Assessing the risks and mitigating the impact of climate change on Canadian winter weight programs

Allan Bradley, P.Eng., RPF
Research Lead, Transportation and Infrastructure, FPInnovations
Vancouver, BC
Allan.Bradley@FPInnovations.ca

Papa Masseck Thiam, P.Eng., M.Sc., M.Eng., PMP
Senior Researcher, Transportation and Infrastructure, FPInnovations
Pointe Claire, QC
Papa-Masseck.Thiam@FPInnovations.ca

Matt Kurowski, P.Eng., M.Sc.
Senior Researcher, Transportation and Infrastructure, FPInnovations
Vancouver, BC
Matt.Kurowski@FPInnovations.ca

Paper prepared for session {SO - Advancements in Testing, Modelling and Innovation for Roadway/Embankment Materials and Geotechnical Engineering}

2025 Transportation Association of Canada (TAC) Conference & Exhibition
Quebec City, Quebec

Abstract

With climate change, shorter milder winters are expected to increase over the next decade causing logistical disruptions and increasing costs for Canadian heavy truck-based industries. Seasonal weight programs are anticipated to experience sometimes dramatic changes through the curtailment of winter weight periods and spring load restrictions starting sooner.

The objective of this paper is to highlight the financial, operational, and technical consequences of shorter winter weight periods resulting from climate change, and to identify potential adaptative management practices that could mitigate these consequences.

Key words: Seasonal weight programs; log trucks; forestry; climate change

Abbreviations

AB, SK, MB, ON, NB	Alberta, Saskatchewan, Manitoba, Ontario, New Brunswick
CanDCS-M6	Canadian Downscaled Climate Scenarios (multivariate downscaling)
CFI	Cumulative Freezing Index
CMIP6	Coupled Model Intercomparison Project, Phase 6
CTI	Cumulative Thawing Index
GCM	Global Climate Model
GCVW	Gross Combined Vehicle Weight
SLR	Spring Load Restrictions
SSP5-8.5	Shared Socioeconomic Pathway scenario with a high (8.5 W/m^2) radiative forcing level by 2100
TPA	Trucking Partnership Agreement
TPCS	Tire Pressure Control System
WW	Winter Weight

Introduction and Problem Statement

Seasonal weight programs are used in Canada and some northern U.S. states to manage truck impacts to public highways. While spring load restrictions (SLR) are commonly employed to lessen heavy truck impacts to thaw-weakened pavements winter weight (WW) programs allow heavier truck loadings because freezing increases the bearing capacity of pavements and makes them less susceptible to heavy truck impacts. WW are perceived by some as compensation for the economic hardships imposed on truck-based industries by spring load restrictions.

Industry relies on frozen conditions to access timber growing in forest areas with wet soils. And for those provinces offering WW programs (i.e., AB, SK, MB, ON, and NB) truck GCVWs on some or all highways are increased (figure 1) and this, in turn, can reduce log transport costs. WW and SLR have traditionally been started on regular dates; however, with climate change most provinces now rely on frost and thaw depth measurements, engineering judgement, and(or) temperature-based rationale indices.[1, 2, 3]

Figure 1. 9-axle log B-trains operating in AB may carry as much as 8.3 tonnes additional payload during the winter weight period.

WW premiums are set in consideration of truck vehicle dynamic performance and of bridge capacities. FPInnovations evaluated the dynamic performance of the most popular Alberta log and chip truck configurations in 2009-2011 to advise Alberta Transportation as to acceptable winter weights under which the configurations would safely operate (given some dimensional changes).[4, 5, 6] These evaluations considered ranges of manufactured vehicle dimensions and typical log lengths and densities. The slow and high-speed dynamic performance of each vehicle arrangement and loading was evaluated to ensure

that it met all provincial dynamic performance thresholds. This work led to some significant increases in winter weight premiums in Alberta. Prior to this work, Alberta Transportation and the Alberta forest industry had instituted a mill levy program – a form of public private partnership agreement wherein fees collected from the forest industry were directed towards upgrading the capacity of bridges on key routes. University of Laval has also investigated the structural capacity of freezing asphalt pavement structures in collaboration with FPInnovations, the Alberta and Quebec Ministries of Transportation, and the City of Edmonton. A key finding was that pavement responses due to heavy truck loads fall to negligible levels when the pavements froze to a depth 40 to 60 cm (depending on pavement structure). [7, 8] Further, frost penetration is most rapid at the start of winter when the thermal differential between the roadbed and the air is greatest.

Increasingly the Canadian forest industry is facing reductions and uncertainty of fibre supply due to climate change (wildfires, drought conditions, intense weather events, and shorter warmer winters). Industry also faces upward pressure on delivered wood costs because trucking costs are increased by longer hauling distances to reach fibre and by the rising costs of equipment, insurance, fuel, and labour.

FPInnovations recently investigated the risk to Canadian forest operations from warmer shorter winters by documenting winter benefits accrued by forest operations and the climate-projected changes to frost and thaw depth for forestry areas across Canada. This paper summarizes the findings of the investigation and presents recommendations for mitigating the risks.

Study Methodology

Large forest companies operating in provinces with winter weight programs were surveyed to learn how log transport costs are affected by winter weight premiums. The survey results were aggregated and extrapolated to a provincial scale to determine the effect of winter weights on the economics of forestry. Operational and technological impacts on forest operations from winter operations and winter weight programs also were identified.

To estimate the impacts of climate change impacts on WW programs in Canada, climate indicators were derived from downscaled global climate models (GCMs). Using 79 locations across Canada, the minimum and maximum daily temperature files for 23 GCMs with a daily, 56 km^2 resolution and spanning 1950 to 2100 were downloaded from the CMIP6 (CanDCS-M6) dataset provided by climatedata.ca At each location, daily average temperatures were derived for the SSP 5-8.5 warming scenario (the highest emissions scenario) and then analyzed for WW period impacts every year in term of its:
1) start - when was there enough cumulative freezing in late fall to stiffen roadbeds sufficiently.
2) end - when was there enough cumulative thawing in the spring to thaw-weaken the roadbeds.

Recent years' frost depth data from AB, SK, MB, and NB provincial networks of thermistor stations was used to assess a correlation of frost depth to cumulative freezing index (CFI). WW programs in AB, SK, MB, and NB start when a frost depth of 75 cm is reached. The MB winter weight policy links this frost depth to a CFI count of -270° C degree-days. A preliminary evaluation of frost depth and CTI for recent years was undertaken to confirm the validity of using this assumption elsewhere in Canada. Data for multiple years and two locations each was kindly provided for this evaluation by the governments of New Brunswick, Manitoba, and Saskatchewan. The findings of this preliminary evaluation found that for the years evaluated a frost depth of 75 cm occurred for CFI counts of -68° to -250° C degree-days, with the average being -193° C degree-days (table 1). The average frost depth occurring at a CFI count of -175° C degree-days was only slightly less than this at 73 cm. Accordingly, a CFI count of -175° C degree-days was used for

making climate projections of frost depth. The projections were repeated using a CFI count of -270° C degree-days; however, the CFI value of -175° C degree-days was a much closer predictor of 75 cm frost depth for most locations.

CFI (cumulative freezing index) was, for this analysis, defined as the accumulation of negative daily mean temperatures (total never above 0° C degree-days).

CTI (cumulative thawing index) was, for this analysis, defined as the accumulation of positive daily mean temperatures plus a temperature adjustment of 0.06° C degrees per day from Feb. 1 to May 31. If the daily mean temperature is negative, half of this is added to the temp. adjustment and previous day's total to derive the CTI value, and the tally never is less than zero.

Table 1. CFI as an indicator of 75 cm frost depth. Multi-year data from SK, MB, and NB

Station Location	Frost Depth (cm)	CFI° C deg-day
Saint Martin, NB (2020-23)	75	-202
	66	-175
	90	-270
Blackland, NB (2020-22)	75	-68
	72	-175
	86	-270
Le Pas, MB (2020-2022)	75	-103
	108	-175
	131	-270
Swan Hills, MB (2020-23)	75	-124
	96	-175
	177	-270
Meadow Lake, SK (2016-19) (2020-2024)	75	-222
	67	-175
	91	-270
Hudson Bay, SK (2008/09) (20010-13) (2020-2022) (2023/24)	75	-250
	63	-175
	62	-270
Average CFI at a frost depth of 75 cm		-193

SLR are commonly imposed when thaw depth reaches 150 to 300 mm as this correlates to a condition of peak vulnerability of flexible asphalt pavements.[3] Further, regulators typically give industry advance warning of impending SLR by considering thaw conditions in the 3-day and 7-day weather forecasts. Those provincial SLR policies that are based on weather indices use a CTI count of 10° or 15° C degree-days with expected warming as a starting trigger for imposing SLR. The end of winter weights, therefore, was assumed to coincide with the start of SLR and projections of this date were made using a CTI count of 12° degree-days with a three-day forecast for a CTI count of 13°+ degree-days.

Although the GCM simulation data spans 1950 to 2100, the projected future starts in 2010. Therefore, to summarize relative changes over time the historical baseline was defined as 1980-2010 and projections were made for two 30-year future periods (2025-2054 and 2055-2084). Absolute values were not calibrated to ground data, so relative differences between baseline and future are the essential information output of the study.

Results and Discussion

Savings from log hauling at winter weights

Transporting higher payloads during the winter (e.g., 7.1 to 10.9 tonnes) increases the revenues earned by log hauling trucks. Forest industry savings from winter weight programs can be considerable and increasingly companies are relying on these to help compensate for disruptions caused by wildfires, prolonged hot weather shutdowns, and other climate-driven weather events.

FPInnovations surveyed 13 large Alberta forest operations to document their economic and operational reliance on winter weights (see table 2). All operations harvest and haul logs during the winter because frozen conditions are needed to harvest in wet areas but also to take advantage of the payload increases offered by highway WW programs. Almost half of the annual fibre volume is moved using the WW program despite this period lasting only about one quarter of the year (an average of 91 days). Alberta has four levels of WW premiums (from highest to lowest these are green, blue, yellow, and red level) and these WW premiums are applied to each highway segment in accordance the lowest capacity bridge. The most popular trucking configurations used by the surveyed forest operations can carry from 7.8 to 10.9 tonnes extra payload on green-rated highways. This sizeable increase in payload generates substantial trucking cost savings through a reduction in trips, reduced ownership, fuel, and labour costs, and increased revenue per trip. Many Alberta forest operations combine summer and winter haul rates into a single “blended” rate used all year; WW trucking savings were calculated for these operations after first back-calculating estimates of the original summer and winter rates using FPInnovations’ trucking cost model.

The total tonnage delivered during the 2023/24 WW program by the 13 surveyed Albertan operations was 7,387,700 tonnes and this generated a total of $16,518,900 in wintertime fibre transport savings. These operations received, on average, 5977 tonnes of logs per day during the winter and the trucking cost saving on these deliveries were, on average, $12,780 per day. Because only a portion of Albertan forest operations were surveyed the winter transport savings accrued by the provincial forest industry was extrapolated based on the ratio of total (2020/21) provincial annual harvested tonnage to the total harvested tonnage of the surveyed operations. Winter weights saved the Alberta forest industry an estimated $28.4M in log transport costs in 2023/24 and played a vital role in supporting the competitiveness and sustainability of the provincial forest industry.

Table 2. Estimated Alberta Forestry Industry winter weight program usage and savings

Item	Quantity	Unit
Survey sample size	13	forestry operations
Estimated total annual log haul tonnage	13,509,300	tonnes
Estimated total winter log haul tonnage	7,387,700	tonnes
Average winter haul tonnage	55%	of annual log haul
Average winter haul period	91	days
Max. WW payload increase	7.1 - 10.9	tonnes (on green-rated routes)

Average winter haul rate reduction	-$ 0.42	per t-hr
Estimated average daily winter log deliveries	5977	tonnes/ day
Estimated average daily winter savings	$ 12,780	per day
Estimated total winter mill savings	$ 16,518,900	for 13 surveyed forest operations
AB total annual log haul tonnage (2020/21)	23,215,935	tonnes delivered on provincial highways
Estimated savings for AB industry	$ 28,387,900	per year

SK and MB highways departments have implemented trucking partnership agreements (TPA) to support companies in remaining competitive despite their far distance from markets. In SK, the TPA offer substantial increases in GCVW on specific configurations for which the vehicle dynamics and safety performance are well established (e.g., 33% over legal for 6-axle tractor/ tridem semi-trailers; 18% over legal for 8-axle B-trains; 46% over legal for 9-axle B-trains.) In SK full TPA weights apply all year long to Class 1 (Primary) highways, all year long except for March to June on Class 2 (9-month Primary) highways, and only during the winter weight (frozen) period on Class 3 (9-month Primary) and Class 4 (Secondary) highways, if these are not otherwise weight-restricted due to de-rated bridges or weak pavement concerns. Table 3 provides a typical set of TPA weight allowances for 8-axle log super B-trains. TPA fees are levied and used to fund pavement rehabilitation. In contrast to a TPA, winter weight premiums in SK are minor on Primary highways and minor for certain larger configurations on Secondary and municipal routes. WW premiums do not apply to trucks operating under a TPA, in general, and so most forest companies in SK utilize TPA instead of the winter weight program for log hauling.

Table 3. Example 8-axle log B-train weight allowances for a Transportation Partnership Agreement

Highway Rating	Winter GCVW	Spring GCVW (end of WW to June 30)	Summer GCVW (July 1 to Program WW)
CLASS 1 (Primary)	75 t (TPA)	75 t (TPA)	75 t (TPA)
CLASS 2 (9-mo Primary)	75 t (TPA)	54.5 t	75 t (TPA)
CLASS 3 (9-mo Primary)	75 t (TPA)	54.5 t	62.5 t
CLASS 4 (Secondary)	75 t (TPA)	54.5 t	54.5 t

Only one of eight major forest operations in SK were surveyed, however, this operation accounts for approximately 22% of provincial production (table 4). Its log haul fleet consists almost entirely of 8-axle super B-trains (figure 2). The company's TPA allows the contracted trucks to operate at 75 t GCVW on all classes of highway during winter frozen road conditions and on Class 1 and 2 highways in the summer. SK forest operations do not usually transport harvested fibre during the SLR period.

Figure 2. In Saskatchewan and Manitoba trucking partnership agreements, implemented in conjunction with winter weights, allow the increased weights on low standard highways only when frozen.

Table 4. Estimated Saskatchewan Forestry Industry winter weight usage and savings

Item	Quantity	Unit
Survey sample size	1	forestry operation
Log truck configuration	8-axle B-train	(represents 96% of fleet)
Average annual log haul tonnage	817,000	tonnes
Total winter log haul tonnage	204,000	tonnes
Average winter haul tonnage	25%	percentage of annual log haul
Winter & summer TPA payload Increase	12.1	tonnes (increase does not apply during SLR period or to Class 3 (9-month Primary) and Class 4 roads in the summer)
Typical log hauling season	250	days
Average daily TPA mill savings	$ 1,820	per day
Total annual TPA mill savings	$ 454,600	(includes TPA fees)
SK total annual log haul tonnage (2021-22)	3,374500	tonnes
Estimated savings for the SK industry	$ 1,875,000	per year

A large, a medium, and a small forest operation in Ontario were surveyed and, when combined, these operations account for approximately 10% of provincial log transport (table 5). The log hauling trucks in Ontario (and in these operations) are almost entirely 7-axle tractor/ quad-axle semi-trailers. Ontario's winter weight program allows log trucks to increase AGVW by 10% over legal for the frozen road period; and the average duration of hauling at winter weights was 49 days for these three operations. The log trucks in these operations carry about 4.7 tonnes more payload per trip in the winter. The additional winter payload generates trucking savings which were, on average, $643,250 per winter per operation. Because only 3 Ontario forest operations were surveyed the winter transport savings accrued by the provincial forest industry was extrapolated based on the ratio of total (2024) provincial annual harvested tonnage to the total harvested tonnage of the surveyed operations. Winter weights saved the Ontario forest industry an estimated $6.3M in log transport costs in 2024 and plays a vital ongoing role in supporting the competitiveness and sustainability of the provincial forest industry.

The additional revenue from log hauling at WW helps offset the higher truck operating costs experienced in winter. Fuel is a major cost in forest product transportation and can represent 30% to 40% of delivered wood costs. Fuel consumption rates are higher in the winter because:

- winter conditions increase air density and, hence, aerodynamic drag.
- the energy content of winter diesel is lower than summer diesel.
- truck idling may be increased in wintertime (to keep the truck warm when parked).

Truck weight gain from snow and ice build-up also reduces available payload. Conversely, rolling resistance on frozen roads is less for both asphalt and gravel-surfaced roads so some fuel efficiency may be regained.

Table 5. Estimated Ontario Forest Industry winter weight usage and trucking savings

Item	Quantity	Unit
Survey sample size	3	forestry operations
Log truck configuration	7-axle tractor/ quad semi-trailer	99% of fleet
Average annual log haul tonnage	585,985	tonnes
Total winter log haul tonnage	101,840	tonnes
Average winter haul tonnage	17%	of annual log haul
Winter weight payload Increase	4.7	tonnes
Typical winter weight log hauling season	49	days
Average daily winter mill savings	$ 12,235	per day
Average annual total winter mill savings	$ 643,250	per operation
ON total 2024 log haul tonnage	17,292,785	tonnes
Estimated savings for the ON industry	$ 6,327,600	per year

Operational benefits from winter weight programs

If no WW program existed, companies would still harvest wet area (winter) blocks but would not save on the highway portion of trucking costs. With WW programs, truck GCVW and payload are increased, and this generates savings on log transport costs (refer to tables 2 and 5).

WW programs increase the number of available log trucks by increasing revenue opportunity which encourages seasonal truck owners to temporarily join the permanent fleet. With the additional trucks and increased payloads, companies can accelerate log transportation in the winter and more rapidly fill both mill yards and satellite storage yards. This can help operations to keep pace with shortening winter weight periods.

WW programs can increase the economic haul distance for fibre and, thereby, increase the volume of available fibre to mills. This helps mitigate fibre losses due to wildfire and insect attack.

Future changes to duration of winter weights

Projections of the temperature-based indices used to start and end seasonal weight programs were made for forestry operational areas across Canada. Figure 3 illustrates the changes in duration of winter weight log hauling period (i.e., averaged from 23 GCMs) projected for the near and far future in the prairie provinces. In the areas of Alberta with active forest operations, the duration of winter weight haul period is expected to reduce by 10 to 13 days from the historical baseline in the near future (2025 to 2054). Table 6 illustrates the expected economic impact from the projected reductions in duration of winter weight period. Losses in trucking savings per operation vary considerably with mill size and to a lesser extent by location. Losses in trucking savings per operation may be as high as $532,000 per year while losses for AB, in total, are estimated to be about $3.1M per year.

Figure 3. Projected reductions in WW duration (days) in the Prairies for future periods (2025–2054) & (2055-2084).

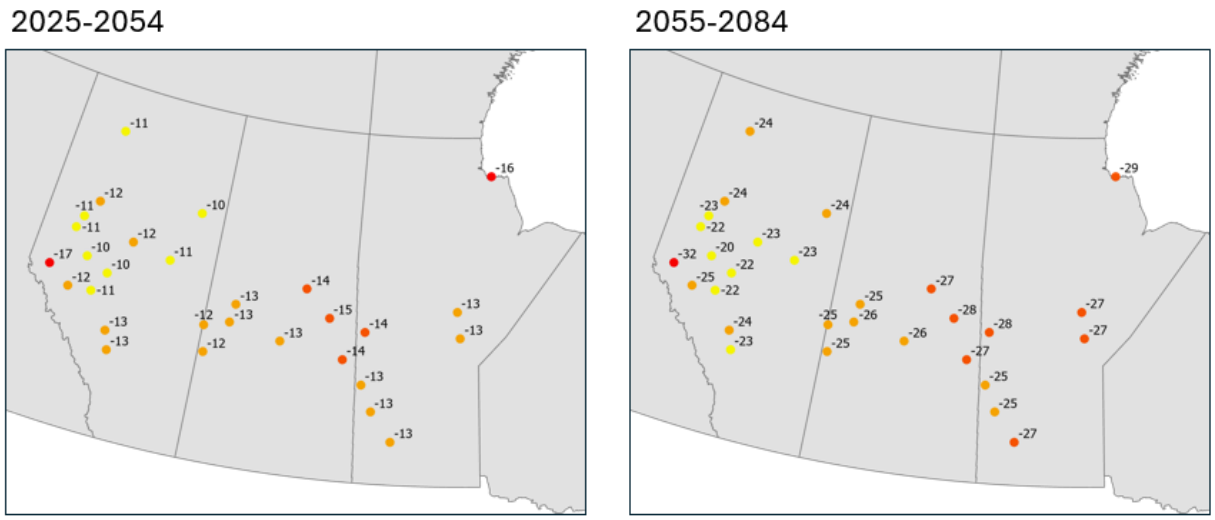

Table 6. Loss of trucking savings in Alberta with 2025-2054 projected reductions of winter weight duration

Forestry operations	Projected change in duration of winter weights from baseline		Projected annual reduction in mill trucking savings (2025-2054)
	(2025 – 2054)	(2055 – 2084)	
Athabasca, High Level, Peace River	-11 to -12 days	-24 days	$81,000 to $532,000
Blue Ridge, Slave Lake, Grande Prairie	-10 to -12 days	-20 to -24 days	$67,600 to $321,400
Hinton, Edson	-12 to -13 days	-23 to -25 days	$8000 to $73,500

Figure 4 illustrates the changes in duration of winter weight log hauling period projected for the near and far future in Ontario. In areas of Ontario with active forest operations, the winter weight haul period is expected to reduce by 11 to 17 days from the historical baseline in the near future (2025 to 2054). Table 7 illustrates the expected economic impact from the projected reductions in duration of winter weight period. Losses in trucking savings per operation may be as high as $195,800 per year while losses for ON, in total, are estimated to be about $1.8M per year.

Figure 4. Projected reductions in WW duration (days) in ON for future periods (2025–2054) & (2055-2084).

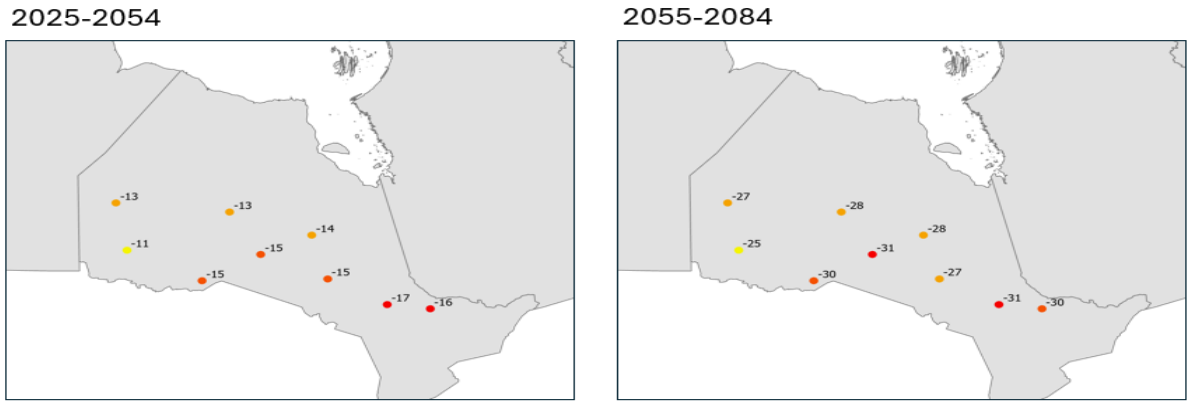

Table 7. Loss of trucking savings in Ontario with 2025-2054 projected reductions of winter weight duration

Example forestry operation locations	Projected change in duration of winter weights from baseline		Corresponding reduction in WW mill trucking savings (2025-2054)
	(2025 – 2054)	(2055 – 2084)	
Cochrane, Red Lake	-13 to -14 days	-27 to -28 days	$ 159,100 to $ 171,300
Hearst, Kenora, Thunder Bay	-11 to -15 days	-25 to -30 days	$ 134,600 to $ 183,525
Chapleau, North Bay	-15 to -16 days	-27 to -30 days	$ 183,500 to $ 195,800

Mitigation strategies

Policy changes to implement winter weight hauling at shallower frost depths would help compensate for shorter warmer winters. In jurisdictions where winter weights are initiated by a CFI count of -270° C degree-days, this count could be set to -175° C and WW periods may be prolonged (our cursory assessment indicates by up to about 10 day). Additional engineering studies of the local pavements, weather, and truck loadings should be conducted to confirm frost depth requirements and what CFI count corresponds to this.

Similar as done by FPInnovations and in Alberta, industry and government in other provinces could conduct vehicle dynamic evaluations to determine acceptable weights at which log truck configurations could be safely operated. In conjunction with this work, assessments of bridge capacity and fatigue life should also be conducted to determine expected impacts to crossing infrastructure. On the basis of these two analyses, increased winter weight premiums could be considered, and upgrades of existing bridges and new bridge designs considered.

Increasing the utilization of trucks helps to reduce the fixed cost component of the hourly trucking rate. Therefore, double shifting and working through weekends during some or all frozen winter period will reduce the cost of winter log hauling and help to mitigate the impact of shorter winters.

The use of reduced tire pressures has been shown to reduce truck damage to thaw-weakened pavements and unpaved resource roads. British Columbia, Saskatchewan, and Manitoba have policies for the SLR period to allow tire pressure control system-equipped log trucks to utilize some or all of the SLR period for hauling full payloads.[9] These programs were introduced in the early 2000s but currently are not widely used. Use of TPCS technology could help forest operations mitigate the impacts of shorter frozen periods by allowing some fibre to be transported economically from roadside in the late spring in these provinces.

It takes more thaw-weakening to shut down timber harvesting than winter log hauling because, in general, low levels of ground disturbance and unpaved road rutting are more accepted than cracking of weak asphalt pavements. One mitigation strategy to deal with a shorter frozen period is to delay log transport to the mill and, instead, store processed logs at roadside. This allows the logs to dry and, by removing water, increases the actual volume of wood per truckload; however, the duration of storage and the end moisture content must be controlled. The optimal moisture content of wood stored at roadside depends on the end use of the wood. For example, if the wood is to be used for energy production the drier the better. Lower moisture content in logs to be chipped helps to ease the load on driers used in the pulping process but too dry can make log debarking more difficult and lead to more bark contamination. Some drying of logs intended as dimensional lumber is desirable, however, roadside storage can accelerate both checking and rot, especially if the logs are from insect or fire-killed trees.

Another option used by some companies to mitigate the effects of a shorter winter is to store harvested logs in a satellite storage yard located beside an all-weather highway (not subject to SLR) and accessible via forest resource roads.[10, 11, 12] Processed logs can be transported to the yard on the resource roads by trucks loaded to off-highway weights. With the yard located close to where harvest takes place the short trips and higher payloads accelerate the process of extracting logs from the forest during winter conditions. The logs can then be sorted so the right log can be transported to the right mill from this year-round accessible location.

The processes of log handling, sorting, and storage are complex and need to be considered carefully before implementing a satellite storage yard. Handling, sorting, and storage of logs away from the mill can allow increased trucking efficiency, reduce traffic congestion, log storage, and associated costs in the main mill log yard, and can reduce land requirements and associated property taxes for mills located on high value land in towns and cities. Unloading and reloading logs at the storage yard, however, adds to the cost of wood delivery. Research has found that merchandising logs at the satellite log storage yard can improve yard economic feasibility.[10] If long cut-to-length logs or even tree-length logs can be brought to the yard these can then be manufactured to market optimized log lengths and trucked directly to destination mills. The waste can be hogged to create biomass for sale to local energy facilities. Transporting only optimized logs without defects to the correct destination is a highly efficient means of log transport and can allow the logs to be fed into the mill directly without any further storage.

Conclusions

Industry relies on frozen conditions to access timber growing in forest areas with wet soils. And for those provinces offering WW programs truck GCVWs on public highways are increased thereby reducing log transport costs and helping forest companies to remain competitive. Winter weight policies and programs vary between provinces with the most generous provisions being in SK and AB and less favourable or no programs in eastern Canada.

This paper undertook an analysis of the reliance of the Canadian forest industry on winter weights and the risks posed by warmer, shorter winters. In AB, SK, and ON, the forest industry can realize large savings in trucking costs during the winter, and these are estimated to be $28.3M, $1.9M, and $6.3M per year, respectively. Climate projections for the next 30 years (2025-2054) indicate that forest operations in AB will experience a 10 to 17-day reduction in winter weight period. The resulting losses in trucking savings may be as high as $532,000 per operation per year while losses for the AB forest industry, in total, are expected to be about $3.1M per year. Climate projections for the next 30 years (2025-2054) indicate that forest operations in ON will experience a similar reduction in winter weight period. The resulting losses in trucking savings may be as high as $196,000 per operation per year while losses for the ON forest industry, in total, are expected to be about $1.8M per year. Projections for the next 30-year period (2055-2084) indicate a continuing of the warming trend and 20-to-30-day reductions (from current levels) in the winter weight period for forestry areas in the Prairies and Ontario.

Numerous strategies and innovations exist to help offset the economic and logistical risks posed by shorter warmer winters. Studies by University Laval indicate that frost depth needed to protect frozen pavements from increased axle loads are 15-35 cm less than used in provincial policies. Additional engineering studies of the local pavements, weather, and truck loadings should be conducted to confirm provincial frost depth requirements. Where rationale methods for triggering seasonal weight are used,

additional studies should be completed to determine what CFI count corresponds to the reduced frost depths.

As done by FPInnovations and Alberta Transportation, industry and government in other provinces could conduct vehicle dynamic evaluations to determine acceptable weights at which log truck configurations could be safely operated. In conjunction with this work, assessments of bridge capacity and fatigue life should also be conducted to determine expected impacts to crossing infrastructure. Based on these two analyses, increased winter weight premiums could be considered, and upgrades of existing bridges and new bridge designs considered - funding for this work could be sought from all levels of government and from industry.

Additional opportunities for streamlining winter hauling exist and the forest industry should consider implementing or enhancing use of satellite wood storage and sorting yards, increasing truck utilization in the winter, and even extending hauling into the SLR period where provincial TPCS SLR policies exist.

References

1. Thiam, P.-M.; S. Mercier. *Summary of provincial transportation policies in Canada. InfoNote 2019-10*. Pointe Claire, QC: FPInnovations. (2019)
2. Bradley, A.; M.A. Ahammed; S. Hilderman; S. Kass. *Responding to climate change with rational approaches for managing seasonal weight programs in Manitoba.* In Cold Regions Engineering 2012: Sustainable infrastructure Development in a Changing Cold Environment*. Washington, DC: ASCE. (2012)*
3. Manitoba Infrastructure. *Implementation of spring weight restrictions*. Standard MEB-P014. Winnipeg, MB: Manitoba Infrastructure. (2017)
4. Sinnett, J. *Further investigation of heavier payloads on the dynamic performance of Alberta vehicle configurations in 2011*. Internal Report. Vancouver, BC: FPInnovations. (2011)
5. Sinnett, J.; S. Parker. *Investigation of heavier payloads on the dynamic performance of additional Alberta logging & chip hauling configurations in 2010*. *Internal Report IR-2011-04-11.* Vancouver, BC: FPInnovations. (2010)
6. Sinnett, J.; S. Parker. *Investigation of heavier payloads & larger configurations on the dynamic performance of Alberta logging & chip hauling configurations in 2009*. *Internal Report*. Vancouver, BC: FPInnovations. (2010)
7. Bilodeau, J.-P.; E.L. Perez-Gonzalez. *Winter weight premium and pavement damage*. Paper presented at XVI World Winter Service and Road Resilience Congress at Calgary, AB. Paris, FR: PIARC. (2022)
8. Thiam, P.-M.; A. Bradley. *Analysis of Alberta's pavement capacity to support winter weight premiums. Technical report No. 28*. Pointe Claire, QC: FPInnovations. (2018)
9. Bradley, A. *Using road-friendly technologies to carry full legal axle weights on seasonally weight-restricted pavements in British Columbia. Advantage Report 6:30*. Vancouver, BC: Forest Engineering Research Institute of Canada. (2005)
10. Bulley, B.; J. Brdicko; J. Mortyn; M. Shetty. 2010. *Feasibility of a satellite merchandizing and storage yard in the Cariboo region of British Columbia. Contract report # 09/10-88.* Vancouver, BC: Forest Engineering Research Institute of Canada. (2010)
11. Webb, C.R. 1999. *The economics of operating a satellite storage yard. Technical Note TN-289.* Vancouver, BC: Forest Engineering Research Institute of Canada. (1999)
12. Shetty, M.; B. Bulley. 2011. *Operational experience with a satellite merchandizing and storage yard (SMSY) in the Williams Lake area: Case study.* Vancouver, BC: FPInnovations. (2010)