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Institut de recherche sur les feuillus nordiques Inc.
Northern Hardwoods Research Institute Inc.

Considering Pre-commercial Thinning in Tolerant Hardwood Stands

June 2017

Technical Note

Silviculture

INTRODUCTION

Managing hardwood stands for high quality sawlog production is an important issue of current hardwood silviculture in southeastern Canada. Different intermediate treatments (pre-commercial and commercial thinnings) are applied in early stage of stand development to release crop trees in overstocked stands in order to prevent stagnation and increase growth rate. We are still unclear about the timing of the first thinning, but stand dynamics theory suggests that a stand should be thinned when canopy closure initiates stem exclusion process. In a pure stand, trees of the same species will have different crown position (Figure 1) as some trees grow faster than their competitors. With the canopy closure, there will be

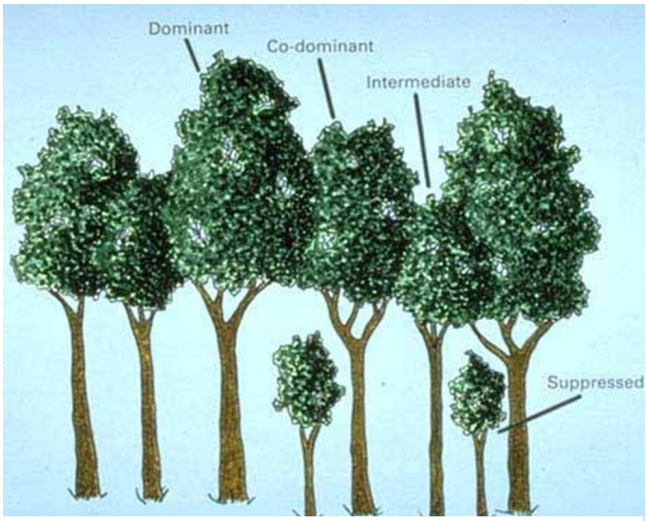

Figure 1: Pictorial representation of the crown position of trees in a stand. Source: http://extension.umn.edu/distribution/naturalresources/images/3473-12.jpg

HIGHLIGHTS

- **Dominant tree growth is less affected by competition during early stages of stand development.**
- **Growth rate of dominant trees peaked around 25-30 years.**
- **Thinning can be delayed until 25-30 years of stand age when there are enough crop trees in dominant crown position in order to improve crop tree stem quality.**

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(1) a density related mortality of intermediate and suppressed trees, and (2) a competition related growth reduction of dominant and co-dominant trees. However, in a mixed stand, the crown stratification will be based on species specific growth rate and their level of shade tolerance. Shade tolerant species may survive and grow well even in intermediate or suppressed crown positions. Past growth rate analysis of different crown position trees growing in an undisturbed stand condition must indicate when the competition related growth starts declining. The first thinning should be applied when tree growth rate starts declining due to competition. To validate the theory, a retrospective growth assessment of different crown position yellow birch trees was conducted using dendrochronology to identify the timing of the first thinning.

METHODOLOGY

For this study, 60 yellow birch trees were selected from different crown positions (Table 1) from a commercial thinning experiment which is located in northwest New Brunswick. Tree DBH, height, height to base of live crown and crown diameter were measured prior to felling. After felling the trees, 2.5 cm thick stem disks were taken at the breast height and transported to the laboratory. The disks were sanded using an electric sander with 180-grit at first and then 320-grit sandpaper until the annual rings were clearly visible. The sanded samples were scanned with an Epson DS-70000 scanner to get a high resolution scanned images (1200 dpi).

Table 1: Sample tree characteristics in 2015. DBH = Diameter at breast height. BLC = Height to base of live crown. CD = Crown diameter.

Crown	n	DBH	Height	BLC	CD
Dominant	20	19.93	16.70	7.01	5.59
Co-dominant	20	13.90	15.10	7.30	3.86
Intermediate	20	10.50	13.10	7.02	3.04

In the scanned image of disks sampled at breast height, the width of each growth ring was measured using ImageJ software. Tree rings were measured in two radial directions and the measurements were averaged to obtain mean tree chronologies. This information was used to calculate annual increment of individual tree basal area (BAI). BAI prior to year of thinning (2005) were regressed with breast height age and tree crown position in 2015 using a nonlinear mixed effect modeling approach (Equation 1).

$$BAI = (B_1 + b_i + CP) \times e^{(-B_2 \times AGE)} \times (1 - e^{(-(B_2+CP)\times AGE)}) \quad (1)$$

Where: BAI = Annual increment of individual tree basal area (cm^2/year)

Age = Breast height age (years)

CP = Crown position of the sample tree in 2015

B_1 and B_2 are fixed effect and b_i is the tree level random effect parameters to be estimated.

RESULTS AND DISCUSSION

Different BAI growth patterns were observed for different crown position trees (Figure 2A). Average BAI varied significantly among different crown position trees, being highest for dominant trees and the lowest for intermediate crown position trees (Table 2). Dominant trees' BAI peaked at around 20 to 25 years of breast-height age, whereas co-dominant and intermediate trees' BAI peaked at around 10 to 15 years of breast-height age (Figure 2B). Average dominant tree diameter for a given stand age was found similar to the trees that were subject to pre-commercial thinning with 2.8m×2.8m spacing at 11 years of stand age (Figure 3A). However, average co-dominant and intermediate tree diameter observed in this study was found lower than the average diameter of the trees that were subject to pre-commercial thinning (Figure 3B and 3C).

The results indicate that the competition related growth decline varies depending on the crown position of the tree. Growth rate of the trees in dominant crown position is least affected due to competition in the beginning of the stand development compared to co-dominant or intermediate trees. These results have very important implications when making pre-commercial thinning decisions in yellow birch dominated hardwood stands that are managed for high quality sawlog production. When timber production is an objective, we need about 300 good quality trees per hectare at the time of final harvest. These crop trees must be tended so well that the trees have faster diameter growth without compromising stem quality. Therefore, this study suggests that thinning can be delayed until 25–30 years of stand age when there are enough crop trees in dominant crown position. Keeping stands at high density for longer helps with self-pruning of the crop trees.

Table 2: Parameters estimates for Equation 1.

Parameters	CP	Estimate	P-value
B_1		27.83	<0.01
	Dominant	31.05	<0.01
	Co-dominant	0	
	Intermediate	-8.76	<0.05
B_2		0.07	<0.01
	Dominant	-0.02	<0.01
	Co-dominant	0	
	Intermediate	0.01	0.14
R-squared		0.68	

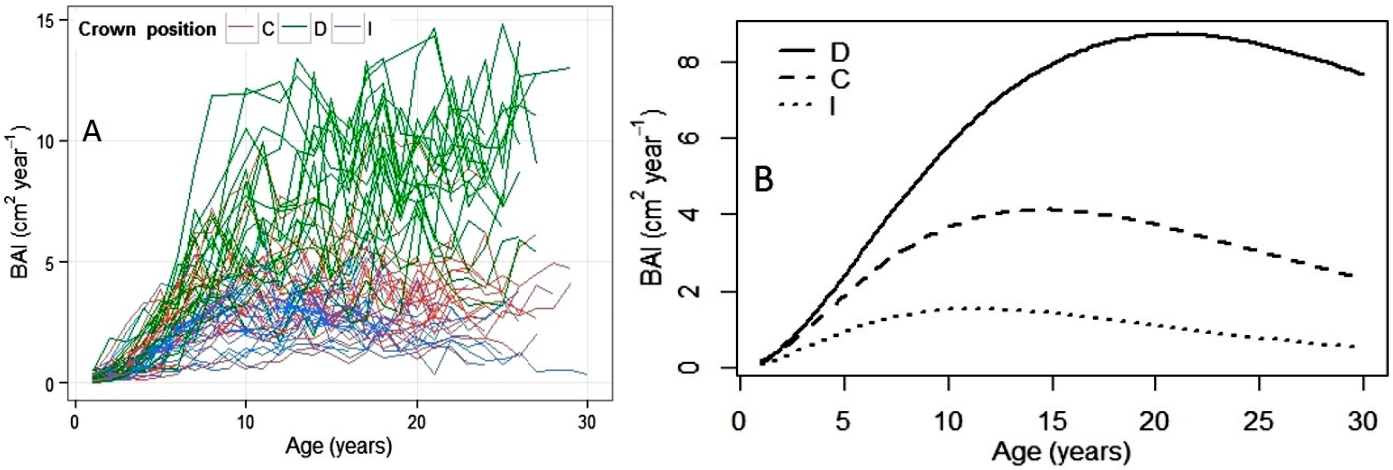


Figure 2: Yellow birch basal area growth trajectories (A) and growth curve projected by the model (B).

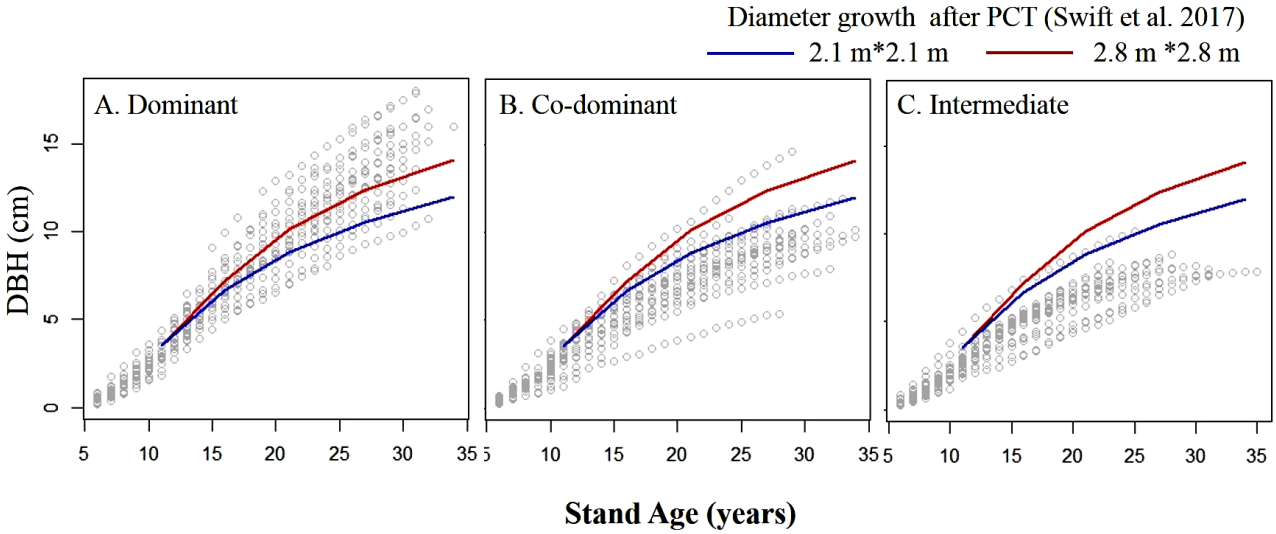


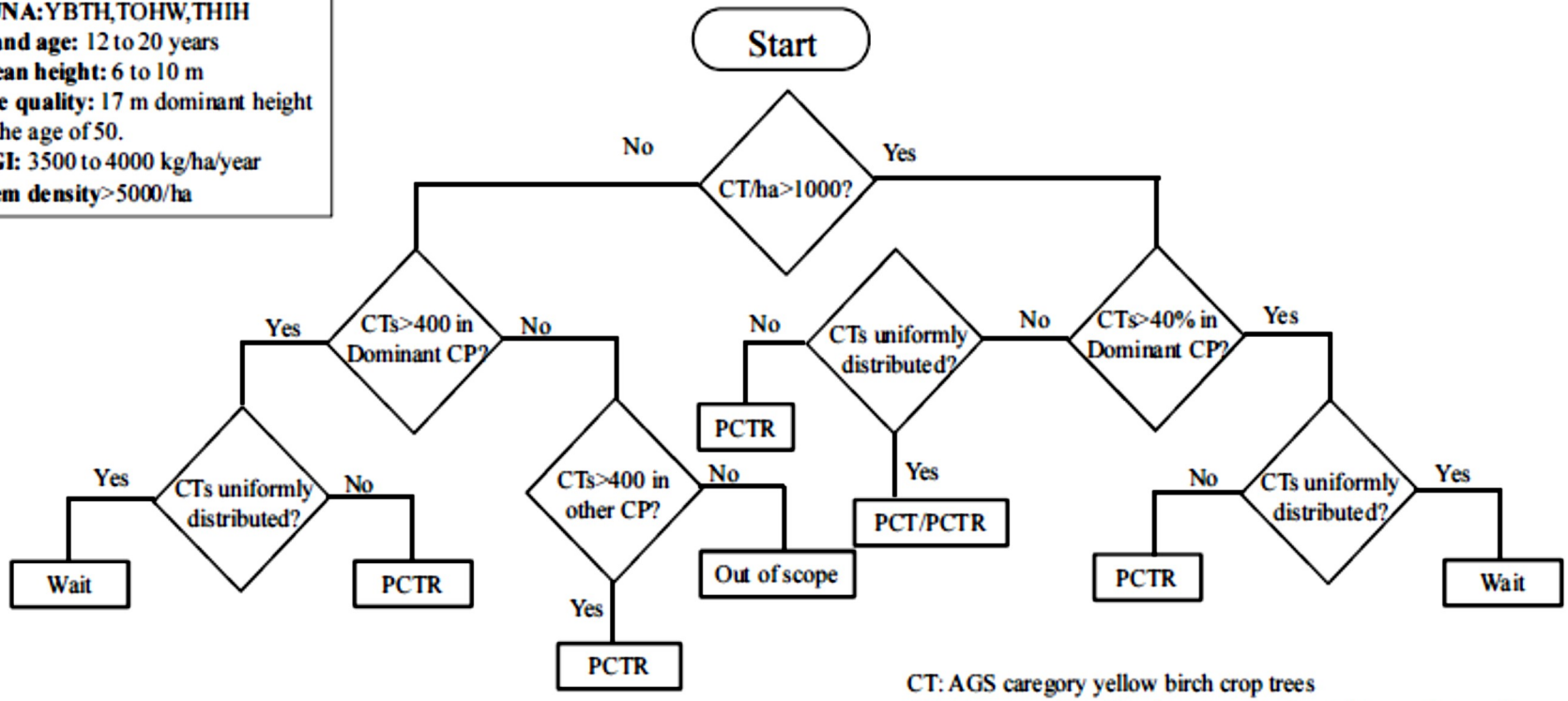
Figure 3: Diameter growth comparison between trees in an undisturbed stand and a stand subject to PCT. DBH= over bark diameter in cm. Stand age=breast height age + years to reach breast height.

OPERATIONAL IMPLEMENTATION

Based on research findings obtained from intermediate treatment initiative at the NHRI, a decision key (Figure 4) is proposed to help determine thinning needs for young, even-aged hardwood stands that are managed for high quality sawlog production. The key is proposed for three FUNA types (YBTH, TOHW, THIH) where there is a possibility of finding enough yellow birch crop trees that can be tended for quality sawlog. Such stands (age: 12 to 20 years, mean height: 6 to 10 m) with more than 5000 stems/ha are eligible for this key. In the key, there are four different treatment options: (1) wait until commercial thinning, (2) pre-commercial thinning, (3) pre-commercial thinning with crop tree release variant, and (4) out of scope, which are explained below:

1) *WAIT: It is suggested to wait until commercial thinning if a stand has more than 400 uniformly distributed crop trees in dominant crown position. Since dominant tree growth is least affected by competition, in this situation, stem quality is the management focus.*
2) *PCT: Pre-commercial thinning is suggested when there are more than 1000 uniformly distributed crop trees/ha but more than 60% of them are not dominant. In this situation, the treatment focus is to release the crop trees that are in co-dominant or intermediate crown position. Since the stems are uniformly distributed throughout the stand, it is better to apply PCT. This will give more choice for crop tree selection in future as risk and form class of trees will be clearer and this will reduce the risk of selecting wrong tree.*
3) *PCTR: Pre-commercial thinning with crop tree release variant is suggested when (1) there are less than 1000 crop trees/ha, (2) less than 400 crop trees are in dominant crown position, and (3) the crop trees are not uniformly distributed throughout the stand. In this condition, the treatment focus is to (1) find the crop trees from different crown positions, (2) ensure uniform crop tree distribution throughout the stand, and (3) release them from at least three or more sides.*
4) *Out of scope: If a stand does not have any possibility of finding at least 300-400 crop trees/ha, this stand can not be managed for high quality sawlog production. Therefore, it is considered as out of scope.*
5) *Before running the key, it is important to stratify the stand into different homogenous blocks (uniform stand condition within the block). Then species-specific stem density and crop tree distribution at different crown positions need to be assessed in each block. Stand age and site quality information can be assessed from existing records or secondary source. Using this information, we can follow the key to reach the management prescription. In the key, the text outlined by a diamond is a question that must be answered. Depending on the answer to these questions the designated path is followed until a rectangle is encountered. These rectangles refer to a management prescription. This is a version 1.0 which is developed based on the research findings that are limited to few sites in northern New Brunswick. Therefore, caution must be exercised while using it in other forest conditions.*

Stand structure: E1 and E2
FUNA:YBTH,TOHW,THIH
Stand age: 12 to 20 years
Mean height: 6 to 10 m
Site quality: 17 m dominant height at the age of 50.
BGI: 3500 to 4000 kg/ha/year
Stem density>5000/ha



CT: AGS caregory yellow birch crop trees
CP: Crown position (dominant, co-dominant, intermediate and suppressed)
PCT: pre-commercial thinning
PCTR: pre-commercial crop tree release

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