United States
Department of
Agriculture

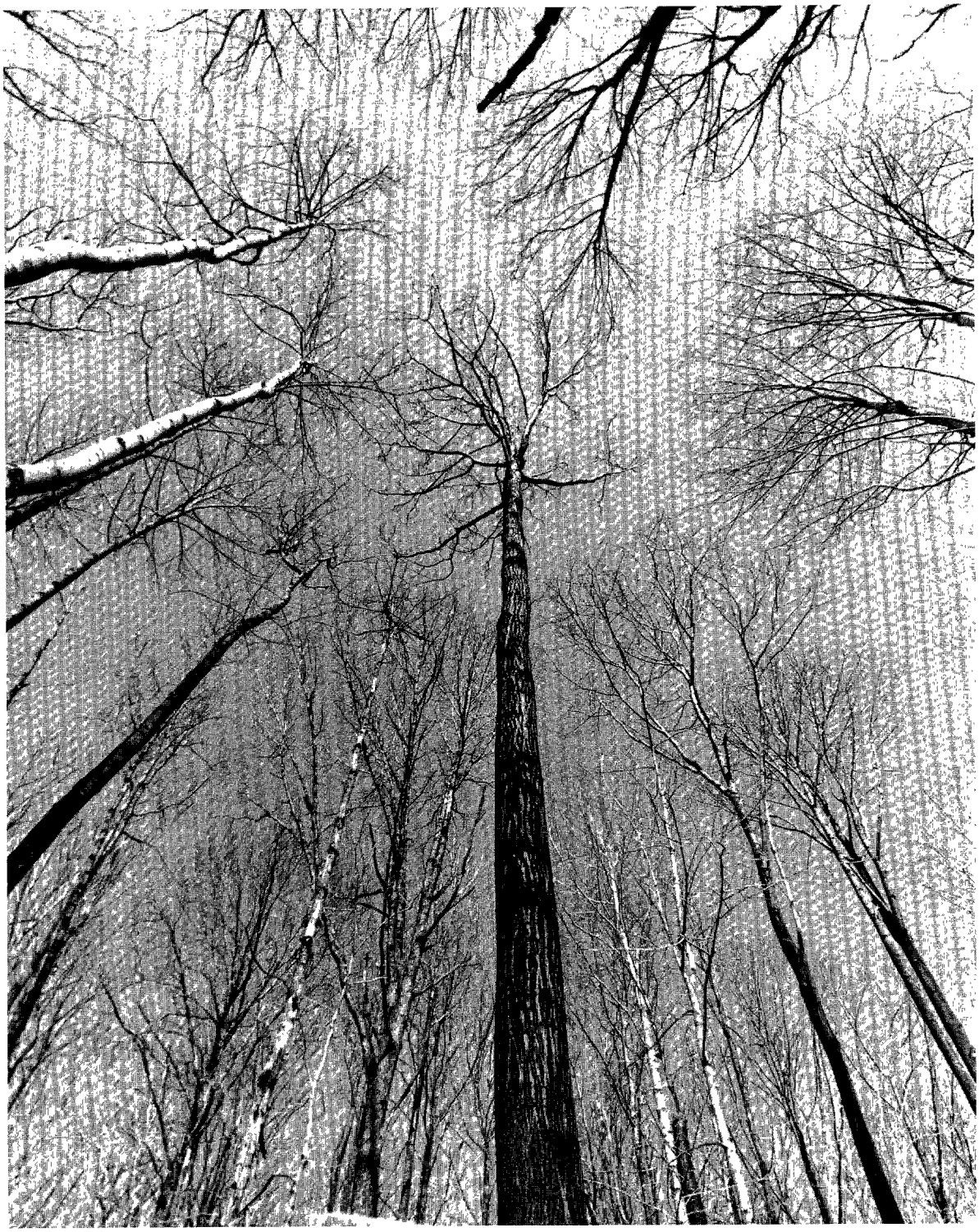
Forest Service

**Northeastern Forest
Experiment Station**

Research Paper NE-635

Crown Release Increases Growth of Crop Trees

Neil I. Lamson
H. Clay Smith
Arlyn W. Perkey
Samuel M. Brock



Abstract

Two Appalachian hardwood stands in north-central West Virginia were thinned. The primary species were red oak, yellow-poplar and chestnut oak. For both stands, the site index for northern red oak averaged 75 feet. An areawide thinning using "basal-area control" was applied to a 54-year-old stand, while specific crop trees were selected and released in a 12-year-old stand. Individual-tree 5-year growth of codominant trees was related to the number of sides of the crown that was free-to-grow. Codominant trees and crop trees grew about 25 percent faster in d.b.h. than similar trees released on one or two sides of the crown. For best diameter-growth response, a tree should be released on at least three and preferably four sides of the crown.

The Authors

NEIL I. LAMSON is with the USDA Forest Service, Northeastern Area, State and Private Forestry at Durham, New Hampshire. Previously, he was a research forester with the Northeastern Forest Experiment Station's Timber and Watershed Laboratory at Parsons, West Virginia, and Forestry Sciences Laboratory at Durham, New Hampshire.

H. CLAY SMITH is Project Leader of timber management research at the Northeastern Station's Timber and Watershed Laboratory at Parsons, West Virginia.

ARLYN W. PERKEY is field representative for forest management and utilization with the Northeastern Area, State and Private Forestry at Morgantown, West Virginia.

SAMUEL M. BROCK is professor of forest economics with the Division of Forestry, West Virginia University at Morgantown, West Virginia.

Manuscript received for publication 1 August 1989

Northeastern Forest Experiment Station
100 Matsonford Road, Radnor, PA 19087
February 1990

Introduction

Thinning from below to a particular basal area is often prescribed to remove slow-growing, low-value trees from even-aged hardwood stands. It has generally been assumed that if the stand basal area is reduced to about 70 square feet per acre, the appropriate distribution of the cut would occur automatically. The end result would be to redistribute stand growth onto fewer stems and increase the diameter growth of the crop trees. Careful examination of a number of stands following such thinnings has revealed that most crop trees are not released properly, even though the stand residual basal area has been reduced to the desired level. Instead of just cutting "bad" trees, foresters need to concentrate on releasing crop trees to maximize stand value production. In fact, most foresters "mentally select" leave trees or crop trees when deciding which trees to cut.

Methods

In 1982 a thinning study was conducted in north-central West Virginia. Twenty plots, each 0.5 acre in size, were established in a 54-year-old Appalachian hardwood stand. The site index for northern red oak averaged 75 feet. The principal species were yellow-poplar and northern red oak with occasional red maple, white oak, and chestnut oak. Target thinning treatments were 45, 60, 75 and 100 (no cutting) percent residual stocking using the stocking guide for upland oaks (Gingrich 1967). Each of the four thinning treatments was replicated five times.

Before treatment, every tree over 1.0 inch d.b.h. was permanently identified with a numbered metal tag, and d.b.h. and crown class were recorded. The plots were marked for thinning from below, i.e., trees were removed from lower crown positions until the desired residual stocking was achieved. These data are summarized in Table 1. The plots were logged by a commercial logger (Fig. 1). After logging, each residual tree was examined for logging damage. For detailed information on this study see Brock et al. 1986.

Five growing seasons after treatment, the d.b.h. of all trees was remeasured and all crop trees were assigned a free-to-grow (FTG) rating. In this instance, a crop tree was defined as a vigorous, codominant tree of commercial species with a potential Grade 1 butt log, with no more than three epicormic branches in the butt log, and no significant decay in the main stem. Before logging, epicormic branches usually are not acceptable in the butt log of a potential crop tree. Free-to-grow means that there is enough space (more than 5 feet) between the crop-tree crown and adjacent tree crowns that the canopy will not close in the next 5 years. Crop trees are rated 0, 1, 2, 3, or 4, with 0 for crop trees that have no sides (quadrants) free-to-grow and 4 for crop trees that are free-to-grow on all four sides (Fig. 2). Table 2 shows the FTG ratings of these crop trees.

Crop trees from a second study area on a good to excellent growing site also were evaluated. In this 12-year-old even-aged stand, 80 crop trees per acre, primarily yellow-poplar and red oak, were selected and released on six 1/4-acre plots (20 crop trees per plot). All crop-tree crowns were released on four sides. After treatment, every codominant crop tree, including those not selected as crop trees, were assigned an FTG rating. This resulted in a good sample of codominant crop trees throughout the range of FTG ratings as some trees near released crop trees were partially released.

Table 1.—Stand data before and after thinning for three thinning levels

Residual stocking treatment (percent)	No. stems/acre			Basal area/acre		Percent stocking		Merchantable volume/acre	
	D.b.h.	Initial	Residual	Initial	Residual	Initial	Residual	Initial	Residual
	Inches			*Ft²*				*Ft³*	*Board feet*[a]
75[b]	1.0 to 7.5	370	157	23.1	114.7	29	96	2,849	9,098
	7.6+	307	92	12.3	70.5	17	59	1,722	6,418
60[b]	1.0 to 7.5	314	157	24.2	128.6	29	106	3,366	11,496
	7.6+	228	72	8.4	59.3	12	49	1,536	6,096
45[b]	1.0 to 7.5	276	144	21.0	124.3	26	101	3,270	10,993
	7.6+	192	56	6.8	43.5	10	36	1,095	3,873

[a]Trees 11.6 inches d.b.h. and larger.

[b]Target stocking percent for plots.

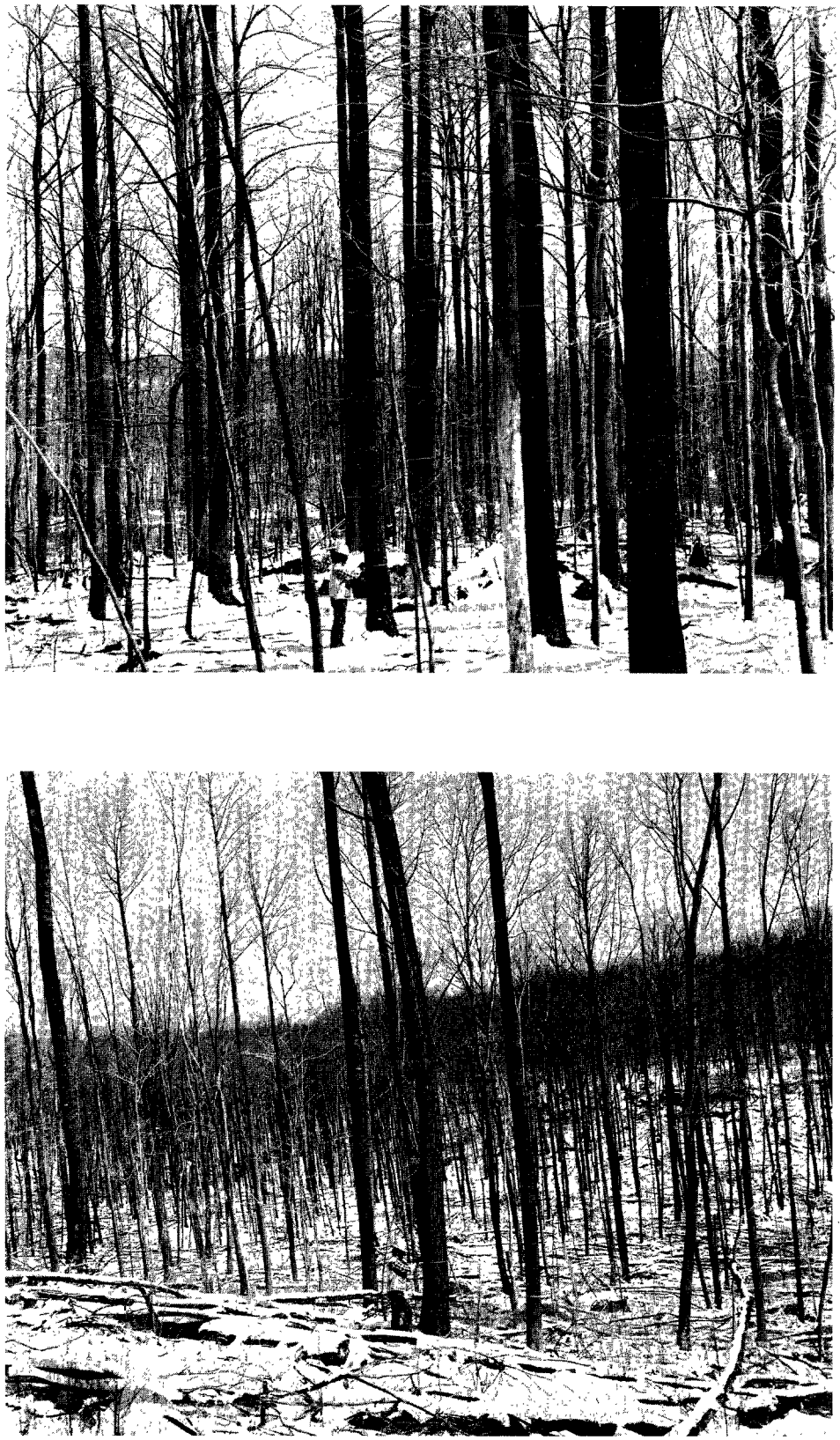


Figure 1.—Stand before (top) and after (bottom) logging.

Table 2.—Number of crop trees per acre, by free-to-grow rating, in 54-year-old stands thinned to three levels of residual stand density

Residual stand density (percent)	Free-to-grow rating					Total
	0	1	2	3	4	
45	1 (3)[a]	3 (10)	9 (29)	14 (45)	4 (13)	31 (100)
60	4 (9)	14 (32)	15 (34)	9 (20)	2 (5)	44 (100)
75	16 (30)	22 (41)	12 (22)	3 (5)	1 (2)	54 (100)
No cutting	43 (77)	12 (21)	1 (2)	0	0	56 (100)

[a]Percentage of trees in parentheses.

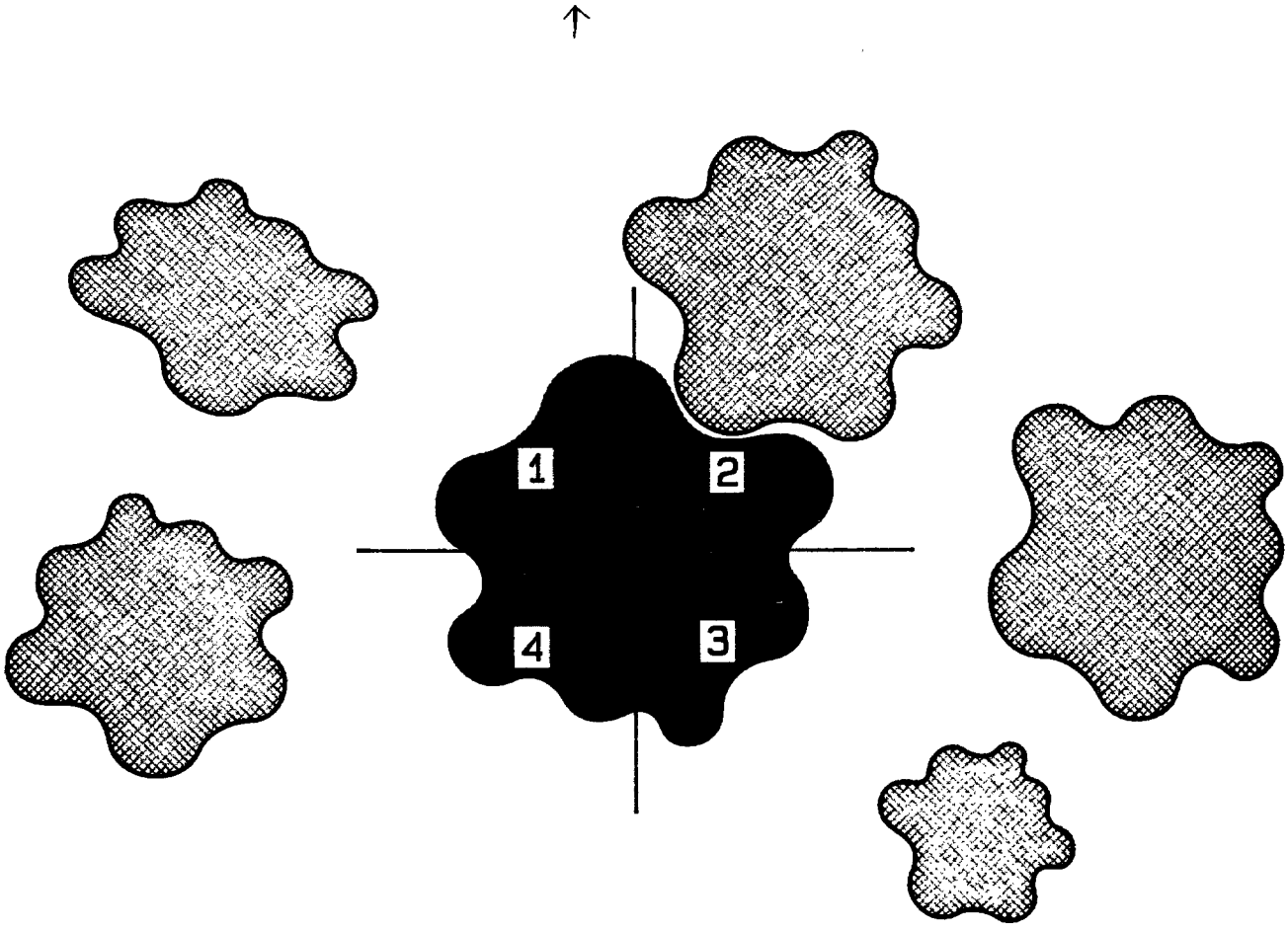


Figure 2.—Schematic showing tree crown with free-to-grow quadrants. This tree crown is released on three sides.

Results

More Release Means More Diameter Growth

How much diameter growth is lost by not releasing crop trees on three or four sides? To answer this question, we looked at the 5-year d.b.h. growth of crop trees in both the 12-year-old stand and the 54-year-old stand. The 5-year d.b.h. growth of the 12-year-old codominant trees as related to the FTG rating is summarized in Table 3. In general, diameter growth increased as the FTG rating increased (Table 3, Fig. 3). Releasing 12-year-old codominant crop trees on one side of the crown (FTG = 1) did not increase 5-year d.b.h. growth. Releasing trees on two sides increased d.b.h. growth over unreleased trees by about 0.2 inch in 5 years. However, trees released on four sides grew about 1.0 inch more than unreleased trees in 5 years.

In the 54-year-old stand, the diameter growth of all crop trees was averaged by FTG rating (Table 3). For all crop trees, 5-year d.b.h. growth was increased 0.25, 0.40, 0.59, and 0.80 inch over unreleased crop trees by releasing trees on one, two, three, and four sides of the tree crown, respectively (Table 3). Trees released on four sides grew about 0.40 inch more in d.b.h. in 5 years than those that had been released on two sides. Trimble (1967) reported d.b.h. growth rates for eight hardwood species in previously unmanaged second-growth stands between 46 and 55 years old. A partial cutting (conditioning cut) was applied to the stand. Specific crop trees were not released. Actual 10-year growth for free-to-grow red oak and yellow-poplar trees was 2.8 and 2.4 inches d.b.h. Projected 10-year d.b.h. growth for the 54-year-old red oak and yellow-poplar crop trees released on three and four sides of the tree crown was 2.8 and 3.5 inches, respectively (Table 3).

We also selected the fastest growing (best) 20 crop trees per acre on each plot and averaged their 5-year d.b.h. growth by FTG rating. We found the same relationship of increased growth with increased FTG rating (Fig. 3). For the best 20 released crop trees per acre, compared to similar unreleased crop trees, releasing crop trees on one to four sides of the crown increased 5-year d.b.h. growth by 0.18, 0.37, 0.53, and 0.95 inch, respectively. For individual species, yellow-poplar and red oak responded better to release than chestnut oak.

These growth response figures are averages. Within the FTG rating category, individual-tree growth will vary, according to the site, and more importantly, the size and vigor of the tree crowns before release. The tree crowns shown in Figures 4 and 5 represent average crowns. Both red oak crop trees are on the same 1/2-acre plot; their d.b.h. at the beginning of the 5-year period was 12.0 and 12.2 inches, respectively. Since this is an even-aged stand, their growth and development before release were similar. The tree in Figure 4 did not receive any release during thinning. It has an FTG rating of zero and a 5-year d.b.h. growth rate of 1.1 inches. The tree in Figure 5 has an FTG rating of 4 due to the thinning, and a 5-year growth rate of 2.1 inches.

Table 3.—Relationship of 5-year diameter growth to free-to-grow rating for crop trees or codominant trees in two stands[a]

Free-to-grow rating	12 years old	54 years old				All crop trees
		Chestnut oak	Red oak	Yellow-poplar	20 Best	
		Inches				
0	1.32 (29) a	0.63 (29) a	0.99 (41) a	0.99 (60) a	1.04 (37) a	0.88 (159) a
1	1.31 (21) a	0.68 (12) a	1.13 (37) a	1.30 (61) b	1.22 (56) ab	1.13 (131) b
2	1.49 (31) a	0.92 (18) a	1.45 (23) b	1.47 (36) b	1.41 (49) b	1.28 (108) b
3	1.75 (13) a	1.01 (13) b	1.39 (17) b	1.70 (28) c	1.57 (39) b	1.47 (71) c
4	2.26 (55) b	0.95 (4) a	— (0)	1.96 (10) d	1.99 (8) c	1.68 (69) d

[a]Means in the same column followed by the same letter are not significantly different using Tukey's multiple range test, P = 0.05; number of trees are in parentheses.

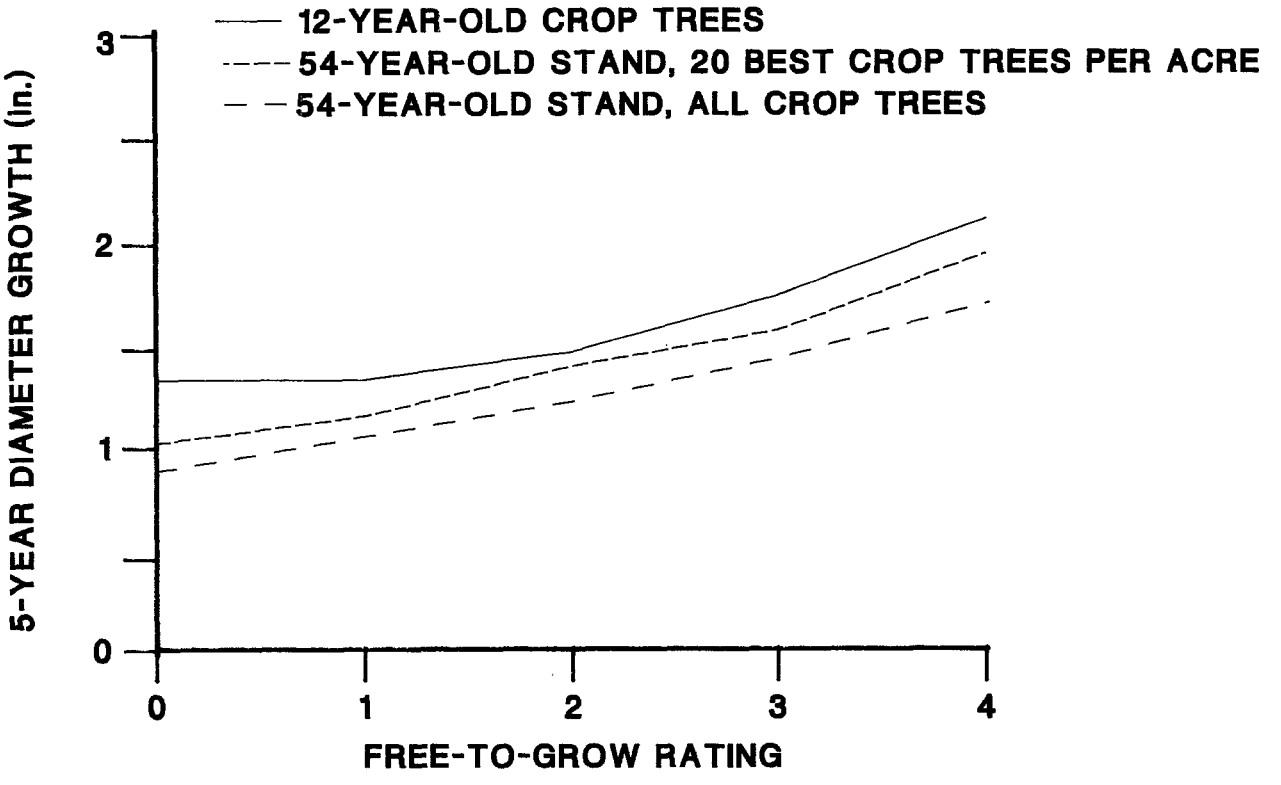


Figure 3.—Relationship of 5-year diameter growth to free-to-grow rating.

Thus, for these two stands, we are losing from 0.4 to 0.8 inch in d.b.h. growth per crop tree in the first 5 years after thinning by releasing crop trees on two rather than four sides. During the second 5 years after thinning, growth differences may be even greater because the canopy will have closed around most crop trees that were originally released on only two sides. The final result may be that crop trees released on three or four sides may increase in d.b.h. by an inch or more over those released on only two sides. This extra inch in d.b.h. will mean extra income when the trees are harvested and/or perhaps even more significantly, a shorter rotation period.

Discussion

Releasing Crop Trees by Percent Stocking—Low Thinning Approach

There were 56 crop trees per acre in the uncut thinning plots (100-percent residual stocking). Most crop trees in uncut plots had an FTG rating of 0 or 1. If thinning is supposed to increase growth of the crop trees, crop trees in thinned stands should have a higher FTG rating than those in uncut stands. In the plots thinned to B-line stocking (60 percent), there were 44 crop trees per acre and one fourth of these had an FTG rating of 3 or 4. Even at 45 percent residual stand density, 40 percent of the crop trees were free-to-grow on one or two sides. It appears that traditional thinning from below does not adequately release many of the crop trees.

Results of this study indicate that the more sides of the crown of codominant trees released, the greater the increase in d.b.h. growth. Ideally, it is best to give tree crowns room to grow on all four sides. In other words, the more room a tree crown has to grow, the greater the response in d.b.h. growth. This relationship probably holds true for a wide range of species and ages as data for this study were from 12- and 54-year-old stands and included four different species.

Quality was not evaluated in this study but the literature suggests that releasing vigorous, codominant crop trees does not cause the development of epicormic branches on the lower tree bole. Smith et al. (1989) reported that 80-year-old codominant Appalachian hardwoods released on four sides did not produce a significant number of epicormic branches. Dale and Brisbin (1985) showed that heavy thinning caused an increase in the number of epicormic branches on white oak, but generally not on other oaks and yellow-poplar.

When using thinning stocking guides, try to concentrate on giving better trees more room to grow. Thinnings from below that reduce the stand to B-line stocking can result in

Figure 4.—Unreleased red oak crop tree was 12.0 inches in d.b.h. before release and 13.1 inches in d.b.h. 5 years after release.

Figure 5.—Released red oak crop tree was 12.2 inches in d.b.h. before release and 14.3 inches in d.b.h. 5 years after release.

stands with several of the best codominant trees released on only one or two sides. This means lost growth potential on the highest value trees. We realize that as the intensity of thinning increases, the number of sides released on residual trees also increases. However, to gain the maximum amount of growth on the best trees in the stand, crop trees should be selected and released, even when doing a thinning from below.

Ideally, crop trees should be released on four sides by a crown-touching release (Fig. 6). This may not be possible in sawtimber-size stands because adjacent crop-tree crowns are touching. However, the general rule should be to make certain that the highest value trees in the stand are released on three or four sides. In stands that contain only a few crop trees, stand value usually will be maximized by releasing only the crop trees. Other trees can be harvested whenever they can be removed at a profit.

Recommendations

To maximize stand value growth we must give the most valuable trees an adequate release. Reducing stands to a prescribed basal area by cutting "bad" trees does an inadequate job of releasing the best crop trees. Therefore, we need to concentrate our efforts more on crop trees when thinning even-aged stands. We recommend the following guidelines for thinning even-aged hardwood stands.

1. *Select and release crop trees.* Select crop trees to be released from among those codominant trees with good healthy crowns and well-formed boles capable of producing a Grade 1 butt log. Mark trees to cut whose removal will give the crop tree crown room to expand. After thinning, crop trees should have three or four sides of their crowns free from competition. When marking, if you are not stumbling over limbs and brush on the forest floor, you probably are not looking up enough.

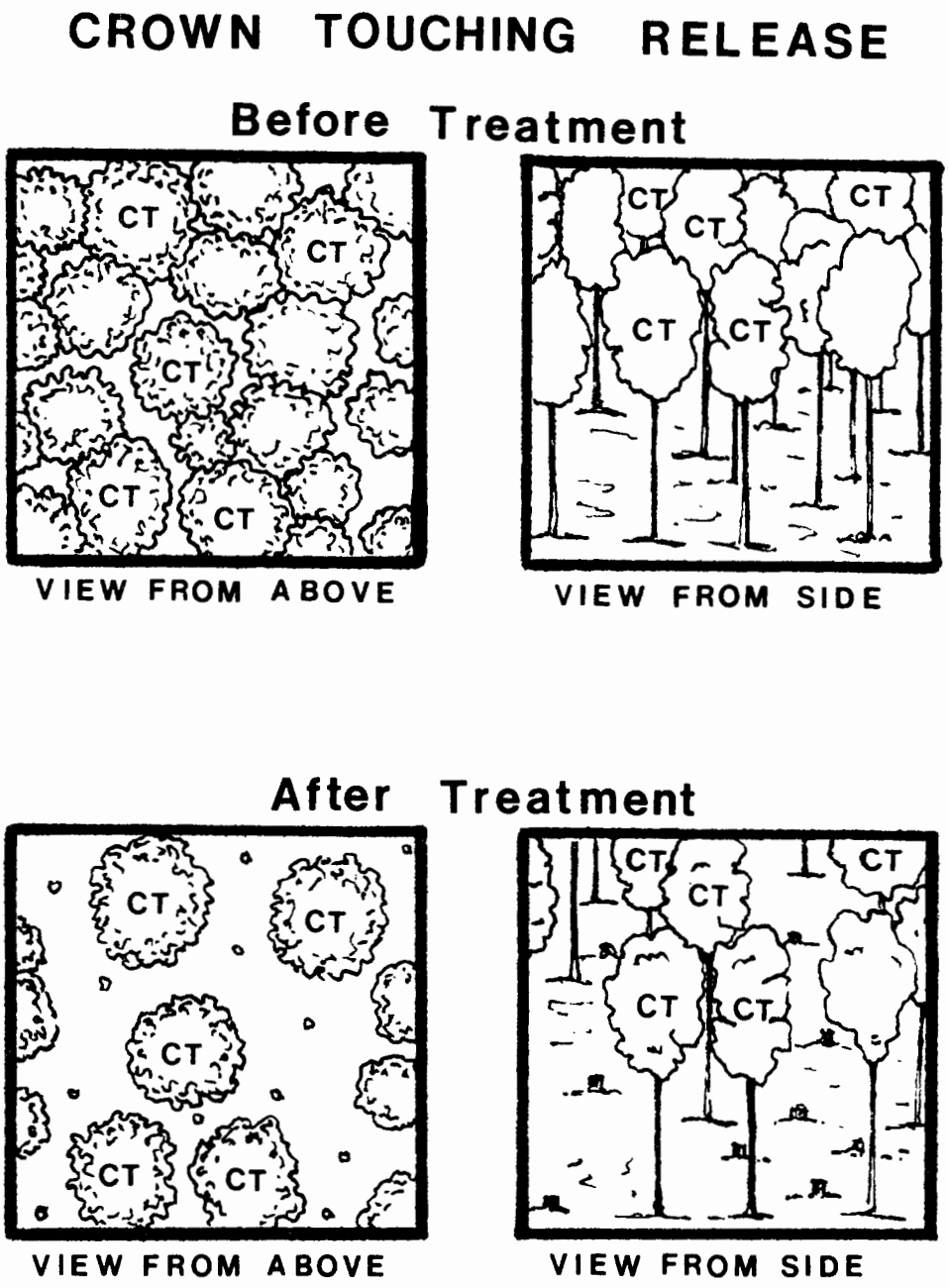


Figure 6.—Aerial and side views of stand before and after releasing crop trees by crown-touching technique.

2. *Reduce residual stand density to 40 to 50 percent.* Providing a three- or four-sided release to the most valuable crop trees may reduce relative stand density to less than B line. More recent studies indicate that stands can be reduced to 40-percent residual stand density without sacrificing volume or value growth (Beck 1986; Dale and Hilt 1986; Dieroff 1986).

3. *Look out for epicormic branches.* Crop trees should not have epicormic branches (living or dead) in the butt log at the time of release. Most butt logs with more than three epicormic branches do not make Grade 1 factory logs (Smith et al. 1989). Be especially cautious when considering the release of species that are prolific epicormic sprouters, for example, basswood, elm, and white oak. Most released crop trees will not produce epicormic branches if at the time of release they were vigorous codominants and showed no signs of previous epicormic branches.

4. *Do not release crop trees when they are expected to be under stress.* For example, if defoliation by gypsy moth or other pests is anticipated, consider delaying release until defoliation is no longer a concern. Defoliated or stressed trees often develop epicormic branches.

Simply reducing stand densities to a prescribed level does not ensure an adequate job of thinning. Cutting "bad" and leaving "good" trees is not enough. Crop trees must be selected and released to maximize diameter growth of the most valuable trees in the stand.

Literature Cited

Beck, Donald E. 1986. **Thinning Appalachian pole and small sawtimber stands.** In: Smith, H. Clay; Eye, Maxine C., eds. Proceedings, guidelines for managing immature Appalachian hardwood stands; 1986 May 28-30; Morgantown, WV. SAF Publ. 86-02. Morgantown, WV: West Virginia University Books: 85-98.

Brock, Samuel M.; Jones, Kenneth D.; Miller, Gary W. 1986. **Felling and skidding costs associated with thinning a commercial Appalachian hardwood stand in northern West Virginia.** Northern Journal of Applied Forestry. 3: 159-163.

Dale, Martin E.; Hilt, Donald E. 1986. **Thinning pole and small sawtimber mixed oak stands.** In: Smith, H. Clay; Eye, Maxine C., eds. Proceedings, guidelines for managing immature Appalachian hardwood stands; 1986 May 28-30; Morgantown, WV. SAF Publ. 86-02. Morgantown, WV: West Virginia University Books: 99-117.

Dale, Martin E.; Brisbin, Robert L. 1985. **Butt log quality of trees in Pennsylvania oak stands.** Res. Pap. NE-568. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Dieroff, Thomas A. 1986. **Thinning oak stands in Virginia.** In: Smith, H. Clay; Eye, Maxine C., eds. Proceedings, guidelines for managing immature Appalachian hardwood stands; 1986 May 28-30; Morgantown, WV. SAF Publ. 86-02. Morgantown, WV: West Virginia University Books: 118-133.

Gingrich, Samuel F. 1967. **Measuring and evaluating stocking and stand density in upland hardwood forests in the central states.** Forest Science. 13: 38-53.

Perkey, A. W. 1988. **Crop tree release—how well have we done?** Forest Management Update. 8: 6-8.

Smith, H. Clay; Lamson, Neil I.; Miller, Gary W. 1989. **Deferment cutting practice—a possible alternative to clearcutting.** Journal of Forestry. 87(3): 14-18.

Lamson, Neil I.; Smith, H. Clay; Perkey, Arlyn W.; Brock, Samuel M. 1990. **Crown release increases growth of crop trees.** Res. Pap. NE-635. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Two Appalachian hardwood stands in north-central West Virginia were thinned. The principal species were red oak, yellow-poplar, and chestnut oak. For both stands the site index for northern red oak averaged 75 feet. An areawide thinning using "basal-area control" was applied to a 54-year-old stand while specific crop trees were selected and released in a 12-year-old stand. Individual-tree 5-year growth of codominant trees and crop trees were related to number of sides of the crown that was free-to-grow. Codominant trees and crop trees grew about 25 percent more in d.b.h. than similar trees released on one or two sides of the crown. For best diameter-growth response, a tree should be released on at least three and preferably four sides of the crown.

ODC: 242:181.65:521.1

Keywords: Thinnings; crop trees; Appalachian hardwood; diameter growth

☆U. S. GOVERNMENT PRINTING OFFICE: 1990/748-070/00019

Headquarters of the Northeastern Forest Experiment Station is in Broomall, Pennsylvania. Field laboratories are maintained at:

Amherst, Massachusetts, in cooperation with the University of Massachusetts

Berea, Kentucky, in cooperation with Berea College

Burlington, Vermont, in cooperation with the University of Vermont

Delaware, Ohio

Durham, New Hampshire, in cooperation with the University of New Hampshire

Hamden, Connecticut, in cooperation with Yale University

Morgantown, West Virginia, in cooperation with West Virginia University

Orono, Maine, in cooperation with the University of Maine

Parsons, West Virginia

Princeton, West Virginia

Syracuse, New York, in cooperation with the State University of New York, College of Environmental Sciences and Forestry at Syracuse University

University Park, Pennsylvania, in cooperation with The Pennsylvania State University

Warren, Pennsylvania
