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Mechanized harvesting to reduce soil and stem damage during selection harvesting in tolerant hardwoods

Author
Brad Sutherland
Eastern Region

Abstract

Selection harvesting of tolerant hardwoods typically stops during the spring and early summer when there is heightened concern over damage to soils and residual stems from felling trees and machine activity. A feller-buncher and an 8-wheel forwarder modified into a clambunk skidder were evaluated as a lower impact alternative to conventional cable or grapple skidders to operate during the traditional shutdown period within acceptable guidelines for soil disturbance, residual stem damage and trail occupancy. This study showed that the feller-buncher and clambunk skidder used for single-tree and group selection harvesting could potentially extend the logging season into the spring shutdown period without exceeding local site impact guidelines.

Keywords:

Soil disturbance, Stem damage, Selection harvesting, Tolerant hardwoods, Clambunk skidders, Skidding, Skid trail, Ground pressure, Feller bunchers, Ground disturbance, Productivity.

Introduction

Hardwood harvesting operations in the Great Lakes–St. Lawrence forest region typically undergo a spring and early summer shutdown period when soils and residual tree stems are more susceptible to damage from harvesting activities. Tom Fisher Logging Inc., a contractor for Tembec in Huntsville, Ont., proposed an innovative approach to harvesting during the spring shutdown period that would minimize damage to soils and residual stems. The use of an 8-wheel clambunk skidder was proposed as a lower impact alternative to conventional cable or grapple skidding (Figure 1).

Figure 1. TimberKing TK 458 clambunk skidder.

Configured with front and rear bogie axles with tire tracks, a loaded clambunk skidder exerts less pressure on the ground at 36 kPa, compared with a conventional 4-wheel cable skidder at 75 kPa[1]. In

1. Estimates assume rear loaded ground pressures as determined by PASCAL, Feric's nominal ground pressure calculator.

addition, a swing boom is used for loading harvested stems, which can further reduce damage to residual trees compared with winching with a cable skidder. To test the potential of this equipment to operate with reduced soil and stem damage, an early start-up was granted during the spring of 2007 by Westwind Stewardship Inc., the sustainable forest license holder. The Feric division of FPInnovations evaluated the potential of the feller-buncher and clambunk skidder to operate during spring shutdown within acceptable guidelines for soil disturbance and residual stem damage. From late May to July of 2007, machine productivity, soil disturbance, residual stem damage and trail occupancy were documented from single-tree and group selection harvesting in a tolerant hardwood stand approximately 40 km north of Huntsville in the Kearney area.

Equipment and methodology

A TimberKing TK 721 feller-buncher and TK 458 clambunk skidder were studied in two adjacent tolerant hardwood blocks, one harvested as a single-tree selection system and the other harvested as a series of group selection openings. Up to one-third of the basal area was marked for harvesting in the single-tree selection block. In the group selection block, a series of one-quarter to one-half hectare openings, uniformly distributed, were marked for harvesting to release/establish mid-tolerant and tolerant regeneration. Terrain in both harvest blocks was characterized by flat-topped ridges with long moderately steep side hills. In the group selection block, the ridge tops were shallow with deeper soils on the side hills.

Feric MultiDAT dataloggers equipped with GPS receivers were installed on both machines and configured to track all machine movements. The GPS records were used to calculate trail coverage and the number of passes by machines on the trail.

To evaluate soil disturbance, all machine trails were surveyed and the location and severity of rutting was assessed. Rut lengths and depths were measured using Feric's methodology and are presented in this report as per Algonquin Park's site impact guidelines (OMNR 1998). Machine trail widths were recorded at various locations throughout the study block.

Residual stem damage was assessed according to injury categories as defined by the Ministry of Natural Resources for tolerant hardwoods and described in Appendix I. In the single-tree block, 23 basal area plots established for assessing the pre-harvest volume were revisited following harvesting to record the basal area of stems that sustained major damage. In addition, the basal area of damaged trees along the trail edge was sampled in a series of 30-m-long segments located approximately every 60 m along the entire network of skid trails. In the group selection block, the basal area of stems in or immediately adjacent to openings that sustained major damage was recorded in 36 of the 45 openings harvested. Using the same methodology as in the single-tree block, the basal area of stems damaged along the trail edge was sampled in the group selection block.

Skidder productivity studies were conducted using Feric's standard detailed time-study techniques.

Results

Tables 1 and 2 summarize machine trail occupancy for the single-tree and group selection blocks, respectively. For trail occupancy of extraction trails, the coverage was 10.8 and 4.0% for the single-tree and group selection blocks in Tables 1 and 2, respectively, which is less than the 20% maximum area that can be occupied by skid trails as specified in the stand level standards for partial cut harvesting systems (OMNR 1998). Rut categories are described in Appendix I.

Table 1. Machine trail occupancy in the single-tree harvest block

Trail class	Length (m)	Area (ha)	Coverage of total block (%)
Clambunk skidder	5780	2.27	10.8
Feller-buncher[a]	1480	0.52	2.5
Total	7260	2.80	13.3

[a] Consists of trail length beyond that of the clambunk skidder.

Table 2. Machine trail occupancy in the group selection harvest block

Trail class	Length (m)	Area (ha)	Coverage of total block (%)
Clambunk skidder	10 020	4.06	4.0
Feller-buncher	1950	0.70	0.7
Total	11 970	4.80	4.6

Figures 2 and 3 (see page 4) present trail layouts of the clambunk skidder and feller-buncher for the single-tree and group selection blocks, respectively.

Table 3 indicates the length of soil ruts recorded into four rut depth categories for the extraction trails. Inspection of rut lengths reveals that none exceeded the maximum allowed by the site impact guidelines for Algonquin Park as outlined in Appendix I. Machine traffic was concentrated on fewer trails in the group selection block and this resulted in a higher average number of extraction trail passes in the 31 to 60 cm category, i.e., 70 versus 20 passes for the single-tree block. The higher number of passes resulted in longer, deeper ruts but spread over a smaller area. For example, the average rut length in the 31 to 60 cm category was 37 m in the group selection block versus 19 m in the single-tree block (Table 3).

Table 3. Length of extraction trail ruts for the single-tree and group selection harvest blocks

	Rut length (m)					
	Single-tree selection harvest block			Group selection harvest block		
Rut depth	Minimum	Maximum	Average	Minimum	Maximum	Average
< 16 cm	5	18	10	5	84	25
16 to 30 cm	3	45	16	4	172	36
31 to 60 cm	7	40	19	7	96	37
> 61 cm	No ruts identified			30	30	30

Figure 2. Clambunk skidder and feller-buncher trail layouts for single-tree selection harvest.

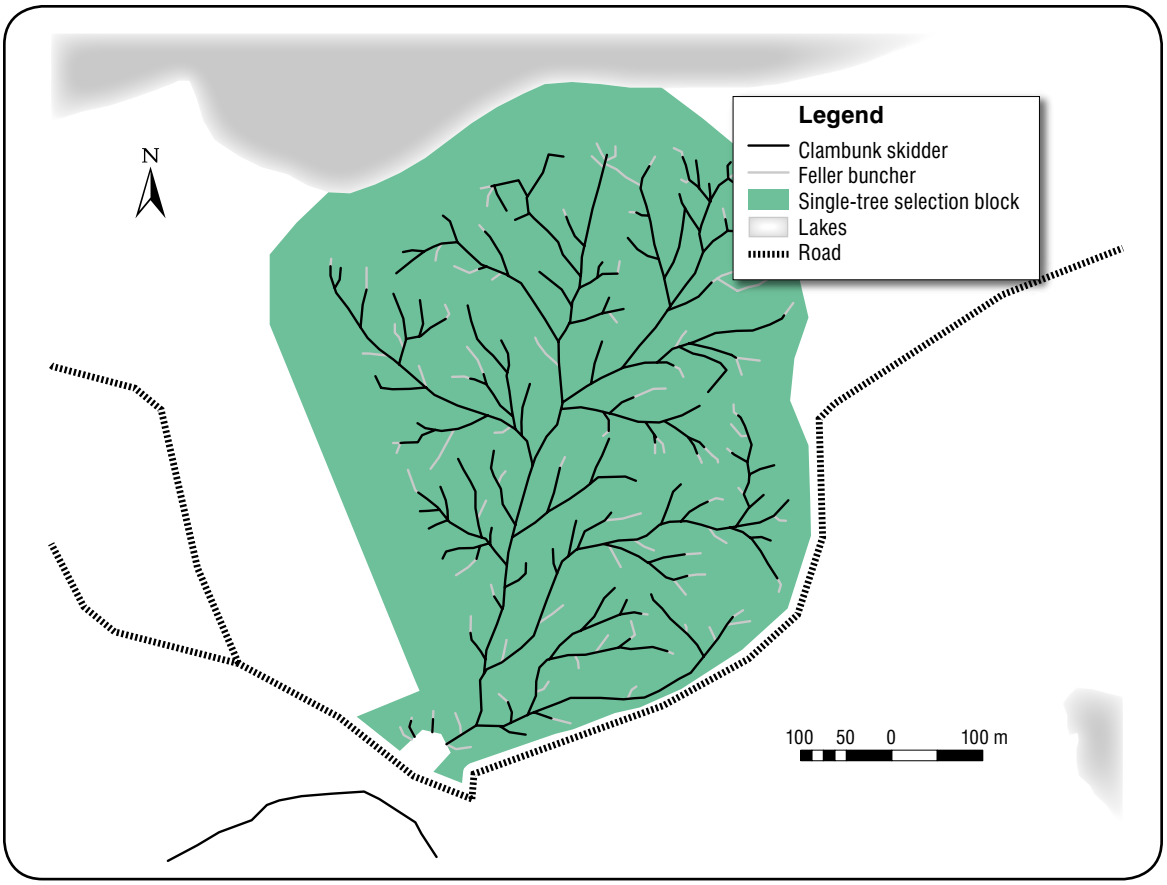

Figure 3. Clambunk skidder and feller-buncher trail layouts for group opening selection harvest.

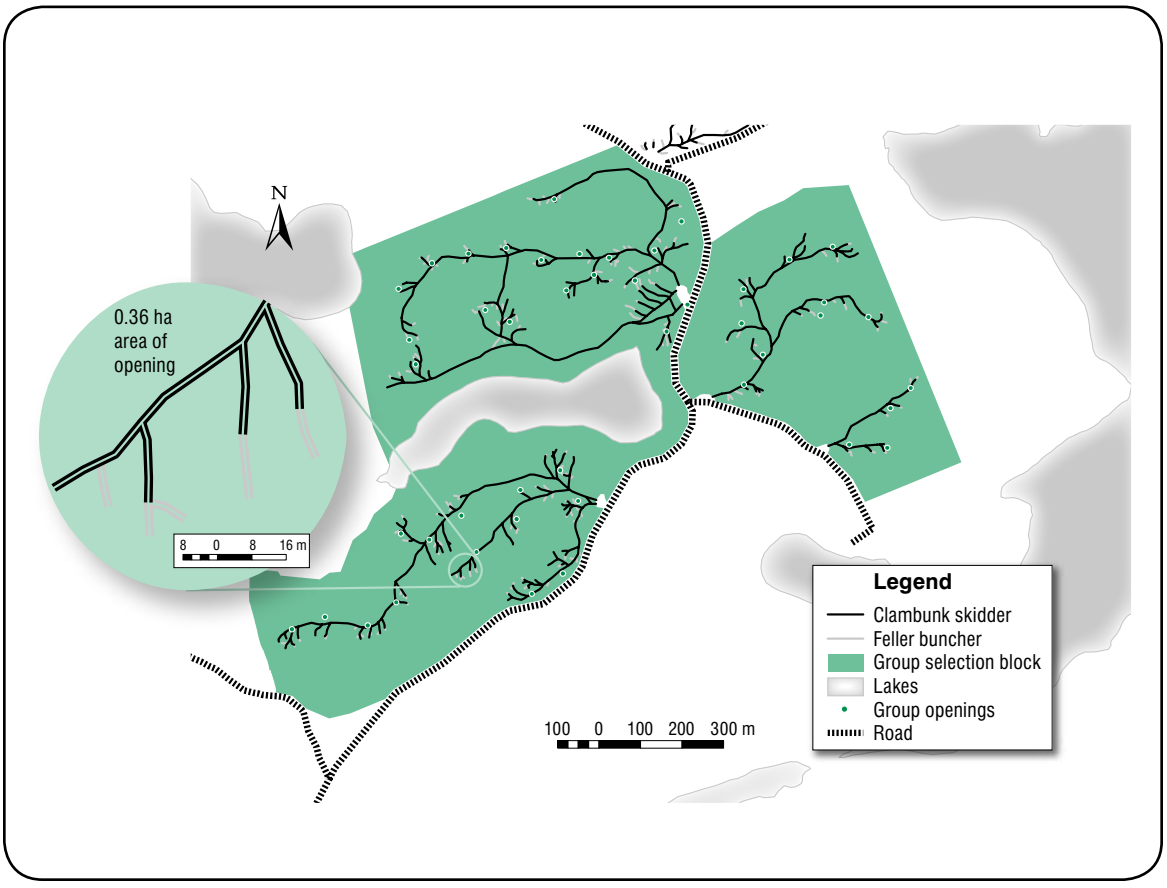

Table 4 summarizes major damage, as defined in OMNR (1998), to residual stems as a proportion of total basal area for the single-tree and group selection blocks. Damage levels in terms of common injuries to trees during logging operations in northern hardwoods are described in Appendix I. For acceptable growing stock, damage totals for in-block plus along trail were 7.2 and 3.4% for single-tree and group selection blocks, respectively. For all trees (i.e., acceptable and unacceptable growing stock), the combined totals for in-block or openings plus along trail were 10.4 and 4.5% for the single-tree and group selection blocks, respectively. These values do not exceed the 10% upper limit in the case of acceptable growing stock and the 15% allowed for all trees under the stand level standards for partial cut harvesting systems (OMNR 1998).

Table 5 summarizes the productivity of the clambunk skidder operating in both harvest blocks. Productivity was similar in both harvest blocks even though average skidding distance was longer at 357 m in the group selection versus 269 m in the single-tree selection block.

Table 4. Summary of residual stem damage for the single-tree and group selection harvest block

	Major damage to residual stems as a proportion of total basal area for block (%)					
	Single-tree selection harvest block			Group selection harvest block		
Tree quality	Along trail	In-block	Total	Along trail	In-block	Total
Acceptable growing stock	4.2	3.0	7.2	2.7	0.7	3.4
All trees	5.9	4.5	10.4	3.6	0.9	4.5

Table 5. Clambunk skidder productivity for the single-tree and group selection harvest block

	Single-tree	Group selection
PMH studied	3.1	10.0
m^3/PMH	14.6	14.3
Number of trips	8	26
Average cycle time (min)	23.3	23.2
Average skidding distance (m)	269	357
Average volume/stem (m^3)	0.9	0.9
Volume/load (m^3)	5.7	5.5

Average cycle time was similar in both harvest blocks despite the longer average skidding distance in the group selection block because wood piles were concentrated in group openings. This reduced moving times for loading versus single-tree blocks where wood piles were dispersed across the block. This shorter loading time offset the greater proportion of time spent travelling loaded and empty in the group-selection blocks. Direct skidding cost based on a typical hourly cost of $130/PMH and using the productivity values presented in Table 5 would be $8.90/m³ and $9.00/m³ for the single-tree and group-selection blocks, respectively.

Discussion and implementation

The main objective of the study was to determine if the feller-buncher and clambunk skidder employed in this case could harvest in tolerant hardwoods within acceptable guidelines for soil disturbance and residual stem damage during the normal spring shutdown period. Results from an evaluation of trail occupancy, rutting and major damage to residual stems reveal that the TimberKing TK 721 feller-buncher and TK 458 clambunk skidder can be operated during this period without exceeding the upper limits specified by local standards.

Figure 4. Clambunk skidder with reduced load.

- Careful selection of stand and site conditions can reduce the likelihood for soil disturbance and stem damage. Choose mature stands with fewer, larger trees that can accommodate equipment passage with less chance of stem damage than in younger and more densely stocked second growth stands. Favour better ground conditions such as well drained soils and avoid steep slopes.
- Residual stem damage can be minimized by employing careful techniques when felling and extracting wood. The feller-buncher is capable of directionally placing cut stems to reduce damage to adjacent trees. In the group selection openings, the operator was frequently observed cutting large diameter trees and backing up prior to dropping the tree to minimize contact with and potential damage to residual trees. Additionally, cut stems were manually limbed and topped at the stump, thus reducing the likelihood of stem damage from large tree crowns during skidding.
- Soil rutting on extraction trails did not exceed local guidelines even during spring conditions when soil moisture is typically higher. One reason for the reduced level of soil damage was the low ground pressure exerted by the 8-wheel, double bogie wheel configuration of the clambunk versus a conventional four-wheel skidder. Bogies allow the use of tracks which further decrease ground pressure.
- Ground pressure of the clambunk skidder can be further reduced by reducing load size deliberately (fewer trees in the clambunk) during extremely sensitive conditions (Figure 4).
- Tensioning of the clam during skidding reduced the lateral spread of the load. This combined with smaller loads reduced the likelihood of bark-damaging contact with residual trees (Figure 4).

- A feller-buncher and clambunk skidder system as used in this study and in these stand and site conditions demonstrated the potential to extend the logging season into the spring shutdown period without exceeding local site impact guidelines. Close supervision of operations is advised under these conditions to ensure that soil disturbance and stem damage do not exceed applicable guidelines. For more information about best management practices, refer to Feric's series of guides on best practices to reduce damage during partial cut operations in the Great Lakes–St. Lawrence Forest Region of Ontario (Partington 2008).

Acknowledgments

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Appendix I

Standards for rut and stem damage *(modified from OMNR 1998)*

Common injuries to trees during logging operations in northern hardwoods	
Type of injury	**Considered major when…**
Bark scraped off	**Trees 10 to 31 cm DBH** Any wound greater than or equal to the square of the DBH (e.g., for a 10 cm DBH tree, a major wound is greater than 100 cm^2)
	Trees 32+ cm DBH Any wound greater than 1000 cm^2
	Note: Wounds on yellow birch (or ground contact wounds on other species) are considered to be major at 60% the size shown above for all size classes (e.g., 60 cm^2 for a 10 cm DBH tree or 600 cm^2 for any tree 32+ cm DBH)
Broken branches	More than 33% of the crown is destroyed
Root damage	More than 25% of the root area exposed or severed
Broken off	Any tree
Bent over	Any tree tipped noticeably

Site impact guidelines for Algonquin Park		
Skid trail category	**Maximum distance of compaction per skid trail**	**Operational status**
Minor – 15 cm or less compaction[a]	Can be maintained over the length of the trail	None
Moderate – 16 cm to 30 cm of compaction	Can be maintained over the length of the trail	None
Major – 31 cm to 60 cm of compaction	120 m	If maximum distance is greater than 120 m, cease operations on an individual trail. This may include up to 30 m of extreme compaction for an individual trail. If maximum distance is greater than 480 m, cease operation on the landing. This may include up to 120 m of extreme compaction for a landing.
Extreme – compaction greater than 61 cm	30 m	If maximum distance is greater than 30 cm, cease operations on an individual trail. If maximum distance is greater than 120 m, cease operations on the landing.

[a] Compaction refers to rut depth.

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Find us online! www.feric.ca

Eastern Region
580 boul. St-Jean
Pointe-Claire, QC, H9R 3J9
(514) 694–1140
(514) 694–4351
admin@mtl.feric.ca

Western Region
2601 East Mall
Vancouver, BC, V6T 1Z4
(604) 228–1555
(604) 228–0999
admin@vcr.feric.ca

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