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Contents

Productivities of various types of harvesting equipment in white birch stands

Abstract

For some years, demand for white birch has been increasing in eastern Canada. However, some contractors have noticed that harvesting this species requires greater effort than that required to harvest softwoods or poplar. This report presents productivity data for seven types of forestry machines used in eastern Canadian to harvest this species. The data permit a comparison of equipment productivity during the harvesting of the white birch, poplar, and softwood species present in the operations that we studied. We have also estimated the harvesting costs as a function of the species and type of equipment, the observed productivities, and the site characteristics.

Keywords:

Productivity, White birch, Poplar, Feller-buncher, Single-grip harvester, Shortwood forwarder, Grapple skidder, Delimber, Roadside processor, Slasher, Harvesting cost.

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Introduction

At the northern limit of its distribution, white birch was formerly considered a marginal species and was only rarely harvested. Today, however, white birch has become a coveted species, not just because of the scarcity of fiber, but also because of improvements in the processing methods available to mills and the opening of specialized mills.

Currently, due to a lack of good information, the rates paid for harvesting white birch are often established based on the harvesting cost for poplar or softwoods. However, some contractors claim that this price does not recognize the additional effort required to harvest this species, particularly because of the characteristics of white birch that make it more difficult (and thus more expensive) to harvest.

To determine the validity of these claims, FERIC performed comparative studies with seven different types of equipment that are used to harvest white birch, poplar, and softwoods. This report presents the results of these studies.

Readers should note that these results represent a limited sample of machines, operators, and sites. Thus, the results don't necessarily apply to other sites, where different factors could affect the performance of the machines and their operators. The results should thus be considered solely as an indication of the potential magnitude of the productivity difference in harvesting these different species.

Operations studied

From the fall of 2003 to the summer of 2004, FERIC visited operations harvesting a mixture of white birch and other species. Table 1 presents a summary of the sites, operations, and machines that we studied.

Physical characteristics of white birch

Certain morphological characteristics of white birch differ from those of other species (softwoods and poplar) and can affect the productivity of harvesting machines (Figure 1):

- The strength and large size of the branches;
- The large tops relative to the branch-free stem (that is, the first branches occur close to the stump);
- The relatively low proportion of merchantable volume contained in the stem compared with that contained in the branches;
- The hardness of the fiber;
- The high frequency of forks;
- Curvature of the stem.

For these reasons, harvesting white birch resembles the harvesting of tolerant hardwoods more closely than it does the harvesting of other boreal species.

Two other general characteristics can affect productivity:

- For comparable diameters at the stump, white birch has less merchantable volume than (for example) poplar;
- In typical mixedwood stands, the birches are almost always smaller than the poplars.

Table 1. Description of the sites, operations, and machines observed by FERIC

Province Region Terrain (CPPA class)	Ontario Wawa and Chapleau 2.1.1	Ontario Shining Tree 1.2.1	Saskatchewan Hudson Bay 1.1.1
Stand	42% white birch 42% poplar 8% spruce–fir 8% maple and other hardwood	54% white birch 26% fir–spruce 5% poplar 15% maple, pine, cedar, and yellow birch	50% white birch 50% poplar
Machines studied	• Single-grip harvester • Shortwood forwarder	• Feller-buncher • Grapple skidder • Delimber • Slasher	• Roadside processor

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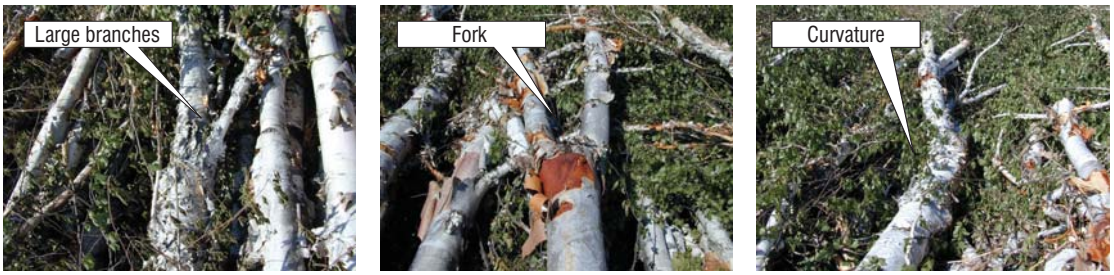


Figure 1. Common difficulties encountered in white birch: large branches (left), forks (center), and curvature of the stem (right).

Results

Single-grip harvester

Figure 2 presents the productivity results for the single-grip harvester, with the productivity for the three species groups plotted as a function of the mean stem volume. It's clear that the productivity of the single-grip harvester when harvesting birch is difficult to directly compare with that of poplar, which always had a greater volume. In stands where both species are found, it would thus be desirable to use a different rate for each species. This rate should be established as a function of the mean stem volume harvested for each species, as opposed to a fixed rate per m³ for the overall group of species, throughout the operating season.

In terms of productivity, it is easier to compare the birch with the softwood at an equivalent volume per stem, since the mean stem volumes overlap. For example, under the study conditions at a mean stem volume of 0.2 m³/stem, the productivity of the single-grip harvester was 28% greater with the softwoods than with white birch. As is the case with the poplar, it would thus be justifiable to pay different rates per m³ for harvesting the softwoods and the white birch. The rate per m³ paid for the birch should account for the additional effort required to harvest this species.

Difficulties during the delimbing of white birch were the main factor that affected the productivity of the single-grip harvester. Despite the use of the topping saw, the operator lost considerable time attempting to recover the last logs towards the top of the stem after encountering the first big branches.

Note that each of the points in the productivity figures (Figures 2 to 8) represents a single time and motion study. The duration of a study varied from a few hours to a complete shift, depending on the operating conditions (e.g., the operator schedules, scheduled preventive maintenance, machine travel, different stands).

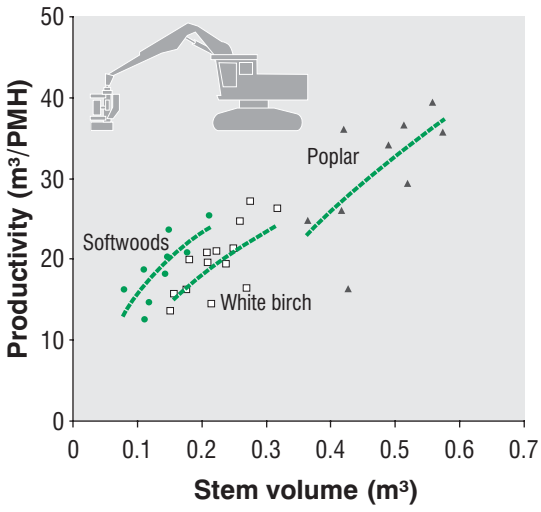


Figure 2. Productivity of the single-grip harvester as a function of the species being harvested.

Shortwood forwarder

The observations of the shortwood forwarder took place in the same operation as with the single-grip harvester.

The data we collected indicates that at our study site, the forwarder was about 15% more productive with the poplar. It's important to note that the productivity of a forwarder will be primarily determined by the mean volume of the logs and stems, and thus, by the harvested species, the average extraction distance, the payload per trip, the mean pile volume, the number of products to sort, the length of the logs (e.g., 2.5 m versus 5.1 m), and the dispersion of the products on the cutover (Favreau 2001, Gingras and Favreau 2002).

Since the data we gathered were all for very long extraction distances, the productivity curves in Figure 3 come from a model developed for each species that includes constant times (loading, maneuvering, unloading), unloaded travel speed, loaded travel speed, and mean payload volume per trip.

Feller-buncher

It was also difficult to directly compare the data for the feller-buncher harvesting white birch and poplar because at the study site, the mean volume of the harvested poplars was considerably larger than the mean volume of the white birch (Figure 4).

The recorded productivities of the feller-buncher suggest higher productivity when harvesting white birch compared with harvesting softwoods in the same stands. At a volume of 0.2 m³/stem for both species, the average productivity with the birch was 35 m³/PMH, versus 22 m³/PMH with the softwoods. The low productivity with the softwoods can be explained by the dispersion of these stems over the cutover. On average, the number of softwood stems harvested per work cycle was 1.8, versus 2.8 for the birch. Note that the productivity observed with the softwoods was lower than the mean results for Ontario from FERIC's database, which estimates a productivity of around 40 m³/PMH for the stem volumes observed at our study site.

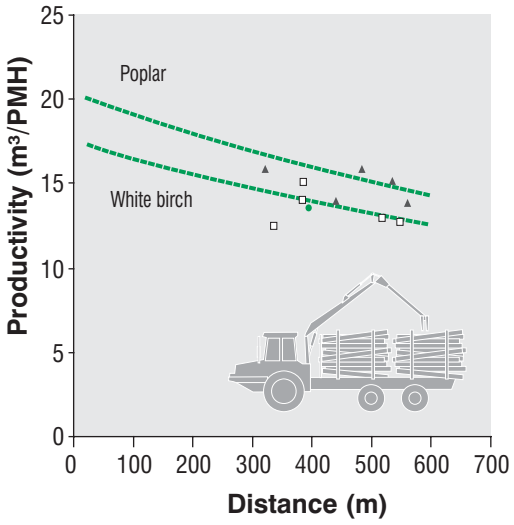


Figure 3. (*left*) Productivity of the shortwood forwarder as a function of extraction distance and the species being extracted.

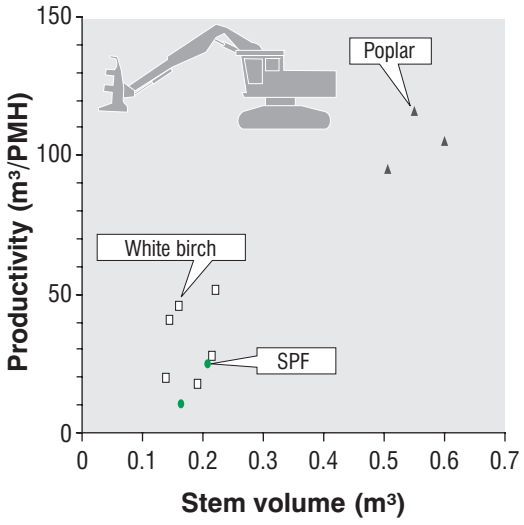


Figure 4. (*right*) Productivity of the feller-buncher as a function of the species being harvested.

Grapple skidder

Figure 5. presents the productivities measured for the grapple skidder as a function of species.

Because the data we collected were primarily for very short distances, the productivity curves in Figure 5 come from a model developed for each specie that accounts for constant times (loading, maneuvering, unloading), unloaded travel speed, loaded travel speed, and mean volume per trip.

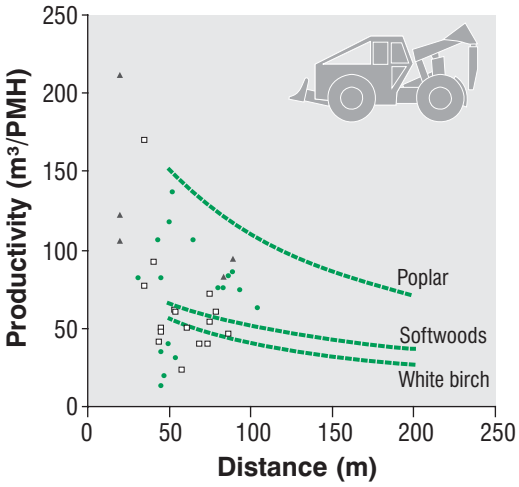
Note that the mean productivity of the grapple skidders we observed during the study was high in comparison with the overall results from previous FERIC studies. The reason for this is that the skidders had a high payload capacity (Caterpillar 535 and 525) and were working on favorable terrain. The average payload of the grapple skidders was around 3 m³ (all species combined).

Certain factors explain the lower productivity observed with the birch. During our studies, we noticed that the white birch with large tops caused problems during maneuvering of the grapple, and this was particularly problematic where the operator encountered a large number of residual stems. The mean grapple load as a function of the species also affected productivity. The mean load was 2.6 m³ for the birch, versus 2.9 m³ for the softwoods and 3.6 m³ for the poplar.

Delimber

Here again, it was difficult to directly compare the productivity of the delimber when working with the poplar and the birch, primarily because the birch never had a volume comparable to that of the poplars (Figure 6).

The delimbing productivity with white birch was higher than with the softwoods in the operation we studied because the operator did not have to delimb the entire stem. This was because the objective was to recover logs in lengths of 420 cm (14 ft) without attempting to recover the entire volume. This approach decreased cycle times, but also led to the loss of fiber contained in the tops. The productivity of the delimber with white birch would have been significantly lower if the work had been performed in a region where the harvesting regulations forbid operators to leave merchantable fiber in the delimbing areas.



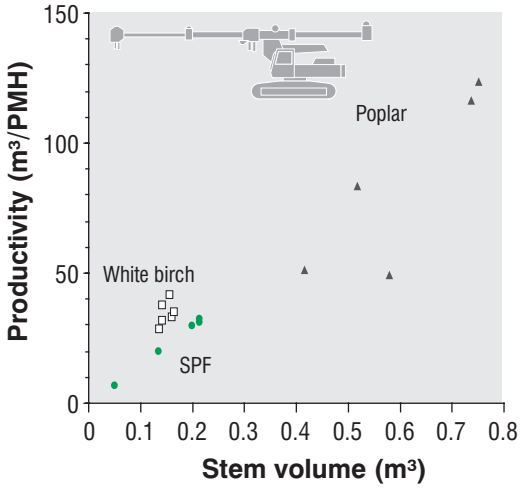


Figure 5. (*left*) Productivity of the grapple skidder as a function of the species being extracted.

Figure 6. (*right*) Productivity of the roadside delimber as a function of the species being delimbed.

Slasher

Because the slasher handled stems that had already been delimbed, topped, and sorted by species, its productivity (Figure 7) was primarily influenced by the mean stem volume, the pile volume, and the distance between piles. In the region where our study took place, the higher mean volume of the poplar stems led to higher productivity with this species than with white birch.

Roadside processor

In light of the data for the roadside processor (Figure 8), it was again difficult to directly compare the productivity between the white birch and the poplar.

Although the mean volume of the white birch logs was 56% less than that of the poplar, the processing cycle proved to be longer (103%). This is because the stronger branches of the birch required the operator to use the topping saw 46% of the time, versus only 16% with the poplar. During the processing of white birch, most delays were caused by breakage of the topping saw's chain, something that did not happen with the poplar. Chain breakage occurred primarily during cutting near branches and forks.

At a comparable stem volume (0.4 m³/stem), the productivity observed with the white birch (around 11 m³/PMH) was well below that of other processors we have observed processing tolerant hardwoods, which averaged around 16 m³/PMH (Hillman 2002). Without accounting for other contributing factors, this suggests that the operator we observed working with the birch may have been less skilful than those in previous studies with tolerant hardwoods.

Costs

Table 2 summarizes the harvesting costs in the systems we studied as a function of the productivities obtained during our field studies. Because the hourly cost attributed to various machines varies widely, depending on the region, Table 2 presents the relative difference (%) in the harvesting costs for white birch and softwoods.

Obviously, the relative differences can vary depending on several factors. The main ones include the operator's relative skill in dealing with one species versus another, the distribution of each species on the cutover, and the mean stem volume of each species, as well as

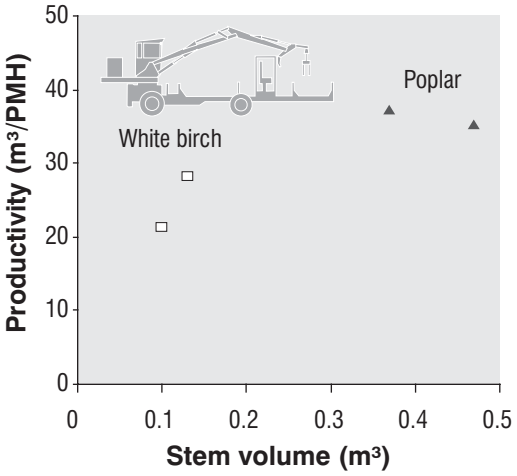


Figure 7. (*left*) Productivity of the slasher as a function of the species being processed.

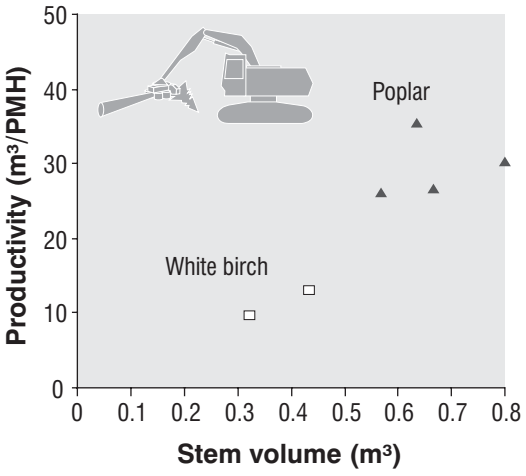


Figure 8. (*right*) Productivity of the roadside processor as a function of the species.

Table 2. Comparative harvesting costs in the two systems that FERIC studied for softwoods and white birch

	Softwoods (@ 0.2 m³/stem)	White birch (@ 0.2 m³/stem)
Shortwood system, two machines	100%	114%
Conventional full-tree system (without slashing)	100%	79%

their general morphology in the operating area, the type of felling or processing head being used, and the local regulations concerning whether merchantable fiber can be left in delimbing areas.

For the two-machine shortwood system, the lower productivity of the single-grip harvester working in birch increased the relative production cost for birch by 14%.

In the conventional full-tree system, the production cost for birch was 21% lower than for the softwoods because of the greater productivity of the delimber measured during FERIC's study. In that operation, there was less effort to recover tops with the birch, so that delimber productivity was greater than with softwoods.

In the studies, the mean stem volume of the white birch was systematically lower than the mean stem volume of even the smallest poplars. A direct comparison of production costs for these two species is thus impossible. However, since poplar is usually larger than the birch in a given stand, it's clear that the production cost will be considerably lower for poplar. These findings suggest the application of a rate that reflects the mean volume of each species when harvesting stands that contain both poplar and white birch.

Implementation

- It is difficult to directly compare the productivities (volume/hour) when working with species that have highly different morphological characteristics and when the mean volumes are typically quite different, as is generally the case with white birch and poplar, which are often found in the same mixedwood stands in the boreal forest. Our observations suggest that the birch generally had a smaller merchantable volume than the poplar in the same stands. It would thus be desirable to establish a table of rates that reflects the difficulty of harvesting the birch and the proportion of species in the stands being harvested.
- During our studies, the softwoods and the white birch we observed were generally of similar stem volume. However, the morphological characteristics of the softwoods generally led to higher harvest productivity. It would thus be desirable to use a different rate per m³ for these two types of wood.
- The harvesting cost related to the feller-buncher should be determined as a function of the mean volume of the

overall stand, since during harvesting, stems of various species are often mixed together. Thereafter, a correction factor is required based on the effort required to separate the products. It is simpler for the feller-buncher to separate hardwoods and softwoods than it would be to separate each species in the stand, which might be difficult, particularly if the stems of different species are found in heterogeneous mixtures.

- For forestry machines, it is necessary to remember that each additional species to sort will reduce the overall productivity. Adding a new species to the harvest plan (e.g., white birch) increases the number of products to extract, and thus leads to greater dispersion of the products on the cutover (Favreau 2001, Gingras and Favreau 2002).
- Harvesting of birch should be performed by contractors with equipment that is well-adapted to the difficulties of processing this species. Even with equipment that appears appropriate, the contractors will experience increased breakdowns. The characteristics of the equipment selected for harvesting white birch are similar to those that have been proposed for harvesting tolerant hardwoods, particularly in terms of the single-grip head and the processing or delimbing heads:
  - Large and robust;
  - Equipped with a topping saw;
  - Extra-strong delimbing knives; and
  - Heavy-duty (3/4 in. steel minimum) holding structure for the delimbing knives.

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