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Precommercial Crop-Tree Release Increases Diameter Growth of Appalachian Hardwood Saplings

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Abstract

Codominant seedling-origin crop trees 25 to 39 feet tall in even-aged, precommercial-size hardwood stands were released in West Virginia. Trees were located on two sites: good oak site index 75 and fair oak site 63. Species studied were black cherry, sweet birch, and yellow-poplar. Three-year results indicated that the trees generally responded to release; the 3-year dbh growth of released trees was 0.2 to 0.4 inch greater than that of unreleased trees. Height growth did not increase.

Introduction

Many forest managers are concerned about selecting and releasing crop trees in young, even-aged hardwood stands. They want to know when and how to release crop trees, the cost, and the benefits of a crop-tree release.

Crop trees are released to:

1. Maintain the selected crop trees in at least a codominant crown-class position until maturity.

2. Manipulate composition by eliminating unwanted trees or species.

3. Stimulate dbh and, if possible, increase the merchantable and total height of crop trees.

4. Increase the quality of the residual stand by putting accelerated growth on the better trees.

5. Reduce the rotation length of the stand.

Generally, crop-tree release is applied as an individual-tree treatment in precommercial-size stands, though crop trees also can be released on a stand basis. When crop trees are selected, several trees per acre are chosen, and some or all of the remaining noncrop trees in the area are removed. Usually, trees are removed from the upper crown canopy to the lower canopy.

Positive results from the application of crop-tree release techniques in young hardwood stands have been reported (Table 1). Ten years after an intensive cleaning in 11-year-old mixed hardwood stands, Della-Bianca (1975) found that differences in dbh growth rates were greatest the first 3 years after release; there were no differences in growth response between the 6th and 10th year. However, growth response has been inconsistent for released crop trees in young stands less than 10 years after clearcutting. Crop-tree recommendations range from questionable to no release for many hardwood species (Table 2).

Table 1.—Positive responses in young even-aged stands from crop-tree release techniques

Species	Stand age	Treatment	Source
Northern hardwoods	13–18	12- to 15-foot tree spacing	Church 1955
Sugar maple, white oak, yellow-poplar	7–14	3-foot crown	Downs 1946
Sugar maple, elm, white ash, basswood	11	5-foot bole	Stoeckler and Arbogast 1947
Northern hardwoods	11	2½- and 5-foot bole	Conover and Ralston 1959
Red maple	7	5-foot bole	Trimble 1974 Smith 1977
Upland hardwoods	6	Stand area	Boyette and Brenneman 1978
Yellow birch	7	8-foot crown	Erdmann et al. 1981
Mixed hardwoods	11	Free to grow	Della-Bianca 1975
Sweet birch, yellow-poplar, black cherry	10	Free to grow	Smith 1981
Appalachian hardwoods[a]	7–12	Free to grow	Lamson 1983

[a]Yellow-poplar, basswood, red maple, black cherry, northern red oak stump sprouts.

Table 2.—Crop tree recommendations ranging from questionable to no release in young even-aged stands

Species	Stand age after clearcutting	Treatment	Source
Red oak, yellow-poplar, black cherry, sugar maple	9	5-foot bole	Smith 1979
Red oak, yellow-poplar, black cherry	7	5-foot bole	Trimble 1973 Smith 1979
Yellow-poplar	6	Free to grow	Beck 1977
Central hardwoods[a]	8	Stand area	Hilt and Dale 1982

[a]Thinned 8, 10, 17, and 22 years after clearcutting; stocking levels were 30, 50, and 70 percent.

Study Area and Methods

Hilt and Dale (1982) used residual stocking levels of 30, 50, and 70 percent in applying a precommercial thinning to hardwood stands 8 years after clearcutting (Table 2). The 30- and 50-percent stocking levels certainly approached the intensity of a crop-tree release, but these treatments did not significantly increase growth. The authors did not recommend thinning. However, in practice, a thinning is different from a crop-tree release. In a thinning, cutting begins primarily in the lower crown classes to harvest the trees that are going to die. In a crop-tree release, cutting begins with trees in the upper crown to provide more growing space for the better trees in the stand. One possible reason for some of the variation in research results (Tables 1 and 2) is that many studies do not include a measure of the degree of release around the crown margin of the crop tree.

In older stands, the diameter-growth response to crop-tree release has been more consistent. Drinkwater (1960) reported a positive response for sugar maple, *Acer saccharum* Marsh., released to a 4- to 10-foot crown margin 25 years after clearcutting. Stone (1977) found positive results when releasing sugar maple trees 50 years after clearcutting to a 5- to 10-foot crown margin. Marquis (1969) reported successful response in 25-year-old, even-aged stands of northern hardwood crop trees released to a free-to-grow crown position. Erdmann and Peterson (1972) and Erdmann et al. (1975) successfully released yellow birch, *Betula alleghaniensis* Britton, to a 10- to 14-foot and 5-foot crown margin 40 and 65 years after clearcutting. Generally, dominant-codominant crop trees have responded well to release. Sugar maple, yellow-birch, mixed southern Appalachian hardwoods, and Appalachian hardwood stump sprouts have shown the best response.

In this paper, we report 3-year results of releasing of sapling-size trees in precommercial-size stands. These results are for central Appalachian hardwood species.

The study was established on the Fernow Experimental Forest near Parsons, West Virginia. The elevation of the study area ranges from 2,300 to 2,500 feet; slopes range from flat to very steep (60 percent). Soils are medium textured and well drained, and are derived from sandstone and shale. The Experimental Forest has a cool climate with a well-distributed annual rainfall of about 60 inches.

From about 1905 to 1910, the study area was logged by a high-grading technique. The second-growth stand was about 55 years old when the stand was clearcut, that is, all trees 1.0 inch and larger in diameter at breast height (dbh) in the study area were cut. The study was done on two oak sites. The good oak sites had an average site index of 75 and the fair sites averaged 63. The most numerous sawlog-size species on the good sites were sugar maple; yellow-poplar; northern red oak, *Quercus rubra* L.; basswood, *Tilia americana* L.; hickory, *Carya* spp.; American beech, *Fagus grandifolia* Ehrh.; and sweet birch, *Betula lenta* L. On the fair sites, the primary species were chestnut, *Castanea* spp.; white oak, *Quercus alba* L.; northern red oak; red maple, *Acer rubrum* L.; sweet birch; black gum, *Nyssa sylvatica* Marsh.; sassafras, *Sassafras albidum* (Nutt.) Nees.; and sourwood, *Oxydendrum arboreum* (L.) DC.

Trees on the good sites were released 10 and 12 years after clearcutting; trees on the fair site were released 11 years after clearcutting. However, in this study total height at time of release was used to decide when to release crop trees. Crop trees were divided into two height classes: trees 25 to 32 feet tall and those 33 to 39 feet. No study crop trees were influenced by the perimeter border of the clearcuts.

All study crop trees were codominant at the time of treatment and were either released to a free-to-grow position or were not released. Crop trees of seedling origin (no visible stump present) were selected on the basis of superficial quality, including no prominent stem fork, a vigorous crown, no wounding or exposed sapwood, and no visible rot. For each species evaluated, about 15 to 20 crop trees were initially selected for each treatment within each height category. The exceptions were 33- to 39-foot trees on the fair sites, where fewer trees were available for sampling.

On the good sites, yellow-poplar, black cherry, and sweet birch were the selected species; sweet birch and black cherry were selected on fair sites. Oaks were not selected because there were no codominant seedling-origin trees on the good sites, and on the fair sites, the oaks were predominantly of sprout origin. Evaluated variables included change in crown-class position, total height, and dbh. Analysis of variance with unequal samples was used to test whether the average dbh and height responses of the released crop trees differed from those of the unreleased (control) crop trees.

Crop trees were released by a crown-touching technique (Fig. 1). Any tree adjacent to the crop tree was cut if its crown touched the crown of the crop tree or if the crown was above or below the drip line or edge of the crop-tree crown. A majority of the crop trees were released on four sides of the crown; the remaining trees were released on three sides. After release, the crown margins of adjacent trees were about 4 feet from the crop-tree crown margin but this distance was quite variable, especially where crop trees were near each other. Trees were cut with a chain saw and stumps were not treated with herbicides. Manhours required to select and release crop trees were recorded for more than 1,000 crop trees. The chain-saw operator did not select trees for release as crop-tree selection was a separate operation.

Three growing seasons after treatment, there was a severe snowstorm during October when the trees were in full foliage. Many of the crop trees had broken tops, were bent over, or were uprooted. Also, many released crop trees were rereleased and control trees were released. The study was terminated after three growing seasons.

Figure 1.—A 25- to 32-foot crop tree before (left) and after release (right).

Results

Crop-Tree Height Class 25 to 32 Feet

Total height.—In general, within each species and site class, there were no significant differences between the height-growth means for released and control trees. The exception was for yellow-poplar on the good site, where the average 3-year growth of released trees was greater than that of the control trees (8.2 versus 5.7 feet, Table 3). There were no differences in height growth between released and control trees for the other species on the good site, and a difference of only about 0.5 foot on the fair site. For the three species released on the good site, the average 3-year height growth ranged from 7.7 to 8.8 feet. On the fair site, the 3-year height growth for the released trees was between 6.3 and 6.4 feet for the two species (Table 3). Since height growth was not measured on damaged trees from the October snow, lack of significance between treatment means may have been due to a small sample size.

Dbh.—In all instances, the average 3-year dbh growth for the released crop trees was significantly greater than for control trees (Table 3). The initial dbh for all crop trees before treatment ranged from 2.3 to 3.0 inches. The 3-year response for all species, treatments, and site classes ranged from 0.9 to 1.6 inches (Table 3). Yellow-poplar had the best response followed by black cherry; sweet birch was a distant third.

Differences in 3-year dbh growth for the released compared with control trees was at least 0.2 inch for yellow-poplar and sweet birch on the good and fair sites. Maximum growth was 0.4 and 0.3 inch for black cherry on the good and fair sites, respectively (Table 3).

Crop-Tree Height Class 33 to 39 Feet

Total height.—As was generally true for the lower height classes, there was no significant difference in height-growth response between released and control treatments. On the good sites, 3-year height growth for all species ranged from 7.2 to slightly more than 8.2 feet; on the fair site the range was about 5.9 to 7.2 feet (Table 3). Because of the snowstorm, the sample size was marginal for this height category on the good sites and for sweet birch on the fair sites.

Dbh.—On the good sites, the average dbh for all trees before release ranged from 3.2 to 3.8 inches; on the fair site, the initial dbh was 2.7 to 3.2 inches. On the good sites, the release crop trees for all species had significantly larger 3-year dbh growth than the control trees. This dbh growth ranged from 1.2 to 1.6 inches with the difference between release and control trees averaging 0.2 inch for yellow-poplar and 0.4 inch for black cherry. On the fair sites, black cherry growth was better than sweet birch growth, but the difference between release and control crop trees was not significant (Table 3).

Regression of Crown Class

The regression of crown class from a dominant-codominant position to an intermediate-overtopped position has been of concern in precommercial-size, even-aged hardwood stands where crop-tree release techniques have been applied. In this study, crown classes generally remained stable after release (for the 3-year period). Of the total of 223 study trees, including all species, release treatments, heights, and site categories, only 12 trees regressed in crown class and 6 of these were yellow-poplar control trees. Of the 112 release trees in the study, only 3 regressed in crown class. Thus, crown-class regression did not appear to have a significant influence on the study trees 3 years after treatment.

Cost of Selecting and Releasing Crop Trees

On the average, 47 crop trees were selected per manhour. The flagged crop trees were selected from thirty-six ½-acre openings, each averaging about 29 crop trees. Premarked crop trees were released with a chain saw and an average of 30 trees were released in 1.6 manhours. At a rate of $6 per manhour, it would cost about $19.20 to release an average of 60 crop trees per acre. At the same rate per manhour, the cost of selecting 60 crop trees before release would be about $7.70 per acre. Travel time to and from the area is not included.

Table 3.—Three-year total height and dbh growth for released and unreleased crop trees

Species and treatment	Total height (feet)			Dbh (inches)		
	Initial	3-year	Difference	Initial	3-year	Difference
			TREES 25.0 TO 32.9 FEET TALL			
Good Oak Sites						
Sweet birch						
Release	28.3 (26)[a]	36.0 (12)	7.7ns	2.3 (26)	3.4 (25)	1.1**
Control	28.1 (26)	35.8 (17)	7.7	2.4 (26)	3.3 (26)	0.9
Yellow-poplar						
Release	28.2 (21)	36.4 (8)	8.2**	2.7 (21)	4.3 (21)	1.6**
Control	29.6 (26)	34.3 (10)	5.7	3.0 (26)	4.4 (26)	1.4
Black cherry						
Release	28.7 (26)	37.5 (10)	8.8ns	2.5 (26)	3.9 (24)	1.4**
Control	29.1 (17)	37.9 (5)	8.8	2.6 (17)	3.6 (17)	1.0
Fair Oak Sites						
Sweet birch						
Release	29.4 (26)	35.8 (25)	6.4ns	2.4 (26)	3.5 (26)	1.1**
Control	30.0 (25)	36.9 (25)	6.9	2.5 (25)	3.4 (15)	0.9
Black cherry						
Release	30.5 (17)	36.8 (19)	6.3ns	2.5 (17)	3.8 (17)	1.3**
Control	30.0 (13)	36.6 (11)	6.6	2.5 (13)	3.5 (13)	1.0
			TREES 33.0 TO 39.9 FEET TALL			
Good Oak Sites						
Yellow-poplar						
Release	36.4 (20)	44.0 (7)	7.6ns	3.6 (22)	5.2 (20)	1.6**
Control	35.7 (19)	42.9 (6)	7.2	3.8 (20)	5.2 (19)	1.4
Black cherry						
Release	36.5 (16)	43.8 (7)	7.3ns	3.4 (17)	5.0 (16)	1.6**
Control	36.3 (15)	44.5 (6)	8.2	3.2 (18)	4.4 (15)	1.2
Fair Oak Sites						
Sweet birch						
Release	34.0 (7)	39.9 (5)	5.9ns	2.7 (7)	3.7 (7)	1.0ns
Control	35.2 (10)	41.2 (9)	6.0	2.9 (10)	3.8 (10)	0.9
Black cherry						
Release	35.3 (12)	42.5 (11)	7.2ns	3.2 (13)	4.7 (12)	1.5ns
Control	35.0 (13)	42.1 (13)	7.1	3.2 (13)	4.6 (13)	1.4

[a]Number of trees in parentheses.
**Means significantly different at 1-percent level.
ns = not significant

Discussion

In this study, codominant crop trees 25 feet or taller produced a significant dbh-growth response when the crown-touching method was used. For all tree species and height classes evaluated, except for 33- to 39-foot-tall sweet birch and black cherry on the fair sites, release trees had significantly higher dbh growth than the control trees. Releasing crop trees increased 3-year dbh growth from 0.2 to 0.4 inch over the control trees. In reporting 5-year results, Lamson (1983) found that releasing stems of stump sprout origin 7 and 12 years after clearcutting produced a significant positive dbh-growth response.

In general, the released seedling-origin trees in this study did not produce a significant height-growth response compared with the control trees; this also was true for the trees of stump sprout origin in Lamson's study.

In previous studies with younger trees, crown-class regression has been of major concern (Trimble 1973, 1974; Smith 1979). During this 3-year study period, crown-class regression apparently was not promoted by crop-tree release as it occurred in only 3 of 112 codominant release crop trees. It may be that these 10- to 12-year-old trees are not responding as rapidly as younger trees because the study was not long enough to allow regression to develop, or that the trees at this height are beginning to decelerate in height growth. Or it may be that as the trees become taller, there is more crown stability, so that crown class is easier to retain than in younger stands. Or perhaps the seedlings at this 10- to 12-year period after clearcutting are similar to sprouts. In a West Virginia study, Wendel (1975) reported that the dominant stump sprout in a clump did not remain the same from year to year; about 50 percent of the red oak stumps had changes in dominant sprouts during the first 5 years. Twelve percent of the red oak sprouts changed dominant position from 7th to the 10th year. In general, as the years increased, the changing of dominating red oak sprouts decreased. This seedling-origin study has been terminated so it cannot be determined whether crown-class regression would have become more apparent over a longer period.

Although the crown-touching techniques resulted in a positive dbh-growth response, it is not known how long this response would have been maintained. More definite information about the degree of release is needed to develop better guidelines. On the basis of these results and general observations, we believe that the crown-touching treatment should be used as a minimum release treatment. More research is needed on applying these methods to a variety of hardwood tree species on an individual-tree and stand basis. If precommercially released trees consistently grow larger in average dbh than nonreleased trees, does this diameter increase at an early age result in the released trees maturing at a significantly earlier age than nonreleased trees? If true, this could result in shorter rotations, and with shorter rotations, economic evaluations may become more favorable to applying crop-tree release treatments. Thus, researchers need to determine the cost and evaluate the growth response and benefits from each release treatment, and then develop guidelines that are easy to understand and apply.

The following suggestions for releasing crop trees in young central Appalachian hardwood stands are based on this and other studies.

- Do not release more than 50 to 75 crop trees per acre. Crop trees are expensive to release. The spacing between crop trees should be at least 25 to 30 feet. Also, additional crop trees could become available from current noncrop trees.
- Cut or remove all adjacent trees that are touching the crown of the crop tree or that are above or below the drip line or edge of the crop-tree crown. Cut all questionable trees. Where there are two excellent crop trees beside each other, retain both trees.
- Select crop trees from among the high-quality, vigorous, desirable tree species. It is better not to release a crop tree or crop trees in part of the stand than to release an obvious unacceptable tree to meet goals for spacing or number of trees per acre.
- Cut only trees whose removal benefit the crop tree. Do not cut "weed" or undesirable tree species throughout the stand unless this is part of the release objective.
- For intolerant species, release only trees in the dominant or codominant crown class.
- For sprout clumps, cut all but the best one or two widely spaced (U-shaped attachment), high-quality, dominant-codominant, low-origin sprouts less than 6.0 inches above the ground (Lamson 1983).
- The earliest probable time when crop trees should be released by the techniques we used is when the codominant trees in the stand have attained a height of about 25 feet.
- In precommercial-size stands with grapevines, delay crop-tree release for about 5 years after the grapevines have been cut. Shading kills the grapevine stump sprouts and if a release and grapevine control cutting is done simultaneously, grapevine sprouting can be stimulated. This recommendation depends on the average height of the trees in the stand or the use of herbicides. As trees become taller and shading increases, the delay in releasing crop trees after a grapevine treatment becomes less important. Grapevines could be treated with herbicides during crop-tree release, but a herbicide application could present a risk to the crop tree.

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Hardwood, codominant sapling crop trees 25 to 39 feet tall in even-aged stands were released in a West Virginia study. Trees were located on two oak sites: good oak site index 75 and fair oak site 63. Species studied were black cherry, sweet birch, and yellow-poplar. Three-year results indicated that the trees generally responded to release; the 3-year dbh growth of released trees was 0.2 to 0.4 inch greater than that of unreleased trees. Height growth did not increase.

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