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Contents

Haul truck travel speeds on forest roads: a comparison of summer and winter

Abstract

The majority of wood hauled by trucks commonly occurs during the winter months when forest access roads are frozen. The Forest Engineering Research Institute of Canada (FERIC) performed a study to explore how log transportation could be extended into the summer months when roads are not frozen. FERIC used the Opti-Grade system to compare truck travel speeds between the summer and winter operating months over a two-year period and to help identify variables affecting travel speeds.

Keywords

Road transportation, Logging trucks, Roads, Opti-Grade, Alberta.

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Introduction

Weyerhaeuser Company Limited's historical data indicate that the best performance from its trucks, in terms of speed and cycle times, occurs when roads are frozen in the winter months. Logs may be stored in the millyard for several months before they are processed, but during this time they may be subject to drying or other deleterious effects. To improve final product quality, increase the number of haul days, and reduce inventory, Weyerhaeuser proposed to increase the amount of wood harvested and hauled during the summer months, if feasible. FERIC undertook a study at Weyerhaeuser's Grande Prairie operations to explore how log transportation could be extended into seasons when roads are not frozen.

The majority of Weyerhaeuser's access roads are built on fine-textured soils. Under the heavy loads and frequent traffic, the aggregate applied to the road surface rapidly mixes with the finer particles. This mixed material has reduced bearing capacity, increased surface maintenance requirements, and ultimately results in reduced travel speeds and reduced load size. Although road stabilization techniques are not widely used at this operation, Weyerhaeuser has experimented with a few products in an attempt to address these problems as well as to extend the haul season (Légère 2002).

FERIC installed the Opti-Grade[1] grading-management systems on two haul trucks to determine how road roughness affects cycle times and how the road surface treatments currently in use affect cycle times. The systems were also used to identify where, due to road roughness and slower travel speeds, future investments in road treatments should be made.

Objectives

The objectives of the study were to:

- Quantify winter and summer speeds for two operating years.
- Identify the variables affecting travel speeds and their contributions to the differences.

[1] Opti-Grade is a registered trademark of FERIC.

Haul operations description

Weyerhaeuser's Grande Prairie operations has an annual harvest of approximately 2.3 million m³. Approximately 70% of this wood is hauled during the winter months when the forest access roads are frozen. The winter haul season usually starts slowly around October 15, reaches full capacity by November 15, and ends around March 15. Logs may be stored in the millyard for up to seven months or longer, although processing of the previous winter's wood is usually completed by early September to minimize negative effects on wood quality.

The roads analyzed in this study are subject to trucks that are not obligated to carry highway weight limits, so the trucks are loaded heavier. Weyerhaeuser's target for summer payloads is 43 tonnes, but the company allows a maximum payload of 53 tonnes. Its target for winter payloads is 50 tonnes, with an allowable maximum of 60 tonnes.

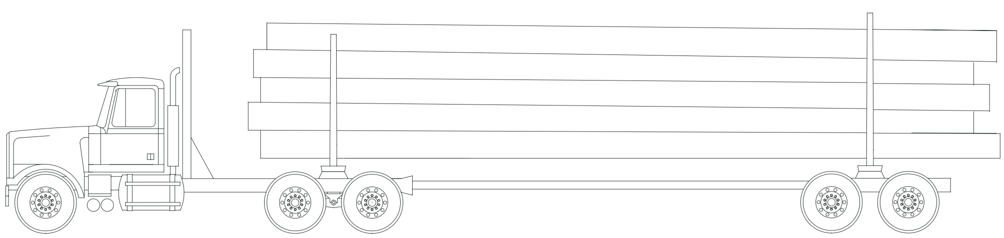
Methodology

Opti-Grade

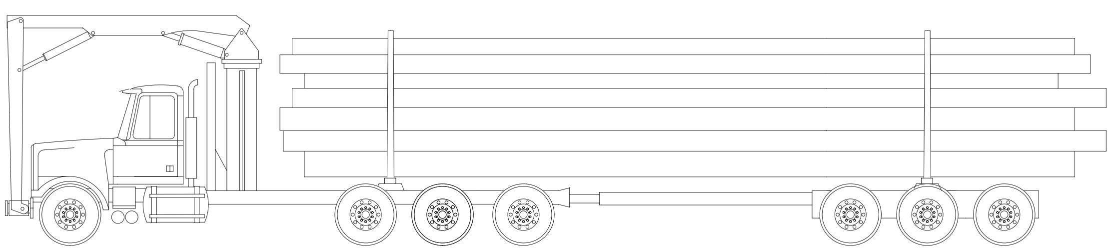
Weyerhaeuser installed the Opti-Grade hardware in two types of haul trucks: a five-axle configuration (tandem drive tractor/ tandem pole trailer) and a self-loading seven-axle configuration (tridem drive tractor/ tridem pole trailer) (Figure 1). After the first operating season, the Opti-Grade system on the five-axle configuration was moved to another five-axle haul truck. Therefore, this report contains sequential information for two five-axle trucks. The one tridem/tridem configuration was monitored for the complete term of the study.

Opti-Grade is a grading management system, developed by FERIC's Eastern Division, that collects and analyzes information on road roughness to efficiently schedule road maintenance (Mercier and Brown 2002). It was designed as a tool to identify the roughest sections of roads for blading

Figure 1. Vehicle configurations used in the study.



Five-axle configuration (tandem drive tractor/tandem pole trailer)



Self-loading, seven-axle configuration (tridem drive tractor/tridem pole trailer)

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priority based on measurements, rather than operator impressions. The Opti-Grade system consists of hardware that collects data on the road's actual condition, and computer software that analyzes this data to produce grading schedules.

When installed on haul vehicles travelling on a road network, Opti-Grade hardware, in combination with analysis software, provides information on the extent and location of roughness on a road. While a sensor continuously measures the roughness of the road, a global positioning system (GPS) receiver determines the time and position of each measurement. A datalogger stores the road roughness values and the position and recorded time of each value. Data from trip files are transferred for analysis, via a removable memory card, from the truck's on-board datalogger to a computer (usually at the logyard weigh scale).[2]

Using these data, the software-generated report develops grading schedules that focus on the sections of roads that have unacceptable sections of roughness. This process usually reduces the grading time necessary while still maintaining the road quality.

The study objectives were met by monitoring the travel speeds and road roughness obtained from the Opti-Grade trip files for the three trucks. The analysis for this report was completed by processing the data collected by Opti-Grade and combining it with supplemental weigh scale information.

At Grande Prairie, Weyerhaeuser's two main haul routes converge to a single 11-m-wide mainline from 0 to 30.7 km from the mill site (Figure 2). An Opti-Grade truck was assigned to each route to collect the necessary information on the road network. A 20.4-km section of the mainline was selected for study as it was heavily travelled, and the trucks on the inward trip could be assumed to be loaded. The data includes a slow section of road approximately 2 km long where the trucks are obligated to slow down as a safety requirement. Since empty trucks often did not travel the mainline to reach their loading point, only the data for the loaded portion of the trip were analyzed.

The Opti-Grade software was not used to complete the data analysis for this project. The Opti-Grade data was post-processed in Microsoft Access, copied into Microsoft Excel for summarizing, and analyzed with analysis of variance and Tukey's multiple comparison tests using MINITAB statistical software.[3, 4]

The GPS data from Opti-Grade were recorded every seven seconds, and were used to determine when the truck entered the study area at the 30.7-km mark and exited at the 10.3- km mark. Travel speeds for each trip were calculated by dividing the distance (20.4 km) by the length of time it took the truck to travel through the area.

Variables

FERIC measured the effect of road roughness on travel speed, as well as several

[2] With the newer Opti-Grade RF system, data are automatically downloaded at the scale.

[3] Microsoft Access and Microsoft Excel are registered trademarks of Microsoft Corporation. MINITAB is a registered trademark of Minitab Inc.

[4] Analysis of variance and Tukey's multiple comparison tests were done at alpha = 0.05.

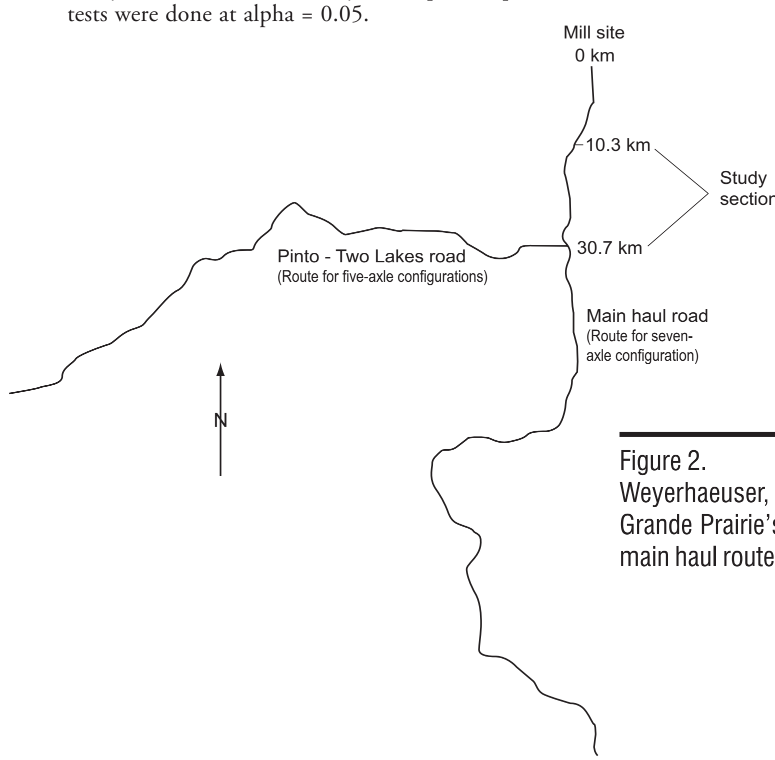


Figure 2. Weyerhaeuser, Grande Prairie's main haul routes.

other variables identified by Weyerhaeuser personnel and logging contractors as affecting travel speed.

- Standardized roughness: The average roughness for each trip was calculated by dividing the sum of the roughness values recorded by Opti-Grade by the number of points collected. The accelerometers used by Opti-Grade are configured on a truck-by-truck basis. Therefore, road roughness readings cannot be compared directly between trucks. The values for each truck, by season, were standardized[5] to reduce the variability in the roughness attributed to the three individual trucks, creating a more consistent and comparable range of values. Each truck's seasonal maximum value was divided into the recorded roughness value, and this result was expressed as standardized roughness.
- Truck type: This was either one of the two five-axle trucks or the seven-axle configuration used in the study. For the purpose of the study, Truck 1 refers to the five-axle truck used in the first operating season (mainly summer), Truck 2 refers to the five-axle truck used in the second operating season (mainly winter), and Truck 3 refers to the seven-axle configuration used in both years of the study (summer and winter).
- Driver: Eight different drivers were used throughout the study.
- Gross vehicle weight (GVW)
- Time of year: This was defined as either summer or winter. Heavier haul weights were in effect in the winter.
- Time of day: Day was defined as when the loaded truck would have travelled through the study area during daylight hours, and night was defined as the period of travel between dusk and dawn.

Each load record included driver and GVW, and was downloaded at the scale house at the end of a trip. Because not all loads returned to the Weyerhaeuser scale house and because FERIC didn't collect the information from other companies' scale houses, it was not always possible to determine the truck's driver or weight. Since only 226 of the 632 trips returned to the Weyerhaeuser scale house, FERIC used all 632 trips in analyses that were independent of the truck's driver or weight, and used the 226 trips for analyses that were dependent on these two variables.

Results and discussion

Time of year

Figure 3 shows that average travel speed was 26% faster in the winter compared to the summer. Of the 199 trips monitored in the summer, the travel speed ranged from 31 to 67 km/h and averaged 46 km/h. In the winter, the average travel speed for 433 trips was 58 km/h and ranged from 29 to 73 km/h.

Standardized roughness

Since the roughness values were widely distributed as a result of the variability created from three different trucks, the values were standardized (Figure 4).

Figure 4 shows that in the winter, the trucks travel faster than in the summer, and that in the summer, the roads are rougher which results in a slower average speed. However, low correlation (R^2) values from an analysis of speed versus roughness by season, indicate that factors other than roughness are influencing the truck speeds.

Time of day

For all trips (summer and winter), the average speed was 53 km/h during the day and 55 km/h at night. This suggests that there are no significant differences between day and night travel speeds.

Truck type

Average speeds were 53, 58, and 51 km/h for Trucks 1, 2, and 3, respectively (Figure 5). The average travel speed for Truck 2 was significantly higher than the other two trucks.

[5] Standardizing is a non-dimensional technique used to reduce the differences in data from different sources.

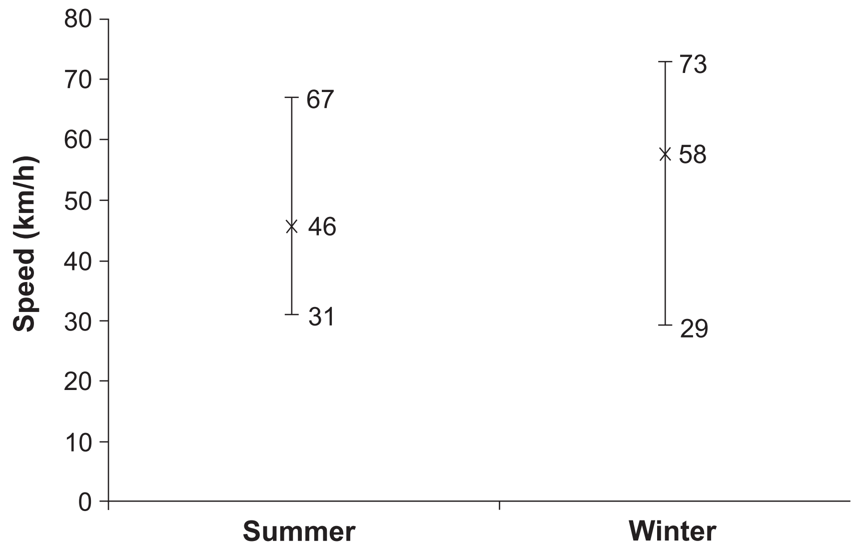


Figure 3. Speed versus time of year.

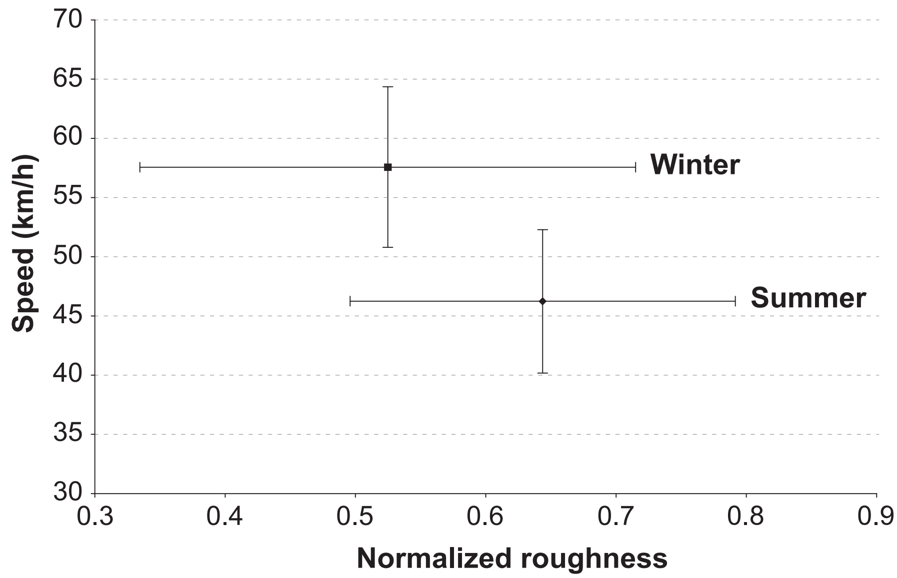


Figure 4. Average speed versus average standarized roughness by season with standard deviations.

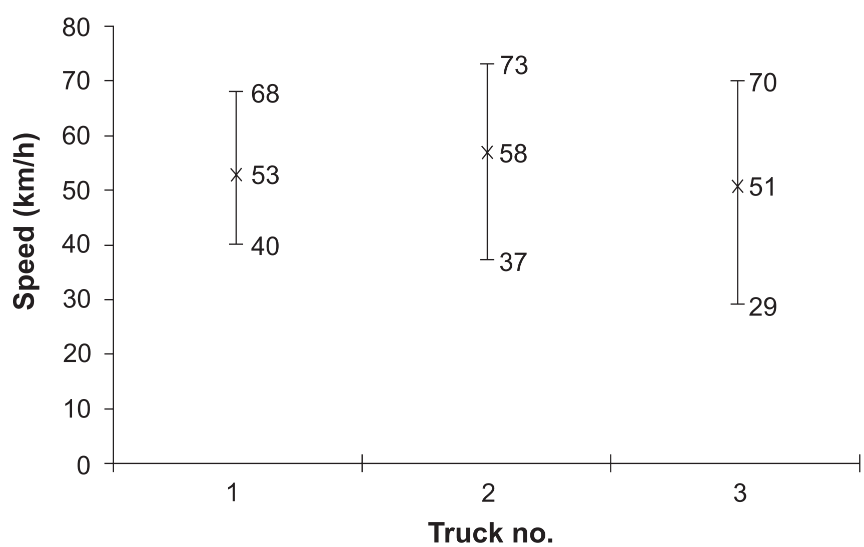


Figure 5. Summary of speeds for the three trucks studied.

In all likelihood, Truck 2 was faster than the other two trucks because 257 of its 260 trips took place in the winter (Table 1). Since Truck 2 only made 3 trips in the summer, it cannot be compared to the other two trucks for that season. In the summer, Truck 1 averaged 51 km/h for 44 trips while Truck 3 averaged 45 km/h for 152 trips, and these travel speeds were significantly different. In the winter, the average travel speeds of the three trucks—56, 58, and 59 km/h for Trucks 1, 2, and 3, respectively—were not statistically different.

Table 1. Number of trips made by each truck, by season

Truck no.	Summer trips (no.)	Winter trips (no.)	Total (no.)
1	44	24	68
2	3	257	260
3	152	152	304
All	199	433	632

Table 2. Number of trips made by four of the drivers, by season

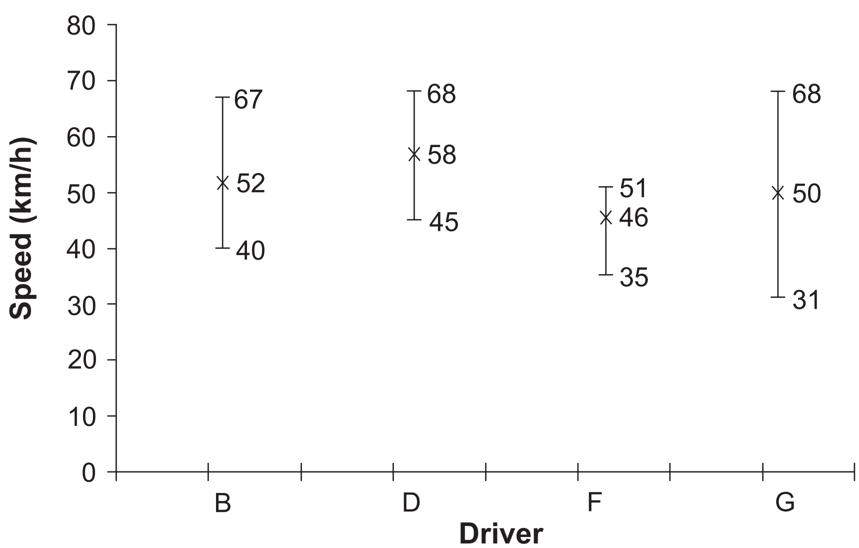
Driver	Summer trips (no.)	Winter trips (no.)	Total (no.)
B	22	0	22
D	0	32	32
F	24	0	24
G	54	56	110

Drivers

Eight drivers worked during the study period: two drivers for Truck 1 (Drivers A and B), three drivers for Truck 2 (Drivers C, D, and E), and three drivers for Truck 3 (Drivers F, G, and H). Four of the eight drivers only made six or fewer trips. Therefore, comparisons of their travel speeds were not meaningful because of the small sample size and their results are not discussed in this report. Table 2 shows the number of trips made by the remaining drivers, and Figure 6 shows the range of travel speeds measured for the four drivers.

The travel speeds for the two drivers with the most trips were significantly different. Driver D in Truck 2 averaged 58 km/h for 32 trips, which was significantly faster than Driver G in Truck 3 who averaged 50 km/h for 110 trips. Knowing that winter travel speeds are faster than in the summer, the difference in average travel speeds can be explained by the fact that all 32 trips for Driver D were in the winter, while the 110 trips for Driver G were spread almost equally between the summer and winter. This means that season may have been the variable of importance, not driver. The influence of season on driver speed is evident when comparing drivers who only made trips in the summer versus those who made trips in the winter. Driver D in Truck 2 was faster than Driver B in Truck 1 and Driver F in

Figure 6. Summary of travel speeds for four of the eight drivers studied.



Truck 3. For Truck 3, Driver F was significantly slower than Driver H.

GVW

The GVW for the 135 trips recorded in the winter averaged 76 700 kg, which was heavier than the average of 73 892 kg for the 91 summer trips. The average speed and standardized GVW, with standard deviations, are presented in Figure 7.

In the winter, the ground is frozen and the roads aren't as rough as they are in the summer which may account for the faster travel speeds under heavier loads. In the summer, the road is rougher which is harder on the suspension and many other components of the truck. This generally encourages drivers to operate at slower speeds than they do in the winter. Also, because the roads are frozen there would be less dust, and probably better visibility, which would allow for faster travel speeds.

The larger standard deviation of the GVW in the winter (Figure 7) can be explained by the variability in the weights hauled. Winter weights averaged 76 700 kg and ranged from 57 360 kg to 93 200 kg. Figure 7 also indicates that speed was not influenced by weight, since the standard deviations overlap.

Cycle time improvement

An example of the effect that travel speed, by season, has on cycle time is presented in Table 3. Although the average travel speed is 26% faster in winter compared to summer, the improvement in cycle time for a haul of 120 km is 13%.

Conclusions and implementation

The study results indicated that travel speeds were significantly higher in the winter compared to the summer because roads are frozen in the winter and are not as rough or dusty, resulting in improved visibility.

Table 3. Difference in cycle times between winter and summer based on higher winter travel speeds and average haul distance of 120 km

Cycle time components	Winter (min)	Summer (min)
Travel loaded	124	157
Travel empty [a]	103	114
Load	30	30
Unload	30	30
Total	287	331

[a] Travel empty speeds were provided by Weyerhaeuser, Grande Prairie.

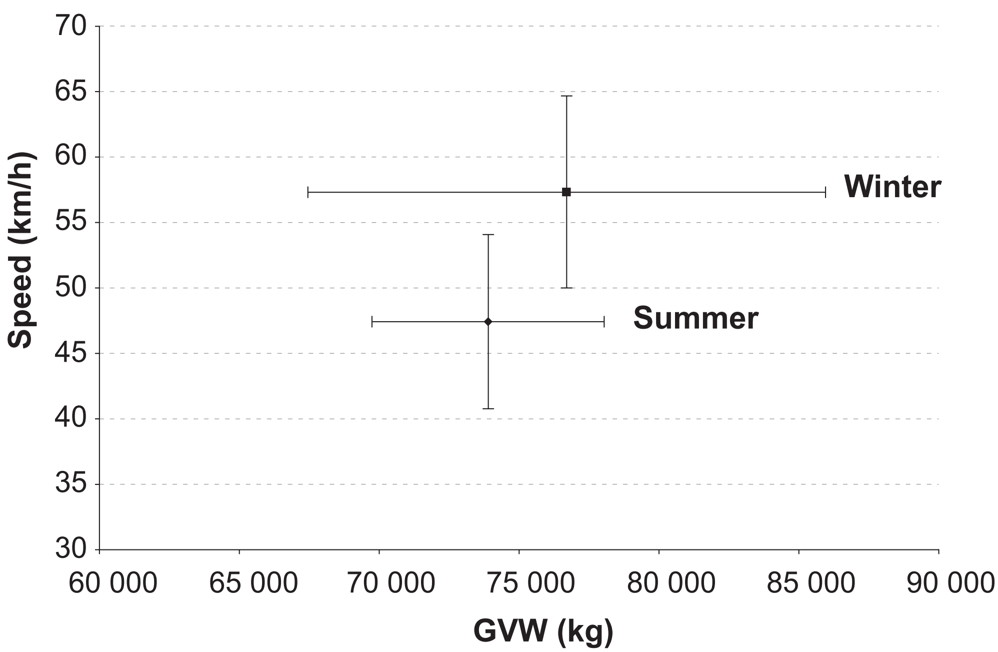


Figure 7. Average speed versus average GVW with standard deviations.

During the study, average travel speed was not influenced by the time of day, truck, driver, or GVW. The time of year was the most influential variable on the travel speed of the logging trucks in the study.

The findings in this report support further consideration for investment in forest road surface stabilization to extend log transportation into periods when roads are not frozen. By investing in road stabilization techniques, Weyerhaeuser will be able to decrease road roughness and increase travel speeds during the summer haul period, which will improve cycle times by approximately 13% for hauls of 120 km. A cost-benefit analysis should be performed to ensure that reduction in cycle times will result in savings greater than the cost of stabilizing a road section.

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