EXTRACTION & PROCESSING
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DOWNSIZING SKIDDERS WITH HIGH-FLOTATION TIRES

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Summary and Conclusions

The objective of this study was to assess the potential for downsizing skidder requirements on soft ground through the use of high-flotation tires. The test was designed to compare the relative performance of a 90-kW skidder with conventional tires and chains to that of a 67-kW skidder equipped with high-flotation tires. The trial was performed in the Abitibi region of Québec under contract to the Ministère de l'Énergie et des Ressources du Québec.

Overall, the higher travel speeds of the smaller, wide-tired skidder permitted it to extract more loads per productive machine hour. However, the larger, conventional-tired skidder's bigger payload compensated for its longer cycle time so that the smaller machine's productivity (m^3/PMH) was actually 17% **less** on a shift-level basis, though only 4% **less** during detailed timing in more controlled conditions. Moreover, in very wet ground, the larger machine became inoperable, while the productivity of the smaller machine remained unchanged, thus providing increased operational flexibility.

In addition, the wide-tired skidder decreased the severity of ground disturbance, thereby improving the site's plantability and regeneration chance. Fuel consumption was also considerably reduced.

In a costing example, the lower purchase price and fuel consumption of the smaller skidder were offset by the added cost of requiring a set of both conventional and wide tires to handle changing site and weather conditions. As such, the smaller machine's direct skidding cost per m^3 was about 11% **higher** than for the conventional machine reflecting the productivity differential. However, the benefits of improved silvicultural and environmental compatibility, and increased operational versatility need also be considered. These factors should make the conversion to smaller skidders equipped with high-flotation tires increasingly attractive, especially to those logging on soft ground or where areas of soft terrain inhibit access to timber except during very dry or winter conditions.

Introduction

The use of high-flotation tires to improve the trafficability of off-road vehicles on both soft ground and steep terrain is continuing to generate interest among the forest industry and government agencies. Earlier wide-tire studies by FERIC demonstrated the potential for improving skidder productivity, while at the same time decreasing fuel consumption and ground disturbance. Moreover, the results suggested that the high flotation and traction and the reduced rolling resistance of wide tires might permit the use of smaller skidders on soft ground. Downsizing might offset the higher tire costs through a reduction in capital investment and operating expenses, while reducing site degradation further. Under contract to the Ministère de l'Énergie et des Ressources du Québec (MER), FERIC investigated the use of smaller skidders with wide tires as compared to the standard practice in the Abitibi-Témiscamingue region of Québec. For the benefit of FERIC members, this note summarizes the study results presented in the contract report.

KEYWORDS: Skidding; Skidders; Machine size; High-flotation tires; Comparison; Productivity; Ground disturbance; Fuel consumption; Costs.

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Test Conditions

The trial was conducted on the limits of Normick-Perron Inc., about 100 km north of Amos, Québec, during August and September, 1985. The relative performance of a John Deere 540B (67 kW) equipped with Firestone 66×50-26* (Flotation 23° Logger) tires was compared to that of a modified John Deere 640B (90 kW) equipped with conventional 74×30.5-32 tires and chains all around (Figure 1). The larger skidder was also equipped with a hydraulic grapple mounted on the side of the blade. This option facilitated bunching and reduced the time required to pick up individual and/or dropped trees in the cutover or along the skid trail. Moreover, the grapple replaced the common practice of flying an empty choker for clean up purposes, thus benefiting skidder productivity. As equipped, the 640B was typical of skidders of this size class working in the region.

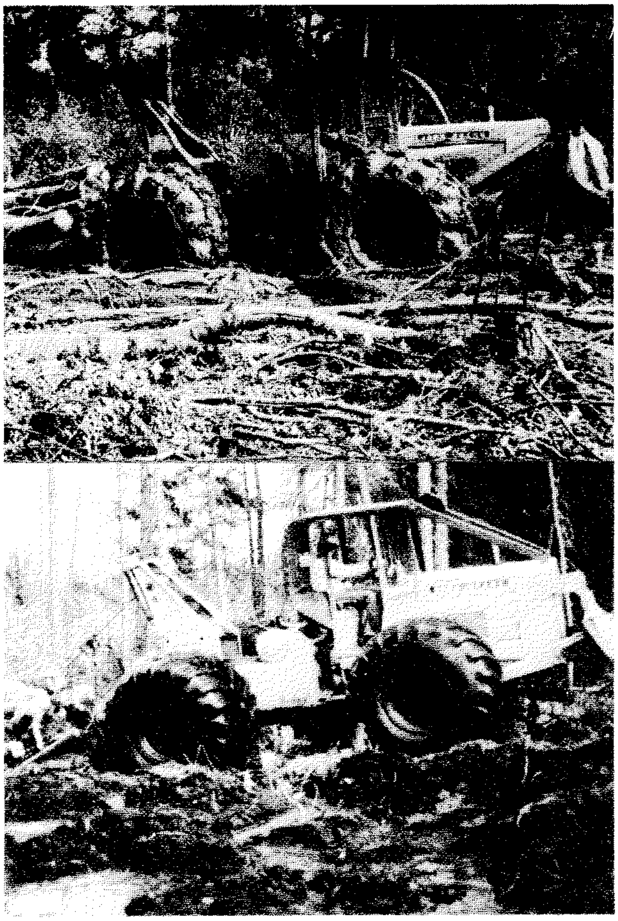

Figure 1. A John Deere 640B equipped with conventional (70×30.5-32) tires and chains (top) was compared to a John Deere 540B with wide (66×50-32) tires (bottom).

The John Deere 640B was owned and operated by a member of the Coopérative St. Dominique du Rosaire contracting for Normick-Perron Inc. The smaller John Deere 540B skidder was leased by FERIC and the high flotation tires were supplied by the MER. One operator was the owner of the JD 640B machine and the other, an employee. The owner/operator was considered to be an excellent operator, whereas the other was judged to be good. As much as possible, the two operators rotated machines daily; their average performance is presented.

The performance of the two machines was assessed during skidding of two adjacent strips (about 15 ha each), one for each machine. However, the two strips were not identical in terms of stand and ground conditions (see Table 1) which raises some concerns about the comparability of the results. The JD 540B operated in a black spruce swamp in which a thin root mat overlaid about one metre of organic soil over clay. The 640B's strip contained similar stand and soft-ground conditions next to the road, but the rear half was comprised of mixed wood on solid, more favourable ground.

Prior to skidding, the merchantable volume in both strips was mechanically felled and bunched with a Koehring K620 feller-buncher. The two skidders then cleared their respective areas concurrently, working only within their own strip. Each machine flew six chokers, each choker being used to sling an entire feller-buncher bunch. The skidded full trees were deposited in separate piles at roadside for subsequent scaling and mechanical delimbing.

Table 1. Description of test areas

Machine	John Deere 640B	John Deere 540B
Total area, ha	13.0	17.1
Terrain class*	4(2).2.1	4.2.1
Organic soil depth, cm	<100(0)	<100
Volume/tree, m^3	0.200	0.218
Trees/hectare	685	391
Volume/hectare, m^3	137.7	86.2

* (Mellgren 1980).

* In North America, tires are commonly sized by a three number code. The first number indicates the tire diameter in inches, the second number represents the tire width in inches and the third number gives the diameter of the bead opening in inches.

Study Results

Shift-Level Productivity

Production data, supplemented by daily Kienzle Recorder charts, were collected on a shift-level basis by FERIC. Scale data were provided daily by company personnel. Table 2 provides a summary of the machines' relative long-term performance over their **entire** respective strip.

The smaller, wide-tired skidder delivered 16% more loads but 17% **less** volume to the landing per PMH than did the larger machine. Thus, the benefits of increased travel speeds, and consequently reduced cycle times, were offset by the downsized skidder's smaller payload (-28%).

Table 2. Shift-level production comparison

Machine Configuration	JD 640B Conventional Tires & Chains	JD 540B Wide Tires	
Productive machine hours, PMH	114.4	126.7	
Volume skidded, m^3	1788	1455	
Stems skidded	8927	6666	
Number of loads	366	443	
Average skid distance, m	286	235	
AVERAGE PERFORMANCE*			
Productivity, m^3/PMH	14.9	12.3	-17%
Loads/PMH	3.2	3.7	+16%
Trees/load	23.6	15.5	-34%
m^3/load	4.7	3.4	-28%

* based on the average of the respective operators' performances to compensate for disproportionate machine usage and skill differences.

A number of factors besides their relative power rating influenced the load size for each machine. As stated earlier, the larger skidder's strip contained both solid and soft ground areas. In the soft area, the conventional tires with chains were able to cut through the humus layer (<1 m) and gain adequate traction on the clay below; and the 640B had sufficient power to overcome the rolling resistance involved. In addition, the use of the recuperator grapple on the larger machine provided an inherent load increase of 1-2 trees/turn. In the smaller skidder's block only, dense alder covered most of the area. This slippery underbrush reduced the wide tires' breakout traction considerably, thereby limiting load size (see Figure 2).

It is interesting to note that the better operator's productivity with the small, wide-tired machine (14.3 m^3/PMH) was comparable to larger skidder results from earlier studies in similar conditions in the Abitibi region (Heidersdorf and Ryans 1986). While such comparisons are not conclusive because of differences in operator skill, they demonstrate the **potential** for smaller, wide-tired skidders to compete against larger, conventional-tired skidders under soft-ground conditions.

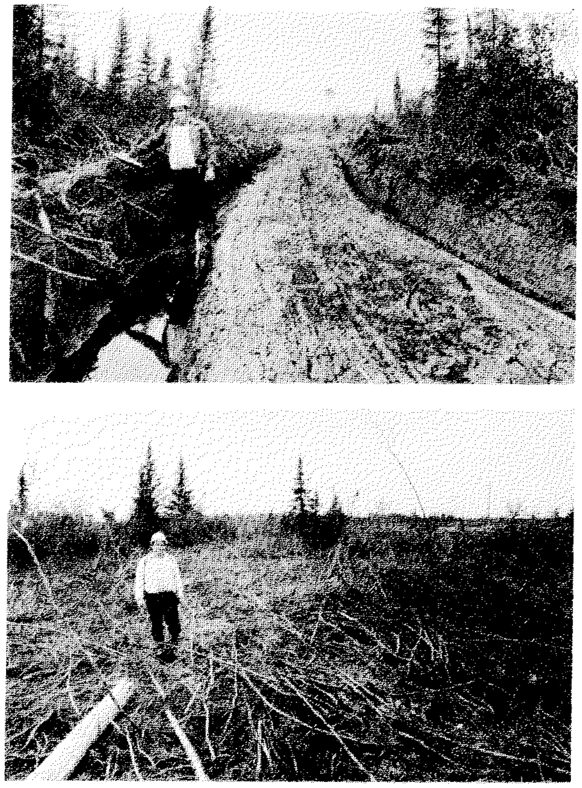

Figure 2. The conventional tires cut through the organic layer to gain adequate traction (top). Dense underbrush in the wide-tired skidder's test area (bottom). Note difference in site disturbance.

Cycle Time Comparison

Since the 640B had to traverse the soft ground to reach the landing, it was possible to compare the performance of the two machines **on soft ground only**. The relative performance of the machines was assessed through detailed timing of the cycle time distribution over about 15 hours of operation (Table 3). For comparison purposes, the data have been adjusted to a standard skid distance of 250 m.

Table 3. Cycle time comparison

Machine Configuration	JD 640B Conventional Tires & Chains	JD 540B Wide Tires	
TIME ELEMENT*	(Minutes/Cycle)		
Travel Empty	2.81	2.29	
Manoeuver	0.39	0.50	
Load	6.82	5.90	
Move during Loading	0.68	0.51	
Travel Loaded	4.99	3.39	
Unload	1.42	1.67	
Pile	0.25	0.28	
Delay			
• Bunch with blade/grapple	1.47	0.43	
• Grapple stray tree	0.11	0.00	
• Winch during travel loaded	0.59	0.42	
• Winch at pile	0.36	0.34	
• Delimb	0.04	0.31	
• Other	0.12	0.11	
			Diff.
Total Time/Cycle	20.05	16.15	-19%
Speed Empty, km/h	5.49	6.55	+19%
Speed Loaded, km/h	3.00	4.45	+48%
Turns/PMH	2.99	3.72	+24%
Trees/Load	29.8	21.1	-29%
m^3/PMH	17.8	17.1	-4%

* based on the average of the respective operators' performances.

The detailed cycle time results again indicated about a 30% higher payload for the larger, conventional-tired skidder. Therefore, the extra power available (+35%) was effectively transferred into tractive effort.

However, once load movement occurred, the wide-tired machine was clearly capable of higher travel speeds than the conventional-tired skidder. Travel empty speed was improved by 19% and travel loaded speed by 48%. The resultant 19% reduction in cycle time compensated for the wide-tired skidder's smaller payload so that productivity (m^3/PMH) was only 4% less than that of the larger, conventional machine.

To further assess their relative performance limitations, the machines were later moved to a second site with a deeper, wetter organic layer (>1 m), thus providing no solid base. Under such conditions, the performance of the wide-tired skidder remained virtually **unchanged**, while the conventional machine proved **inoperable**. The versatility and operational flexibility to harvest such soft-ground areas during the summer eliminates the expense of returning during winter.

Fuel Consumption

During the trial, daily fuel usage was measured with an electric meter while fueling. Table 4 summarizes the results of the fuel consumption comparison.

Table 4. Fuel consumption comparison

	JD 640B Conv. Tires & Chains	JD 540B Wide Tires	Difference
PMH	114.4	126.7	
Volume skidded, m^3	1788	1455	
Litres consumed, L	1636	1006	
L/PMH	14.30	7.94	-45%
L/m^3	0.915	0.691	-25%

The smaller, wide-tired skidder consumed 45% less fuel on an hourly basis and 25% less on a volume basis. This difference reflects the 35% disparity in engine power between the two skidders as well as the wide tires' enhanced flotation and lower rolling resistance.

Ground Disturbance

The post-skidding ground disturbance was measured in the soft-ground areas in both strips. A systematic point-sampling method developed by the MER was employed. The first 20 m from the roadside were excluded from the sample since the road drainage and heavy skidder traffic made this area unrepresentative. Table 5 summarizes the results of the ground disturbance assessment.

Table 5. Ground disturbance comparison

Machine Configuration	JD 640B Conv. Tires & Chains	JD 540B Wide Tires
Undisturbed, %		
Outside tire tracks	34	32
Between tire tracks	9	12
Disturbed, %		
Within tire tracks	57	56
	100%	100%
Depth		
0-15 cm	7	83
16-30 cm	18	11
31-60 cm	36	4
61-100 cm	38	2
>100 cm	1	0
	100%	100%

Figure 3. Typical ground disturbance caused by the larger, conventional-tired skidder (left) and the smaller, wide-tired machine (right).

In each test strip, about 55% of the area showed evidence of skidder passage (i.e., tire tracks). This is nearly double that observed during earlier experience (Heidersdorf and Ryans 1986) and was probably a consequence of the higher than average rainfall for the region during the test period reducing ground strength substantially. The wet ground conditions forced the operators to seek untravelled areas to maintain adequate traction, thus increasing the total ground area traversed.

While the percentage of rutting was similar for both machines, the degree of disturbance was not (see Figure 3). With the high-flotation tires, only 17% of ruts were more than 16 cm in depth, whereas with the conventional tires, 93% of the ruts exceeded that depth. In general, the improved flotation and decreased ground disturbance provided by wide tires on sensitive sites result in an improved regeneration potential. The smaller machine's lighter weight (-17%) also contributed to reduced site damage.

Example of Operating Costs

The costs (1986) presented below combine both known and **estimated** inputs. As such, they are indicators of relative performance in the study conditions rather than absolute values. Readers can adapt this costing procedure to their own situation using the following equation:

$$\$/m^3 = \left[\left[\frac{I-R}{L} \left(\frac{1 + i(N+1)}{2} \right) + \frac{iR}{n} + M + W \right] \frac{1}{U} + F \right] \frac{1}{P}$$

where:

	JD 640B	JD 540B
I - Purchase Price ($)		
• base machine (fob, Grimsby, Ontario)	92 000	86 000
• conv. tires, 74x30.5-32	11 200	-
• conv. tires, 67x23.1-26, winter only	-	6 000
• rims	3 600	3 200
• wide tires, 66x50-32, summer only	-	20 000
• rims	-	6 400
• chains, conv. tires only	3 000	2 000
Total	109 800	123 600
R - Residual Value ($) (10% of I)	10 980	12 360
L - Economic Machine Life (SMH)	12 000	12 000
i - Interest and Insurance (%) .... prime rate +2% +2% (insurance)	15	15
N - Depreciation Period (years)	5	5
n - SMH/year	1 500	1 500
M - Maintenance Cost ($/SMH) .... (100% of I + extra set(s) of tires)	12.70*	12.63*
W - Operator's wage, $/SMH .... ($12/h + 25% fringe)	15.00	15.00
U - Utilization (%)	85	85
F - Fuel and Lubrication ($/PMH) .... (L/h × 0.53/L + 0.35 lubes)	7.93	4.56
P - Adjusted Productivity (m^3/PMH)	17.8**	15.6**

* Maintenance cost assumes that three additional sets (excluding rims) of conventional 30.5-inch tires with chains (JD 640D) and one extra set of wide and narrow 23.1-inch tires with chains (JD 540D) will be required during each respective machine's economic life.

** Productivity for 640B as per detailed study. Productivity for 540B assumes 4% reduction in summer (8 months) as per detailed study and 30% reduction in winter (4 months) to reflect the power differential.

Using the above values in the equation gives the following results:

	JD 640B	JD 540B	
Total machine cost, $/PMH	$55.87	$54.34	-3%
Production cost, $/m³	$ 3.14	$ 3.48	+11%

Based on the above assumptions, the savings in fuel and purchase price associated with the smaller, wide-tired skidder are offset by the added cost of requiring a set of both conventional and high-flotation tires to handle changing site and weather conditions. Therefore, the hourly costs of both machine configurations are almost equal. As such, the **direct** skidding cost ($/m³) of the smaller, wide-tired skidder is about 11% **higher** than for the larger, conventional-tired skidder reflecting the productivity differential. However, under soft ground conditions, the **indirect** cost savings associated with an improved regeneration chance and greater operational flexibility should make the conversion to smaller, wide-tired skidders increasingly competitive to standard practise.

Literature Cited

Mellgren, P.G., 1980. Terrain classification for Canadian forestry. Can. Pulp and Paper Ass., W.S.I. rep. 2840. 13 p.

Heidersdorf, E.; Ryans, M. 1986. Joint FERIC/MER high flotation tire trials, Québec, 1984. Forest Engineering Research Institute of Canada, Technical Report TR-64. 49 p.

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