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Comparison of product distribution resulting from in-woods versus in-yard hardwood log production

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Abstract

Two methods for producing hardwood logs were studied: semi-length to be bucked at the mill yard and clean logs cut at the stump. For a given tree, equal sawable material can be expected from the two methods. Assessment was based solely on meeting JD Irving's requirements for hardwood sawlogs. The clean log method offers higher pulpwood recovery and does not leave any waste at the stump. The productivity of the clean log harvesting method was lower due to the fact that it was still a relatively new approach.

Context

The value derived from hardwood logs depends on critical decisions made at the log production phase. One widely used method is to harvest and haul the stems in tree-length form to a yard where a specialist cuts them. However, the leftover woody material, due to its inadequate quality, diameter or length, requires disposal. In the best of cases, it might end up as fuel stock but only after having incurred significant harvest and hauling costs.

An alternate method is to process logs at the stump (herein called "clean logs"), thereby leaving woody waste on the cutover and offering potentially better pulpwood recovery, or fewer "*under-lengths*" as the whole tree is available during processing. However, working this way means leaving the bucking decision to the harvesting team. In the case of a fully mechanized cut-to-length (CTL) system, a harvester operator, typically untrained in hardwood log production, would have to learn to make the sophisticated decisions required to recover potential product value.

FPInnovations and JD Irving Ltd conducted a comparative trial of these two methods in early 2010. The objectives of the study were to:

- Characterize the respective product volume of the two processes;
- Assess the initial harvester productivity and cost of the in-woods log production compared with the reference mechanized tree-length method.

Methodology

Two lots of 200 trees were harvested from a site located 7 km northeast of St. Leonard (Dupéré rd). Softwood had previously been removed from the site and study trees were marked. Although the operator of the Volvo FPR2800/Waratah 622 (Figure 1) was new to this activity, he was considered as one of the most productive shortwood forwarder operators (Green River 2008). The operation, namely in clean logs, was subject to many visits from a grader to help him learn about the hardwood log production process. For the purpose of the study, products were piled in their processing order, which deviated from normal practice.

In both scenarios, a team from FPInnovations carried out a detailed time study while noting tree morphology. The tree butts were numbered in order to associate cycle time to product scaling. Characteristics pertaining to log quality were also noted.

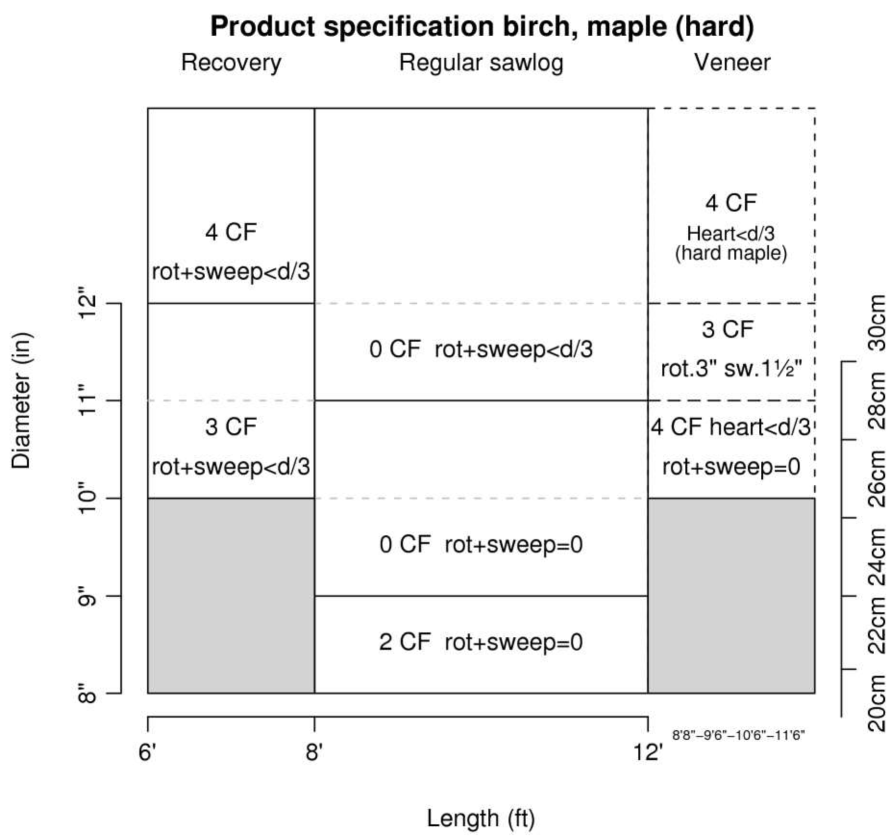
Figure 1: Volvo carrier with Waratah 622 head

Figure 2: Hood 42000 slasher in yard

Semi-lengths were hauled to JD Irving's sawmill yard where a mobile slasher performed bucking. Logs and waste were laid in their processing order for final scaling (Figure 2).

Log grading was done according to JD Irving's product specifications (Figure 3). Generally, four faces were observable in the yard whereas two were on the cutover. An assessment of the sensitivity of the number of observable faces showed that observing only two of four faces would likely cause a 1% variation in sawlog proportion in these conditions. Any veneer was categorized as sawlogs.

Figure 3: JD Irving specifications – hardwoods



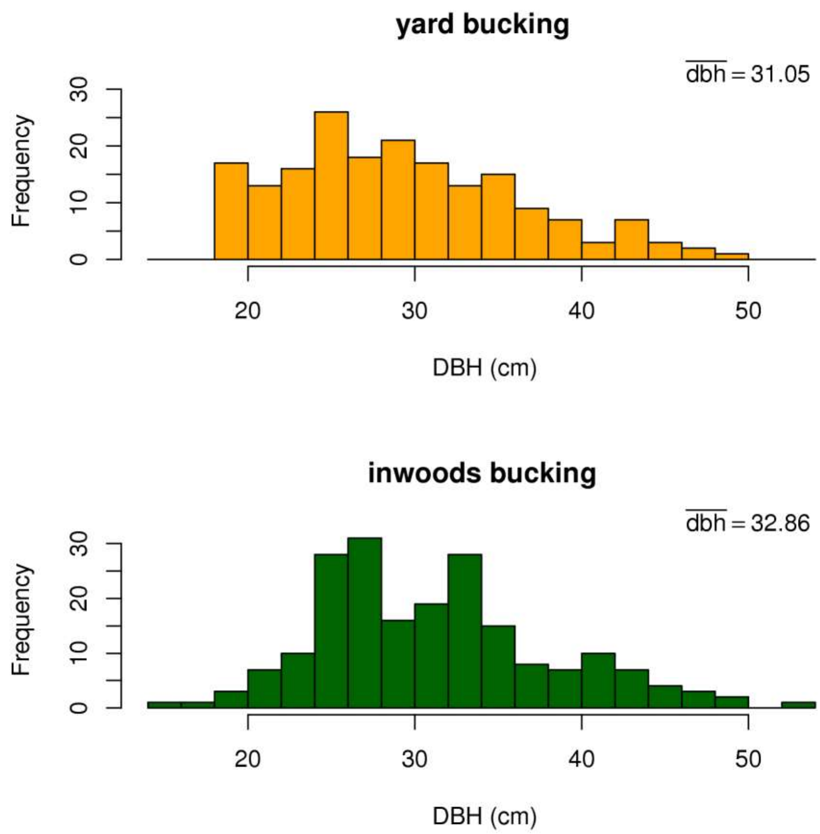
Results and Discussion

Description of lots

Lots showed somewhat different dbh distribution (dbh was measured 1 m from the cut on felled trees, not those standing).

Figure 4 presents dbh frequency for both lots (Δ 1.8 cm). Species-wise, yellow birch dominated in both cases (respectively 78 and 70%). For the purpose of the analysis, species were grouped together, the low number of maples not allowing a valid distinction to be made.

Figure 4: Dbh relative frequency for both lots

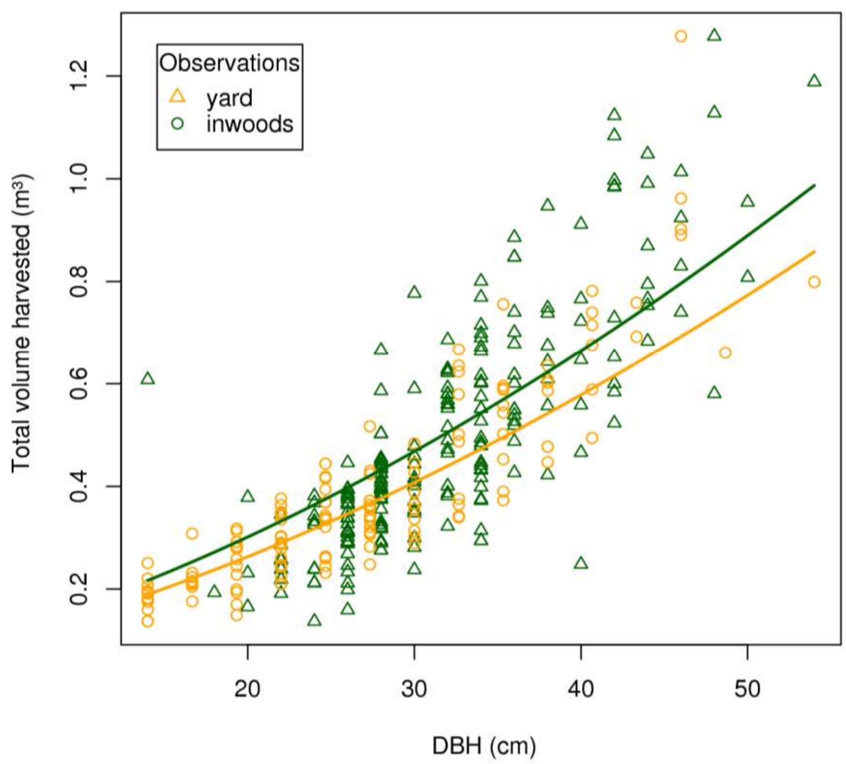


Volumes

Dbh and volumes versus slashing method

Dbh is the common denominator allowing a volume yield comparison for both scenarios. Figure 5 presents scaled volumes as a function of dhb for both lots and their specific curves.

Figure 5: Volume as a function of dbh - semi-length and clean logs



Sawable volume

Notwithstanding average dbh variation between the lots, the 20 dm^3 difference in average sawable volume per log (Table 1) is not statistically significant (t=1.05, p=0.17). Moreover, the dbh spread between 31 et 32.8 cm would alone account for a 10 % increase along the regression curve, thus making the two scenarios equivalent volume-wise. However, nothing beyond sawlog specification conformity can be seen in the data in terms of quality.

Table 1: Average sawable volume per method

Log production method	Semi-length	Clean logs	Variation
n trees	188	201	–
Sawable volume (m^3)	0.132	0 .153	-0.020

Product distribution

Figure 6 presents proportions of products for both methods (all species). Sawable proportions are mostly the same. The waste proportion observed in the yard resulted from cutting out rot, crooks or other defects, but also from the insufficient length of final section to produce a pulp log.

FPInnovations noted (about a dozen cases) some apparently sub-optimal bucking choices both in-woods and at the yard. These observations were made "after the fact" and thus did not provide the full context required to be rigorously assessed. A more elaborate experimental design including the log producers' motives would be needed to do so.

Figure 6

Product proportions - semi-length and clean logs

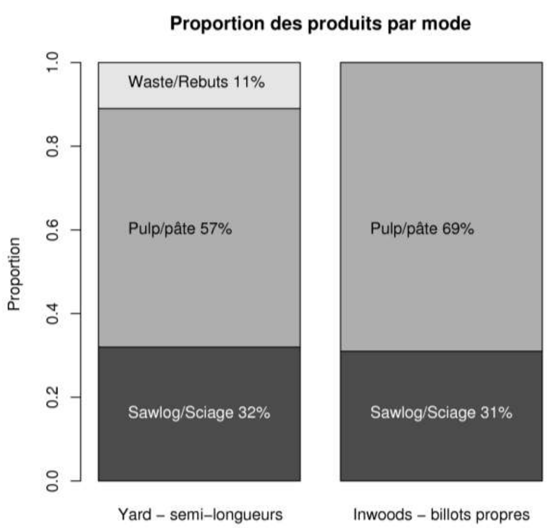
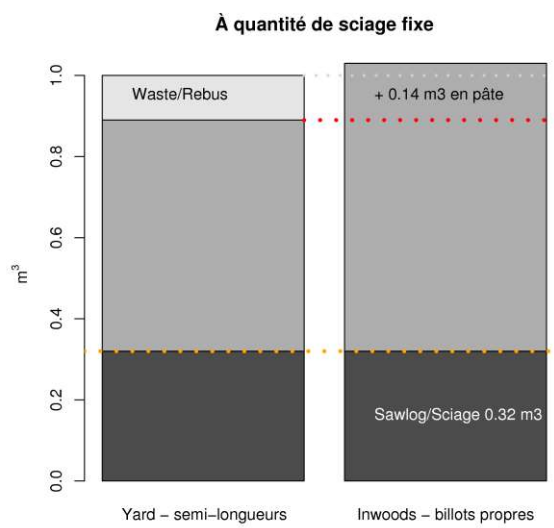


Figure 7

Comparative scenario - equal sawable material basis



Some tops (in-woods) may have had diameters of 20 cm and more on part of their length but no sawable material could be detected in them.

Figure 7 presents the proportion of products for the two scenarios on an equal volume basis. Since sawable volumes appear equal under both methods, a *clean log cubic metre* can be seen as converting part of the waste to pulp thereby increasing recovery. Such assessments are made on a volumetric basis. Effects on the quality of sawable material and on ensuing yield may have economic impacts cancelling potential gains obtained from *promotion* of waste to pulp.

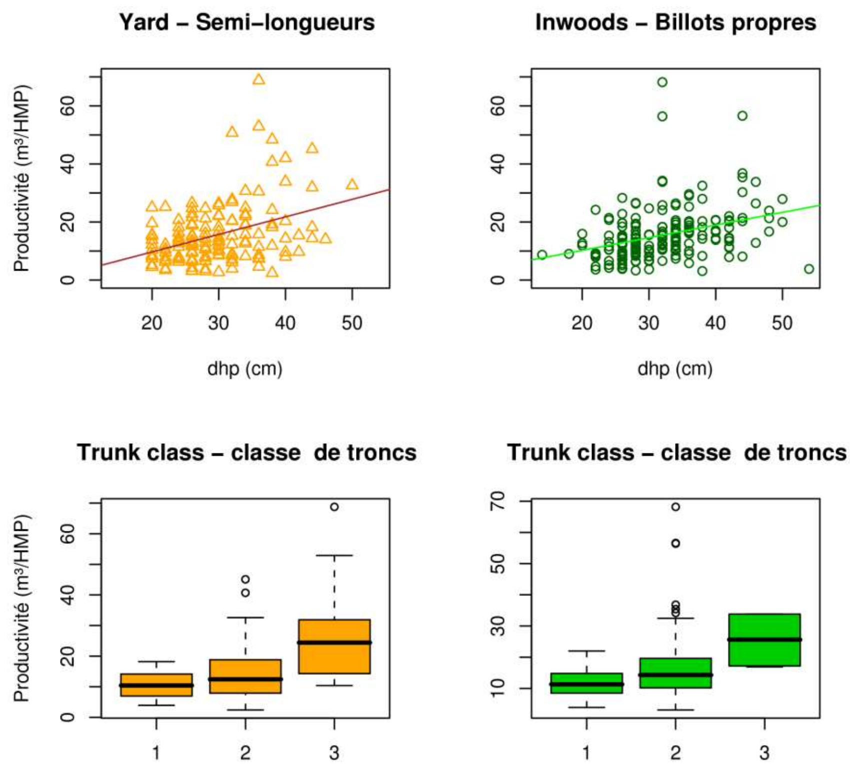
Harvesting productivity

Table 2 presents the results of the detailed time studies. Similar productivities should not conceal the fact that clean logs benefited from large sized trees (dbh of 32 cm). Work cycle elements are mostly identical for the two methods, except for processing which accounts for most of the variations in overall cycle times (0.35 over 0.38 min. total).

Table 2: Results of the detailed time studies.

Duration (PMH)	**5.1**	**8.3**
number of cycles	**144**	**199**
Work cycle elements (min)	**semi-length**	**clean logs**
Move	0.157	0.187
Brush	0.077	0.057
Position	0.414	0.372
Fell and drop	0.31	0.319
Process	1.068	1.421
Delays	0.087	0.140
Total	**2.113**	**2.496**
Volume (m^3)	0.389	0.507
Average dbh (cm)	29.7	32.0
Productivity (trees/PMH)	28.4	24.0
(m^3/PMH)	11.0	12.2
Adjusted productivity (m^3/HMP)	16.9	12.2

Figure 8: Productivity of both methods per dbh and trunk class.



A match between trees and their specific scaling makes it possible to calculate cycle level productivity. The upper part of Figure 8 shows these productivities as a function of average dbh and their corresponding regression curves.

Regressions are statistically significant (t=4.72 *et* t=4.95), but use of the dbh as a predictor reduces variability of results only by a small margin (R^2=0.13 *et* R^2=0.11). Relations are not sufficiently similar among them to allow the use of an additional variable for the method used. The wide variation in processing times and the small slope as a function of dbh in the clean logs scenario may reflect an early learning curve in log production. As an indication, a semi-length scenario with 32 cm average dbh (clean logs Table 2) would result in an adjusted productivity of 16.9 m^3/PMH, a figure much higher than the 12.2 observed.

Among the morphologic factors noted, i.e. trunk and crown, only the trunk class showed a statistically significant effect:

- semi-length: t=6.343, p<0.001;
- clean logs: t=2.473, p=0.0143.

The lower part of Figure 8 shows box plots for three trunk classes:

- class 1: fork height h<5 m;
- class 2: fork 5 m<h<10 m;
- class 3: fork 10 m<h

Class 3 represents a practically fork-exempt trunk and its effect on productivity would be increases resulting from a dbh increase of 14 cm and 10 cm respectively for semi-length and clean logs.

Conclusion

Two lots of 200 hardwood trees from two log production approaches were studied with respect to product distribution and harvesting productivity. The reference method at-the-yard (*semi-length*) and the alternate in-woods method (*clean logs*) both delivered similar sawable material quantities. At equal diameter breast height (dbh), the clean log method yielded more pulpwood while eliminating waste *downstream* of the cutover. The semi-length method produced 11% of its volume as yard waste. In all cases, the wood left in the tops did not contain any sawable material.

The scope of the quality assessment was limited to meeting specifications and the study did not offer a comparative yield that could result from their application.

The clean log harvesting was still a relatively new approach and, all other things being equal, was less productive than its semi-length counterpart. The cycle-based productivity showed wide variation and use of the dbh as a *predictor* only slightly reduced this variability. As for qualitative classes, trees branching at heights above 10 m offered higher productivities while other parameters such as crown class and species showed no effect.

Acknowledgments

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