 daily reservations, the Virginia International Gateway has seen a 32 percent reduction in truck turn times, while at the Norfolk International Terminal, which sees 567 reservations daily, the truck turn time has been reduced by 16 percent (see text box for more information) (Gillis, 2019). Similarly, the Port of Tacoma has seen a 20 percent reduction in truck turn times, though other improvements were also implemented in addition to the truck reservation system (Port of Vancouver, 2019).

Similar systems would be beneficial at forest products processing facilities. Wait times and peak rush periods result in trucks waiting and idling. The time spent waiting and idling could be otherwise used more productively if the truckers knew that the processing facility was already at capacity and had a reservation for a set time. Processing facilities could implement a similar app system at the ports, allowing truckers to register and reserve times days in advance. The system could also help the processing facility better predict when quotas will be met, control when specific type of wood/logs are delivered and improve on-site vehicle circulation. Several companies offer systems that could be used directly or revised to meet specific needs.

TRUCK RESERVATIONS AT THE PORT OF VIRGINIA

The reservation system operating at the Port of Virginia is operated by eModal and requires truckers to register at the Port's website. It is free to join the system. Each trucking company creates a profile and can manage a fleet through the profile, arranging reservations. In addition, each trucker can login to the mobile site from their phone and check or change reservations as needed.

Typically, there is a set number of appointment slots per hour, which are divided into pick-ups and drop-offs; the share of each varies by time of day and volume factors. In the mornings, there are usually more appointment slots, and they taper towards the middle of the day as delays and backlog naturally increase. The trucks are required to register and have the Pro-Pass system that comes with an RFID tag. The RFID tag is like an EZpass and is mounted on the driver-side windshield. The RFID tag is read by scanners at the entrance and exit gates, and at each stack. This allows the port to monitor where trucks are while they are on the port and saves time so that boxes are ready for trucks that are on port on schedule.

Each reservation is for a 1-hour time slot and includes a 30-minute grace period on either side of the appointment window to account for traffic delays. If an appointment is missed, the appointment must be reset, or the truck will have to wait until the non-mandatory hours when reservations are not required. The turn times are slower during the non-mandatory hours, prompting truckers to meet their appointment times. When first implemented, reservation slots were mandatory for all pick-ups and drop-offs between the hours of 8 am to 11 am. Because of the success, the mandatory hours were expanded to 4 am to 2 pm.

Efficiency has increased and turn times have decreased, especially first thing in the morning. Overall, both the Port and truckers like the system.

Additional information about the reservation system can be obtained through the Port's General Manager of Planning and Automation. Mark Higgins works directly with truckers and can offer advice and recommendations. He can be reached at 757-686-6404 or mhiggins@vit.org.

4.4 Routing Decision Support Systems

In order to choose the best route in terms of cost, companies are increasingly opting for a centralized approach (Epstein et al., 2007), an approach where the decision is made for the entire fleet of vehicles, rather than left to the judgment of each driver.

As the size of the work areas increase, the use of more expensive computer-assisted planning methods becomes justified. These methods are based on problem solving algorithms incorporating decision support systems. However, their use is rather limited, notably due to the lack of precision of the information available on the road network, or the need to use standards, for example for weight and volume units (Audy et al., 2012).

Studies show that their use provides substantial savings. More specifically, FlowOpt software, used in Sweden, saves 5 to 12.8 percent (Audy et al., 2012), and MaxTour software (FPInnovation Suite) saves 2 to 7 percent (Marier et al., 2017).

4.5 Collaborative Logistics

Collaborative logistics is when several companies pool their fleet of vehicles to reduce transportation times. Shared log transport services (pooled dispatch), which means sharing trucks and using a simple dispatch algorithm that accounts for logger status, was shown to move 12 percent more wood than random dispatch and 20 to 30 percent more wood than when truck ownership is limited to a single logger (Marier and Rönnqvist, 2015).

Initiatives are already being employed in some regions to foster this collaboration. For example, Union of Wood Producers of Estrie in Quebec has started the development of an Internet wood transport board respecting the characteristics of an open and heterogeneous system that allows drivers to plan their deliveries and shipments by finding lots of wood available in all regions of Quebec and reducing empty returns. The tool is constantly improved.

Obstacles to such a system include:

- Resistance to a new way of doing things
- Lack of confidence of the producer towards a carrier he/she does not know
- Transportation agreements may not recognize carriers from other regions

5 Task 4: Comparison of Wheel Configuration and Weight Limits

The following section provides a review of wheel configurations and weight limits for Maine and other peer forest products states and provinces. The review is followed by a summary of how Maine compares to its peers.

5.1 Peer Analysis of Wheel Configurations and Weight Limits

The maximum allowable gross vehicle weight limit in pounds varies from state to state and typically with the number of axles on the vehicle. More axles allow for higher weight and stability for the vehicle at higher speeds. In many cases, the weight per axle also depends on the distance between axles and the total axles. In Maine, a single axle may have a maximum of 22,400 pounds, a tandem (double) axle may have a maximum of 38,000 pounds, and the tri-axle maximum is 48,000 pounds. Unpermitted vehicles may weigh up to 80,000 pounds inclusive of the vehicle and payload.

A maximum 80,000-pound gross vehicle weight is common among the peer states for regular operations. However, there are several variations in the axle configurations and associated maximum weights. In Maine, the 80,000-pound maximum varies under several special exceptions, including:

- 100,000 pounds maximum for a combination of three-axle truck tractor and tri-axle semitrailer
- Exemptions for snow plows and farm vehicles transporting potatoes
- Variance of 110 percent for forest products on the tri-axle unit of a four-axle, single-unit vehicle not to exceed 64,000 pounds
- Exemptions for overweight fines in January and February except on interstates (Maine Legislature (1))

In addition, there are specific allowances for vehicles traveling across the border between specific points in Canada and Maine along designated routes. Vehicles traveling between Calais-Baileyville, Edmundston-Madawaska, and Saint Leonard-Van Buren may weigh up to 108,900 pounds on a three-axle trailer with a three-axle semitrailer or up to 137,700 pounds on a three-axle truck trailer with a semitrailer-semitrailer combination (Maine Legislature (2)).

Table 3 summarizes the maximum allowable vehicle weights and axle configurations, as well as special exceptions for the peer states and Canadian provinces.

Table 3: Maximum Allowable Vehicle Weight and Axle Configurations by State/Province

State/Province	Single Axle[1]	Tandem Axle[1]	Tridem Axle[1]	Maximum GVW[2]	Special Exceptions and Notes
Northeastern United States					
Maine	22,400	38,000	48,000	100,000	• For a combination of 3-axle truck tractor and tri-axle semitrailer: 100,000 lbs. • Variance for forest products on the tri-axle unit of a 4-axle single-unit vehicle: 110% (not to exceed 64,000 lbs.). • Exceptions for vehicles traveling between specific points in Canada and the U.S. (Calais-Baileyville, Edmundston-Madawaska, Saint Leonard-Van Buren) along designated routes. ○ 3-axle truck trailer with a 3-axle semitrailer: 108,900 lbs. ○ 3-axle truck trailer with a semitrailer-semitrailer combination: 137,700 lbs. • Fines are waived for violations of axle and axle group weight limits for January and February
Massachusetts	22,400	34,000		99,000	• 5+ axles
New Hampshire	22,400	36,000	54,000	99,000	• 6+ axles
Vermont	22,400	36,000		90,000	• Combination vehicles with 5 axles on non-interstate highways (permit required): 90,000 lbs. • 6+ axles (special annual permit): 99,000 lbs.
Canada					
New Brunswick	20,000	40,000	57,300	137,700	• GVW for B Train Double
Nova Scotia	20,000	40,000	57,300	137,700	• GVW for B Train Double • For self-steering quad axle, a maximum weight of 53,000 lbs. per axle group during spring thaw on Schedule B roads
Quebec	20,000	40,000	57,300	137,700	• GVW for B Train Double • For B Train Double, a maximum weight of 65,000 lbs. per axle group during spring thaw.
Upper Midwest United States					
Michigan	20,000	34,000		80,000	• Axle loading limit increased for vehicles carrying timber: 10%. • Combination vehicles with 11-axles (permit required): 164,000 lbs.
Minnesota	20,000	34,000	42,000	88,000	• Increase for axle group in winter: 10%. • GVW restrictions for vehicles transporting pulpwood: 82,000 lbs. • Three-unit-vehicle combinations on 8 axles for special paper products (permit required): 108,000 lbs.
Wisconsin	20,000	34,000		98,000	• 6+ axles on non-interstates: 98,000 lbs. • Forestry biomass, woodchips: 169,000 lbs. • 5 axle winter maximum on non-interstate highways: 98,000 lbs.

State/Province	Single Axle[1]	Tandem Axle[1]	Tridem Axle[1]	Maximum GVW[2]	Special Exceptions and Notes
Pacific Northwest and Western United States					
California	20,000	34,000		80,000	• Exceedances on tandem-axle restrictions for log trucks: 4.4% (up to two consecutive sets of tandem-axles).
Idaho	20,000	34,000		80,000	• Excess weight permits for up to 105,500 lbs. GVW • Idaho maintains a route network on which vehicles may be permitted for GVW in excess of 105,001 lbs. but not exceeding 129,000 lbs. (9+ axles)
Montana	20,000	34,000		131,060	• Vehicles carrying a divisible load over 80,000 lbs.: 131,060 lbs. • Vehicles operating under the Montana/Alberta Memorandum of Understanding: 137,800 lbs. (B Train, 8 axle)
Oregon	20,000	34,000		80,000	
Washington	20,000			105,500	• Non-interstate highways: 105,500 lbs.
Southeastern United States					
Alabama	20,000	34,000	42,000	84,000	• Non-interstate highways: 84,000 lbs.
Arkansas	20,000	34,000	50,000	85,000	
Florida	20,000	40,000		80,000	• Scale tolerance: 10%.
Georgia	20,340	34,000		80,000	• Variance within 100 miles: 5% • Exceedances for single and tandem-axle trucks transporting forest products: 13% (for vehicles transporting forest products from where first cut to the first point of processing or marketing). • Hauling equipment greater than 80,000 lbs. requires a permit
Louisiana	20,000	34,000	42,000	88,000	• Permit allowances for forest/logging equipment permit: 105,000 lbs. • Prohibited from traveling on interstates and at night under this permit.
Mississippi	20,000	34,000		80,000	
North Carolina	20,000	38,000		90,000	• For hauling raw logs to market within 150 miles for point of origin
South Carolina	20,000	36,000		92,000	• Enforcement tolerance for vehicles or trailers transporting unprocessed forest products on non-interstate highways: 15%. • Timber equipment is exempt from South Carolina laws governing size, weight, and load on non-Interstate highways.
Texas	20,000	34,000		84,000	• Variance for forest products (permit required): 5%.

[1] Axle weights for vehicles in regular operations (Sources: https://ops.fhwa.dot.gov/freight/policy/rpt_congress/truck_sw_laws/app_a.htm#wa; https://comt.ca/english/programs/trucking/Atlantic/Atlantic%20Guide%202010.pdf)

[2] GVW for vehicles hauling forest products (Sources: see Section 9. Appendices)

5.2 Summary of Wheel Configurations and Weight Limits

Maine falls within the typical range of maximum allowable loads per axle and has the same unpermitted maximum gross vehicle weight of 80,000 pounds as its peers. For a single axle, Maine allows 22,400 pounds, which is greater than all its peers at 20,000 pounds. For tandem axles, the range of maximum weights is 34,000 to 46,000 pounds, and Maine falls within this rage at 38,000 pounds. There is a wider range of maximum allowable weights on tri-axles, from 42,000 to 73,000 pounds; Maine allows 48,000 pounds, again falling in the typical range. The peers also have several exceptions and variations of the allowable loads based on routes, axle numbers, distance between axles, and vehicle types. In addition, some peers allow a 5 to 10 percent variance on the weight restrictions. Maine appears to be the only state to waive overweight fines in January and February on interstates, and the weight limit of up to 137,700 pounds for certain cross-border shipments is among the highest weights allowed by the peers; only Michigan and Wisconsin allow higher weight limits.

6 Task 5: Comparison of Vehicle Load Size

The following section provides a review of vehicle load sizes for Maine and other peer forest products states and provinces. The review is followed by a summary of how Maine compares to its peers.

6.1 Peer Analysis of Vehicle Load Size

Additional regulations and permits apply to vehicles or loads, including all structural parts, in Maine that are wider than 8 feet 6 inches. This width is standard among the peer states/provinces, including Vermont, New Hampshire, Massachusetts, New Brunswick, Nova Scotia, Quebec, Minnesota, Wisconsin, Washington, Oregon, North Carolina, South Carolina, Alabama, Louisiana, Mississippi, Arkansas, Texas, Michigan, Georgia, Florida, California, Idaho, and Montana.

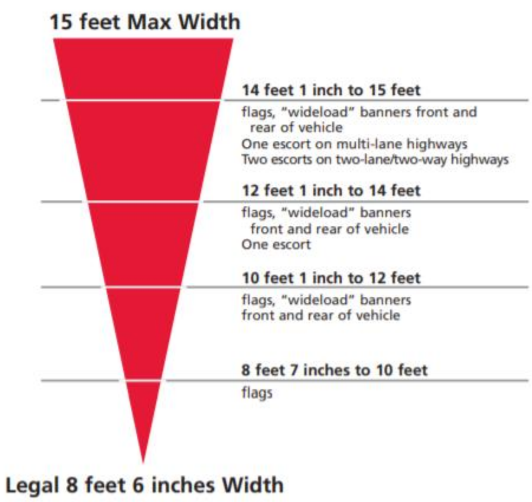
Fees must be paid for permits for oversized vehicles. As certain width requirements are exceeded, various safety additions are needed, including flags, escort vehicles, and limitations on routes and time of day. In Maine, each foot over the 8 ½-foot maximum incurs additional fees. Long-term, over-dimensional permits are issued in increments of 1 month. Restrictions on permitted wide loads in Maine also include (see Section 9. Appendices for sources):

- Limits on weekend and Friday moves for certain mobile homes and modular units
- Restrictions for oversize loads to travel during daylight hours (within 1/2 hour before and after sunrise) and not on holidays or weekends in July and August
- A blanket exemption for oversized equipment (such as logging, construction, or agricultural machinery) being moved on Saturdays and Sundays in July and August for the seven northernmost counties of Aroostook, Franklin, Oxford, Penobscot, Piscataquis, Somerset, and Washington counties; moves must be completed by 9 am and should avoid congested areas
- A requirement for pilot vehicles if over 80 feet long or 12 feet wide
- Restriction on over limit permits to a stated route and for a limited period; restrictions include safety, routing, time of day, holidays, and escorts

- Separate restrictions for the Maine Turnpike and the Bureau of Motor Vehicles permits
- Requirements for specific permissions from towns and municipalities

Like Maine, most states also have travel restrictions for daylight hours, weekends, weather conditions, and holidays, and exceptions are made for certain vehicle types. For example, snow removal vehicles are exempt from width restrictions in Maine. Dimensional and procedural requirements are dictated for oversize signs, lighting, flags, and escorts. North Carolina has increasing requirements as vehicle width increases, to the maximum of 15 feet (see Figure 5).

Figure 5. North Carolina Load Size Procedure Requirements



Source: NCDOT https://connect.ncdot.gov/business/trucking/Documents/Oversize%20Overweight%20Permit%20Handbook.pdf

Vermont limits the speed of oversize vehicles to 45 miles per hour on state highways and 60 miles per hour on interstates (Vermont Department of Motor Vehicles (1)).

Minnesota has travel restrictions on holidays from 2 pm the day before until 2 am the day after the holiday when exceeding 9 feet wide. Summer restrictions include no travel between 2 and 8 pm on Fridays and Sundays when exceeding 9 feet wide. In the Twin Cities and Duluth, no travel is permitted during rush hours. The Twin Cities restricts night travel to 12 am to 5 am only on weekdays if exceeding 14 feet 6 inches wide on non-divided roads and 16 feet on divided roads (Minnesota Department of Transportation, 2017).

Wisconsin has operating hour restrictions if wider than 12 feet that include no driving in the dark, 4 to 8 pm on Sundays, 4 to 8 pm on Fridays from the end of May to Labor Day; noon Saturday until sunrise Sunday and starting at noon the day before a holiday until sunrise the day following. Width exceptions are made for (Wisconsin State Legislature):

- Agricultural commercial vehicles can be up to 10 feet without a permit, and snowplows are not restricted by width.
- Twelve feet is the maximum unpermitted width for skidders, forwarders, harvesters, and wheeled feller bunchers for logging purposes operated during daylight hours if traveling less than half a mile. The 12-foot limit does not apply to interstates.
- Nine feet is the maximum for loads of tie logs, tie slabs, and veneer logs, but they are excluded from interstates.

Some states provide exceptions for logging trucks, with allowances of up to 9 feet in Wisconsin[4] and Michigan,[5] and 12 feet in South Carolina (Wisconsin State Legislature, Michigan Legislature, South Carolina Department of Transportation). Forestry machinery is exempt from width and height restrictions on state highways in Florida altogether,[6] and Louisiana exempts vehicles from width restrictions (as long as the vehicle has blinking hazard lights) when transporting timber cutting or logging equipment from one job site to another and when owned or leased by the same person (Arkansas Department of Transportation, 2019; Louisiana Department of Transportation & Development, 2013).

6.2 Summary Vehicle Load Size

Maine's maximum load size is 8½ feet, consistent with all other peer states and Canadian provinces. In addition, exemptions for certain vehicle types, such as snow plows or logging trucks, are not unusual and restricted travel on routes, time of day, and weekends or holidays are also common among the peers. Oversize permits are available with additional restrictions such as pilot vehicles and flagging and are applicable over limited time periods. Overall, Maine is on par with its peers with regards to vehicle load size.

7 Task 6: Comparison of Seasonal Weight Limits

The following section provides a review of seasonal weight limits for Maine and other peer forest products states and provinces. The review is followed by a summary of how Maine compares to its peers.

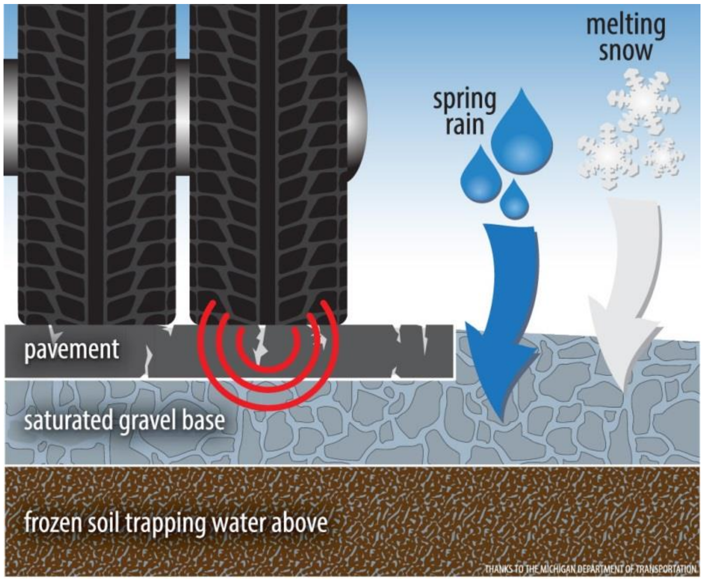
7.1 Peer Analysis of Seasonal Weight Limits

In many northern states and provinces, weight limits are posted on roads during the spring thaw, or "mud season." The dates of the spring thaw season vary by location, but the purpose of the weight restrictions is to preserve the structure of the roadway during the period when the roadbed is

[4] https://docs.legis.wisconsin.gov/statutes/statutes/348/II/05
[5] http://www.legislature.mi.gov/(S(k4u4qlm4mc0ljd1c1qc4kqgn))/mileg.aspx?page=GetObject&objectname=mcl-257-717
[6] http://www.arkansashighways.com/highway_police/2019%20PERMIT%20RULES.pdf

susceptible to cracking and damage (Figure 6). This is because a road could carry a much heavier load in summer or winter than in spring when it thaws.

Figure 6. Impact on Roads from Spring Thaw Cycle



Source: Maine DOT, https://www.maine.gov/mdot/postedroads/_assets/img/WeightRestrictGraphic_ME_flat.jpg

By restricting the weight of trucks that can traverse certain routes, the structural integrity of the roadway can be maintained, and damage can be minimized. In Maine, it can cost $300,000 to $1 million per mile to repair or rebuild a road (Maine Department of Transportation (1)). If a road is posted, the maximum weight limit during the spring thaw is 23,000 pounds, with few exceptions. In general, the guideline states that if the air temperature is below 32 degrees (Fahrenheit) and there is no standing water on the road, then the road should be frozen and therefore passable (Maine Department of Transportation (2)). However, if water is present in the cracks, the road should be posted using an orange poster at each end of the closed highway noting the date of the posting, a description of the highway that is closed, the vehicles exempt from the closing, and other required references (Maine Department of Transportation (3)).

Exceptions to the posted weight limit are made for certain vehicles and those with permits. Permits are not required for vehicles carrying less than 34,000 pounds of certain commodities, including heating fuel, petroleum, groceries, bulk milk and feed, solid waste, animal bedding, returnable beverage containers, sewage from private septic tanks, and medical gases. Limited Load Permits are issued for some trucks carrying over 34,000 pounds, based on axle configuration and tire width. Municipalities and counties are also authorized to enact rules on the roads under their jurisdiction.

Few of the peer locations outside of the northeastern region have posted weight limits during the spring thaw. The following lists the restrictions and notable variations:

- In Vermont, the mud season and weight limits vary by town and axle load from 15,000 to 40,000 pounds (Vermont Department of Motor Vehicles (2)).
- In New Hampshire, typically the spring thaw is March 1 through May 1, and the posted maximum weight limit varies by class of road and municipality (New Hampshire Municipal Association).
- Massachusetts has no restrictions.
- New Brunswick's weight limit varies by route and ranges from 80 percent to 100 percent of the legal axle group weight. A pilot program that began in 2013 is still running for four zones under which certain designated routes allow for increased weights during frozen road conditions, but the program only applies to the forest industry (New Brunswick, 2019).
- Nova Scotia has limits that vary by route and axle group (Nova Scotia Regulations). For example, for a self-steering quad axle, regulations list a maximum weight of 53,000 pounds per axle group on Schedule B roads, 40,000 pounds per axle group on Schedule D roads and 26,000 pounds per axle group on all other roads.
- In Quebec, the maximum allowable weight varies by zone and vehicle class (Transports Quebec, 2019). However, there are ongoing negotiations to increase the weight limit during the winter.
- In Minnesota, the maximum posted weight limit is 20,000 pounds, typically effective March 15 through mid-May. Depending on the route, some loads can be limited to 10,000 to 20,000 pounds (Minnesota Department of Transportation, 2019).
- In Wisconsin, on state roads the maximum posted weight limit is 48,000 pounds. It varies by route and axles from 12,000 to 20,000 pounds per axle with a maximum gross weight of 48,000 pounds. The restrictions are effective typically starting in the second week of March until late April or early May. An RS permit allows 98,000 pounds of raw forest products on 6 axles during the spring thaw (Wisconsin Department of Transportation).
- Michigan has restrictions that vary by route, effective March 11, with reductions of 25 percent on rigid pavements and 35 percent on flexible pavements (Wisconsin Department of Transportation).
- Montana has restrictions that vary by route from 14,000 to 32,000 pounds per axle group (Montana.gov).
- The remaining peer states have no listed restrictions. Many are in the southern portion of the United States: Alabama, Arkansas, California, Florida, Georgia, Idaho, Louisiana, Mississippi, Oregon, North Carolina, South Carolina, Texas, and Washington.

7.2 Summary of Seasonal Weight Limits

Maine's posted weight limit during the spring thaw is somewhat of an outlier given that the other northeastern states and Canadian provinces vary their limits based on routes and vehicle classes. Only Minnesota and Wisconsin also set maximum posted limits, but they can also vary. Maine's maximum falls between Minnesota's and Wisconsin's. None of the southeastern or pacific northwestern states have weight restrictions given the differences in climate compared to Maine, the northeast, and the upper Midwest. If Maine municipalities and the Maine Department of Transportation have experienced substantial roadway damage from overweight vehicles during the spring thaw, it would be beneficial to consider restrictions based on vehicle classes, routes, and axles.

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9 Appendices

9.1 Sources for Wheel Configurations and Weight Review

State/Province	Source
Northeastern United States	
Maine	http://www.mainelegislature.org/legis/statutes/29-A/title29-Asec2353.html http://www.mainelegislature.org/legis/statutes/29-A/title29-Asec2354-C.html
Massachusetts	https://www.mass.gov/service-details/commercial-truck-regulations
New Hampshire	http://www.gencourt.state.nh.us/rsa/html/XXI/266/266-18-b.htm
Vermont	https://legislature.vermont.gov/statutes/section/23/013/01392
Canada	
New Brunswick	https://comt.ca/english/programs/trucking/Atlantic/Atlantic%20Guide%202010.pdf
Nova Scotia	https://novascotia.ca/just/regulations/regs/mvwd.htm#TOC1_5
Quebec	http://legisquebec.gouv.qc.ca/en/showdoc/cr/C-24.2,%20r.%2031
Upper Midwest United States	
Michigan	http://www.legislature.mi.gov/(S(vvpiz315cggphxxk0jl44poo))/mileg.aspx?page=getobject&objectname=mcl-257-722&queryid=1945485&highlight=seasonal+weight
Minnesota	http://www.dot.state.mn.us/cvo/mntruckbook/2019/sect4.pdf https://wisconsindot.gov/Documents/dmv/shared/permitscomparison.pdf
Wisconsin	https://wisconsindot.gov/Documents/formdocs/sp4075.pdf https://wisconsindot.gov/Documents/dmv/shared/permitscomparison.pdf
Pacific Northwest and Western United States	
California	http://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?lawCode=VEH&division=15.&title=&part=&chapter=5.&article=1.
Idaho	https://legislature.idaho.gov/statutesrules/idstat/title49/t49ch10/sect49-1001/
Montana	https://leg.mt.gov/bills/mca/61/10/61-10-107.htm
Oregon	https://www.oregon.gov/ODOT/MCT/Documents/weight_limits.pdf
Washington	https://www.wsdot.wa.gov/publications/manuals/fulltext/M30-39/CVG.pdf
Southern United States	
Alabama	https://www.dot.state.al.us/maweb/pdf/Permits/AlabamaCode32-9(1.18.2017).pdf
Arkansas	https://codes.findlaw.com/ar/title-27-transportation/ar-code-sect-27-35-203.html
Florida	http://www.leg.state.fl.us/statutes/index.cfm?App_mode=Display_Statute&Search_String=&URL=0300-0399/0316/Sections/0316.535.html
Georgia	https://advance.lexis.com/documentpage/?pdmfid=1000516&crid=b4261fa9-4cdd-4a83-a96b-e2bb4adabe93&config=00JAA1MDBlYzczZi1lYjFlLTQxMTgtYWE3OS02YTgyOGM2NWJlMDYKAFBvZENhdGFsb2feed0oM9qoQOMCSJFX5qkd&pddocfullpath=%2Fshared%2Fdocument%2Fstatutes-legislation%2Furn%3AcontentItem%3A5V8M-CMJ0-004D-83YH-00008-00&pddocid=urn%3AcontentItem%3A5V8M-CMJ0-004D-83YH-00008-00&pdcontentcomponentid=234186&pdteaserkey=sr1&pditab=allpods&ecomp=kgw7kkk&earg=sr1&prid=6e502124-81a4-4806-9aae-3ee7dd34b2a6
Louisiana	http://perba.dotd.louisiana.gov/welcome.nsf/RegBook2013.pdf
Mississippi	https://advance.lexis.com/documentpage/?pdmfid=1000516&crid=00dff5b5-71c5-4258-a509-21e09286cabe&nodeid=ABHAAEAAO&nodepath=%2FROOT%2FABH%2FABHAAE%2FABHAAEAAO&level=3&haschildren=&populated=false&title=%C2%A7+63-5-27.+Wheel+and+axle+loads.&config=00JABhZDIzMTViZS04NjcxLTQ1MDItOTllOS03MDg0ZTQxYzU4ZTQKAFBvZENhdGFsb2f8inKxYiqNVSihJeNKRlUp&pddocfullpath=%2Fshared%2Fdocument%2Fstatutes-legislation%2Furn%3AcontentItem%3A8P6B-8562-8T6X-71F5-00008-00&ecomp=k357kkk&prid=3d53bd0a-2e2b-4a88-a469-e79276e3fed4

State/Province	Source
North Carolina	https://www.ncleg.net/EnactedLegislation/Statutes/PDF/BySection/Chapter_20/GS_20-118.pdf
South Carolina	https://www.scstatehouse.gov/sess121_2015-2016/bills/4932.htm https://law.justia.com/codes/south-carolina/2012/title-56/chapter-5/section-56-5-4140/
Texas	https://statutes.capitol.texas.gov/Docs/TN/htm/TN.621.htm#621.001

9.2 Sources for Wide Loads Review

State/Province	Source
Northeastern United States	
Maine	http://www.maine.gov/sos/cec/rules/29/250/250c156.doc
ME Turnpike	http://www.maineturnpike.com/Business-With-MTA/Policies-Rules.aspx
Massachusetts	https://malegislature.gov/Laws/GeneralLaws/PartI/TitleXIV/Chapter90/Section19
New Hampshire	https://www.nh.gov/safety/divisions/nhsp/fob/troopg/motorcarrier/faqmc.html
Vermont	https://dmv.vermont.gov/commercial-services/permits/rules
Canada	
New Brunswick	https://www2.gnb.ca/content/gnb/en/services/services_renderer.3635.Trucking_Services_-_Special_Permits.html
Nova Scotia	https://novascotia.ca/sns/paal/rmv/paal280.asp
Quebec	http://legisquebec.gouv.qc.ca/en/showdoc/cr/C-24.2%2c%20r.%2031
Upper Midwest United States	
Michigan	https://www.legislature.mi.gov/documents/2003-2004/billanalysis/House/htm/2003-HLA-0736-5.htm
Minnesota	https://www.dot.state.mn.us/cvo/oversize/OSOWBrochure-Colorv.pdf
Wisconsin	https://wisconsindot.gov/Pages/dmv/com-drv-vehs/mtr-car-trkr/osow-permit-req.aspx
Pacific Northwest and Western United States	
California	http://www.dot.ca.gov/trafficops/trucks/width.html
Idaho	https://legislature.idaho.gov/statutesrules/idstat/title49/t49ch10/sect49-1010/
Montana	https://leg.mt.gov/bills/mca/61/10/61-10-102.htm
Oregon	https://www.oregon.gov/odot/mct/pages/over-dimension.aspx
Washington	http://www.wsdot.wa.gov/CommercialVehicle/NeedaPermit.htm
Southern United States	
Alabama	https://www.dot.state.al.us/maweb/pdf/Permits/AlabamaCode32-9(1.18.2017).pdf
Arkansas	http://www.arkansashighways.com/highway_police/2019%20PERMIT%20RULES.pdf
Florida	https://www.lawserver.com/law/state/florida/statutes/florida_statutes_316-515
Georgia	https://legalbeagle.com/7217597-georgia-dot-regulations.html
Louisiana	http://perba.dotd.louisiana.gov/welcome.nsf/RegBook2013.pdf
Mississippi	http://mdot.ms.gov/documents/enforcement/permits/permit%20information/permit%20rules.pdf
North Carolina	https://connect.ncdot.gov/business/trucking/pages/overpermits.aspx
South Carolina	https://www.scdot.org/business/pdf/osow/OSOW_Guidelinesfor_movement.pdf
Texas	https://www.txdmv.gov/motor-carriers/oversize-overweight-permits/texas-size-weight-limits