Advantage

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Contents

Four evaluations of compact tracked harvesters and forwarders in commercial thinning

Abstract

FERIC studied four compact tracked harvesters and their associated forwarders working in commercial thinning. The harvesters produced wood at costs ranging from $7 to $33 per cubic metre, with forwarding costs adding $4 to $15 per cubic metre. The lowest costs were obtained with experienced operators using larger machines, but the smaller machines can also produce wood at an acceptable cost and may be more suitable in operations that produce insufficient wood annually to justify the costs of the more expensive machines. For optimal productivity, the harvester should be able to produce enough wood to keep the forwarder fully occupied.

Keywords:

Commercial thinning, Single-grip harvesters, Tracked harvesters, Kubota KX161, Patu SH400 head, Patu RH405 head, Takeuchi TB070, Neuson 11002 HV, Logmax 3000 head, Rottne Rapid SMV forwarder, Turboforest TF 605 forwarder, Valmet 828 forwarder, Vimek 606 forwarder.

Author

Roderick H. Ewing
Eastern Division

Introduction

There is a strong incentive to mechanize manual or semi-manual thinning operations in order to reduce both the high operating costs and the labor requirements. Smaller tracked harvesters are beginning to fill this niche, and for some time, FERIC has been investigating the use of these machines to determine whether their lower cost and greater maneuverability make them an economical and productive alternative to large harvesters. This report presents the results of four studies of compact tracked harvesters and the associated forwarding operation with an emphasis on determining the suitability of these machines in thinning operations.

Common features

Each of the four compact harvesters that FERIC studied (Figure 1) was based on a narrow excavator with minimal tail swing, and exerted a low ground pressure. With the exception of the Neuson harvester, their operating weights were less than 8 tonnes. As well, all four machines had a dozer blade that could provide additional stability on uneven terrain or perform light leveling work such as uprooting small stumps or smoothing the entry slope onto a trail. The Neuson harvester also included a leveling system that provides 15° of platform and cab tilt to either side and 25° of fore and aft tilt; this allows the machine to operate on steeper slopes (up to 30°). The excavator hydraulic systems typically included two variable-displacement pumps and one gear pump, and provided sufficient flow and pressure to power the harvester head and boom without significant modification.

The most noteworthy feature was that each machine's primary boom was attached to a slewing (swing) mount on the front edge of the excavator's rotating platform. This setup allows the boom to offset 80° to the left and 45° to 50° to the right independently of the cab when operating in tight situations. This provides flexibility when selecting difficult-to-reach trees and reduces the risk of the machine's rear overhang damaging trees along the trail's edges. This design also positions the mounting of the primary boom further forward on the cabin's right side, where visibility for the operator is somewhat restricted in conventional excavators.

Each cab had good ergonomics, with comfortable seating and well-positioned controls. Visibility to the front and sides of the cab was largely unobstructed, and full or partial skylights provided good views of the forest canopy. Most routine servicing can be accomplished from the ground, thereby reducing the need to climb onto the machine and the related risk of injury. Dealer-installed protective structures surrounded the cab and

Figure 1. (A) Kubota KX161 with a Patu SH400 head, (B) Kubota KX161 with a Patu RH405 head, (C) Takeuchi TB070 with a Patu RH405 head, and (D) Neuson 11002 HV with a Logmax 3000 head.

Find us Online!
www.feric.ca

Forest Engineering Research Institute of Canada (FERIC)

Eastern Division and Head Office
580 boul. St-Jean
Pointe-Claire, QC, H9R 3J9

☎ (514) 694–1140
🖹 (514) 694–4351
💻 admin@mtl.feric.ca

Western Division
2601 East Mall
Vancouver, BC, V6T 1Z4

☎ (604) 228–1555
🖹 (604) 228–0999
💻 admin@vcr.feric.ca

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engine compartment of the Kubota and Takeuchi machines to improve protection against debris or falling trees. The Neuson did not require additional protective structures around the cab. Table 1 summarizes the characteristics of the harvesters.

Table 2 summarizes the characteristics of the forwarders observed in this study. Two of the operations used compact forwarders (3.0- and 4.5-tonne capacities) to match the harvesters' output. A Vimek 606 forwarder was used alongside the Kubota KX161–Patu SH400 harvester, and an earlier version of the Turboforest TF 605 forwarder was paired with the Takeuchi–Patu RH405 harvester. The operation with the Kubota KX161–Patu RH405 harvester used a Valmet 828 forwarder, and the Neuson was paired with a high-capacity Rottne Rapid SMV forwarder.

Stand conditions

The study sites were located in the Abitibi, Lac St-Jean, and southern Laurentian regions of Quebec in stands ranging from natural softwoods (jack pine, spruce, and tamarack) to mixedwood stands (birch, spruce, and pine). The CPPA terrain classifications of these stands ranged from 2.1.1 to 3.1.2 (level, well-drained sand flats to gentle slopes). The pre- and post-treatment stand conditions appear in Table 3.

Table 1. Characteristics of the four tracked harvesters

	Kubota KX161		Takeuchi	Neuson
	SH400 head	RH405 head	TB 070	11002 HV
Approximate cost ($)	175 000	197 000	225 000	415 000
Carrier				
Power (kW)	37		52	75
Weight (tonnes)	6.1		7.5	11.6
Ground pressure (kPa)	28.0	28.3	34.0	38.0
Drawbar pull (tonnes)	4.9		7.7	11.9
Track width (cm)[a]	55		55	50
Machine width (m)	2.0		2.3	2.4
Ground clearance (cm)	32		38	52
Tail swing (cm)	50		60	36
Boom				
Brand	Patu 915		Standard digging boom	Neuson
Max. reach (m)	8.1 (incl. 1.6-m extension)		6.4	9.1 (with telescoping extension)
Felling head				
Make	Patu SH400	Patu RH405	Patu RH405	Logmax 3000
Type	Stroke-feed	Roller-feed	Roller-feed	Roller-feed
Cutting capacity (cm)	45	45	45	50
Feed rate (m/s)	0.6	4.3	4.3	3.7
Feed force (kN)	41.0	15.0	15.0	17.2
Weight (kg)	310	480	480	525

[a] Rubber tracks are an available option.

Table 2. Characteristics of the four forwarders

	Vimek 606	Valmet 828	Turboforest TF 605	Rottne Rapid SMV
Approximate cost ($)	85 000	380 000	125 000	350 000
Engine power (kW)	15	64	48	88
Drive	6 wheels	8 wheels	6 wheels	6 wheels
Width (m)	1.6	2.4	2.1	2.7
Weight (tonne)	1.9	8.4	4.7	11.6
Payload capacity (tonne)	3.0	8.0	4.5	12.0
Ground clearance (cm)	40	62	46	55
Max. travel speed (km/h)	20	33	25	25
Turning radius (m)	<5.0	5.8	4.3	8.5
Grapple loader				
Brand	Vimek 362	Cranab 570	Arbro-Lift 42-2	Rottne RK 60
Lifting capacity at max. reach (kg)	250	820	409	875
Max. reach (m)	3.6	6.8	4.2	7.0

Table 3. Pre- and post-treatment stand conditions

	Kubota KX 161–Patu SH 400 harvester			Kubota KX 161–Patu RH 405 harvester			Takeuchi TB 070-Patu RH 405 harvester			Neuson 11002 HV (Natural mixedwood stand)		
CPPA class	2.1.1 – 2.1.2			2.1.1 – 3.1.2			2.1.1			2.1.1		
	Before	After	Diff. (%)	Before	After	Diff. (%)	Before	After	Diff. (%)	Before	After	Diff. (%)
Density (merch. stems/ha)	2900	1800	–38	2350	1200	–49	2150	1050	–51	1340	996	–26
Basal area (m^2/ha)	45.7	31.5	–31	40.0	22.7	–43	37.7	24.0	–36	27.1	18.4	–32
Merchantable volume (m^3/ha)	204	148	–27	200	122	–39	237	166	–30	161	107	–34
Average DBH (cm)	14.1	14.9	+6	14.8	15.8	+7	15.0	17.2	+15	16.0	15.3	–4
Average volume (m^3/stem)	0.070	0.082	+17	0.086	0.106	+23	0.111	0.160	+44	0.120	0.108	–10

Operational results

Table 4 summarizes the results of the four thinning treatments. Overall, the levels of damage to the residual stands averaged less than 5%, and damage was most prevalent along the edges of the extraction trails as a result of forwarder traffic.

The operation that used the Kubota KX161–Patu SH400 harvester thinned the extraction trail and both sides of the leave strip in a single pass, and produced a single product (2.5-m bolts). The operator used a single ghost trail between extraction trails to access the central portion of each leave strip. The operation with the Kubota KX161–Patu RH405 harvester used unusually wide leave strips that required the use of two ghost trails to treat the center of these strips. This operation produced 2.7- and 3.6-m log lengths.

The Takeuchi harvester followed a serpentine trail layout that created a system of meandering trails running adjacent to each other, with leave strips between. The width of each leave strip was determined somewhat by the harvester's effective boom reach while thinning to either side of each trail. Mobility of the forwarder (maneuverability, travel speed, ease of loading) was not affected by this trail layout. This approach produced a thinned stand with relatively inconspicuous extraction trails compared with the use of parallel trails. This operation produced a single product (2.5-m bolts).

The Neuson's long boom effectively reached the center of each leave strip without requiring the use of ghost trails. However, even though the extraction trails were narrower than with the Kubota–Patu 405, they were wider than necessary, and this resulted in a high percentage coverage of the site by trails. The harvester produced a range of log lengths (from 2.5 to 4.1 m).

Table 5 summarizes the results of the harvester productivity studies. The feeding speed of the stroke-fed Patu SH400 harvester head was typically slower than that of its roller-fed counterpart, the RH405. The results suggest that the roller-fed version of the Patu head offers potential productivity gains of up to 55% compared with the stroke-fed version, though high branchiness and big trees may reduce this advantage.

Table 4. Summary of the four thinning treatments

	Kubota KX 161		Takeuchi TB070,	Neuson 11002 HV,
	Patu SH400	Patu RH405	Patu RH405	Logmax 3000
Trail width (m)	2.6	4.6	2.8	3.4
Trail spacing (m)	20	45	16	13.5
No. of ghost trails	1	2	None	None
Area occupied by trails (% of total)	13	11	15	19
Damage to residual stand (%)	<3	—[a]	1	<5

[a] Not measured

Table 5. Harvester productivity summary

	Kubota KX161 Patu SH400 head	Kubota KX161 Patu RH405 head	Takeuchi TB 070, Patu RH405 head	Neuson 11002HV, Logmax 3000
Merch. volume harvested (m^3/stem)	0.083	0.064	0.082	0.211
Productivity:				
stems/PMH	48	39	108	67
m^3/PMH	4.0	2.5	8.9	14.1
Direct operating cost ($/PMH)[a]	78	83	81	96[b]
Estimated wood cost ($/$m^3$)	20	33	9	7

[a] Based on 2000 PMH/year over 7 years, excluding transportation, supervision, and other overhead costs.
[b] Based on 4000 PMH/year over 5 years, excluding transportation, supervision, and other overhead costs.

The predicted performance of the compact tracked harvesters as a function of average stem volume based on the study results is shown in Figure 2. In addition to this relationship, operator experience also influenced productivity significantly. The highest productivity levels were attained with the Neuson–Logmax combination. This machine's operator had more than 6 months of thinning experience. The productivity of the Takeuchi–Patu RH405 combination was also very good, but the operator had more than 2 years of thinning experience. The Kubota–Patu harvesters both had relatively low average productivities. With the SH400 head, productivity ranged from 3.2 to 4.6 m³/PMH for an operator with more than 6 months of experience. This productivity compares favorably with that reported in other FERIC studies of the same harvester head, but mounted on wheeled carriers. The Kubota–RH405 harvester achieved the lowest productivity, mainly because of a lack of operator experience (about 6 weeks) and the fact that it was harvesting trees with a small average stem volume (0.064 m³). With experience, performance should eventually exceed that obtained with the SH400 head.

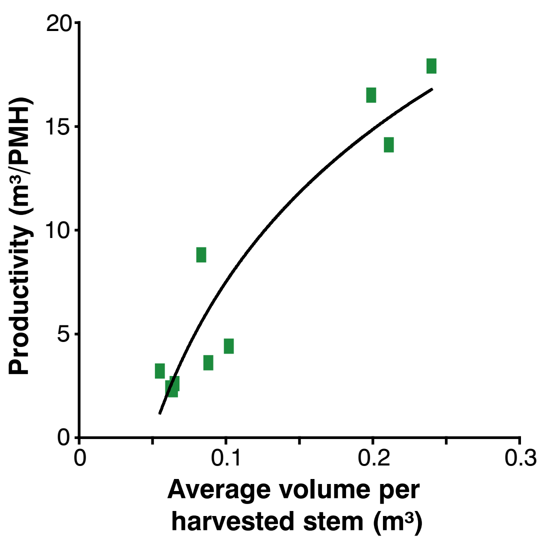

Figure 2. Productivity of the compact tracked harvesters as a function of average stem volume.

Table 6 presents the productivities of the four forwarders. The Vimek forwarder

	Vimek 606	Valmet 828	Turboforest TF605	Rottne Rapid SMV
Average volume/trip (m^3)	3.0	5.1	6.2	19.1
Productivity (m^3/PMH)	5.5	7.9	8.9	21.4
Direct operating cost ($/PMH)[a]	57	120	60	87[b]
Estimated wood cost ($/$m^3$)	10	15	7	4

Table 6. Forwarder productivities (extraction distance standardized at 150 m)

[a] Based on 2000 PMH/year over 7 years, excluding transportation, supervision, and other overhead costs.
[b] Based on 4000 PMH/year over 5 years, excluding transportation, supervision, and other overhead costs.

had the lowest payload capacity, but the operator was able to optimize each load because the harvester produced only a single product (2.5-m logs). However, operating over longer forwarding distances would decrease its productivity. Productivity with the Valmet forwarder was below average, mainly because the harvester did not generate sufficient volume for the forwarder. The machine also worked from relatively short extraction trails and had to forward multiple products. The Turboforest forwarder extracted a single product (2.5-m logs) over relatively short forwarding distances, resulting in modest productivities given the machine's capacity. The above-average productivity levels of the Rottne forwarder paired with the Neuson harvester resulted from operating under ideal stand conditions. However, if stand conditions had prevented the harvester from attaining such high productivity levels, the high-capacity forwarder (12 tonnes) would probably have been underutilized.

From the perspective of ground disturbance, tracked carriers generally have a light footprint as a result of their even distribution of the machine's weight over the full track length, and this makes them attractive for use on ghost trails. The Kubota carrier had the lowest ground pressure that FERIC has observed in this study for a compact tracked harvester. With tracked carriers, slight soil disturbance usually occurs when the harvester changes directions and the moving tracks shear the duff layer. As with all cut-to-length systems, operators of these harvesters typically leave limbs and tops on the trail to create a protective debris mat for themselves and for subsequent forwarding in the extraction trails. Although the limited ground clearance on the lighter harvesters may be a concern under some operating conditions (e.g., the presence of boulders), it did not pose a problem for machine travel during our studies. These relatively compact harvesters can maneuver quite freely under most stand conditions. Moreover, they can surmount windfalls or heavy debris by pushing down against the ground with the boom and head, thereby raising the front portion of the track carriage and allowing the machine to "walk" over the debris.

Implementation

Tracked compact excavators have gained in popularity in recent years because they are simple and relatively inexpensive to convert into harvesters. These carriers have also developed a reputation for dependability and efficiency, both of which are important factors for contractors, particularly during this period of rising fuel costs and uncertain markets. Converting these harvesters back to their original excavator configuration could also be considered when there is insufficient harvesting work.

- On steeper slopes and where the trail layout requires extended boom reach, the Neuson harvester offers impressive productivity. However, it may be too expensive for small-scale contractors who lack enough work to operate the machine year-round or who are operating solely on level to moderate terrain.
- Large forwarders will typically prove most productive and will provide wood at the lowest cost, but may be too expensive for contractors who cannot operate the machines year-round. Because of the high productivity of these forwarders, an operation using compact harvesters may require two or more harvesters, or very long extraction trails, to produce enough wood to fully utilize the forwarder. Moreover, larger forwarders require wider extraction trails, and this may unacceptably increase the proportion of the site covered by trails unless various alternative trail layouts are used, such as those described by Meek (2001).
- Increasing concerns over ground disturbance have increased the pressure on operators to minimize soil exposure and compaction during harvesting. The tracked harvesters in FERIC's study can help meet these criteria because of the low ground pressures they exert on forest soils.
- Compact, custom-built harvesters offer a lower capital cost than dedicated harvesters and can let contractors gradually increase their annual workload until it makes economic sense to upgrade to a larger, dedicated harvester.

Acknowledgments

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