Institut de recherche sur les feuillus nordiques
Northern Hardwoods Research Institute

TECHNICAL NOTE

Can commercial thinning in young hardwood stands improve our resource: 17-year response to treatment in Northwestern New Brunswick

INTRODUCTION

Managing tolerant hardwood stands for increase production and maximum high quality saw material recovery is an important aspect of silviculture in the Acadian Forest Region (AFR). Commercial thinning is one of the tools Foresters can use to improve stand quality and reduce competition to allow for increased production in the remaining trees. However, the removal intensity of a commercial thinning treatment can greatly impact the results. Removing too little will not allow the benefits of the commercial thinning to be maximized, while removing too much may reduce log quality due to excessive large branching. To investigate the impacts on growth of various treatment intensities, a commercial thinning trial was established in northwestern New Brunswick in a tolerant hardwood leading stand (Fig. 1). Remeasurements were taken in 2005, 2012, 2015, and 2022 and have been assessed to determine the impact of treatment intensity on individual tree growth, quadratic mean diameter, basal area, species composition, and tree form. These results will be assessed in comparison to common expected commercial thinning outcomes at 10+ years after treatment and used to present best practices for removal intensity.

HIGHLIGHTS

- NHRI's desired outcomes of commercial thinning 10-years after treatment include increasing growing space occupied by desired species (target > 80%), increased proportion of high-quality stems (target > 75%), and individual crop trees achieving > 4cm diameter growth (0.4 cm/yr).
- It is important to consider pre-treatment stand conditions such as species composition, tree vigor and quality, and density to ensure the stand can benefit from thinning (e.g., excessive component of non-target species, prevalence of poor form, presence of pathogens).
- Results of this study show that only the high intensity removal treatment met the species composition and stem quality targets while approaching the individual growth objective. The medium intensity treatment also came close to meeting the objectives of the treatment.
- From this long-term study, we recommend that in stands meeting criteria, to remove between 35% and 45% of the basal area focusing on releasing crop trees

METHODS

Initial Stand Condition and Treatment

The stand established naturally following clearcut felling in in the early 1960's and was dominated by yellow birch, followed by beech, red and sugar maple with small amounts of white spruce, balsam fir, white birch, trembling aspen, and non-commercial hardwoods including pin cherry, striped maple, mountain maple, and mountain ash. Prior to treatment in 2005, it was well-stocked with a density of 955 stems/ha, basal area of 18.8 m^2/ha and a quadratic mean diameter (QMD) of 15.9 cm for merchantable stems (>10 cm). The 15-ha trial consisted of 4 levels of treatment intensities: control (D1; 0%), low removal (D2; 15-25%), moderate removal (D3; 26-35%), and high removal (D4; 36-40%; Table 1.). Fixed area Permanent Sample Plots (PSP) approximately 400 m^2 in size (11 x 36.4 m) were established and measured prior to harvest to verify the initial conditions. Field measurements including diameter at breast height (DBH; cm), height (m), and a status note, were recorded initially for all stems > 3 cm and at each remeasurement for surviving trees. In 2015 and 2022, risk and form were collected and used along with species in the Tree Classification System for New Brunswick to classify each stem as either acceptable growing stock (AGS) or unacceptable growing stock (UGS; NHRI 2020). A cut to length system was used to remove volume with a small 6-wheel single-grip harvester and forwarder. Thinning was completed as a crop tree release with a pecking order favouring sugar maple, yellow birch, and spruce.

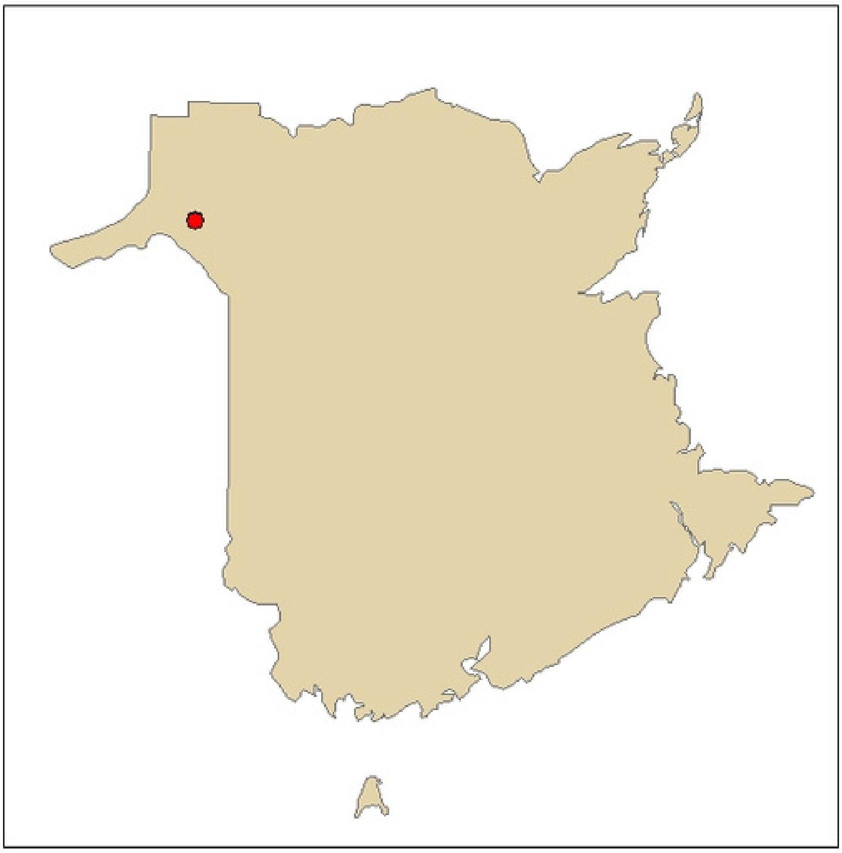

Fig. 1. Location of Beardsley Brook commercial thinning trial in northwestern New Brunswick (NB)

Table 1. Average removal intensity result by prescription

Prescription	Target Removal	Average Removal Intensity (%)	Min. Removal (%)	Max. Removal (%)
D1	0%	0.8	0	4
D2	15-25%	21.8	20	27
D3	26-35%	29.2	25	31
D4	36-40%	35.8	30	40

DATA ANALYSIS

Remeasurement data was used to calculate the periodic annual increment in DBH (PAI_d; cm/tree/year) from 2005 to 2015, and the quadratic mean diameter (QMD; cm) in 2022 for each treatment for all stems including those of non-commercial size and species. These results were compared visually using boxplots and statistically using a one-way fixed effects ANOVA to determine if the means of these variables differed significantly by prescription. A Tukey test was also applied to identify which group(s) of means differed significantly. Species composition, expressed as relative abundance, was calculated using the basal area represented by each species. Composition was compared between pre- and post-treatment as well as in 2022 to identify trends and improvements. Further analysis regarding the species-specific response of yellow birch and sugar maple included analysis of QMD and stem quality.

RESULTS

Periodic Annual Increment

Periodic annual increment in diameter (cm/tree/year) between 2005 to 2015 only (10-years) exhibited consistent increase with treatment intensity. Control, low, moderate, and high removal treatments averaged 0.17, 0.22, 0.26, and 0.29 cm growth per year, respectively. Between group assessment showed pairing between incremental levels with the control and low, low and moderate, and moderate and high not significantly different from one another (Fig. 2).

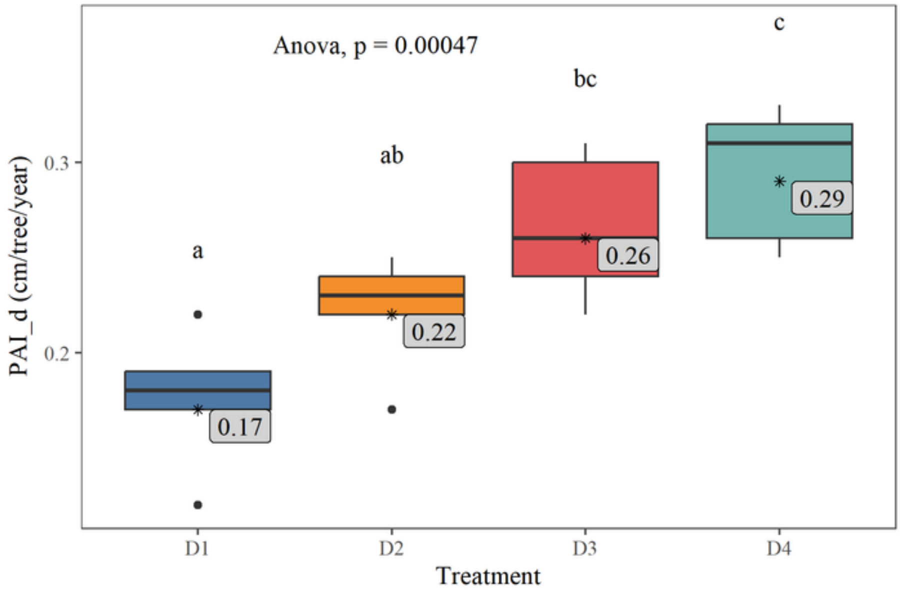

Fig. 2. Periodic annual diameter at breast height increment per tree (PAI_d; cm/tree/year) between 2005 and 2015 by treatment level including non-commercial species and stems. Asterisk and label denote mean value.

Quadratic Mean Diameter

In 2022, QMD was very similar between the control and low intensity removal treatment but increased for both moderate and high removal intensity, although no significant differences were found between the treatment means (Fig. 3). The high removal intensity had the highest mean and minimum QMD at 15.1 and 14.0 cm, respectively, while the control group had the highest individual value at 17.5 cm (Fig. 3). There does not appear to be a ready explanation for the exceedingly high QMD value obtained by the control treatment in Block B Section 1. It had a slightly higher than average QMD in 2005 and a much lower density than blocks A, C, or D, however, Block E had similar conditions and obtained only a QMD of 14.4 cm in 2022 (the next highest). When looking at a projected average QMD for 2035 (i.e., 30 years post-harvest) calculated using the 2022 DBH values and the PAI_d, the disparity between the treatments continues to widen. While the low removal treatment does increase over the control by 2035, it remains significantly lower than the moderate and high removal treatments (Fig. 4). The high removal treatment increases at a slightly higher than the moderate removal, widening the distance between the two (Fig. 4).

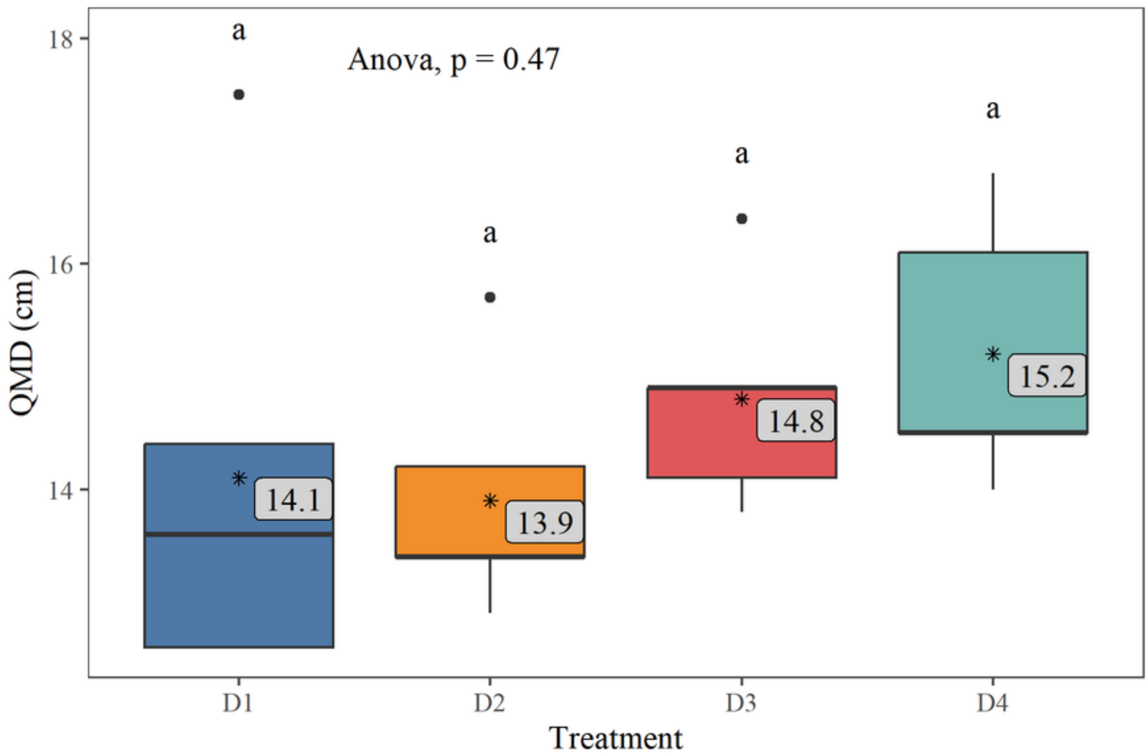

Fig. 3. Quadratic mean diameter (QMD; cm) in 2022 by treatment level including non-commercial species and stems. Asterisk and label denote mean value.

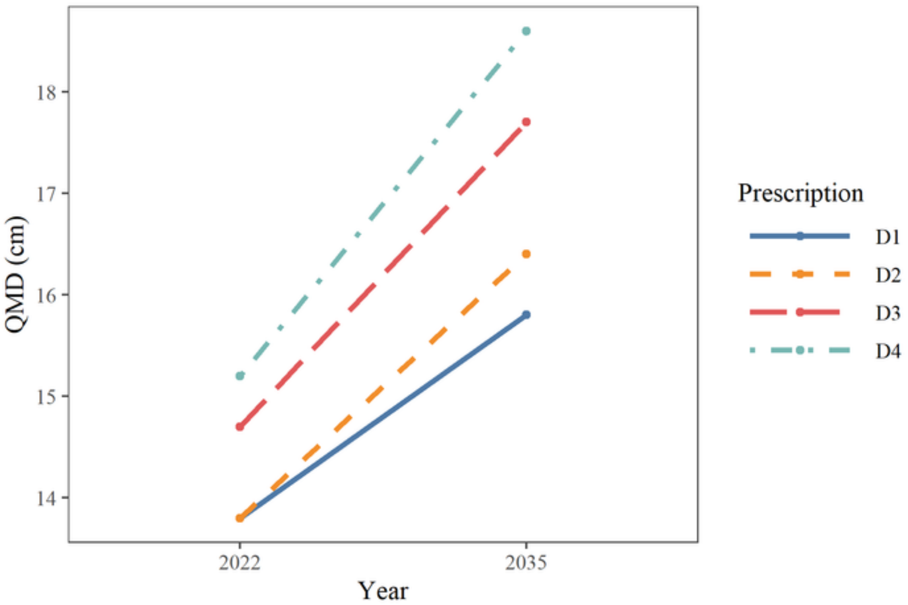

Fig. 4. Projected quadratic mean diameter (QMD; cm) at 30-years post-harvest (2035) based on 2022 diameters and the 2005-2015 period annual diameter at breast height increment (PAI_d; cm/tree/year)

Species Composition

Species composition, presented as relative abundance (i.e., a fraction of basal area), was improved immediately by treatment and continued to improve over time. Pre-treatment conditions differed across the four treatment levels due to natural variation in the stand. Immediately following treatment for the low, moderate, and high removal scenarios, the relative abundance of yellow birch was increased by 13, 12, and 11%, respectively, while sugar maple increased by 1.1, 0.4, and 4.2 % (Fig. 5). The low treatment decreased the relative abundance of non-commercial species, balsam fir, and beech by 2.5-5% while all other species changed < ±1% (Fig. 5). The moderate and high treatments were able to further reduce the relative abundance of undesirable species by 4-11% and 3-9% for beech and balsam fir, respectively, while again all other species were changed by < ±1% (Fig. 5).

Over time the control treatment improved naturally following the high mortality of non-commercial species combined with growth in the remaining stems (Fig. 5). However, by 2022 the overall abundance of desirable species (i.e., yellow birch and sugar maple combined) for the control treatment was only 61%. From post-treatment to 2022, the low removal treatment saw an 8.6% increase in the relative abundance of yellow birch, followed by red maple, sugar maple, and balsam fir at 1.1 – 1.9 %, resulting in a total abundance of desirable species of 77% (Fig. 5). The moderate removal treatment showed a 7.4% increase in yellow birch and a 3.6% increase in beech, followed by red maple, sugar maple, and balsam fir at 1.6-2.2%, however, the moderate treatment shows a desirable species content of only 64% in 2022 due to the initially high beech content (Fig. 5). The high removal scenario had a lower increase in average basal area from 14.8 to 24.7 m^2/ha with a relative abundance increase of 6.5% for yellow birch, 2.5% for sugar maple, and 1.8 and 1.3% for trembling aspen and beech, respectively, with a total desirable species content of 82% (Fig. 5).

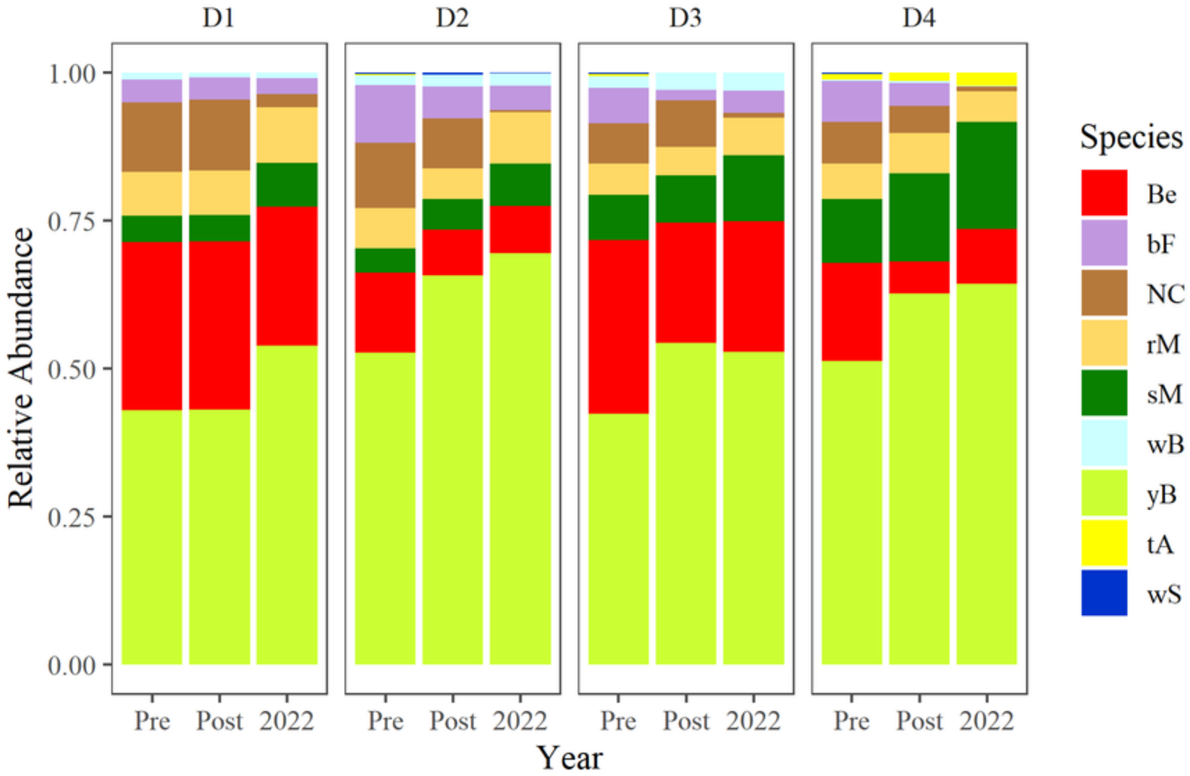

Fig. 5. Species composition by treatment prior to treatment (Pre), immediately following treatment (Post), and in 2022 including non-commercial species and stems (Be = beech, bF = balsam fir, NC = non-commercial hardwoods, rM = red maple, sM = sugar maple, wB = white birch, yB = yellow birch, tA = trembling aspen, wS = white spruce)

Growth Response in Sugar Maple and Yellow Birch

QMD was above average for yellow birch and increased faster and more consistently that the other species in all treatment scenarios (Fig. 6). While the growth trend was identical, a response to thinning and increase in QMD can clearly be seen for the moderate and high removal treatments (Fig. 6). QMD for sugar maple did increase with treatment, however, it did not exceed the average for the Other species group (Fig. 6). Overall, the moderate removal treatment had the largest impact on QMD for all species by 2022. Recruited stems were included for the first time in 2022, which is the cause of the slight decrease in QMD for some species (Fig. 6).

Percentage of acceptable growing stock declined between 2015 and 2022 for both yellow birch and sugar maple, largely due to increasing risk class (Fig. 7). In the control treatment, AGS declined for both sugar maple and yellow birch from 81 and 75% to 72 and 70%, respectively (Fig. 7). The low and moderate treatments saw a much more dramatic declines, particularly in sugar maple from 68 to 37% and 98 to 89%, while yellow birch also declined significantly from 84 to 62% and 81 to 60%, respectively (Fig. 7). The high treatment showed the best maintenance of AGS overall, losing only 1-2% from both species with sugar maple declining from 75 to 74% and yellow birch from 78 to 76% (Fig. 7).

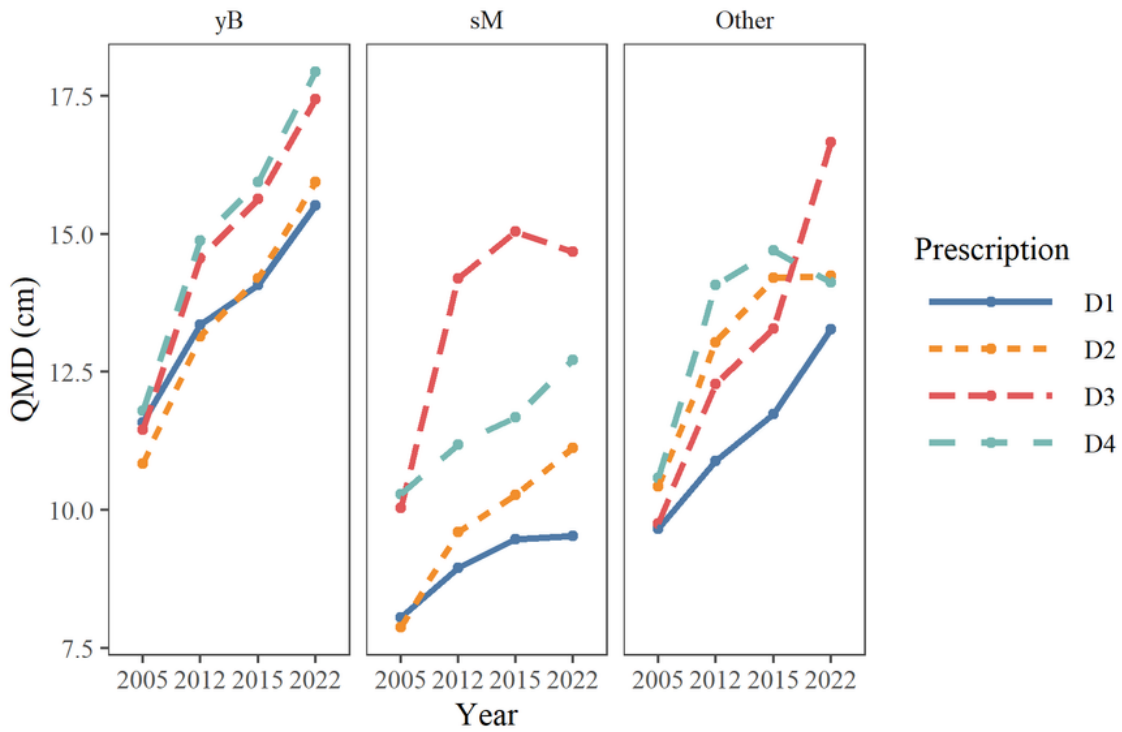

Fig. 6. Quadratic mean diameter (QMD; cm) over time by prescription for yellow birch (yB), sugar maple (sM), and all Other species including non-commercial species and stems

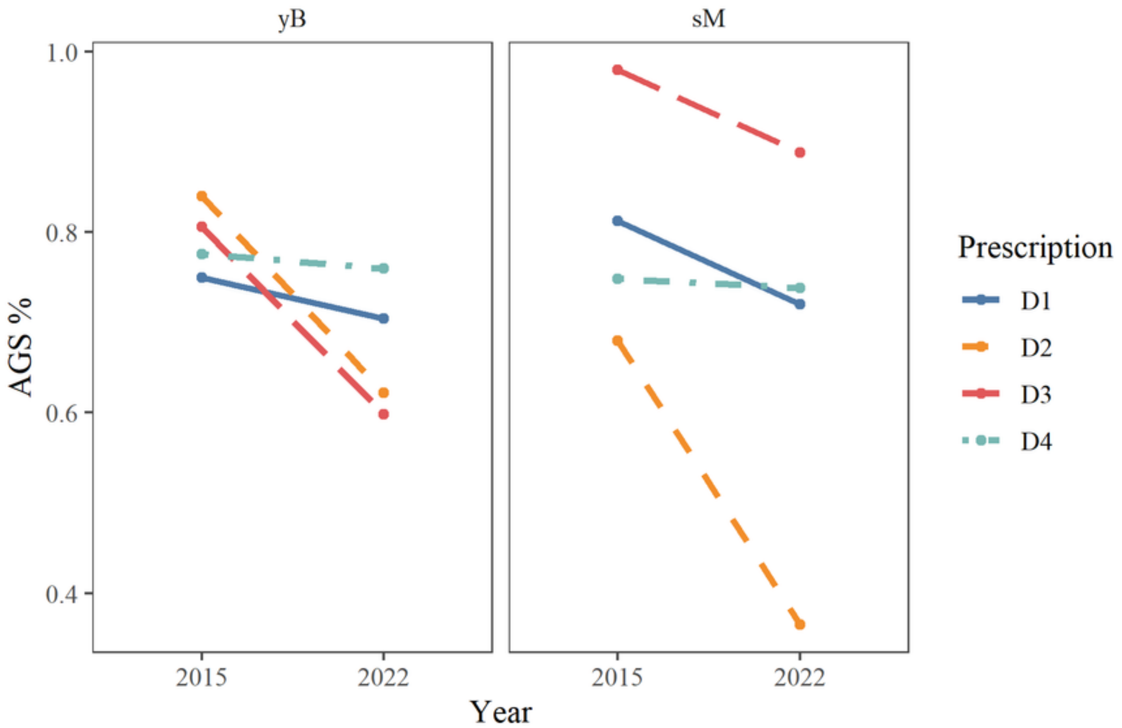

Fig. 7. Percentage of Acceptable Growing Stock (AGS) in 2015 and 2022 by prescription for yellow birch (yB) and sugar maple (sM)

DISCUSSION

Commercial thinning is an important silvicultural tool for decreasing rotation time, while increasing high quality material recovery in the slow-growing tolerant hardwood stands of the AFR. However, the timing and intensity of thinning are important considerations when planning treatment and can greatly impact the overall success and commercial viability of the project. Overall, in this trial, a positive impact was seen on growth, species composition, and quality with increasing treatment level.

Individual tree growth (PAI_d) was increased by all levels of treatment, however QMD was only impacted at the moderate and high removal levels. Moderate and high removal had very similar response, although the high removal had slightly higher QMD and PAI_d. The low intensity treatment was not sufficient to produce a desirable response in stand growth, with only a slight increase in PAI_d. Despite growth increases, when compared against the target of individual trees attaining > 0.4cm growth per year in the 10+ years following treatment, none of the treatment responses can be deemed successful with the maximum reached by the high treatment at 0.26 cm/tree/year.

Species composition and stand quality were also improved with increasing treatment level. The pecking order established for the thinning favoured tolerant hardwood and commercial softwoods of good form, while intolerant species are left to maintain stocking levels. Efforts are made to remove non-commercial species and stems of any species with poor form, but density must be maintained so often they are not eliminated completely. The NHRI's target outcome for commercial thinning treatment is a relative abundance of >80% desirable species (i.e., combined relative abundance of the target species) by 10 years post thinning. When assessed in 2022, at 17 years post treatment, only the high removal treatment had reached >80% relative abundance of desirable species at 82%. However, the initial species composition pre-treatment must be considered when assessing this target. For example, in the pre-treatment conditions, the control and moderate removal treatments had a much higher beech content than the low and high removal areas due to natural stand variability. Although the relative abundance of beech was reduced by 9% by the moderate removal treatment, it is not possible to force the species composition any further while maintaining the appropriate density and spacings.

In all treatments, including the control, the combined abundance of acceptable growing stock for yellow birch and sugar maple was greater than 75% in 2015 (i.e., 10-years post-treatment), however this stem quality was not maintained and by 2022 (i.e., 17-years post-treatment). By 2022, only the high treatment had maintained sufficient stem quality to meet the >75% objective. Unfortunately, data was not collected to explain the risk class changes that led to the perceived degradation of the quality to discuss the causes however, increasing risk class with age is common. Influences on risk class include inter and intra specific competition, stem injury, pathogens, and natural decline in vigor with aging and size.

Overall, the high removal treatment (36-40%) was the most successful in reaching the targets for species composition (>80%), stem quality (AGS > 75%), while approaching the individual stem growth of 0.04 cm/yr. As well, the high removal scenario would generate the most income at the time of treatment, off setting the cost of harvesting. The moderate removal treatment also had positive growth results but was influenced heavily on quality by the high content of beech in the stand – however, this could not have been corrected with a high removal scenario as the content of beech would have remained higher than recommended. These results indicate that a removal of 36-40% is the best choice to increase growth and quality of the stand and maximize revenue at harvest. However, the 25-35% removal is a viable option if there are other constraining factors for the stand such as concerns of epicormic branching or windthrow. From our experience and beyond the results of this study, we believe that in suitable young even-aged stands, silviculturists should aim for 35%-45% removals. Stocking guides or stand management diagrams are useful tools to fine-tune the treatment prescription.

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