Advantage

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Contents

A comparison of the productivity of mechanized clearcutting and selection cuts of hardwood and mixed forests

Abstract

This report summarizes work that was performed at the request of Quebec's Ministère des Ressources Naturelles et de la Faune (MRNFQ) as part of updating their economic models for hardwood forest. The study compared the productivity of mechanized felling in a selection cut with the productivity of the same equipment and operators working in a regeneration cut. This comparison generated regression equations for the productivity of mechanized felling as a function of mean stem volume for each type of cut in hardwood and mixed forests.

Keywords:

Feller-buncher, Felling, Clearcutting, Partial cutting, Hardwood stands, Mixedwood stands, Selection cut, Regeneration cut.

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Introduction

Harvesting of tolerant hardwood forests in Quebec's Crown forests is generally done by selection cuts. These treatments are governed by a series of rules that define the stem selection and protection of the residual stands. In terms of stumpage credits, compensation is provided if the quality criteria are met to cover the additional harvesting costs imposed by the treatment guidelines. It is generally assumed that selection cuts will have increased harvest costs compared to regeneration cuts. The lower volume harvested per hectare, the decreased visibility within the stand, interference from residual stems, and the need to protect these stems and minimize wounds explain the decreased productivity. For some years, mechanized felling using feller-bunchers and manual topping have replaced manual felling and delimbing for these stand treatments. However, no comparison of the productivity of the mechanized felling equipment in selection cuts and regeneration cuts has yet been performed.

The present report summarizes the results of field studies conducted in the winter of 2007–2008 by FPInnovations, Feric Division. This work was performed at the request of Quebec's Ministère des Ressources Naturelles et de la Faune (MRNFQ) during updating of their economic models for hardwood forest. The study was designed to compare the productivity of felling in a selection cut with the productivity of the same equipment and operators working in a regeneration cut.

Study methods

Four operations in the Laurentians and the Ottawa Valley region of Quebec were studied. The forests selected for these studies were designated in the annual management plans as selection treatments with tree marking according to the provincial guidelines in effect for the 2007–2008 season (MRNFQ 2007). For the comparative purposes of the study, special regeneration cut guidelines were prescribed in blocks of around 2 ha that were originally scheduled for selection cuts. The work instructions provided to the operators for the regeneration cut can be summarized as felling all hardwood stems larger than 24 cm and all softwood stems larger than 10 cm in DBH, without regard to their quality. These conditions are normally favorable for feller-buncher productivity.

The study design comprised similar condition block pairs. In each operation, four time studies of the felling phase were performed: two studies of around 4 productive machine hours (PMH) in the selection cut and two studies of around 4 PMH in the regeneration cut. The treatments observed in each pair were both performed by the same machine and operator under comparable forest conditions. Detailed time and motion studies, combined with measurements of a sample of the harvested stems, were performed to estimate the productivity of the harvesting. The harvested stem volumes were obtained using regional volume tables.

The four operations studied were conducted in stands with different characteristics. They differed in the composition of the forest, terrain conditions, and stand densities, covering a wide range of the conditions that are typical of selection cut operations in Quebec. In general, the terrain was firm with slopes ranging from nil to moderate (<30%). These conditions caused few problems in terms of equipment mobility. Terrain roughness ranged from uniform to rough, and the trail planned network occasionally deviated around obstacles.

Table 1 presents the mean stand information for all the blocks treated in the regeneration and selection cuts.

Before harvesting, the stands in the regeneration cut were comparable, on average, to those in the selection cut. In some cases, the differences in operating conditions between each pair of blocks (regeneration cut + selection cut) were greater than the differences between the overall averages. In the regeneration cut, the harvesting guidelines led to harvesting of stems that were 66% larger than the average standing trees, whereas the selection cut guidelines targeted harvesting of stems 83% larger than the average. Figure 1 shows an area harvested in a regeneration cut and Figure 2 shows a feller-buncher working in a selection cut.

Table 1. Average characteristics of the harvested stands		
	Regeneration cut	**Selection cut**
Density (stems/ha)	425	465
Total basal area (m^2/ha)	24.0	22.9
% hardwood	90	90
% softwood	10	10
Volume per hectare (m^3)	188	176
Mean DBH (cm)	26.8	25.1
Mean stem volume (m^3/stem)	0.44	0.38

Figure 1. Area harvested in the regeneration cut.

Figure 2. A feller-buncher working in a selection cut.

Results and discussion

Table 2 presents the average results for all the productivity studies in this project. By chance, the mean volumes of the harvested stems were essentially identical in the two treatments. As expected, the average productivity in the selection cut was less than that in the regeneration cut. The productivity difference averaged 17.5 m^3/PMH. Given a mean hourly cost of $150/PMH, the difference in the felling cost was slightly less than $1/$m^3$.

Table 3 shows the distribution of the productive time among the various work cycle time elements for a typical feller-buncher. The time required to produce 1 m^3 of wood was higher in a selection cut than in a regeneration cut. The difference in travel time explains most of the increased production time. The distance between the harvested trees and the care required during travel account for most of this difference. The absolute and relative travel times for bunching were slightly higher in the selection cuts. In single-tree selection, positioning of the felled trees to facilitate extraction while minimizing wounds to residual trees is very important, as this makes it easier to meet the quality criteria for the treatment.

The productivity data for the eight pairs of observations were used to create the regression curves presented in Figure 3. The high correlation coefficients (R^2) confirmed the reliability of the regression, since they indicate a small difference between the measured and estimated values. Note that the two curves come closer together as the mean stem volume increases, which indicates that the productivity difference between the two types of cut also decreases.

Table 2. Summary of the productivity results

	Regeneration cut	Selection cut
Total productive time (PMH)	28.9	32.2
Mean volume harvested (m^3/stem)	0.753	0.752
Mean productivity (stems/PMH)	85	62
Mean productivity (m^3/PMH)	64.0	46.6
Productivity difference (m^3/PMH)	17.5	
Mean felling cost ($/h)*	150	150
Mean cost ($/$m^3$)	2.34	3.22
Cost difference ($/$m^3$)	0.88	
Cost difference (%)	38	

* Estimated hourly cost of a feller-buncher working one shift per day. The direct operating cost excludes transportation, supervision, accommodation, profits and other overhead.

Table 3. Times for the work cycle elements

Work cycle elements	Regeneration cut		Selection cut	
	%	min/m³	%	min/m³
Travel	34	0,32	47	0,61
Felling	19	0,18	14	0,18
Brushing	3	0,03	3	0,04
Delimbing or topping	4	0,04	2	0,03
Travel to bunch	7	0,06	8	0,10
Felling unmerchantables	1	0,01	1	0,02
Handling of piles	7	0,06	6	0,07
Bunching	20	0,18	14	0,19
Operational delays	5	0,05	5	0,06
Total	**100**	**0,93**	**100**	**1,30**

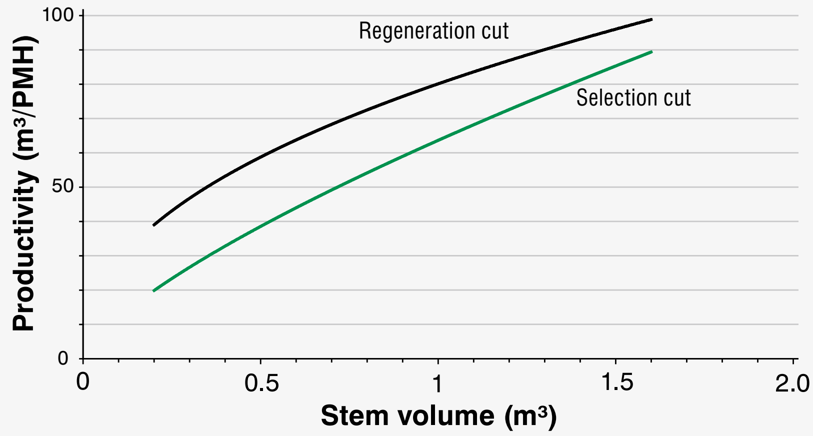

Figure 3. Regression equations for the productivity of the feller-bunchers in the selection cut (Productivity = 63.628 x Vol. $^{0.7227}$, $R^2 = 0.90$) and the regeneration cut (Productivity = 80.097 x Vol. $^{0.4471}$, $R^2 = 0.97$)

Implementation

The partial cutting results presented in this study were obtained in stands marked according to Quebec's provincial guidelines in 2007–2008 and harvested by experienced operators. The removal rate, the operator experience, the trail spacing, and the use (or not) of tree marking are all elements that can greatly affect the operation's productivity. Note that while the estimates provided by the regression equations cover a wide range of conditions, the results may differ in operations with different operational characteristics. Nonetheless, it's helpful to look at these results while keeping in mind that the relative difference between the treatments is the most reliable element of the comparison.

To understand the expected productivity of such operations, it's necessary to consider the effects of the treatment on the mean stem volume that is harvested. The productivity of a feller-buncher in partial cutting is lower than that in a regeneration cut at equal harvested stem volumes, but this difference decreases as the mean harvested stem volume increases. The productivity difference between the two treatments for a given stand can be calculated from the productivities estimated based on the mean harvested stem volume in each treatment. These mean volumes are often different. A fraction of the stems in a stand (typically the largest ones) will be harvested in a selection cut, whereas a regeneration cut will target a larger proportion of the stems (with a smaller mean volume). Figure 4 illustrates how to use the productivity curves in this manner and presents the analysis a manager should perform to properly evaluate the cost impact of the treatment.

For example, for a mean harvested stem volume of 0.80 m^3 in the selection cut, the equivalent mean stem volume harvested in the regeneration cut would be lower at 0.60 m^3. The productivity difference between the two points on these curves is 9.6 m^3/PMH (15%). The accuracy of the estimated mean stem volume that is harvested will be crucial in determining the reliability of the estimated productivity difference.

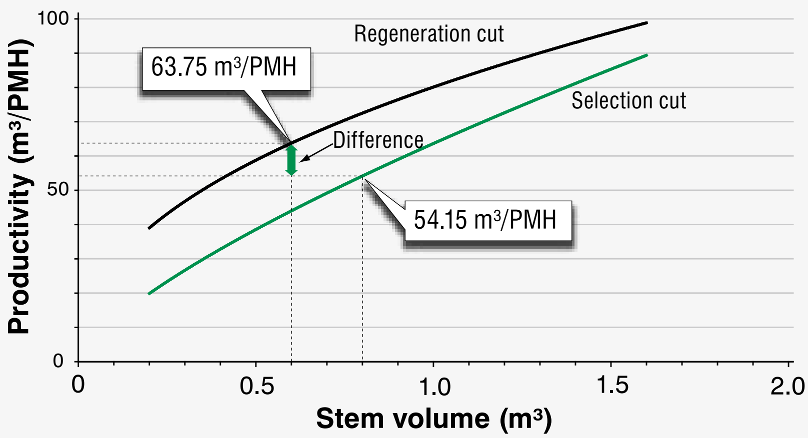

Figure 4. Example of a productivity comparison between the two treatments in a given stand. The cost difference (green arrow) accounts for the differences in the mean harvested stem volume that result from the different treatment prescriptions.

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