Effects of Repeated Precommercial Thinnings In Central Hardwood Sapling Stands

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ABSTRACT. Precommercial thinnings were repeated four times in a central hardwood sapling stand beginning at age 8 and ending at age 22. Treated plots were thinned on an areawide basis to specified density levels of 30-, 50-, and 70-percent stocking. The species composition of all stems in the stand was altered somewhat by thinning, but similar trends occurred on control plots. The species composition, growth, and quality of potential crop trees were not improved substantially by thinning. Results indicate that repeated areawide precommercial thinnings to specified density levels is not an effective timber management alternative for hardwood sapling stands.

The most common purpose of a precommercial thinning is to transfer the growth of undesirable trees and trees that would later die to desirable crop trees. The thinning produces no immediate economic return. Increased return is anticipated at a later date. Guidelines for appropriate thinning procedures are needed because precommercial thinnings generally require considerable expertise and expense.

In this study, plots established in an 8-year-old sapling stand were thinned at intervals on an areawide basis to specified density levels. The study objective was to relate growth responses of residual trees to the specified density levels for the purpose of establishing thinning guidelines in precommercial-size hardwood stands. The results are based on a 16-year growth period.

METHODS

Study Area

The study was established in 1962 in an 8-year-old, even-aged hardwood stand on the Vinton

Furnace Experimental Forest in southeastern Ohio. Site index on the study area was 65–70 according to Schnur's (1937) site index curves. The sapling stand originated after a complete clearcut of a 100-year-old upland oak stand that was primarily black, scarlet, chestnut, and white oaks.[1] Yellow-poplar and red maple accounted for a good portion of the new stand inasmuch as oaks failed to regenerate substantially. Many other hardwoods were also present.

Thinning Treatments

Initial precommercial thinnings in the 8-year-old sapling stand were made in the winter of 1962 on plots that were either 96 or 64 milacres in size. Thinning treatments reduced plot density levels to 30-, 50-, or 70-percent stocking (Figures 1 and 2). Control plots were not thinned. Each thinning treatment was replicated three times, and the control was replicated twice.

All trees taller than 4.5 feet were used to determine the percent stocking on a plot. Percent stocking was calculated using Gingrich's (1967) tree-area-ratio equation:

$$\text{Tree-area (milacres)} = -.0507\,N + .1698 \sum D + .0317 \sum D^2,$$

where N = number of trees and D = diameter at breast height. Solving this equation for N = 1 and D = any given diameter, defines the tree-area requirements for that size tree. A stand having 1,000 milacres of tree-area per acre is 100-percent stocked. Inspection of the tree-area-ratio equation reveals that the number of residual trees per acre, and hence their spacing, vary according to the desired density level and size of the trees. Initial thinnings reduced the number of trees per acre that were 0.6 inches d.b.h. and larger from 4,510 to 2,821 for the 70-percent treatment, 4,389 to 2,002 for the 50-percent treatment, and 4,506 to 1,212 for the 30-percent treatment. The number of trees that must be removed, hence the cost of thinning, increases as the desired stocking level decreases.

The major consideration during thinning was to achieve uniform spacing among residual trees for a specified density level. Within this framework, noncommercial species such as dogwood, sassafras, and sumac, commercial species in the lower crown classes, and larger trees with stem deformities (forks, crook, and sweep) were removed first. Some of these less desirable trees had to be left to achieve uniform spacing.

Treated plots were thinned again at ages 10, 17, and 22 years to the prescribed density levels. The

[1] See Little (1978) for scientific names of all species referred to in this study.

Figure 1. Plot thinned to 30-percent stocking at 8 years.

Figure 2. Plot thinned to 30-percent stocking 14 years after initial thinning.

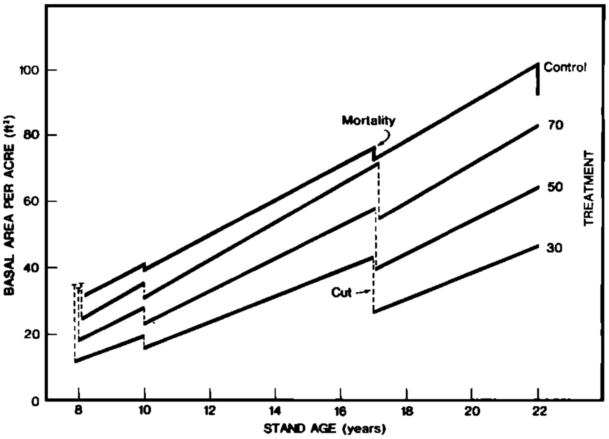

Figure 3. Intensity of thinnings, trees 0.6-inch d.b.h. and larger.

timing and intensity of the thinnings from ages 8 to 22 are shown in Figure 3.

Measurements

Diameter at breast height (d.b.h.) was recorded to the nearest 0.1 inch for all trees in 1962, 1964, 1971, and 1976. The d.b.h. of small trees was measured with a machinist's caliper. The total height of all residual trees was measured in 1962 to the nearest foot with a telescopic pole; d.b.h., total height, and length of clear bole (height to lowest live or dead limb ⅓-inch in diameter and larger) were recorded in 1978 for the largest 125 trees per acre from each plot (8 or 12 trees per plot, depending on plot size).

Data Analyses

All trees were measured to determine the specified density levels, but only trees equal to or greater than 0.6-inch d.b.h. were used to analyze stand development and basal area growth for the first 14 years of the study. Trees smaller than 0.6 inch never became a major component of the stand because they were generally cut during thinning. The development of the largest 125 trees per acre was analyzed for the entire 16-year study period.

RESULTS

Stand Development

Species composition. The percent distribution of basal area by species was fairly uniform over treatments before thinning in 1962 (Figure 4). Oaks made up about 8 percent of the stand basal area. Yellow-poplar and red maple combined averaged 38 percent of the basal area for all treatments. Dogwood and other noncommercial species were a major component of the basal area, particularly on the 30-percent treatment, averaging 37 percent of the stand basal area for all treatments.

Most of the oaks, red maples, and dogwoods in the new sapling stand originated as stump sprouts. Other species such as yellow-poplar, black cherry, and aspen originated from seed or advanced reproduction.

In general, the repeated thinnings increased the percent of stand basal area composed of the more desirable commercial species: oaks, yellow-poplar, and red maple (Figure 4). The heavier the thinning, the larger the percent of basal area in these three species. Also, at age 22 dogwood and other noncommercial species made up a smaller percent of basal area on thinned plots than on control plots.

Although not as dramatically, similar trends in species composition occurred on the control plots. Natural mortality due to suppression reduced the percent of basal area for dogwood and other noncommercial species. The percent of basal area in oaks did not increase, but yellow-poplar and red maple combined increased from 37 to 55 percent of the basal area. Species composition of the control plots should continue to approach that of the thinned plots with increasing stand age.

Tree Size. Distribution of basal area by diameter class was fairly uniform among treatments before thinning (Figure 5). The 30- and 50-percent treatments had more 4-inch trees, but the control had more basal area in trees 2 inches and larger.

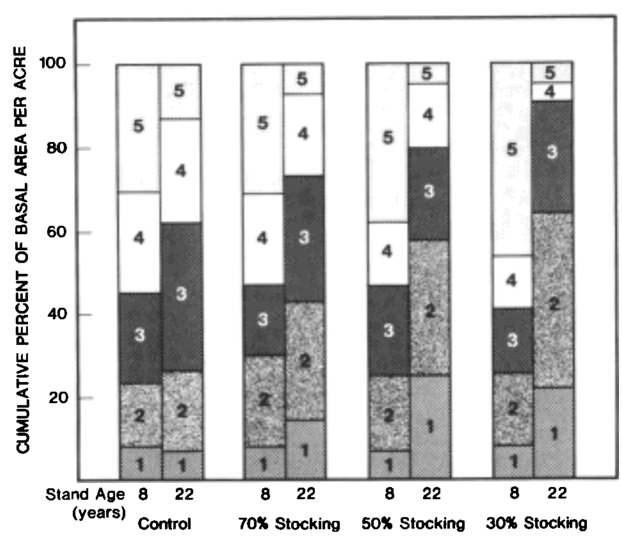

Figure 4. Percent distribution of basal area by species before initial thinning in 1962, and residual stand at age 22. Species Group 1: oaks—white, black, chestnut, scarlet, red; Group 2: yellow-poplar; Group 3: red maple; Group 4: aspen, hickory, elm, black cherry, blackgum; Group 5: dogwood, sassafras, sumac, hazelnut.

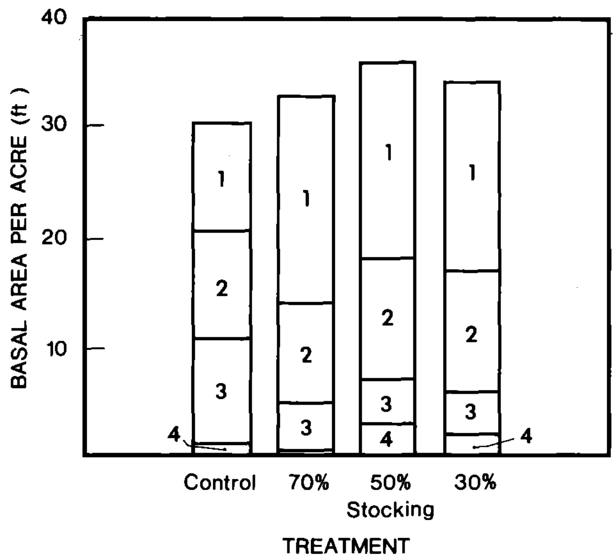

Figure 5. Distribution of basal area by diameter class before initial thinning in 1962 (Numbers in bars indicate diameter classes).

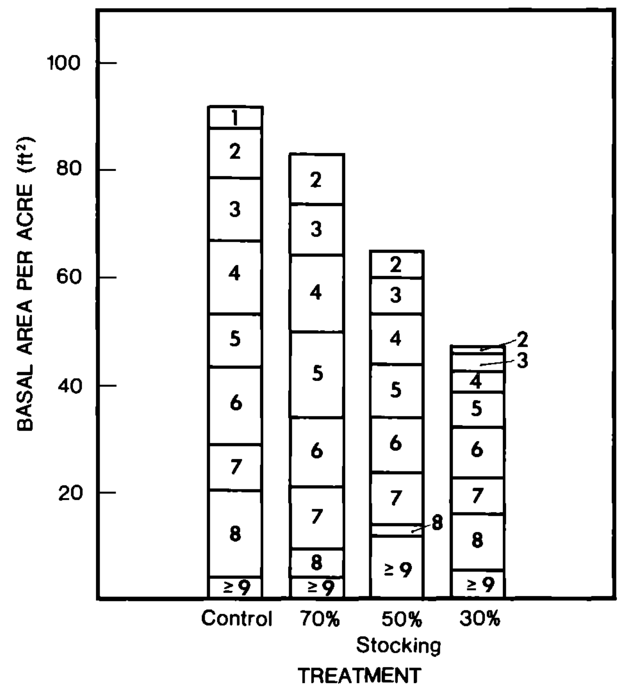

Figure 6. Distribution of basal area by diameter class at age 22 (Numbers in bars indicate diameter classes).

Dogwood and other noncommercial species constituted most of the basal area in the 1-inch diameter class on all treatments.

The basal area in the larger diameter classes at age 22 was consistent for all thinned plots, regardless of density level (Figure 6). Below 6 inches d.b.h., the basal area in each diameter class was reduced with increased thinning intensities because the small trees were removed first. As expected, the control plots had more basal area in larger trees at age 22 than the thinned plots, partly due to the fact that the control had more basal area in trees 2 inches and larger initially, and partly because thinning removed some of the larger trees that were considered "rough" (low quality).

Basal Area Growth

Total stand basal area growth rates for the thinning treatments are shown in Table 1. Gross growth (basal area 1976 − basal area 1962 + mortality + cut − ingrowth) was calculated using the entire 14 years as the growth period. Mortality and cut values represent the initial basal area of trees lost to mortality and cutting. This growth rate reflects only the growth on trees that were alive in both 1962 and 1976; hence it can be labeled more specifically as survivor growth (Husch et al. 1972). Survivor growth is the most meaningful growth rate for comparison of thinning treatments in precommercial stands because cut trees and trees lost to mortality are too small for merchantable products.

The basal area growth was successfully transferred to the residual trees at the 70-percent stocking level. However, growth was reduced somewhat at the 50-percent level, and reduced even more at the 30-percent level.

Potential Crop Trees

The most important aspect of thinning young sapling stands is the effect of thinning on the size and quality of the future crop trees. Comparisons

Table 1. Basal area growth of trees 0.6 inch d.b.h. and larger for 1962–1976 period.

Treatment	Basal area 1962	Basal area 1976	Cut	Mortality	Ingrowth	Gross p.a.i.[1]
Percent stocking			*Square feet per acre*			
Control	30.60	91.80	—	9.01	2.49	4.84
70	33.08	82.51	18.49	1.79	1.31	4.89
50	36.01	64.40	26.30	1.31	0.26	3.98
30	34.26	46.95	28.46	0.70	0.19	2.98

[1] *p.a.i. = periodic annual increment.*

of the treatment effects on tree size and quality should be made only on equal numbers of crop trees per acre (Adams and Chapman 1942, Smith 1962). All plots were remeasured in 1978 after a fourth thinning in 1976, and trees that were the equivalent of the largest (d.b.h.) 125 trees per acre were selected from each plot as potential crop trees. The development of these largest trees is important because they will most likely constitute a large portion of the final harvest. In fact, two of the plots with the 30-percent treatment had *only* the equivalent of 125 trees per acre left in 1978. Thirty-four percent of these potential crop trees at age 24 were yellow-poplar, 34 percent red maple, 16 percent oaks, and 16 percent other commercial species. There were no noncommercial species among the largest 125 trees per acre, even on the control plots.

Thinning did not substantially alter the composition of these larger trees from 1962 to 1978. There was a slight increase in the number of red maple and yellow-poplar trees among the largest 125 trees per acre, but this trend also occurred on the control plots. Ninety-eight percent of the potential crop trees were classified in the dominant and codominant crown positions in 1978. All but one of these trees were also in the dominant and codominant crown classes in 1962, indicating that trees in the lower crown classes are not likely to become potential crop trees even if repeated thinnings are applied. This inability to manipulate growth in the lower crown classes in conjunction with spacing requirements is the main reason why species composition is not altered substantially by precommercial thinnings.

The average diameter of the potential crop trees was larger for the control plots than for the thinned plots in 1978 (Table 2). This was expected because the average diameter was larger for the control plots initially, and also because thinning removed some of the larger rough trees. However, the periodic annual diameter growth was not significantly different among treatments ($\alpha = .05$). In fact, compared to the unthinned plots, periodic annual diameter growth was slightly higher only on the 30-percent treatment. This result was not anticipated. Even though the repeated thinnings removed some of the faster growing rough trees, we expected diameter growth rates to increase with increased thinning intensity. For example, thinning to the 50-percent level in 20- to 30-year-old oak stands increased diameter growth rates by approximately 20 percent, and thinning to the 30-percent level increased growth rates even more (Hilt 1979). The largest trees on the unthinned plots apparently established dominance early and were not severely affected by competition in these sapling-size stands.

Thinning apparently did not affect the height growth of the 125 largest trees per acre either (Table 2). There was no significant difference ($\alpha = .05$) in periodic annual height growth among treatments.

Since the repeated thinnings did not have any overall effect on tree size for the largest 125 trees per acre, the only remaining advantage for thinning might be to improve the quality of these crop trees. Clear bole length, height to the lowest live or dead limb ⅓-inch in diameter and larger, was used as the criterion for measuring tree quality. Branches of this size are considered a grade defect in the quality zone of trees this size. Clear bole length was expressed as a percent of total height (Table 2). On the basis of these criteria, there was no significant difference ($\alpha = 0.05$) between treatments.

This result is surprising because larger rough trees were removed in thinning. We believed that the 70-percent treatment would most improve tree quality because rough trees were removed at this stocking level and the stand is not opened up enough to retard natural pruning or cause epicormic sprouting. There was a slight increase in clear bole length as a percent of total height on treated plots compared with the unthinned plots, but not much. Epicormic branching on the 50- and 30-percent stocked plots, particularly in the red maples and oaks, reduced tree quality. Yellow-poplar saplings did not suffer from epicormic branching for any treatment.

Table 2. Diameter and height growth of largest 125 trees per acre in 1978 for 1962–1978 period.

Treatment	Average d.b.h. 1962	Average d.b.h. 1978	Periodic annual d.b.h. growth	Average height 1962	Average height 1978	Periodic annual height growth	Clear bole (percent of total height, 1978)
Percent stocking	*Inches*			*Feet*			*Percent*
Control	2.90	7.91	0.31	27.7	58.3	1.91	27
70	2.26	7.13	0.30	22.5	53.2	1.92	29
50	1.95	6.94	0.31	21.5	52.8	1.96	31
30	1.87	7.12	0.33	20.4	50.3	1.87	28

DISCUSSION AND CONCLUSIONS

Results of this study indicate that repeated areawide precommercial thinnings to specified density levels is not an effective timber management alternative in 8-year-old hardwood sapling stands. The largest trees in a hardwood sapling stand assume a dominant crown position at an early age and are not severely affected by competing vegetation. Some of the larger trees with stem deformities are removed in thinning, but overall, the species composition, growth, and quality of potential crop trees are not improved substantially. Species composition of all stems in the stand is altered somewhat by thinning, but similar trends occur on control plots.

An alternative to areawide thinnings is the crop-tree release method. This method has produced inconsistent results for hardwood sapling stands. Intensive cleanings of mixed hardwood sapling stands in the southern Appalachians significantly increased the diameter and basal area growth of selected crop trees (Della-Bianca 1968, 1975). Another study in western North Carolina revealed that the height and diameter growth of selected yellow-poplar seedlings increased significantly after removal of black locust sprouts (Beck and McGee 1974). On the other hand, the height growth of released crop trees in 7- to 9-year-old sapling stands in central Appalachians was not significantly increased by thinning (Trimble 1973, 1974; Lamson and Smith 1978). Significant increases in diameter growth of released trees in these stands was also not guaranteed, and clear bole length was generally reduced because natural pruning was retarded.

The removal of grapevines from the largest high-quality crop trees may have merit as a silvicultural practice in these young stands, especially on the better sites (Trimble 1973, Lamson and Smith 1978). Grapevines cause serious stem deformities in trees, particularly in red maple and cherry. They promote stem crook, sweep, forking, and excessive limbiness.

Silvicultural improvement must be substantial to offset the high costs of precommercial thinning in hardwood sapling stands. The repeated thinnings tested in this study did not result in substantial improvements.

Literature Cited

Adams, W. R., and G. L. Chapman. 1942. Crop tree measurements in thinning experiments. J. For. 40:493–498.

Beck, Donald E., and C. E. McGee. 1974. Locust sprouts reduce growth of yellow-poplar seedlings. USDA For. Serv. Note SE-201. 6 p.

Della-Bianca, Lino. 1969. Intensive cleaning increases sapling growth and browse production in the southern Appalachians. USDA For. Serv. Note SE-110. 6 p.

Della-Bianca, Lino. 1975. An intensive cleaning of mixed hardwood saplings—10 year results from the southern Appalachians. J. For. 73:24–28.

Gingrich, Samuel F. 1967. Measuring and evaluating stocking and stand density in upland hardwood forests in the central states. For. Sci. 13:38–52.

Hilt, Donald E. 1979. Diameter growth of upland oaks after thinning. USDA For. Serv. Res. Pap. NE-437. 12 p.

Husch, Bertram, C. I. Miller, and T. W. Beers. 1972. Forest mensuration. 2nd ed. The Ronald Press Co., New York. 410 p.

Lamson, Neil I., and H. C. Smith. 1978. Response to crop tree release: Sugar maple, red oak, black cherry, and yellow-poplar saplings in a 9-year-old stand. USDA For. Serv. Res. Pap. NE-394. 8 p.

Little, Elbert L. 1978. Important forest trees of the United States. U. S. Dep. Agric., Agric. Handb. 519. 70 p.

Schnur, Luther G. 1937. Yield, stand, and volume tables for even-aged upland oak forests. U.S. Dep. Agric. Tech. Bull. 560. 87 p.

Smith, David M. 1962. The practice of silviculture. 7th ed. John Wiley & Sons, New York. 578 p.

Trimble, G. R., Jr. 1973. Response to crop-tree release by 7-year-old stems of yellow-poplar and black cherry. USDA For. Serv. Res. Pap. NE-253. 10 p.

Trimble, G. R., Jr. 1974. Response to crop-tree release by 7-year-old stems of red maple stump sprouts and northern red oak advance reproduction. USDA For. Serv. Res. Pap. NE-303. 6 p.