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Harvesting with the protection of small merchantable stems: costs and implementation

Author
Deric Hillman
Eastern Division

Abstract

From the summer of 2001 to the winter of 2003, FERIC studied several harvesting operations in Quebec to determine the productivities and costs of harvesting with the protection of small merchantable stems (HPSMS). The observations included both cut-to-length and full-tree systems. The cut-to-length system with a single-grip harvester produced wood at a lower cost in HPSMS than in harvesting with the protection of regeneration and soils (HPRS). With a feller-buncher, the cost was higher in HPSMS than in HPRS. The report presents a summary of the operational trials of HPSMS and provides guidelines to help managers implement this type of operation.

Keywords:

Harvesting, Harvesting with the protection of small merchantable stems, Harvesting with the protection of regeneration and soils, Cut-to-length harvesting system, Full-tree harvesting system.

Introduction

In Quebec, the most common prescription for softwood forests is harvesting with the protection of regeneration and soils (HPRS). This consists of a type of clearcutting in which machine travel is limited to widely spaced trails so as to limit the area of the site subject to disturbance and to protect advance regeneration. In softwood stands with irregular or multilayered structures, HPRS is not always the most appropriate treatment. These stands have variable proportions of stems with marginally merchantable dimensions (10 and 12 cm DBH) that could contribute significantly to the future stand's volume. These small stems are expensive to harvest, decrease the lumber yield, and add little to the total volume harvested (Légère and Gingras 1998). Harvesting with the protection of small merchantable stems (HPSMS) resembles an HPRS operation, but stems 10 to 12 cm in DBH (sometimes up to 16 cm) are protected.

The present report discusses the operational aspects of HPSMS with the machines typically used in harvesting operations in eastern Canada. Monitoring the response of stands treated by means of HPSMS is currently the subject of research projects by Laval University, the University of Quebec in Abitibi-Témiscamingue, and Quebec's Ministère des Ressources Naturelles. Currently, HPSMS is only permitted in Quebec as an experimental treatment, but the scientific advisory committee responsible for Quebec's forest management manual has recently proposed that HPSMS become an admissible treatment in the next version of the manual (Government of Quebec 2002).

Operations studied

To cover the full range of conditions in the province of Quebec, FERIC visited cut-to-length and full-tree operations in the Laurentians, on the North Shore, in the Gaspé region, and in the Abitibi and Lac St-Jean regions. Terrain conditions varied greatly from one operation to another. We observed two different cut-to-length systems: a two-machine system comprising a single-grip harvester followed by a forwarder, and a three-machine system comprising a feller-buncher, a processor working at the stump, and a forwarder. In the latter system, the feller-buncher arranged trees perpendicular to the trails to facilitate the processor's work.

In the full-tree system, all the operations we studied used a feller-buncher, followed by a grapple skidder or a clambunk skidder. Our trials focused both on conventional HPSMS operations with widely spaced trails and on a two-in-one approach with secondary trails (Légère and Gingras 1998, Meek 2001).

We also observed full-tree operations based on harvesting with the protection of tall regeneration and soils (HPTRS). This approach represents an HPRS operation in which the emphasis is on the protection of regeneration and saplings by maximizing the space between harvesting corridors and avoiding "mowing" of regeneration (brushing) with the harvester head. In this treatment, operators sometimes intentionally leave small merchantable stems (10 to 12 cm in DBH) intact so as to avoid destroying adjacent clumps of regeneration and saplings.

Results

Protection of small merchantable stems

In cut-to-length harvesting, the two-machine system protected the trees better, retaining 60 to 70% of the stems targeted for protection after the treatment (Table 1, Figure 1). The three-machine system provided considerably less protection, and residual stems bore more wounds, often caused by the arrangement and handling of stems in the trails (Figure 2). All the full-tree operations observed in HPSMS were somewhat deficient in terms of protection of the stems to be retained, with results below the 50% level attained in previous studies. Note that in the full-tree operations and the three-machine cut-to-length operations, the operators had a negative attitude towards the HPSMS treatment.

Productivity

Despite the highly variable terrain conditions, multivariate analysis revealed that the variation in productivity for a given treatment is explained primarily by differences in the mean volume of the harvested stems. Adding variables such as the amount of brush (the proportion of regeneration and saplings), firmness of the ground, terrain roughness, and slope did not significantly improve the productivity curves. Based on our observations, other factors such as operator skill and motivation affect productivity considerably more strongly. However, these variables are very subjective and difficult to quantify.

Forest Engineering Research Institute of Canada (FERIC)

Find us Online! www.feric.ca

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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As in previous studies with single-grip harvesters, the greater mean volume of the stems harvested in HPSMS explained the system's higher productivity (Figure 3). In a stand with a mean stem volume of around 0.13 m³, the mean volume of the stems harvested in HPSMS was around 15% greater than that of stems harvested

Table 1. Protection rates in HPSMS as a function of the harvesting system used

	Number of blocks studied	Protection of stems in the classes to be protected (%)[a]
Full-tree systems	2	32
Cut-to-length:		
three-machine system	2	34
Cut-to-length:		
two-machine system	10	65

[a] Some data from Genin et al. (2003 a,b).

Figure 1. View of an HPSMS site after treatment (two-machine cut-to-length system). Note the narrow trail.

Figure 2. Examples of wounds caused by the processor head (at left) and by the machine's rear overhang (at right).

in HPRS (Figure 4). The productivity was thus around 8% higher in HPSMS than in HPRS. This result was smaller than the range of 14 to 15% observed in previous studies (Riopel et al. 2000, Hillman 2002).

The feller-buncher was less productive in HPSMS than in HPRS, in large part because its travel time was around 15% greater. In the traditional harvesting method with widely spaced trails and the two-in-one method with secondary trails, the operators had to move continually to fell trees on either side of the stems to be protected so they could accumulate enough wood to create bunches. Regression equations calculated based on our observations (Figure 5) demonstrate that (for example) at a mean volume of 0.13 m³/stem, the feller-buncher's productivity was around 17% greater in HPRS than in HPSMS.

Cost analysis

Our data show that from the perspective of direct costs, single-grip harvesters perform better in HPSMS than in HPRS. In stands with a mean volume of 0.13 m³/stem, the two-machine cut-to-length system delivered wood to roadside at costs of around \$12.20/m³ in HPSMS and \$12.80/m³ in HPRS, for a cost saving of around 5% in HPSMS. The feller-buncher, on the other hand, worked at a disadvantage in HPSMS. The cost of wood at roadside for the three-machine cut-to-length system was around \$13.00/m³ in HPSMS versus \$12.45/m³ in HPRS. The wood cost at roadside for the full-tree system was around \$10.70/m³ in HPSMS versus \$10.10/m³ in HPRS, which represents an increase of around 6%. In HPTRS, the operators of the feller-bunchers obtained productivities comparable to those in HPRS.

Note that during these short-duration studies, we observed no productivity difference between the HPSMS and HPRS systems for the grapple skidders and forwarders.

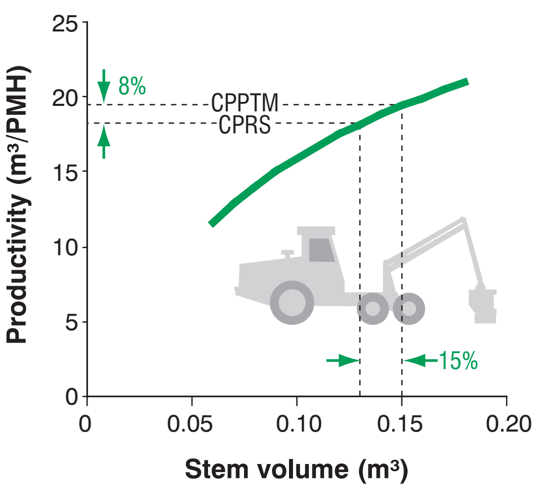

Figure 3. Productivity of the single-grip harvester ($r^2 = 0.31$) as a function of mean stem volume.

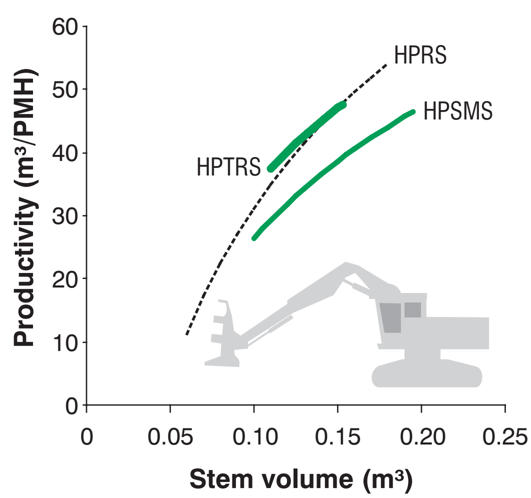

Figure 4. (*left*) An HPSMS site seen from a forest road. Note that the piles contain logs with larger diameters than the residual stems.

Figure 5. (*right*) Productivity of the feller-buncher in HPSMS ($r^2 = 0.16$), HPRS ($r^2 = 0.66$), and HPTRS ($r^2 = 0.30$) as a function of mean stem volume.

Implementation

During the implementation of a new harvesting prescription such as HPSMS, managers should follow a clear, well-defined approach to avoid the operational problems that inevitably arise when a treatment is imposed on unprepared contractors. Here's an example of one such approach for implementing an HPSMS operation:

1. Before beginning the operation, identify the contractors who are most likely to make the treatment succeed. Desirable characteristics for these operators include an openness to new ideas, an interest in ongoing improvement, appropriate harvesting equipment, good technical skills, and an interest in protecting the environment.
2. Communicate clearly with all the staff involved in the process (e.g., foremen, technicians, supervisors) so they understand the company's intention to proceed with the implementation of a new treatment. It's also important to clearly explain the benefits of HPSMS and to remind them that the primary goal is to preserve the maximum number of stems likely to respond well to the treatment.
3. Arrange a meeting with the contractors chosen to do the new work so you can explain HPSMS and the objectives of the treatment. Since these people work every day in the forest, they will be able to figure out how to attain the treatment objectives once they understand the prescription's goal. For operators and supervisors, encourage visits to operations in which the treatment succeeded and meetings with workers who have performed HPSMS operations successfully.
4. At the beginning of the harvesting season, set aside a period of 1 to 2 weeks for training and for trials of HPSMS in easy terrain. It can be beneficial during the first few hours of work to mark stems 10 and 12 cm in DBH that should be protected; this helps operators calibrate their felling decisions. Don't forget that for many years, operators were pressured to recover all stems, and that it can take considerable effort to overcome this conditioning.
5. Throughout the first season, monitor the results and communicate with operators so they can adapt their approach to changing forest conditions and continuously improve the quality of their work.
6. After the first year of operation, repeat the training process with new contractors as well as with existing contractors who did not participate in the HPSMS operations during the previous year, and adjust the training based on your experiences during the first year.

The best results in terms of protection occur in stands with a large component of stems 2 to 12 cm in DBH. In addition, the small stems of stands with irregular or multi-layered structures would be the ones most likely to respond well to the thinning that occurs during HPSMS (Government of Quebec 2002). Thus, it's important to carefully select suitable areas before beginning the treatment. A guide for the selection of stands suitable for HPSMS was proposed in Appendix 1 of the scientific advisory committee's report on HPSMS for Quebec's forest management manual.

Within a heterogeneous cut block, a multi-treatment approach (e.g., HPRS, HPSMS, and HPTRS) should be considered for the stand. A GPS navigation system can facilitate this approach by informing the operator where to change treatments. The system would also let night-shift operators orient themselves within the stand and maintain an acceptable spacing between trails despite the very high density of regeneration and saplings in stands suitable for HPSMS (Forgues 2002, Hillman 2002).

In HPSMS, the volume harvested per km of road can be expected to decrease. Thus, the construction cost ($/m^3) will be amortized over lower volumes. On the other hand, the increased mean volume of the stems hauled on these roads as well as the improved lumber yield (m^3/mfbm) can sometimes compensate for the additional road construction cost per m^3.

With the single-grip harvester, costs should be lower in HPSMS than in HPRS. Based on our observations, articulated, wheeled single-grip harvesters (e.g., Timberjack 1270, Ponsse Ergo, Valmet 901) working with narrow forwarders appear to provide the best results in terms of protection of residuals. These results will improve if the operator uses the full reach of the boom during felling. As much as possible, it's preferable to equip the machines with a long boom or a telescoping extension, as well as a cab-leveling device to provide stability. Avoid machines with a rear overhang, which can increase the width of felling corridors and directly affect protection levels. The forwarder operator must be as well trained as the operator of the single-grip harvester; if not, the forwarder can undermine the work performed during felling.

During harvesting, we recommend piling logs in natural openings or in gaps created by harvesting rather than piling all logs on the same side of the trail. Avoid using good-quality residual stems to brace the logs. We recommend not using an in-woods processor in an HPSMS treatment (the three-machine system), but if you do choose this system, avoid models that require considerable room to maneuver, such as stroke-fed processors.

With a feller-buncher, production costs are likely to be higher in HPSMS than in HPRS. The two-in-one harvesting method with secondary trails always costs around \$0.12/m^3 more than the traditional method with widely spaced trails, but will preserve more saplings and small merchantable stems (Légère and Gingras 1998). However, harvesting with secondary trails is difficult in rough terrain or on steep slopes.

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