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Commercial Thinning to Enhance Quality in Tolerant Hardwood Stands

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Technical Note

Silviculture

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INTRODUCTION

Managing tolerant hardwood stands for high quality sawlog production is an important aspect of current hardwood silviculture in southeastern Canada. Even-aged stands are thinned to increase survivor tree growth, adjust species composition, and increase proportion of higher quality stems in the residual stand. Change in stand density also affects natural pruning of lower branches which is important for stem quality development of an individual trees. While natural pruning increases clear bole length, dead branch stubs work as entry points for pathogens that induce discoloration. This will eventually lead towards stem decay if the stubs are not sealed off quickly. Presence of knots, decay and discoloured wood column (commonly known as dark heart) are the major defects that downgrade hardwood logs.

In this context, it is important to know when and how to thin hardwood stands to produce maximum volume of high quality sawlogs. Therefore, the case study I assessed the effect of stand density on tree stem properties. Case study II examined whether different intensities of commercial thinning re-allocated growth potential to better quality trees of desired species in a young even-aged hardwood stand with stratified mixture of different tree species. The results are combined to discuss and provide some silviculture implications.

HIGHLIGHTS

- **Thinning (stand density management) is a silvicultural tool for growing hardwoods for quality logs.**
- **During the early stage of stand development (QMB < 15cm), maintain higher stand density for promoting natural pruning (Q-line in Figure 6).**
- **At pole stage (QMD ≥ 15cm), thin stand to B-line (Figure 6) to increase growth.**
- **Free thinning helps to maintain desired species composition and enhance stand quality.**

METHODOLOGY

Case study I:

In 2005, a 15-ha commercial thinning experiment was established in a stand that was regenerated after clear felling in 1965 or about, in northwestern New Brunswick. Although the stand was largely dominated by yellow birch, significant proportion of shade intolerant (white birch and trembling aspen) and shade tolerant species (American beech and sugar maple) were present. Four different thinning treatments (control (0% removal), light thinning (15-25% removal), moderate thinning (26-35% removal) and heavy thinning (36-40% removal)) were randomly applied in five different blocks. The thinning treatment was similar to free thinning in which trees were removed from all diameter classes. Commercially less desirable tree species (mostly beech, softwoods and other hardwood species) and other poor quality trees were removed to reduce competition for good quality trees of commercially valuable species (sugar maple and yellow birch). Rectangular, 400 m^2 permanent sample plots (approx. 11m x 36.4m) were established in each treatment unit prior to harvest. Trees (DBH > 2cm) in the plots were tagged, numbered, and measured systematically. Plots were re-visited immediately after treatment to tally survivors and were re-measured in 2015. Tree form and risk class was assigned to each living tree in 2015 using the tree classification system for New Brunswick (Pelletier et al. 2016). While managing hardwood stands for high quality products, on the one hand, landowners should consider whether the site is optimally used by higher quality stems of desired species. On the other hand, it is equally important to make sure every crop tree produces maximum volume of high quality products. Therefore, data (crown size, growth rate, and stem properties) coming from a sample of 60 sugar maple and 60 yellow birch trees that were destructively sampled outside the permanent plot of this thinning experiment was used to assess the effects of stand density on wood quality of individual trees (Case study I).

Case study II:

This study assessed whether the site was optimally used by higher quality stems of desired species in plots that were subject to different intensity thinnings. For this, three components of stand basal area increment were computed and compared among different levels of treatments using the data measured in 2005 and 2015. These components are: (i) the basal area increment due to survivor growth (BAI_{SG}), (ii) the basal area increment due to ingrowth (BAI_{IG}); and (iii) the basal area loss due to mortality (BA_{ML}). Average basal area proportion of different species in merchantable tree (DBH >10cm) class at different levels of thinning treatment was computed and compared between 2005 and 2015 to assess the change in species composition. In addition, tree risk and form class information was used to assess the proportion of acceptable growing stock (AGS) in different intensity thinning plots (for detail: Pelletier et al. 2016).

RESULTS

Case study I: Producing higher volume of high quality products.

Trees were sensitive to competition (stand density). While higher level of competition increased bole length due to natural pruning of lower branches, increased competition for light and nutrients reduced growth rate of the tree (Figure 1). The results of this study showed that the time required to seal a branch stub depends on its size (length and diameter) and growth rate of the tree (Figure 2). Smaller branch stubs were sealed faster. Moreover, rapidly growing trees sealed branch stubs faster. Branch stubs that were open for a long period provided entry point for micro-organisms that induced decay and discolouration (e.g.: Figure 2B). In addition, late pruning left larger branch stubs and thus larger knotty core (Figure 3, Tree 1).

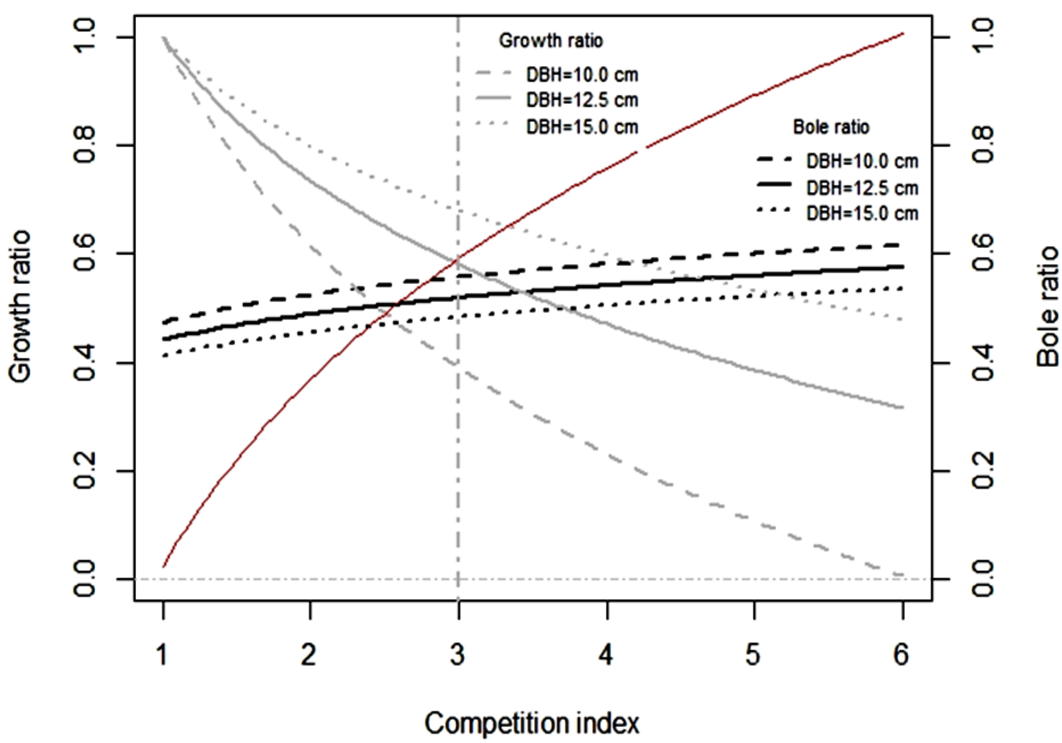

Figure 1: Comparison of growth ratio (Basal area increment of a tree/Basal area increment of a tree growing in no competition) and bole ratio (branch free bole length/tree height) across the gradient of competition index. Vertical gray line is the point of compromise for balancing tree growth and branch free bole.

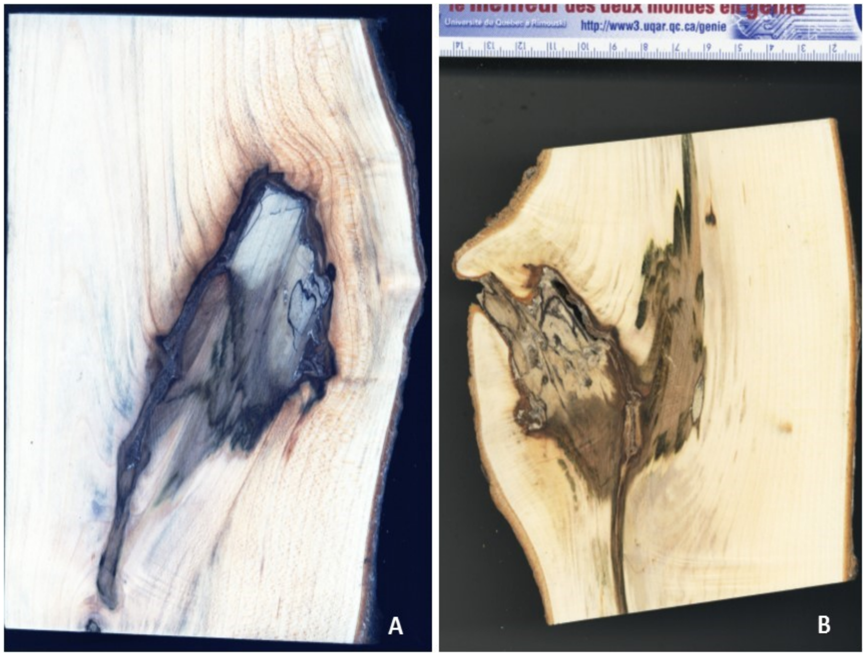

Figure 2: Radial section through branches of sugar maple that were dead in 2000 (A) and 1997 (B).

Figure 2A: Branch 'A' was 2.9 cm in diameter and the stub was 2.1 cm long. The branch died in 2000 and the stub was closed in 2007. This tree was growing in dominant crown position with an average radial increment at breast height between 2000 and 2007 of 0.179 cm/year.

Figure 2B: Branch 'B' was 3.2 cm in diameter and the stub was 5.6 cm long. The branch died in 1997 and the stub was not closed until 2016. This tree was growing in intermediate crown position with an average radial increment at breast height between 1997 and 2015 of 0.128 cm/year. Calluses grew more rapidly from above than below in both cases. Note that the dead branch part has already started to decay and there was larger extent of discoloration in 'B'.

Larger knotty core generally reduces high grade lumber recovery ratio. For example, in Figure 3, tree (2) yields more clear boards than tree (1) as tree (1) has a smaller knotty core than tree (2). Therefore, it is important to achieve the 5 m long branch-free bole when trees are small. This will not only reduce size of knotty core but also reduce the size and occurrence of decay and discolouration in trees. Smaller trees have smaller dead branches that leave smaller branch stubs. Once the desired bole length is achieved, lower levels of competition provide better growth conditions to crop trees that helps to seal dead branch stub faster.

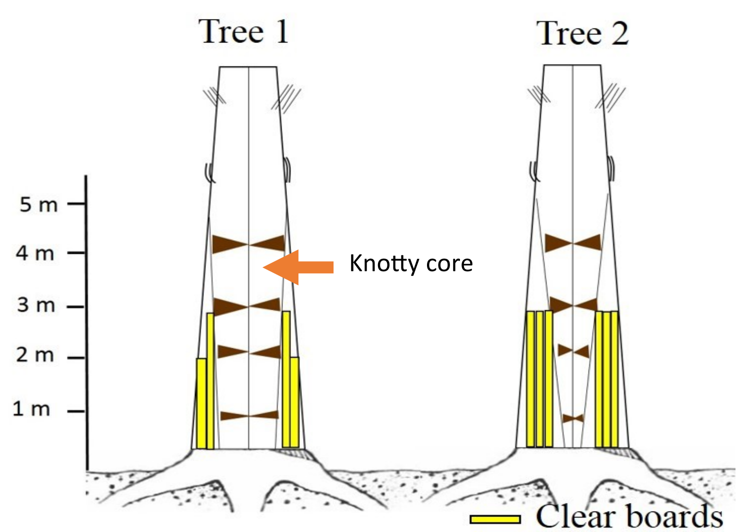

Figure 3: Distribution of clear wood from late-pruning (Tree 1) and early self-pruning (Tree 2)

Case study II: Re-allocating growth potential to better quality trees of desired species.

There was higher net basal area increment (BAI) in thinned plots than in control. BAI due to ingrowth did not significantly vary among treatments. Thinned plots had higher BAI due to survivor growth and lower basal area loss due to mortality but the difference was not statistically significant than control plots. Similarly, no significant difference on stand growth characteristics was observed among three different levels of thinning treatments (Figure 4). However, % basal area growth (plot level) was significantly higher in thinned plots than in control when only the trees that were greater than 10 cm DBH were compared (Results not shown).

Thinning treatment left higher proportions of SM and YB in thinned plots, which contributed to maintain significantly higher proportions of SM and YB in thinned plots (Table 1). There were larger proportions of beech in control and 30% removal (medium) plots compared to other treatment levels (Figure 5).

The ratio between acceptable growing stocks (AGS) to unacceptable growing stock (UGS) increased significantly in high intensity thinning (40% removal) plots than in control. Beech proportion was found to be one of the contributing factor to reduced proportion of acceptable growing stock in control and medium intensity thinning (30% removal) plots (Figure 5).

Table 1: Sugar maple (SM) and yellow birch (YB) basal area proportion (%) in 2005 (post-treatment) and in 2015.

Treatment	Year	
	2005	2015
Control (0% removal)	44	55
Low (20% removal)	72	76
Medium (30% removal)	62	66
High (40% removal)	76	84

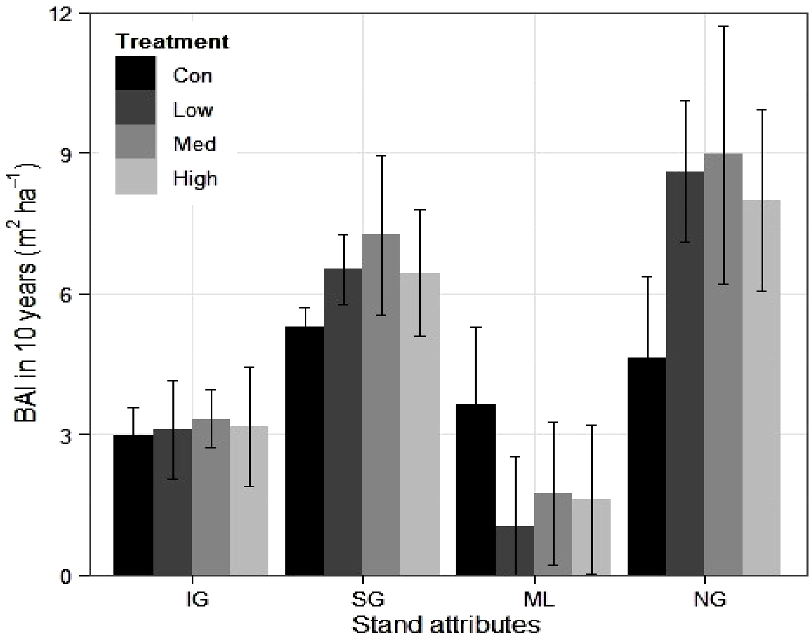

Figure 4: Mean basal area increment in 10 years period at different levels of thinning treatments. IG = In-growth, SG = Survivor growth, ML = Mortality, NG = Net growth. Error bars indicate 95% confidence intervals. Con = Control, Low = 20%, Med = 30%, High = 40% removal.

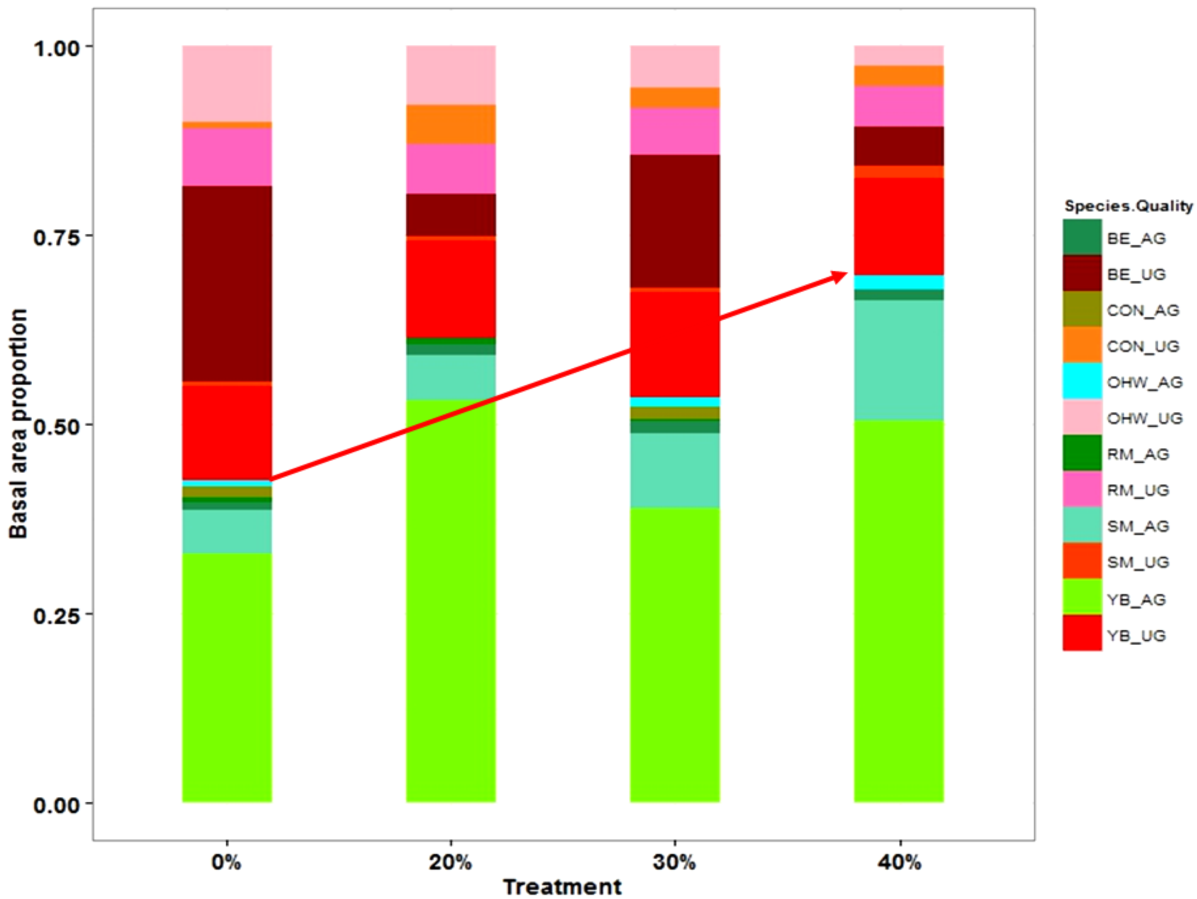

Figure 5: Proportion of acceptable growing stock (AGS) and unacceptable growing stock (UGS) in each treatment (Tukey HSD test: AGS/UGS ratio in 40% removal > AGS/UGS ratio in control; p-value < 0.05) observed in 2015. BE = American beech, CON = conifers, OHW = other hardwoods, RM = red maple, SM = sugar maple, YB = yellow birch. AG = acceptable growing stock, UG = unacceptable growing stock.

CONCLUSION

Case study I highlights the four must-have features that should be considered while growing hardwoods for quality logs, namely (1) longer branch free bole (at least first 5 m), (2) faster occlusion of dead branch stubs, (3) smaller knotty core, and (4) low or minimum decay and discolouration. For fulfilling these conditions, when artificial pruning is not a silvicultural option, stand density management in even-aged stands or in even-aged patches in uneven-aged stands is a useful tool for silviculturists. Competition during sapling or early pole stages of a tree leaves smaller dead branch stubs that will occlude faster with no or minimum decay/discolouration. This will produce butt logs with smaller knotty core.

Case study II results indicate that commercial thinning at the pole stage leaving residual stand condition with an average residual basal area = 12 m^2/ha and mean stand diameter = 15.2cm improves growth, maintains desired species composition and enhances stand quality. Therefore, to produce high quality saw-logs, as suggested by Smith et al. (1997), free thinning is recommended when managing yellow birch dominated even-aged stratified mixture stands. Both sugar maple and yellow birch crop trees should be selected from the dominant and co-dominant crown positions. Good quality sugar maple trees can also be selected from intermediate crown position. Then the stand should be thinned to release the selected crop trees. However, it is important to maintain optimum residual stocking and uniform distribution of the crop trees for optimum utilisation of the site's potential. Since this was a case study from a site located in northwest New Brunswick, caution should be exercised when extrapolating the results to other northern tolerant hardwood regions.

FIELD EXECUTION

When young even-aged hardwood stands are managed for producing high quality logs, the two-phase stand density management approach developed in Europe (Spiecker et al. 2009) is recommended. The stocking guide calibrated for even-aged hardwood stands in northwest New Brunswick (Figure 6) is suggested to be used as a tool to implement this approach. At first, management focus is to promote natural pruning until the crop trees have 5m long clear bole. At this stage, the stocking level should be around the Q-line (refer to Figure 6).

In phase two, when crop trees have their first 5m branch-free bole, the management goal is to speed up the diameter growth of crop trees. In hardwood stands around northern New Brunswick, the quadratic mean diameter of a stand is around 15cm or greater for most trees having a clear bole in their first 5m. This is the time to thin the stand to the 'B' line.

Even though the total wood production of a stand is roughly the same at any level of stocking between 'A' and 'B' lines, thinning stands to 'B' line increases net growth and favours product development. When stands are around the 'A' line, growth is distributed among many trees of different quality classes. Individual tree growth rates are slow, and some of the growth potential is wasted on poor quality trees that are going to die soon. To the contrary, when stands are thinned to 'B' line, the growth is distributed among fewer trees of good quality. In this condition, the growth is accumulated in better quality stems that will yield higher volume of high-quality product in future.

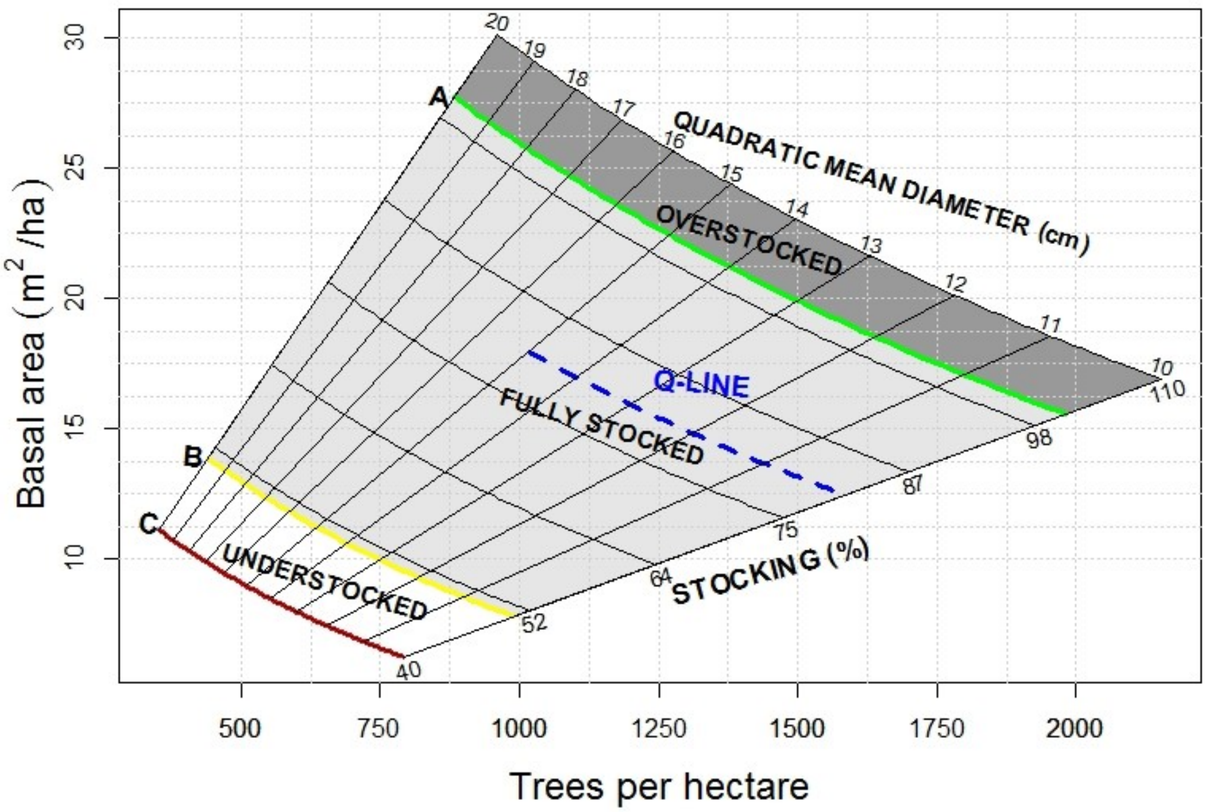

Figure 6: Stocking guide (developed by: Gingrich, 1967) calibrated for tolerant hardwood stands in northwest New Brunswick. 'A' line: maximum stocking for undisturbed stands of average structure. 'B' line: the lower limit of stocking needed for full occupancy of the site. 'C' line: stocking level which is expected to reach the 'B' level within 10 years, 'Q' line: stocking level suggested to ensure natural pruning.

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