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Report for Forintek Members

Maximizing the Value of Hardwoods through Intensive Silviculture

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Resource Assessment

Lumber Manufacturing – Eastern Region

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ABSTRACT

This study shows that partial cutting in sugar maple stands has a series of effects on tree growth and stem quality of residual trees, as well as on product recovery. Forest managers can use it to improve stand quality and value. On the other hand, partial cutting may lead to logging damage, which will reduce stem quality and value; proper practices should therefore be defined in such a way as to minimize such damage. This study indicates that the product value of individual sugar maple trees increases steadily until the breast height diameter (DBH) reaches approximately 45 cm, and then tends to decrease due to rot and other defects.

INTRODUCTION

Sugar maple and beech are major eastern Canadian hardwoods. Their wood is used to manufacture a number of high-value products. While the overall quality of the hardwood resource has decreased over the last decade, prices have experienced a continuous upward trend over the same period. This leads to a need for increasing value recovery at the processing level. More efficient management and utilization of this valuable resource will contribute significantly to the sustainable growth of the hardwood industry.

Partial cutting has been a common silvicultural practice to improve the quality and value of maple and beech stands. Traditionally, the focus has been on tree growth and stand yield (wood volume). The quality of a volume unit of wood can be quite variable, however, and this is particularly true in hardwoods. For example, the lightcoloured sugar maple sapwood is highly valued for value-added appearance products, whereas the dark-coloured heartwood produces only low-value products. To define improved forest management strategies, it is therefore important to quantify the impact of partial cutting on the forest-wood value chain. Any management strategy that reduces internal defects or increases sapwood content in sugar maple and beech trees will significantly increase the value of the trees, but we need to better understand relationships between tree/stand/site characteristics, internal log characteristics and product recovery.

Methodology

The study site was located on Crown lands in the Parry Sound District near Huntsville, Ontario. It is part of the Great Lakes St. Lawrence forest region, which is characterized by well-drained soils on granitic bedrock. The stand was uneven-aged and dominated by sugar maple and American beech. A single-tree selection partial harvest in the fall and winter of 1983-1984 preceded the establishment of 12 experimental plots. Tree marking had been done by the Ontario Ministry of Natural Resources (OMNR), and harvesting by Weldwood of Canada Incorporated.

Stand growth response in the trial was evaluated: 1) after 16 years following selection harvesting in all plots, and 2) after 20 years (whole cutting cycle) in plots that were measured again in 2003-2004 (plots 1 to 5, and 12). Trees of all commercial species were grouped according to health status. As defined in the Ontario Tree Marking Guide (2004), AGS (acceptable growing stock) trees have an appearance suggesting that they can reasonably be expected to contribute significantly to future crops in the form of vigorous, high quality stems, while UGS (unacceptable growing stock) trees are high risk and expected to decline over the next cutting cycle. UGS trees may also be of poor form and/or low quality and cannot reasonably be expected to improve in quality.

In the stand, plots 1, 2 and 3 were clear-cut in August 2003 as part of this study. Of stand basal area (BA), approximately 97% (24.1 of the 24.8 m^2/ha available), including all stems larger than 20 cm DBH, were removed. In total, 68 sugar maple and 27 American beech trees were harvested. The stems were bucked into sawlogs using Petro & Calvert (1976) grading criteria that allowed selection of the optimal bucking pattern. The logs were graded according to the Ontario Scaling Manual, log grading system (OMNR, 2000). The sawlogs were shipped to the Forintek sawmill and carefully sawn. Lumber products were graded according to the National Hardwood Lumber Association rules (NHLA, 2000). Boards were priced on the basis of average mill gate prices. Lumber values were calculated as the summation of the nominal value given to each board generated from a log. Pulp logs were also scaled, and their value was assessed with a constant conversion factor of $65.00 per bone-dry metric ton (bdmt) of chip, delivered to the mill. All prices were obtained from studies conducted by Forintek in Central Ontario.

Results and discussion

1. *Individual Tree Growth Response*

For both observation periods, species and size class were the only significant variables explaining DBH and BA growth rate variations (p was <0.0001 in almost all cases). As beech responded to the partial cut better than maple, further analyses were conducted separately for the two species. Generally, poles also grew faster than sawlogs. As tree size still explained most of the growth rate variation within each species, size class was included as a co-variable in the models to ensure that no hidden size effect distorted the quality or damage class analyses.

As with beech, growth rates in sugar maple were mainly affected by tree size class. Growth rate expressed on a relative basis decreased dramatically with increasing tree size. For both observation periods, poles had significantly higher relative DBH and BA growth rates than trees of all other size classes ($p<0.0001$ in all cases). Between 1983 and 1999, large and medium sawlogs showed the highest average BA increment, and they grew significantly faster than poles. Medium sawlogs also had a higher average BA growth rate than small sawlogs. Poles showed significantly higher DBH growth rates than small sawlogs for both observation periods. Overall, damage class had no significant effect on average and relative DBH and BA growth rates in sugar maple. From 1983 to 1999, AGS sugar maple trees showed a greater BA increment than UGS ones.

2. *Volume, Products and Value Recovery*

Volume recovery, lumber yield and product value in sugar maple increased constantly with increasing tree size. Merchantable volume yield was closely related to size class, with large sawlogs having the maximum volume. Product value and lumber yield were comparable for medium and large sawlogs, and, in both cases, higher than for poles and small sawlogs. However, when expressed on a volume basis ($/$m^3$), only medium and small sawlogs had significantly higher product value than pole trees. Quality class had a significant effect on product value ($ and $/$m^3$) in sugar maple: stems with quality attributes corresponding to AGS trees showed greater averages than low quality stems (UGS trees) in both cases. Other dependent variables remained unaffected by stem quality class, and no significant effect was found for damage class overall.

Total product value recovery after clear cutting in plots 1 to 3 was $15,773.44/ha. Sugar maple yielded approximately 109 m^3/ha, i.e., 68 m^3/ha (62%) in lumber and 41 m^3/ha (38%) in pulp products. The beech yielded about 22 m^3/ha, i.e., 7 m^3/ha (32%) in lumber and 15 m^3/ha

(68%) in pulp products. Overall, 45% of the total volume harvested (47% of the lumber volume and 44% of the pulp volume) consisted of AGS trees. It is worth noting that the UGS trees yielded 8,697 bf/ha; their value per lumber volume unit was, however, much lower than the value recovered from AGS trees: $160/m^3$ for UGS rather than $213/m^3$ for AGS.

3. *Discussion*

Stand growth response after the 1983 single-tree selection harvest was rather low. For both observation periods, in-growth was good, but slow survivor growth and high mortality rates negatively affected stand BA reconstruction. If logging damage was directly responsible for the death of the wounded trees that died after the cut, then a loss of 0.58 m^2/ha (all plots) and 0.18 m^2/ha (plots 1 to 5 and 12) could have been avoided 16 and 20 years after the harvest through the adoption of more careful logging practices. However, this would have had little effect on average mortality rates. Indeed, the most obvious explanation for the relatively high mortality is that many weak trees were left standing to meet structural stand targets and wildlife needs. Unfortunately, no detailed stand data are available to evaluate size and quality status structure prior to the 1983 harvest, which makes it impossible to quantify the level of stand quality improvement achieved through tree marking. The operation was carried out in strict adherence to state-of-the-art rules for single-tree selection silviculture in 1983, with the aim of improving stand quality following treatment. While we are confident that a degree of quality improvement was actually achieved, many stands with a high grade history would require two or three cutting cycles to attain the target structure and quality level required for optimum stand growth.

As already stated, tree species and size were the most important variables explaining tree growth response in DBH and BA following selection harvesting. Overall, a strong reaction was observed in poles, with lower growth response in sawn timber classes. Majcen and Richard (1995), Majcen (1995, 1997) and Bédard and Majcen (2001, 2003) also observed a stronger growth response in stems smaller than 30 cm in DBH. Nevertheless, since tree value is proportionally related to tree size, it is economically justified to keep large trees standing as long as they are gaining volume without losing quality.

The differences observed between sugar maple and American beech in terms of individual tree growth reaction rates may be related to the fact that American beech trees occupied lower dominance classes and younger age classes than the sugar maple trees. Young and suppressed trees of shade-tolerant species are more likely to benefit from the gaps created by a selection cut.

The absence of any quality or damage class effect on growth parameters is somewhat surprising. However, it seems obvious that cull, weak and severely damaged trees were more likely to die when left standing. In this study, approximately 15% of the trees that died in the years following the cut had been severely impacted by logging operations. In addition, both stand volume production and lumber yield are likely to be negatively affected in the long term if these damaged and poor quality stems remain on the site. However, future tree marking activities and harvests (on a 20-year cutting cycle) will target many of these poorer quality stems, resulting in a more healthy and vigorous stand.

Sugar maple outperformed American beech with respect to lumber volume, board-foot units and product value. This may be due to: 1) the sugar maple trees being larger than the beech trees, and 2) maple lumber having a higher market value than beech lumber. For both species, volume, lumber and value recovery increased with increasing tree size. In sugar maple, product value peaked in the medium sawlog class for UGS trees. This is probably the consequence of degradation processes affecting large trees with low quality attributes. There were, unfortunately, insufficient data to assess the average product value of large AGS maple trees. Nevertheless, given the much greater value of medium AGS trees over UGS trees of the same size, growing large quality stems in sugar maple dominated stands appears to economically desirable.

While we are confident that a degree of quality improvement was actually achieved, many stands with a high grade history would require two or three cutting cycles to attain the target structure and quality level required for optimum stand growth.

Benefits and Implementation Costs

Partial cutting has become an increasingly important silvicultural practice for tolerant hardwoods in eastern Canada. It can change species composition, stand structure and growth. More importantly, this silvicultural practice will improve the diameter growth and stem quality of residual trees, and thus increase the product quality and value of the treated stands. Although this study did not include an economic analysis, limited work indicated that partial cutting is economically feasible. The study suggests that sugar maple trees should be harvested at a DBH of approximately 45 cm for maximum value.

Conclusion

This study revealed that stand growth rates after a single-tree selection harvest were slightly lower than expected after the first cutting cycle. Within only one rotation, however, stand quality had largely improved: the proportion of AGS trees had more than doubled in 20 years. Since UGS trees are likely to show slower growth and suffer from decay with aging, stand productivity is also expected to improve over future cutting cycles. Finally, considering that stem quality largely determines lumber product value in hardwoods, logging operations conducted without care can have serious negative consequences on both stand growth and product yield. This study indicates that tree value increases steadily with DBH until it reaches approximately 45 cm, and then tends to decrease due to rot and other defects.

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Report Available

The report entitled ***Maximizing the Value of Hardwoods through Intensive Silviculture*** (E-4107) is available to Forintek members. Please contact:

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