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Article

Policy Recommendation from Stakeholders to Improve Forest Products Transportation: A Qualitative Study

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Abstract: With recently announced federal funding and subsidies to redevelop vacant mills and the communities they were in, the forest products industry in Maine is poised to gain its momentum once again. One of the important components influencing the cost of delivered forest products is transportation. A recent study in the region has shown that the location and availability of markets along with lack of skilled labor force are the major challenges faced by the forest products transportation sector in Maine. This study was focused on developing a management guideline which included various field level options for improving trucking enterprises in Maine. For this, a qualitative research approach utilizing a case study research tradition was employed, with in-depth semi-structured interviews with professionals directly related to the forest products transportation sector used for data generation. Thirteen semi-structured interviews were conducted, with each being audio recorded and later transcribed verbatim. Interview transcriptions were analyzed using NVivo 11. Suggestions, like increasing benefits to drivers and providing training, were proposed for challenges related to manpower shortage, while the marketing of new forest products and adjustment in some state-level policies were proposed for challenges related to the forest products market condition of the state.

Keywords: case study; labor force; management guideline; secondary transportation

1. Introduction

The flow of forest products from harvesting sites to the processing facilities is a combined effort of different stakeholders. The supply chain of the forest products generally starts with foresters laying out harvest plans for forest landowners i.e., small woodlot owners, industrial land owners, and public lands. Logging operators with the direction of foresters and logging contractors take responsibilities of felling trees and piling the wood at the log landings. With guidance from a procurement manager and trucking contractor, the products are hauled from landings to facilities (usually primary forest products industries or bioenergy plants) (Figure 1). The trucking (also referred to as secondary transportation) part in this process is considered important because of its essential function of moving products from one place to another. It is also one of the expensive phases and can be crucial in fixing prices of delivered forest products [1–3]. Despite the prevalence of railroad transportation, trucking is the most common way to deliver wood products [4]. Its popularity can be associated with well-developed road networks, limited access to railway lines, and embargos in using water for timber hauling in the US and other parts of the world [5,6]. After the last log drive on the Kennebec River in 1976, the transportation of woody commodities from northern forests in Maine has predominantly been performed by trucks

and tractor-trailers [6]. There are separate types of trucking fleets for specific products such as tractor trailers to haul logs, whereas chip vans to haul wood chips and comminuted biomass materials. Even with the inherent need to haul forest products, there are various challenges in this sector that needs to be addressed for its efficient operations. These challenges can be specific to the region and thereby require a local level understanding of constraints and potential mitigation strategies including policy formulation. Hence, strategic suggestions from closely related stakeholders and experts in the field are important. The recent closing of pulp and paper mills has imparted significant impacts on the entire forest products market in the state of Maine. The forest product market is highly scattered in the state; the situation has been further exacerbated by the recent closing. The increased hauling distance resulting from the closing of pulp and paper mills has increased the cost of trucking forest products compared to the situation in the past [7].

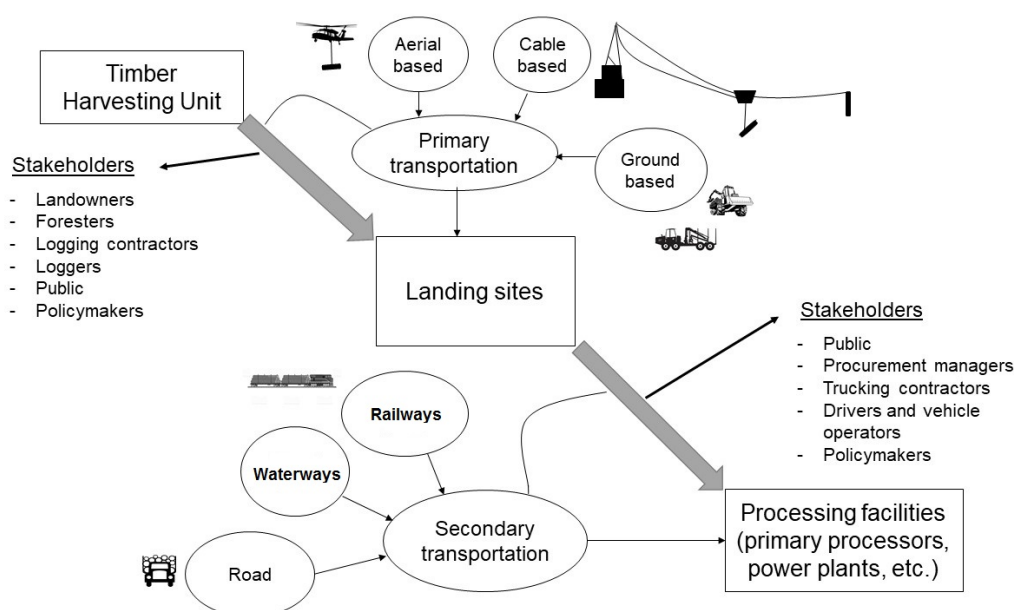


Figure 1. A sketch showing the flow of raw forest products from timber harvesting unit to the processing facilities like mills, powerplants, and industries. For this study, the focus, however, will be on the transportation from landing sites to the processing facilities.

Concerns regarding higher costs associated with forest products transportation have led to several studies in forest operations including analysis of wood products hauling costs [8–11]; increasing efficiency in transportation [12–15]; and survey analysis of logging and transportation sectors [16–20]. Similarly, there are research studies utilizing qualitative methods, such as semi-structured interviews, to comprehend views and opinions of experts [21,22]. To this end, such a qualitative research approach has not been utilized to get in-depth information on forest products transportation. The purpose of this research was to: (a) gain an in-depth understanding of stakeholders' perceptions of the problems related to trucking; and (b) identify possible measures to resolve them. Understanding related stakeholders' attitudes towards the applicability of particular solutions in the state of Maine could help the industry and policymakers implement them.

2. Materials and Methods

A qualitative research approach was selected to allow in-depth understanding of a problem within a concrete setting [23,24] and learn the interpretation of verbal experiences from stakeholders [25].

2.1. Philosophical Foundation

The methodology was based on the constructivist paradigm and used a single case study design to explain related stakeholders' perceptions and experiences. The epistemological approach of constructivism proclaims that different individuals describe the same problem in multiple ways [26]. Constructivism is based on the fact that truth is dependent on perception. Another important assumption is that problems are solved by the interaction between researcher and respondents, hence, open-ended question formats like interviews and discussions were used [27]. These questions used generally begin with how and why, rather than what and when with the intention of getting comprehensive insights on the subject [28].

2.2. Case Study Design

A case study is a research design that allows researchers to gain an in-depth understanding of a problem, process, situation, or even individual, and a group of people within a bounded system [23,24]. A common way to conduct case study research is to collect comprehensive information on the case by utilizing and triangulating across different data collection techniques such as interviews, document review, direct observations, and archival records [29,30]. The case includes bounded time, context, region, and phenomenon or topic of study [23,24]. The state of Maine was the area of study, while 2015–2016 was the timeframe for this study. The research used an instrumental case study design [23,24] to understand the phenomenon of challenges facing the forest trucking industry subsector, and local level measures adopted in different parts of Maine to mitigate forest trucking related problems. Multiple data collection methods were used, including a stakeholder questionnaire, thorough review of the literature, and in-depth semi-structured interviews with key stakeholders in Maine. Phase 1 of the study included the identification of potential solutions via a stakeholder questionnaire, unstructured interviews with key informants, and review of the scientific literature [2,7]. This phase was followed by the in-depth interviewing phase to further understand the challenges and validate the appropriateness/soundness of solutions identified in phase 1. This paper includes results from phase 2; for detailed results for phase 1 please refer to prior citations [2,7].

2.3. Participant Selection Strategy

The stakeholders were divided into four categories based on their job profile: (a) Foresters; (b) Truck owners/logging contractors (from here on referred to as contractors); (c) Representatives from forestry professional societies; and (d) Procurement managers. The categories were selected for providing appropriate and relevant responses to address the objectives from different perspectives.

The Forest Resource Association (FRA), a group of more than 500 organizations and businesses related to the forest products industry, was consulted first for participant recruitment. A public announcement for interested individuals to participate in the study was made at a FRA forum in Brewer, Maine. The process did not yield sufficient ($n = 2$) responses; hence the combination of criterion and snowball sampling techniques was used to select participants [31]. Professional contacts were utilized to recruit interviewees and enhance the gaining of entry and rapport building. First, the selection criteria were that the participants should have more than 15 years of experience in forest products handling and transportation, should have a primary workstation within the state, and be willing to participate in the study. Further, the snowball selection strategy allowed for participants and key informants from phase 1 to refer other participants to include in the study [32,33] while ensuring different regions (North, Central, South) to be included.

2.4. Ethics Statement

Approval was obtained from the Institutional Review Board (IRB), University of Maine, Orono for conducting research on human subjects prior to the interviews on 4 January 2017. A written informed

consent form was given to the participants prior to the interviews which ensured confidentiality and voluntary participation.

2.5. Data Collection, Analysis, and Quality Assurance

The primary data collection method for this study phase was semi-structured face-to-face interviews with mostly open-ended questions. This method has advantages over other qualitative techniques like focus group discussions because interviews allow more privacy and a safer atmosphere to talk on dedicated issues than the latter; participants have more time to express their feelings and discuss the subject matters in detail as well [34]. Interviews were helpful for the triangulation of information gained from supplementary sources from phase 1, which ensured credibility of the study results [24].

The interview protocol consisted of 13 major open-ended questions; each question included four additional probing questions (on average). The interview protocol along with the consent form were emailed to the participants three weeks prior to the interviews in order to facilitate a review of the questions and to allow time to decide a response. Interview questions were developed based on the results of the survey, unstructured interviews, and literature analysis, and were organized into four themes: (a) outlook on forest trucking sector; (b) major challenges faced; (c) potential measures; and (d) applicability of those measures in Maine. To obtain regional based information, the respondents were further categorized based on regions of their primary workplace: Northern, Central, and Southern regions.

Thirteen semi-structured interviews with open-ended questions were conducted from February to May 2017. Interviews were continued until ongoing data analysis suggested data saturation had been reached (i.e., new interviewees did not provide any additional information on the subject) [35,36]. There were no rigid rules on the number of interview participants a priori, but rather the study followed established procedures in qualitative research on data saturation [32,37]. However, the number of interviews in this study (13 interviews) was consistent with other studies that utilized a similar research approach [38].

With an average of 51 min, the total duration of the interviews ranged from 33 to 71 min. Due to the general interests on particular topics, most interviews lasted longer than the slated time frame.

The whole content of the interview was audio recorded, and the recordings were later transcribed verbatim [39] and uploaded into NVivo 11 [40]. The transcripts were meticulously read several times and important phrases/dialogues were subsequently highlighted using open coding [39] as the first coding cycle. These open codes were then abstracted into concepts identified previously through the literature review and listed in the interview protocol; this axial coding was used as the second coding cycle. The codes were generated by an iterative process that involved reviewing data multiple times [41]. This process also helped in determining the point of saturation for each question.

3. Results and Discussion

3.1. Participants' Description

Among 13 interview participants, four were based in Northern regions, three in Central regions, and three from Southern regions of the state. Based on job profiles, the majority were foresters (Table 1). The average work experience of the participants in their respective profession was 25 years, and respondents ranged from 36 to 74 years of age. The majority of the respondents worked for industrial timberland companies, while some were also small timberland owners (less than 2000 ha). All of them were Caucasian males.

Table 1. Description of the participants interviewed for the study to comprehend the challenges faced by forest trucking sector and probable resolutions to those challenges.

Stakeholder Categories	Number of Participants (by Subregions of Maine)	Experience (in Years)
Foresters (company based or consultant)	5 (Central = 3, Northern = 1, Southern = 1)	30
Truck owners/Logging contractors	2 (All subregions = 2) ¹	28
Professional society representatives	2 (Southern = 1, All regions = 1)	25
Procurement managers	4 (Northern = 3, Southern = 1)	19

¹ Participants having primary workstation in more than one subregion or working for forestry sector for the whole state.

3.2. Responsibilities and Services

The services provided by the companies or organizations that respondents were affiliated with were of diverse nature. Nearly all of them were involved in multiple forestry related tasks. One of the participants stated:

“We have forest operations of every nature. We do harvesting, trucking, chipping, loading, slashing, merchandising, building forest roads, developing forest management plans, managing our own lands, and other people’s lands. We have three equipment shops; one for forest harvesting machines and two for trucks and trailers.”

One of the procurement managers described his duties as overseeing entire harvesting operations, dealing with logging/trucking contractors, along with inspecting and regulating dispatch of trucks and chip vans. There was also a procurement manager just to oversee transportation-related works whose duties were, “...to look after road maintenance for the company, and transportation of all raw materials to the mills.”

Primary duties of company foresters interviewed were managing woodlots, preparing management plans, hiring and managing temporary workers, and dealing with contractors and truck drivers. Independent consultant foresters generally worked for various landowners at any provided time.

The participants were from varying company sizes, in terms of number of employees, ranging from small (<5 employees) to large (>50 employees) companies. Basic benefits to the workers (including truck drivers) included health insurance, paid leaves, and subsidies for buying wood products. One procurement manager noted:

“We have health and many benefits like other businesses, but the additional one is the career (sic) we really enjoy and passionate about. I think there are other disciplines with higher pay (sic), but this profession provides flexibility of schedule and time. I’m not in a cubicle daily and I’m doing something different.”

The above statement from the procurement manager could be applied to loggers and log truck drivers as well. There are factors other than money that drive novices to the logging and trucking industries such as the involvement of past generations of family (a family profession), the ability to work locally, and independence in the work.

Participants who hired trucking service from contractors were unaware of the exact benefits package offered to the employees and drivers working under trucking contractors. One forester specified:

“...I’ve not known exact details, but there should be enough to make a person sit on that giant (log trucks) and drive on rough terrain all day.”

3.3. Trucking in Maine

All participants regarded trucking as an essential component, as more than 90% of the wood hauled in the state was done by road. Railway systems were also in use in northern and western parts

of the state, however, trucks were still used for a certain portion of that journey. Most of the timberland owners and management companies did not own trucks but hired trucking service. The participants seemed aware of the role of trucking in determining the end price of the delivered forest products. They were also concerned about the losses incurred due to inefficient trucking. One procurement manager stated:

"...as far as the role of trucking, it's a key to the business. When you look into harvesting and trucking of wood to our mill, it's probably one of the biggest costs both for distance and other factors like payload. It's the cost that continues to go up every year because it's something that you cannot increase productivity like in the harvesting operations. You can only put so much wood on the truck and you can only drive so far, safely and efficiently."

Several factors affected the cost of trucking, including fuel price, maintenance cost, trucking distance, and payload. Contractors were always trying to make their operations efficient enough to avoid extra expenditures: *"...it's everything for us. We have more trucks than truck drivers. We have to keep an eye on every detail to make profits. All of them operates year around and are maintained timely. We are a service provider, so no compromise at all."* The fewer truck drivers, in this case, was the strategy to reduce expenditures on extra drivers. It also implied that all trucks were not running at the same time.

Both above statements, although addressing different discussion points, allude to the issues faced day to day by forest trucking enterprises. As a different perspective, one participant from the professional society stated:

"...most of the logging contractors, probably 75 percent, have a truck or two. This provides them with more stability in their services. Owning and operating trucks makes them more flexible and competitive."

There were mixed responses regarding the outlook on trucking business for the region, with participant responses articulated in terms of challenges and opportunities in the field. In general, the participants considered trucking to be a challenging business but expected that prospects will increase with a new horizon of market opportunities for products like biomass, hardwood pulp, biofuels, and others (Table 2).

Table 2. Examples of the participants' responses regarding the outlook of the forest trucking business in Maine. The blank cells indicate the absence of positive or negative attitudes of the participants.

Stakeholder Responsibility	Region in Maine	Key Ideas Showing Outlook of Trucking Business in Maine ¹	
		Positive Attitude	Negative Attitude
Forester	Central	<i>"...the weight limit has been raised..."</i> <i>"...drastic drop in the oil price over recent years..."</i>	<i>"...having hard time finding drivers..."</i> <i>"...profit margins are very tight..."</i>
Trucks owner	Entire Maine	<i>"...trucks are in demand and will be in future."</i>	
Professional society representative	Southern		<i>"...more expensive than it used to be."</i> <i>"...much more difficult for owner operator to get started."</i>
Procurement manager	Northern	<i>"...the forest trucking market is growing..."</i>	<i>"If trucking cost doesn't work out then we're not going to be able to operate."</i>
Forester	Northern	<i>"...trucking business for northern climate can be profitable..."</i> <i>"...room for new business to enter in the market."</i>	<i>"...moving more volume of wood, as the payload is based on ton."</i> <i>"...primary concern is about the aging workforce."</i>

¹ Participants' direct quotation.

In a different context, participants (except contractors) mentioned that for forest products companies, it might be better to contract the trucking portion of forest operations than to own and

operate entire trucking fleets. One procurement manager mentioned, *“We had a fleet of trucks that we managed in the past but it’s to our benefit that we hire contractors. They can run this business better than us. There are certain things that contractors are more efficient than company managed fleet (sic).”* Another forester agreed, *“This section is difficult to handle if you are dealing with many other things.”*

3.4. Challenges to Trucking

All participants agreed that there were numerous challenges to efficient trucking operations. The majority (more than 80%) regarded the lack of skilled drivers as the most prominent challenge at present time (Table 3). Similar to the forest trucking industry’s experiences, driver shortage was also a prominent challenge for other trucking businesses as well; a report prepared by the ATA (American Trucking Association) pointed out that the US trucking sector was short of 35,000 truck drivers in 2015 [37]. This challenge was not only getting severe due to the aging workforce, but also the difficulty to keep truck drivers in this profession for a longer period. Even with enough experience and physical abilities, many drivers did not pass the mandatory drug tests for operation, which also contributed to the cause. For international shipping, age factor was also an issue, as drivers below 21 years face restrictions in crossing the Canadian border. Because of these legal complications, participants mainly from the northern region (two from the central region) ranked the border crossing requirement as the main challenge. A forester stated:

“A lot of our wood goes across border into Canada. So, there are new restrictions on border crossing, their weight restrictions are different than ours (two tiers systems in US). Contract rates needs to be adjusted accordingly.”

All respondents agreed that a key challenge to the forest industry in general was due to the recent closures of five pulp mills in central and southern parts of the state within the last two years [42]. It resulted in harvesting and marketing of new forest products which were not considered valuable before. There is a need for research on the diffusion of new forest products and services to achieve global sustainability goals from the forestry sector [43]. The impact of mill closures was reflected in trucking as it increased hauling distances and transportation costs of forest products in the state. However, the effects of the closing appeared to be less severe in the northern parts compared to other regions. One respondent from northern Maine explained, *“It does have effects, but not much than (sic) the adjoining regions. It affected us in a way that wood started moving in different direction and started infringing on the markets that we always relied on.”* For small landowners, the impacts were of another nature, a forester working for a small landowner stated, *“...it has affected some of our capability to market low-value products like everybody else. We have very little market cloud because we’re small. So, this probably affects us more than big land owners. We don’t have negotiating powers like landowners who produce 250,000 * cords a year does (sic). Last year we cut 3200 * cords.”* (* 250,000 cords ~906,000 cubic meters and 3200 cords ~11,600 cubic meters).

Despite having been affected by the closing of mills, participants were optimistic about the future of forestry businesses in Maine. They agreed that certain products like hardwood pulps and biomass which were not in demand previously were in high demand at present due to mill closures. The trucking sector was directly benefited with this as trucks started delivering these new products to new markets and increased their chances to back-haul products.

Another challenge was regarding the conditions of public and forest roads. Participants from northern Maine were especially disgruntled by the condition of public roads in the region. Some of them also compared the bad conditioned roads with good Canadian roads across the border.

Other challenges mentioned were related to back-hauling, payload, high equipment owning and insurance costs, timber harvesting season, safety, and turnaround times (Table 3). Some of these were common to all forest operations, in general. Results also showed that specific challenges can be less important for one stakeholder group while representing major concerns for another. For example,

all foresters were convinced that the legally allowable payload for the public highways in the state was sufficient, while the contractors and procurement managers wanted the weight limit to be increased.

Table 3. Examples of the participants' responses to the challenges faced by the forest trucking industry in Maine.

Stakeholders' Responsibility	Main Challenges	Participants' Direct Quotes
Forester	Drivers, roads, and safety	<i>"Finding good drivers is the main thing. We hear that all the time from our contractors. The other thing is the worse roads. I am very much concerned about the safety of drivers as well as public."</i>
Procurement manager	Supply chain issues and contractors' nature	<i>"There is a supply chain issue. Majority of logging contractors own everything, logging equipment and trucks, and they employ drivers and operators. This is somehow inefficient. They want to do that because they want their wood to reach the market first."</i>
Forester	Contractors' nature	<i>"Trucks are passing each other with same products and same origin and destination, it seems there is a competition between contractors."</i>
Professional society representative	Drivers and insurance cost	<i>"Many of these contractors could not find drivers because of the drug tests; most of them failed the test. The insurance cost goes really high if you don't have good drivers."</i>
Truck owner/ Logging contractor	Aging workforce and back-hauling	<i>"There are two major challenges. The drivers hauling wood out of the forest require a special skill, which many do not have. The ones we had are also retiring. The other challenge is too much percentage of empty drive miles that makes the transportation costs very high."</i>
Truck owner/ Logging contractor	Market condition and state policies	<i>"Closing of mills has affected our business tremendously. We lost literally a third of our business over sales in about a twelve-month period of time, which is very painful, very hard to adjust and we haven't fully adjusted yet. The other thing is the state's regulations; some of them are terrible and not business friendly."</i>
Procurement manager	Roads	<i>"Public roads in this region (northern Maine) are terrible. I mean it was really bad this time of year as the frost comes out, but they don't get a lot better anymore in the summer and fall winter. Terrible terrible!!"</i>
Professional society representative	Transportation distance	<i>"...increased hauling distance is the main issue at present"</i>

3.5. Possible Solutions and Applicability in Maine

The interview questions were designed to group potential solutions based on the problem type. Several options emerged when participants were asked about mitigating some specific challenges such as the shortage of skilled truck drivers and current market conditions. Participants also put forward solutions which could turn these challenges into opportunities in the future. One respondent appeared very optimistic, *"I agree there are problems now, but we will get through this. Maine is a very resilient state; we have dealt with a lot of issues in the past—take spruce-budworm outbreak."* The same individual responded to the shrinking market condition, *"It requires new investments and business models to start up. It will take time, but it will eventually. New markets are opening for new products because our market is changing."* The group representing contractors provided a suggestion for the improved market situation: *"Maine has a forest-based economy; we need to become a business-friendly state. Policies should be in favor of startup forestry businesses. There are examples that you have to wait for two to three years only to get an agreement from the state."* According to them, adjustment of policies at the state level can have a greater impact on new businesses. They were also in favor of providing subsidies to new products for struggling businesses. From the perspective of foresters, the introduction of new technologies in the business could help revamp the shrinking market. However, they were not certain that conditions would be similar to those of the last decade. One forester mentioned, *"We have been rescued by technologies in (sic) past. We started off cutting the trees with an average diameter of 12 inches * and soon we ran out of that tree diameter class. Then technology comes in where we started chipping and had mills that took smaller sized logs."*

So, our technology has changed over the years and I expect it will again.” (* 12 inch = 30 cm). Like other stakeholder groups, procurement managers also believed that the present market condition could be better. Their suggestion was to utilize new products as much as possible: *“Currently it appears that there is extra fiber in the Maine wood market, I think this will help us be a good spot to build new facilities. A company in Skowhegan, Maine has decided to put almost two hundred million dollars in new products. So, something is telling those guys that this is a good place to invest.”* Another procurement manager provided an opposite view towards the market condition. He believed that the market will stabilize first before getting better, and the businesses with efficient operations will stay while others might shut down. He added, *“The only solution I see is that companies should be more efficient and start harvesting and selling varieties of products. For trucking, we should figure out how to manage empty miles.”*

For tackling the problem of manpower shortage, most of the participants suggested good benefits and proper training to drivers. Participants were also asked to validate solutions that had been adopted in other parts of the world. For instance, as a motivation to stay on the job, drivers were given a certain portion of truck shares to create the feeling of ownership [44]. The participants were not aware of this kind of practice in Maine. Contractors disagreed with this as a proper solution to keep drivers on the job, while all the other stakeholder groups believed it to be a novel approach. However, a large portion (actual data unknown due to an anti-trust policy of the state) of trucking fleets in Maine are run by owner-operators [45]. Truck owners mainly focused on better benefits for drivers: *“...because we offer good benefits, and have a good reputation, we have steady employment. Many logging and trucking companies don’t have that.”*

To attract the younger generation to the sector, some participants suggested logging and trucking companies should focus on extension activities to showcase the novelty in equipment and technologies being used, *“Trucking is becoming increasingly comfortable compared to (sic) past. Now all trucks are equipped with climate control cabs and drivers do make fairly good money based on their education.”* According to a forester, the state government entities can be key players for promoting employment in trucking, *“...the Forest Service and Department of Transportation can promote trucking as a highly skilled profession like others, through different publication series and extension.”*

Some foresters suggested truck owners pay their drivers using an hour-based payment system instead of the load-based system. Another forester noted the work-related pressure to drivers, pointing out the need for providing independence to drivers in regard to time scheduling and work issues. The problem can be related to another problem regarding supply chain issues and contractors’ nature. In order to manage issues related to dispatching, procurement managers suggested that the trucking and the actual harvesting process should be separated (decoupled). In their view, at present, there is a trust issue between different contractors working in the same area. Separating harvesting and trucking will ensure efficiency and stability in the market. This can be helpful in minimizing competition between contractors and easing up the pressure on drivers and the supply chain.

Regarding the issues related to roads, participants from northern Maine proposed an increment on state spending on maintenance of public roads, while participants from southern Maine were more worried about public outcry and aesthetic issues created by large log hauling trucks. Some companies have started using crushed rocks on the last hundred feet of the forest roads leading to public highways to eliminate mud and clay deposition from trucks tires on the later. The problem of ruts and depreciation of roads also seemed to be associated with the legally allowable payload. When asked about their views on legally allowable payload on the public highways the opinions of the respondents were contradictory. Mainly trucking contractors and procurement managers were positive about increasing the payload on public highways, as it could increase trucking efficiency including fuel consumption. One of the contractors stated, *“There could be certain situations where you could have increased weight limits for certain types of trucks on certain roads and that could help the industry. I think that’s something nice to keep on the table but could be hard to do politically.”* As an opposing view, one forester argued, *“I agree the work they did to get interstate payload raise from 80,000 pounds * to 110,000 pounds * is important. But for safety, we must remember that my wife and daughter drive on that road. Big companies*

might have different views because if they can haul more amount of woods with the same amount of fuel then it can be profitable for them. But they also want to be safe. So, I think increasing the payload is not an option." (* 80,000 pounds ~36,300 kg and 110,000 pounds ~49,900 kg).

In a different context, one participant also pointed out the benefit of having an east-west highway in the state, especially for improving the transportation of forest products and minimizing the extra costs associated with long hauls. Route I-95 is the only interstate highway (running from north to south) connecting Maine with other states. The east-west project has been a long debated topic in Maine's infrastructure development history, but the project has been rejected up to the present time due to its expected effects on wilderness and recreation [46].

Apart from the challenges mentioned above, there were other issues related to truck-turnaround times, back-hauling opportunities, and climatic adjustments. Most of the participants ($n = 8$, 62%) agreed that waiting time is a problem at mill yards. Some suggestions were to increase coordination between drivers, manage concentration yards, and use self-loading trucks. However, they also agreed that the self-loading trucks could be a bad option in terms of the extra loader (dead weight) being carried. Some of them also pointed out the \$20-million investment proposed by a forest product industry in southern Maine as a potential means in which to help minimize turnaround time at their mill yard.

Although participants regarded back-hauling as a challenging job to perform, they still believed it can be carried out with some adjustments. Interestingly, the increased hauling distance incurred by the recent closing of mills seemed to be an opportunity for trucking contractors to back-haul different products. Some of the important suggestions to increase chances of back-hauling were: building more concentration yards; adopting proper networking strategies between mills within and outside the state; using self-loading trucks for short hauls, and making trucks and trailers as dynamic as possible to transport different types of products.

Similarly, participants also regarded seasonal adjustment in harvesting and trucking as an important issue for transportation. They seemed very concerned about transportation of wood in the muddy season as well as during the winter season. During the heavy winter season, log trucks used chains on their tires while driving through forest roads. Except for plowing snow and clearing public highways, no new anti-slip innovations were used in the state to mitigate this seasonal barrier.

Based on the strategies suggested and accepted by participants, a summary table was prepared, which is expected to serve as a basic guideline (managerial perspective) for trucking companies and related stakeholders (Table 4).

Table 4. Summary and highlights of potential mitigation measures. The measures are represented as views and suggestions of participants. The stakeholder groups favoring those strategies are also included.

Challenges	Views and Suggestions	Favoring Stakeholder Group(s)
Present market condition	New technologies, new investments, and marketing new products	All
	Opportunities to negotiate with new markets which were not accessible before	All
	Attracting new investors; showing the potentiality of the state in terms of forest products	All
Manpower shortage	Favorable policies for startup businesses and subsidies in certain products	Trucking contractors and procurement managers
	Good benefits, proper training, more vocational schools	All
	More extension activities; showing young generation the modern technologies currently used in forest trucking	All
	US Forest Service and Department of Transportation as lead organizations to attract youths	Forester and professional society
	Ownership sharing mechanism to drivers (giving certain percentage of truck shares)	Forester and procurement manager

Table 4. Cont.

Challenges	Views and Suggestions	Favoring Stakeholder Group(s)
	Flexible time schedule and independency to drivers	Forester and professional society
	Developing a well maintained and disciplined trucking fleets	Forester and professional society
	Change in payment methods to truck drivers from load based to hour based	Forester
Roads and payload	Straight forest roads as much as possible	All
	More federal and state budget for maintenance of public roads	Procurement managers and foresters from north region
	Avoiding public roads (not interstate highway) as much as possible due to aesthetic issues	Forester and professional society representative from south region
	East to west interstate highway in Maine	Professional society representative
	Different measures to clean truck tires before entering public roads	Professional society representative and foresters from south region
	Minimize repeated maintenance of private forest roads by constructing them properly at the beginning	Trucking contractors and foresters
	Increasing legal allowable payload on interstate highways for certain situations	Trucking contractors and procurement managers
	Not increasing legal allowable payload on interstate highways to insure public safety and minimize impacts on the roads	Foresters and professional society
	Light trailers to increase capacity of trucks	Trucking contractors
Turnaround time	Adding some self-loading trucks to the fleets	All
	More unloading cranes at the mill (e.g., overhead cranes used by big mills)	Trucking contractor and procurement managers
	More concentrated landing sites	Trucking contractor and forester
	Pavements in wood landing sites	Forester
	Proper coordination in dispatching between different mills in same area	Procurement manager
Backhauling of empty trucks	Long distance hauling of the forest products; an opportunity to back-haul	All
	More concentrated landing sites	All
	Proper networking between mills from different regions.	All
	Dynamic trucking configurations to accommodate various products	All
Seasonal and topographic barriers	Using trucks for other works during muddy season when timber harvesting stops	Forester
	Learning road building knowledge from other US states, mainly for steep terrain	Forester
Fuel efficiency	Use of stud tires during snow season	All
	Learning new innovations from other countries for winter transportation	Trucking contractors and procurement managers
	Using air deflectors in the trucks	Procurement manager
	Increasing payload	Trucking contractors
Contractors	Separating harvesting and trucking parts (i.e. using two different contractors for each work)	Forester and procurement manager
	Proper dispatching strategy to minimize competition between contractors	Forester and procurement manager

3.6. Limitation of the Study

This study has presented views and suggestions of people closely associated with transportation of forest products in Maine. As such, since the suggestions are explicitly based on the situation of Maine, the results of this study cannot be generalized for a broader perspective like other quantitative studies. However, these findings can have significant effects for new studies attempting to tackle these issues. The resolution identified can be validated for other regions by interviewing stakeholders operating in those regions. The fact that truck drivers were not interviewed in this study is one of the major limitations. However, the trucking contractors, who have driven their own trucks for many years before becoming contractors, can be considered as truck drivers' representation. Another concern

in this study was about the representation of landowners. Some of the foresters and contractors interviewed have their own timberlands in Maine. They have experience in managing the procurement of forest products on their own lands.

4. Conclusions

This research has validated mitigation measures that can be adopted for sound forest trucking operations in the context of a forest-based economy. The study is the first of its kind for the forest products transportation sector and can serve as a basic guideline to test the technological feasibility behind the suggested resolutions. The use of a semi-structured interview method has proved to be an important approach to gain insights into the field level challenges and mitigation measures in forest products transportation.

The results of this study suggested that lack of skilled manpower and forest products market condition of the state were major challenges to this sector. However, issues like border crossing requirements and road conditions were also considered highly important. Typically, differences in regulations between the US and Canada for many issues (roads, tax, truck size, driver's age) are always a concern for businesses in northern Maine. The condition of public as well as forest roads in Maine is not satisfactory. The high movement of log trucks in public or town roads was also another concern for local residents.

Overall, due to recent changes in the forest products market condition regarding the state and shortage of skilled labor force, the trucking enterprise is a challenging business to operate. In general, the disintegration of trucking business from harvesting operations was regarded as being potentially productive for the long run. The local field-level suggestions for the mitigation of major challenges seemed crucial in the trucking sector. The region-specific suggestions can also help forest products companies and trucking enterprises to focus more on the solutions. A constant collaboration among forest products companies, contractors, and foresters is important to resolve supply chain issues like trucks dispatching, turnaround times, and backhauling. Nonetheless, coordination with the public and policymakers for issues related to public road conditions and safety is vital for the better trucking business.

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