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Precommercial Crop-Tree Thinning in a Mixed Northern Hardwood Stand

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Abstract

The effectiveness of precommercial crop tree thinning was investigated by thinning crop trees of paper birch, yellow birch, and sugar maple to two intensity levels at 8 years of age. Analysis of covariance on post thinning growth measurements taken 7 years later indicated a significant increase in diameter and crown-diameter growth, with the pattern of response varying by species. The study suggests that a uniform crop-tree thinning treatment for a stand composed of species with varying tolerances will rarely produce the best response for all the species.

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Introduction

The current condition of the typical northern hardwood forest in Vermont indicates the long-term effects of past cutting practices. These practices have increased the amount of cull in an old-growth forest by as much as one-third of the gross volume (Gilbert and Jensen 1958). This undesirable increase has focused attention on management tools that concentrate the growing stock into fewer and better stems. For young even-aged northern hardwood stands, the best method for accomplishing this is either crown-tree thinning or crop-tree thinning (Smith 1962). This study investigates crop-tree thinning performed on an 8-year-old stand of mixed northern hardwoods. The effects on the stand and its structure are examined by analyzing diameter, height, and crown growth, and by relating these measures to tree quality.

Study Area

The area is in a 231-acre northern hardwood stand on the eastern side of the Green Mountains in central Vermont at an elevation of 1,800 feet. The site index is 55 for sugar maple and the major species are paper birch, sugar maple, yellow birch, and red maple with many minor component and understory species including beech, striped maple, and white ash. The stand had been cut as part of the Green Mountain National Forest Boyden Brook Sale. Five years later, the stand had an average basal area of 40 square feet per acre, an average stand diameter of less than 1 inch, and was treated with a prescribed TSI release that yielded the sapling stand thinned for this study. The thinning was performed when the stand was 8 years old. The stand was densely stocked with average diameters of 1.3 inches for yellow birch, 1.1 inches for sugar maple, and 1.7 inches for paper birch with average heights of 16.9, 13.9, and 20.0 feet, respectively.

The soils are about 50 percent Berkshire and 40 percent Marlow: extremely stony, well-drained loams which are formed in glacial till derived from quartzite and schistose rocks. They often have a large amount of organic surface accumulation, a gravelly surface layer, and the Marlow soils often have a fragipan at 15 to 30 inches below the surface. The average temperature in the area for the study period, 1977-83, was 41.3 degrees Fahrenheit with average highs of 93 degrees and average lows of –22 degrees. The average precipitation was 46.5 inches, close to 1 inch above normal.

Methods

A total of 308 crop trees were selected at 20-foot intervals along parallel lines spaced 20-feet apart. At each 20-foot interval a stem meeting the crop-tree criteria was chosen: a tree of good quality appearing to have the potential for developing into a sawtimber-quality tree. To ensure selection of young trees, the tree diameter had to be less than 2 inches at breast height. The goal was to choose 100 trees for each species, with species determined by availability of suitable stems and perceived value of the species. Priority was given to choosing 100 stems of the highest valued species. Approximately 100 stems each then, of yellow birch, sugar maple, and paper birch were chosen. Each stem was randomly assigned to control, light, or heavy treatment. The crowns were released by thinning from stem outward to a radius of 4 feet for the light treatment or 8 feet for the heavy treatment. The thinning treated all stems two-thirds or more the height of the crop tree and any other overtopping trees with major limbs extending into the thinning radius.

Measurements were made at the time of thinning and 7 years later on d.b.h., total height, crown diameter (average of N-S and E-W measurements), height to crown base, and height to the first branch longer than 24 inches. Diameter measurements were also taken at 1.2 and 4 years after thinning. The data were analyzed as a completely random factorial design, with factors species and treatment. Analysis of covariance was performed on the 7-year postthinning diameter growth using initial diameter as the covariate, and on change in crown width using initial crown size as the covariate. Total height growth, change in height to base of crown, and change in height to the first major limb were analyzed using analysis of variance.

Results

The average diameter growth increased by treatment for all species, but each species responded differently to the treatments (Table 1). Analysis of covariance showed that overall, treatment was significant. For individual species, it showed that yellow birch had a significant increase ($p = 0.05$) from control to light treatment and from light to heavy treatment; paper birch had a significant increase from control to light treatment and from control to heavy treatment, but not from light to heavy treatment; and sugar maple did not respond significantly to either treatment. Intermediate d.b.h. growth data indicated that the increase in growth continued longer as thinning level increased. For example, the paper birch trees in the heavy thinning grew 36.7 percent of the total growth increase during the last

Table 1.—Average 7-year diameter growth at breast height adjusted by initial diameter (inches)

	Treatment		
Species	Control	Light	Heavy
Paper birch	1.33a	1.68b	2.05b
Yellow birch	1.44a	1.79b	2.15c
Sugar maple	1.11a	1.46a	1.83a

Means within rows followed by the same letter are not significantly different ($p = 0.05$).

study period (years 5 through 7), as compared with the control group that grew 30.5 percent of the total growth increase during the same period (Table 2).

The average crown diameter growth increased as thinning intensity increased. One exception was sugar maple which had an average of 1.88 feet for the light treatment group as compared to 2.14 for the control group, but the control value was exceptionally high as compared to averages of 1.06 and .94 feet for yellow and paper birch, respectively. The analysis of covariance indicated that overall treatment was significant, but as with diameter growth, each species responded differently (Table 3). Yellow and paper birch had significant increases from control to light treatment and from light to heavy treatment, while sugar maple had a significant increase only from light to heavy treatment. The lack of significance for this difference could be attributed to the unusually large value for control.

The average total height growth was not significantly different by treatment for any species and was about 12 to 13 feet for all treatment and species combinations. So, despite thinning, the canopy structure was similar to what was present at the onset of the study.

The effect of thinning on stand quality was indicated by analyzing change in height to base of crown and change in height to the first major limb. Treatment was significant for both of these measures, with trends showing a general decline as thinning intensity increased (Figs. 1 and 2). The change in height to base of crown showed the most decline in the heavy thinning for all three species. An increase was found in the light paper birch thinning. The amount of decline in height to the first major limb was more dramatic for both yellow and paper birches, which started with longer clear boles at the time of thinning, than for sugar maple, which showed less decline but also had less clear bole at the outset. These trends indicate there may be a more negative impact on the quality of less tolerant species when the thinning treatment prescribed is one, like the heavy treatment described here, that maximizes d.b.h. and crown diameter growth.

Somewhat comparable results were obtained from the 16-year remeasurement of a previously reported thinning study (Marquis 1969) in a 25-year-old northern hardwood stand on the Bartlett Experimental Forest, New Hampshire. At Bartlett, the heavy thinning treatment removed all trees that competed with the crowns of the crop trees and the light treatment removed the one most severe competitor. Residual stand basal areas for trees 0.5 inches d.b.h. and greater were 56, 72, and 100 square feet per acre for the heavy and light treatments and the control group, respectively.

As in the Boyden Brook study, there were no significant differences in the diameter growth response of paper birch to the light and heavy thinning treatments. Paper birch's small-sized crown may not need any more than a light release to completely free it from competition, or its fast growth may allow it to take advantage of a newly thinned area more quickly than other species. In contrast to the results of this study, sugar maple at Bartlett showed response to both light and heavy thinnings. In addition, the growth response from the heavy thinning at Bartlett did not persist any longer than the response from the light thinning.

Table 2.—Average diameter growth by intermediate periods (percentage of the total growth for the 7-year period)

Species	Year	Treatment		
		Control	Light	Heavy
Paper birch	1	16.7	15.4	15.1
	2	22.1	20.1	16.9
	3, 4	30.7	29.4	31.3
	5, 6, 7	30.5	35.1	36.7
Yellow birch	1	15.3	14.8	11.5
	2	19.6	18.6	19.7
	3, 4	28.2	33.4	31.1
	5, 6, 7	36.9	33.2	37.7
Sugar maple	1	16.9	16.7	13.7
	2	21.6	18.1	18.3
	3, 4	27.8	28.1	28.0
	5, 6, 7	33.7	37.1	40.0

Table 3.—Average 7-year crown diameter growth adjusted by initial crown diameter size (feet)

Species	Treatment		
	Control	Light	Heavy
Paper birch	.94a	2.56b	3.37c
Yellow birch	1.06a	2.48b	4.60c
Sugar maple	2.14a	1.88a	3.22b

Means within rows followed by the same letter are not significantly different (p = 0.05).

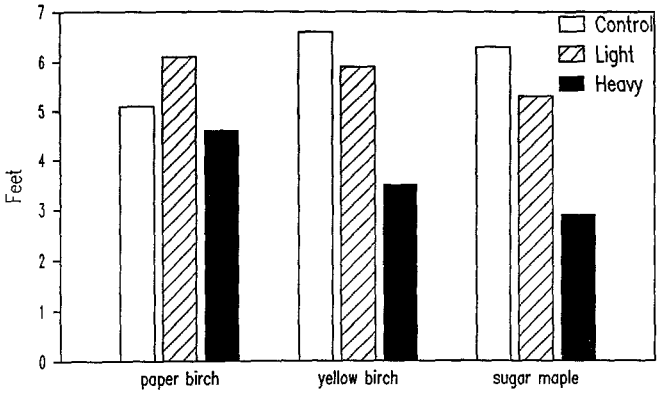

Figure 1.—Change in height to crown base, by species and treatment.

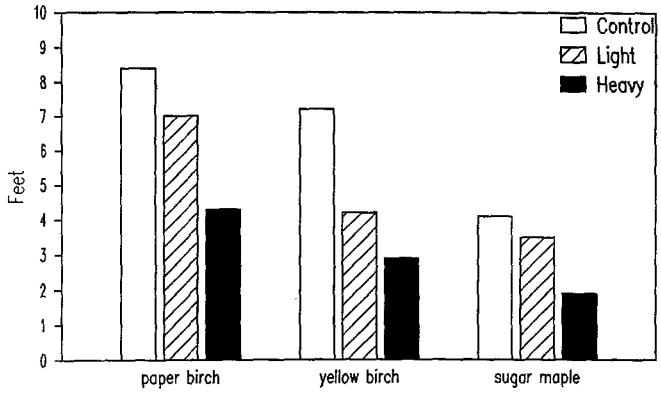

Figure 2.—Change in height to first major limb, by species and treatment.

Conclusions

Many thinning studies have been conducted to answer the question: Is it worth it? It is well understood that crop-tree thinning does increase growth (Erdmann and Godman 1981, Hannah 1978, Marquis and others 1969, Stoeckeler and Arbogast 1947). The worthiness of crop-tree thinning in this study focuses on two issues: were the trees released at the appropriate age, and did the methods produce the best possible response for all three species?

Any thinning should begin after crown closure. Successful crop tree thinning also begins after good choices for crop trees can be made. Applying these guidelines in a mixed stand may present an ambiguous situation. Faster growing species may appear ready for thinning while slower growing species do not. This study showed that age 8 was an appropriate time for choosing paper birch crop trees, but was too early for choosing yellow birch and sugar maple crop trees. At the time of final measurements (age 15), many stems of yellow birch and sugar maple were observed that were more vigorous and of better quality than those chosen as crop trees at age 8.

One simple solution is to wait until the slower growing species have differentiated in stem quality, but not to wait so long that the faster growing species have begun to dominate the stand. Other researchers have found success in choosing crop trees in pure stands of sugar maple at 11 years of age (Godman 1968, Stoeckler and Arbogast 1947) and in choosing yellow birch crop trees at 10 years of age (Erdmann and others 1981). The total height data from this study showed that thinned and unthinned paper birch did not grow significantly faster than any of the other species, so thinning between the ages of 10 and 14 would increase success in choosing crop trees and would not change the prethinning canopy structure. Site index relations show that the difference in height between paper birch, sugar maple and yellow birch will increase as the quality of the site increases (Marquis and others 1969), thus thinning at age 10 to 11 is ideal for better sites and age 13 to 14 is ideal for poorer sites.

Discussion of the second issue pivots on the definition of the best response to thinning. Ideally, the best response is that which produces the most increase in growth. Realistically, it is also the method which produces the least decrease in quality. Ambiguity in a mixed stand can arise when the best thinning method varies between species, and choosing one method for the whole stand will involve compromises. For example, the diameter growth results indicate that yellow birch responded most to the heavy thinning, while paper birch responded equally to the light and heavy thinnings, and sugar maple did not respond to either. Taken individually, the conclusion might be to thin yellow birch heavily, paper birch lightly, and sugar maple to an even larger radius than was used. But it is unclear if *one* thinning method is appropriate. The prescription of thinning to a fixed radius in a mixed stand with species of varying growth rates and shade tolerances may not be the best method. The pattern of growth response found in this study shows that faster growing species require a smaller thinning radius, while slower growing species require a larger thinning radius. This may be emphasized by the indirect release of faster growing species on the edge of the thinned area around a slower growing species, which reduces the effective size of the thinned area (Leak and others 1987). One possible technique is to leave only edge trees of the same species. For example, begin at the stem of the chosen crop tree, thin outward to a radius of 8 feet, then

continue to thin outward until a tree of the same species as the crop tree is found and can be left as the edge tree. It is clear that more studies will be needed to substantiate whether this method will work.

Despite so many thinning studies, there is still subjectivity involved in determining whether a particular thinning method is "worth it". The data from this study indicate that a precommercial crop-tree thinning to an 8-foot radius in a mixed stand will produce a significant increase in diameter and crown growth in paper and yellow birches without severely decreasing quality. But, the data also show that this may not be the most efficient or effective way to thin in a mixed stand.

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Analysis of growth measurements taken 7 years after thinning an 8-year-old hardwood stand showed significant diameter and crown-diameter growth increases. Further analysis showed dissimilarities in the pattern of response of the three species observed: yellow birch, sugar maple, and paper birch.

Keywords: crop-tree; thinning

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