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Crop-Tree Release Thinning In 65-Year-Old Commercial Cherry-Maple Stands (5-Year Results)

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Abstract

Crop trees were selected and released in a 65-year-old cherry-maple stand in north central West Virginia. Six crop-tree treatments were evaluated. Crop trees were selected based on potential for quality sawtimber and veneer products. Initially, released crop trees averaged 12.5 inches d.b.h. and 80 feet tall and were released an average of 13 feet from the edge of their crown. Five-year stand growth, mortality, and ingrowth are discussed for the treatments. Tree quality as related to butt-log grade and epicormic branching also are discussed. Detailed information is given for d.b.h. growth as related to degree of crown release. In general, black cherry, free-to-grow crop trees for the 40 and 60 crop-trees-per-acre treatments grew 1.0 inch in 5 years. Similar crop trees in the control areas, where tree crowns were not released, grew 0.6 inch during the same period. Growth response increased with an increase in number of sides of the tree crowns released. After 5 years, less than 2 percent of the released crop trees had a reduction in butt-log quality due to epicormic branching.

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Introduction

One primary objective in the management of central Appalachian hardwood stands is the production of high quality sawlogs and veneer products. Practices used to achieve this objective include thinning cultural practices in precommercial- and commercial-size even-aged stands. Common thinning practices in precommercial stands include a timber stand improvement approach where undesirable trees are removed or individual crop trees are released. For commercial stands, stocking guides or basal area techniques often are used in thinning. The overall objective in the application of these techniques is to provide growing space for the more desirable trees. Basically, forest managers want to concentrate future growth on the better residual trees to increase stand growth and stand value, and improve species composition without sacrificing stand productivity.

Stocking guides generally involve the relationship of crown area ratio to basal area and number of trees. These guidelines currently indicate that residual basal areas of 50 to 60 percent full stocking provide the maximum individual diameter growth possible for commercial-size stands without reducing total per-acre production (Gingrich 1967; Marquis et al. 1984). A strict basal area thinning application involves leaving a number of the "best" residual trees per acre to attain the selected residual basal area goal. For both the stocking guide and basal area approaches, trees are removed using a low-crown thinning approach. Poor-quality and low-vigor trees underneath the main overstory canopy (suppressed and intermediate crown-class trees) and occasionally some overstory trees (codominants) are removed until the desired residual percent stocking or stand density is achieved. There are several major concerns in these marking concepts. Specific desirable trees are not selected for the purpose of stimulating growth. Residual tree crowns are not released deliberately to a free-to-grow condition. Thus the choice of residual trees as well as their response to thinning is left to chance. Also, it is sometimes necessary to leave low-quality or undesirable tree species to attain the desired stand density. In most cases, forest managers using these approaches usually thin stands without specifically providing crown growing space for the desirable individual residual trees.

In addition to stocking guides and basal area thinnings, another possible approach to consider when thinning commercial stands is the crop-tree crown thinning method. As indicated, this crop-tree approach commonly is used in precommercial stands. Crop trees are selected based on criteria related to both forest management and landowner objectives. Usually only trees whose removal benefit the crop trees are cut (Smith and Lamson 1986). Depending on the number of crop trees selected and released per acre, crop trees could occupy the entire stand at maturity. The principal advantage to the crop-tree method is that selected trees based on objectives are released to grow and increase in value (not always monetary). Their development is not left to chance.

The purpose of this paper is to provide a 5-year evaluation of applying the crop-tree crown thinning approach to a 65-year-old black cherry-maple commercial stand.

Study Methods

Study Area

The study area was located on the Monongahela National Forest, Loop Road Research Area, on Middle Mountain near Thornwood, north central West Virginia. In general, these fully stocked, 65-year-old, commercial stands were composed primarily of black cherry (*Prunus serotina* Ehrh.) and maples (*Acer* sp.). Cherry dominated the stand, accounting for approximately 56 percent of the stand basal area and 79 percent of the board-foot volume (International 1/4-inch log rule). Maples (red and sugar) represented 29 percent of the basal area and 13 percent of the volume. White ash (*Fraxinus americana* L.) and cucumbertree (*Magnolia acuminata* L.) were common associate species. Basal areas for trees 1.0 inch d.b.h. and larger range from approximately 170 to 190 square feet per acre in these large pole-, small sawtimber-size stands. Generally, the study areas had very uniform topography with slopes from 0 to 10 percent. Stand elevations were approximately 3,650 feet above sea level and the annual precipitation averaged 59 inches. Soils were moderately deep, well-drained DeKalb soils of sandstone origin. These good growing sites had an estimated northern red oak site index in the middle 70's.

Crop Tree Selection and Release

Selection criteria. Criteria for selecting crop trees were developed with the objective of producing high-quality sawlogs and veneer products. The criteria used were as follow:

- Dominant or codominant crown class.
- Butt-log grade 1 or 2 will become grade 1 or 2 with additional diameter growth.
- No forks in 16-foot butt log.
- No epicormic branches below 33 feet.
- No dead major branches in the upper crown.
- No main-stem forks with evidence of splitting, below live crown.
- No large holes or open wounds in the second log.
- No black knot on the main stem or threatening more than 50 percent of the crown.
- No old residuals.
- No leaning trees.
- No more than two crop trees per sprout clump.
- When applying the crown-touching crop-tree release, space the crop trees so that crop-tree crowns are released on three or four sides.

When trees were of similar quality, crop-tree selections were made based on species. Black cherry was considered the most valuable timber and wildlife species. Other species of commercial importance were white ash, red maple (*Acer rubrum* L.), and cucumbertree.

Release method. Crop trees were released using the crown touching method. Any tree 7.0 inches d.b.h. and larger with a branch touching the crown of a crop tree or extending beneath or above the crown of a crop tree, was considered "touching" and was cut. Where two crop trees had crown branches that touched, both were selected for release. All other adjacent trees touching the crown of the two crop trees would be felled. In this instance, each crop tree would then have three sides of the crown released.

Merchantable trees were 7.0 inches d.b.h. and larger. Cut trees were not marked; instead, a mark-leave tree method was used for designating crop trees. High-risk trees that were 7.0 inches d.b.h. and larger were cut, too. These high-risk trees included black cherry with a black knot on the tree bole or at the base of a fork when more than 50 percent of the crown would be above the knot. Although the preferred method to release crop trees was in a free-to-grow crown position on all four sides of the crown, many trees were released on three and some released on only two sides. The two-sided releases were particularly evident in the 60 crop-tree-per-acre treatments.

Treatments

There were three overstory (trees 7.0 inches d.b.h. and larger) crown treatments each combined with one of two understory (trees 1.0 to 6.9 inches d.b.h.) treatments, for a total of six treatments.

The treatments were to:

- Select and release 40 crop trees per acre using the crown touching method (40 CT)--Figure 1A.
- Select and release 40 crop trees (CT) per acre using the crown touching method. Fell all trees 1.0 to 6.9 inches d.b.h.--(40 CT, cut < 7")--Figure 1B.
- Select and release 60 crop trees per acre using the crown touching method. Fell all trees 1.0 to 6.9 inches d.b.h.--(60 CT, cut < 7").
- Select and release 60 crop trees per acre using the crown touching method (60 CT).
- Fell all trees 1.0 to 6.9 inches d.b.h. No trees 7.0 inches and larger were cut--(Control, cut < 7")--Figure 2A.
- Cut no trees--(Control)--Figure 2B.

Each treatment was replicated three times with the exception of the 60 CT, cut <7" treatment, which had two replications. All cut trees 7.0 inches d.b.h. and larger were skidded (tree length) to a log landing and sold. Felled trees less than 7.0 inches d.b.h. were not removed from the study area.

Plots

Size of the treatment plots was 2.0 acres. Within each 2-acre treatment plot, a 0.5-acre measurement plot was established. All data for trees 1.0 inch d.b.h. and larger were collected on seventeen 0.5-acre measurement plots. Some additional individual crop-tree information was recorded after treatment for trees throughout the 2-acre treatment plots. For the four commercial stand treatments, the initial cut ranged from 53 to 69 percent of the basal area (40CT--91.8÷172.2 = 53.3 percent to 40CT, cut <7"--121.4÷176.4 = 68.8 percent; Table 1). Cutting understory trees (1.0 to 6.9 inches d.b.h.) in the Control, cut <7.0" accounted for approximately 20 percent of the basal area (33.0÷173.8 = 19 percent). The amount of cubic-foot volume removed during the initial cut ranged from 55 to 63 percent of the total (40 CT--1888÷3440 = 54.9 percent to 40 CT, cut <7"--2118÷3350 = 63.2 percent; Table 1). For the Control, cut <7" treatment, 6 percent of the cubic-foot volume (215÷3446) was cut (all small trees less than 7 inches d.b.h.). Initially 44 to 52 percent of the board-foot volume was removed from the crop-tree treatment plots (Table 1).

Crop tree sample data including d.b.h., average total height, crown width, and amount of release were summarized by species and overstory crop-tree treatments (Table 2). When released, the crop trees for all treatments averaged 12.5 inches d.b.h., 80 feet tall with an average clear bole of 42.6 feet. Tree crown widths (diameter) averaged 20.5 feet and crop trees were released an average distance of 13 feet from the edge of the crop tree crown to the adjacent tree crown.

All study data were analyzed using analyses of variance or chi-square methods with significance tested at the 5-percent level. Special interest testing was done using Student-Newman Tests.

Results and Discussion

Stand Growth

Basal area growth. Net basal area growth was increased by the crop-tree crown thinning treatments when compared to the uncut control treatment (Table 3). For the 40 and 60 crop-tree treatments, where all trees less than 7.0 inches d.b.h. were felled, stand basal areas increased an average of 11.2 ft^2/acre in 5 years. On the 40 and 60 crop-tree treatment areas, where trees below 7.0" were not cut (40 CT, 60 CT), 5-year basal-area increased an average of 13.8 ft^2/acre. Stand basal-area growth for the control plots where small trees below 7.0 inches were felled (Control, cut <7"), increased 11.1 ft^2/acre; and for the control areas where no cutting was done, the 5-year basal-area growth was 7.2 ft^2/acre.

Periodic mortality varied from 7.4 ft^2/acre in the uncut control plots to nearly 0 for the 40 crop-tree treatment areas where all trees less than 7.0 inches d.b.h. were felled (Table 3). Since mortality in these stands is concentrated in the understory stems, cutting small trees less than 7.0 inches

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Figure 1A.--A 65-year-old black cherry-maple stand where 40 crop trees per acre were released. Only trees 7.0 inches d.b.h. and larger were cut.

Figure 1B.--A 65-year-old black cherry-maple stand where 40 crop trees per acre were released. In addition, all trees 1.0 to 6.9 inches d.b.h. were cut.

Figure 2A.--A 65-year-old black cherry-maple stand where only trees 1.0 to 6.9 inches d.b.h. were cut.

Figure 2B.--Uncut 65-year-old black cherry-maple stand with a basal area of 180 square feet per acre in trees 1.0 inches d.b.h. and larger.

Table 1.--Per-acre stand data before and after cut, by crop-tree thinning treatments

Item	Stems 1.0 inch d.b.h.+		Stems 5.0 inches d.b.h.+		Stems 11.0 inches d.b.h.+		RSD[a]
	No. of trees	*Basal area ft²*	*No. of trees*	*Volume ft³*	*No. of trees*	*Volume bd ft.*	*Percent*
			40 CT, CUT < 7"				
Initial	898	176.4	318	3350	82	8353	111.5
Cut	814	121.4	234	2118	43	4357	75.3
Residual	84	55.0	84	1232	39	3996	27.6
5-year	393	67.4	83	1511	51	6242	43.8
			40 CT				
Initial	661	172.2	314	3440	85	10107	103.6
Cut	305	91.8	164	1888	44	4758	52.0
Residual	357	80.6	150	1552	41	5349	49.7
5-year	412	93.5	159	1853	51	7525	57.7
			60 CT, CUT < 7"				
Initial	586	188.7	250	4131	108	19507	110.2
Cut	521	117.5	185	2355	50	8996	74.9
Residual	65	71.2	65	1776	58	10511	27.7
5-year	249	81.1	63	2005	59	12777	32.4
			60 CT				
Initial	723	187.8	302	3805	99	13435	111.2
Cut	367	104.8	174	2147	46	5945	57.6
Residual	356	83.0	128	1658	53	7490	47.1
5-year	405	97.6	147	2013	60	10160	54.8
			CONTROL, CUT < 7"				
Initial	772	173.8	272	3446	91	12783	103.2
Cut	580	33.0	80	215	0	0	32.9
Residual	192	140.8	192	3231	91	12783	69.2
5-year	188	151.9	188	3578	107	15585	72.8
			CONTROL				
Initial	858	171.5	315	3214	72	8918	108.8
Cut	0	0.0	0	0	0	0	0.0
Residual	858	171.5	315	3214	72	8918	108.8
5-year	761	178.3	300	3464	83	11219	108.0

[a]RSD--Relative stand density trees 1.0 inch d.b.h. and larger.

Table 2.--Crop-tree release data after treatment

Treatment	Species	Trees[a]	D.b.h.	Total height	Clear bole[b] stem	Base crown	Crown width (diameter)	Crown[c] release
		No.	In.	Ft.	Ft.	Ft.	Ft.	Ft.
40 CT/A	Black cherry	102	12.5	79.2	44.0	52.8	20.2	13.5
	White ash	16	11.3	75.9	36.8	48.3	19.8	12.4
	Basswood	2	13.0	87.0	44.2	53.2	16.5	18.1
	Average		12.3	80.7	41.7	51.4	18.8	14.7
60 CT/A	Black cherry	144	13.6	81.9	45.2	54.1	21.2	10.6
	White ash	2	14.6	81.0	54.8	42.0	26.8	11.6
	Red maple	3	12.0	84.5	39.5	54.0	19.2	13.2
	Average		13.4	82.5	46.5	50.0	22.4	11.8
Control	Black cherry	151	12.8	77.5	42.9	50.8	19.2	0.0
	White ash	24	10.8	76.8	44.2	48.7	18.1	0.0
	Red maple	5	12.0	75.0	32.1	40.8	23.1	0.0
	Average		11.9	76.4	39.7	46.8	20.1	0.0

[a]A sample of crop trees measured throughout the 2-acre treatment plot.
[b]Height to first branch at least 1.0 foot long or merchantable height.
[c]Distance between edge of crop-tree crown and adjacent tree.

had a major influence on mortality regardless of thinning treatments done in the overstory.

The crop-tree crown release treatments concentrated the stand growth on fewer, more valuable trees, and where the understory was removed, newly established reproduction (black cherry, red maple, and striped maple) was readily abundant. For example, for the control treatments a net basal-area stand growth of 7.2 ft²/acre was distributed throughout 665 trees (1.0" d.b.h. and larger). Where only understory trees less than 7.0 inches d.b.h. were cut, a net basal-area stand growth of 11.1 ft²/acre was distributed over only 185 trees (Table 3).

Five-year net basal-area survivor growth per tree ranged from 0.02 for the control to a maximum of 0.15 ft²/tree for the 40CT, cut <7.0" plots. As expected, all plots where trees less than 7.0 inches d.b.h. were removed, had higher basal-area survivor growth per tree (Table 3).

Ingrowth into the 1.0-inch d.b.h. class was strongly related to intensity of overstory removal and the felling of all trees less than 7.0 inches d.b.h. Generally within the thinning treatments, the heavier the cut, the greater the ingrowth. However, after 5 years, it is too soon for pole and sawtimber ingrowth comparisons among the thinning treatments. Due to overhead shading, no ingrowth occurred in areas where only the understory was removed.

Cubic-foot-volume growth. Per acre 5-year net cubic-foot-volume growth of all trees 5.0 inches d.b.h. and larger ranged from 229 to 279 ft³, for the 60 and 40 crop-tree treatments where trees less than 7.0 inches d.b.h. were felled, to 301 to 355 ft³ for similar treatments where trees less than 7.0 inches d.b.h. were not felled (Table 3). Likewise, survivor growth per tree was highest for the 60 and 40 crop-tree treatments where trees less than 7.0 inches were cut (4.0 and 3.4 ft³, respectively). The Control and Control, cut <7" treatment areas had the lowest cubic-foot-volume growth per tree when compared to the thinning treatments (1.2 and 2.0 ft³/tree).

Five-year cubic-foot volume mortality for the thinned plots was variable but low, averaging from 0 ft³/acre in the control plots to 52 ft³/acre in the 40 crop-tree treatment where understory trees less than 7.0 inches d.b.h. were not cut. Cubic-foot-volume ingrowth was evident only where the crop trees were released and the understory was not cut. After 5 years, ingrowth into the pole-size stand (5.0 inches d.b.h. and larger) averaged 23 and 48 ft³ for the 40 CT and 60 CT areas, respectively.

Board-foot-volume growth. The 5-year net board-foot-volume growth ranged from 2,176 bd ft/acre for the 40 crop-tree treatment (understory not cut) to 2,755 for the control areas (understory was cut) (Table 3). Approximately 24 percent of this volume growth was ingrowth (trees crossing the 11.0-inch d.b.h. threshold for board-foot-volume calculations) for all the 40 crop-tree treatments while the 60 crop-tree treatments averaged about 7 percent ingrowth and the control treatments 14 percent. Board-foot-volume growth of surviving sawtimber trees averaged

Table 3.--Five-year growth and mortality, by crop-tree thinning treatment

Treatment	Residual	Final (5-year)	Ingrowth	Mortality	Net growth[a]	Survivor growth per tree[b]
			TREES 1.0 INCH D.B.H. AND LARGER			
			Basal area (ft²/acre)			
40 CT, cut <7.0"	55.0	67.4	3.1 (309)[c]	0.2 (1)[c]	12.4 (391)[c]	0.11 (83)
40 CT	80.6	93.5	0.6 (81)	3.4 (25)	12.9 (387)	0.05 (331)
60 CT, cut <7.0"	71.2	81.1	1.5 (186)	1.1 (2)	9.9 (247)	0.15 (63)
60 CT	83.0	97.6	0.6 (74)	2.0 (25)	14.6 (381)	0.05 (331)
Control, cut <7.0"	140.8	151.9	0.0	1.8 (4)	11.1 (185)	0.07 (189)
Control	171.1	178.3	0.1 (19)	7.4 (105)	7.2 (665)	0.02 (751)
			TREES 5.0 INCHES D.B.H. AND LARGER			
			Volume (ft³/acre)			
40 CT, cut <7.0"	1232	1511	0	4 (1)	279 (83)	3.4 (83)
40 CT	1552	1853	23 (9)[d]	52 (10)	301 (149)	2.2 (159)
60 CT, cut <7.0"	1776	2005	0	24 (2)	229 (61)	4.0 (63)
60 CT	1658	1490	48 (19)	16 (5)	355 (141)	2.5 (147)
Control, cut <7.0"	3236	3578	3578	36 (4)	342 (185)	2.0 (189)
Control	3206	3472	0	0	266 (280)	1.2 (300)
			TREES 11.0 INCHES D.B.H. AND LARGER			
			Volume (bd ft/acre)			
40 CT, cut <7.0"	3996	6242	528 (12)[d]	0	2246 (51)	44.0 (51)
40 CT	5349	7525	514 (10)	74 (1)	2176 (50)	44.1 (51)
60 CT, cut <7.0"	10511	12777	39 (1)	91 (1)	2266 (59)	39.9 (59)
60 CT	7490	10160	315 (7)	0	2670 (60)	44.5 (60)
Control, cut <7.0"	12783	15538	416 (16)	30 (1)	2755 (107)	26.5 (107)
Control	8918	11294	319 (11)	0	2376 (83)	28.6 (83)
			RELATIVE STAND DENSITY			
40 CT, cut <7.0"	27.6	43.8	—	—	16.2 (391)	
40 CT	49.7	57.7	—	—	8.0 (387)	
60 CT, cut <7.0"	27.7	32.4	—	—	4.7 (247)	
60 CT	47.1	54.8	—	—	7.7 (381)	
Control, cut <7.0"	69.3	72.8	—	—	3.5 (185)	
Control	108.5	108.0	—	—	-0.5 (665)	

[a]5-year net growth = survivor growth + ingrowth - mortality.
[b]Growth of trees that were alive in both the residual stand and 5 years later.
[c]Numbers in parentheses are numbers of trees per acre.
[d]Number stems correct, values estimated.

43 bd ft/tree in the release areas and 28 bd ft/acre in the control areas. As indicated previously, there was little to no mortality of sawlog-size trees during the first 5 years.

Relative stand density. For the thinned plots, the relative density (Stout et al. 1987) increased an average of approximately 12 percent for all the 40 crop-tree areas and 6 percent for the 60 crop-tree areas over the 5-year period (Table 3). While relative density for the Control, cut <7" treatment, increased 3.5 percent, no increase occurred in the uncut stands where basal areas approached 180 sq ft/ acre.

D.b.h. response. Crop trees that were released averaged 1.0-inch d.b.h. growth during the 5-year period, while crop trees in the two control treatments averaged 0.6 inch d.b.h. growth (Table 4). This difference was significant at the 5-percent level of testing.

Data shown in Table 4 indicate that the crown thinning increased individual tree d.b.h. growth. However, meaningless conclusions can result in comparing individual tree growth data if the number of trees in each treatment are not equal or if they change. After 5 years, number of trees per acre ranged from 63 to 751, while number of crop trees per treatment ranged from 55 to 90 (Table 4). To clarify the response of individual trees, d.b.h. growth of the 40 largest d.b.h. crop trees/acre per treatment plot also was compared (Table 4). These data indicate that the thinned areas where crop trees were selected and released, had significantly more d.b.h. growth response than any of the control plots. Five years after treatment, the average d.b.h. growth for the 40 largest crop trees per acre in the thinning treatment areas was 1.05 inches, while the 40 largest crop trees in the control areas averaged 0.73 inch.

Number of sides released. A majority (71 percent) of the crop trees were free-to-grow on three or four sides of the crown. Many of the crop trees not released on three or four sides were in areas where trees less than 7.0 inches d.b.h. were not cut on control areas. Data related to sides of crown released were grouped by species for analyses. However, too few samples were available for red maple, basswood, and white ash to make meaningful statistical comparisons. Five-year d.b.h. growth significantly increased with the increase in sides released (Table 5). Black cherry with no crowns released (254 trees) grew 0.6 inches d.b.h. in 5 years, while trees free-to-grow on 1 or 2 sides (81 trees) grew 0.9 inches d.b.h., and trees free-to-grow on 3 to 4 sides (160 trees) grew 1.1 inches d.b.h. For most situations, the more sides of the crown released, the greater the d.b.h. response (Fig. 3).

Removing trees less than 7.0 inches d.b.h. Growth response (d.b.h.) was not related consistently to removal of trees less than 7.0 inches d.b.h. In one case, 40 crop-tree treatment, growth of the black cherry crop trees was slightly higher when cutting the small trees. However, the trend was reversed for the 60 crop-tree per-acre treatment. Crop trees established where trees less than 7.0 inches d.b.h. were not cut, grew about 0.1 inch more compared to similar crop trees in areas where all trees were cut less than 7.0 inches d.b.h.

Tree-Quality Development

Epicormic branches result in lumber discoloration primarily through ingrown bark and are considered a grade defect for factory sawlogs grades 1 to 3. This grade defect can result in a significant loss of monetary value to the landowner. Crop-tree quality was evaluated by number of epicormic

Table 4.--Average 5-year d.b.h. growth, by thinning treatments

Item	All trees[a]	Crop trees	40 largest trees
		40 CT, CUT < 7.0"	
No. trees/acre	83.00	55.00[b]	40.00
Initial d.b.h. (inches)	11.00	1.90	13.54
5-year growth (inches)	0.93d[c]	1.02d[c]	1.01d[c]
		40 CT	
No. trees/acre	331.00	59.00	40.00
Initial d.b.h. (inches)	6.54	12.78	14.31
5-year growth (inches)	0.73e	1.02d	1.06d
		60 CT, CUT < 7.0"	
No. trees/acre	63.00	58.00	40.00
Initial d.b.h. (inches)	14.22	14.45	16.46
5-year growth (inches)	1.00d	0.95d	1.02d
		60 CT	
No. trees/acre	331.00	90.00	40.00
Initial d.b.h. (inches)	6.70	13.09	15.24
5-year growth (inches)	0.63e	0.98d	1.10d
		CONTROL, CUT < 7.0"	
No. trees/acre	189.00	90.00	40.00
Initial d.b.h. (inches)	11.61	12.82	16.02
5-year growth (inches)	0.53f	0.58e	0.70e
		CONTROL	
No. trees/acre	751.00	90.00	40.00
Initial d.b.h. (inches)	6.32	12.20	14.66
5-year growth (inches)	0.28g	0.64e	0.75e

[a]Trees 1.0 inch d.b.h. and larger that were alive in both the residual stand and 5 years after treatment.
[b]Crop trees, not per acre, but total number available after 5 years.
[c]Five-year growth means in the same column followed by the same letter are not significantly different at 0.05-level of testing.

Table 5.--Black cherry crop-tree d.b.h. growth response, by sides of crowns released and thinning treatment[a,b]

Treatment	Sides crown released		
	0	1-2	3-4
40 CT, cut < 7.0"	—	0.92 (11)d	1.08 (37)e
40 CT	—	0.85 (8)d	1.11 (42)e
60 CT, cut < 7.0"	—	0.79 (25)d	1.08 (31)e
60 CT	—	0.94 (37)d	1.01 (50)d
Control, cut < 7.0"			
40 CT	0.59 (55)	—	—
60 CT	0.52 (78)	—	—
Control[c]			
40 CT	0.64 (47)	—	—
60 CT	0.63 (74)	—	—

[a]Parentheses = number of trees.
[b]Values in the same row followed by the same letter are not significantly different at 0.05-level of testing.
[c]First 40 trees are in the 40 crop-tree treatment and an additional 20 crop trees make the 60 crop-tree treatment for the control areas only.

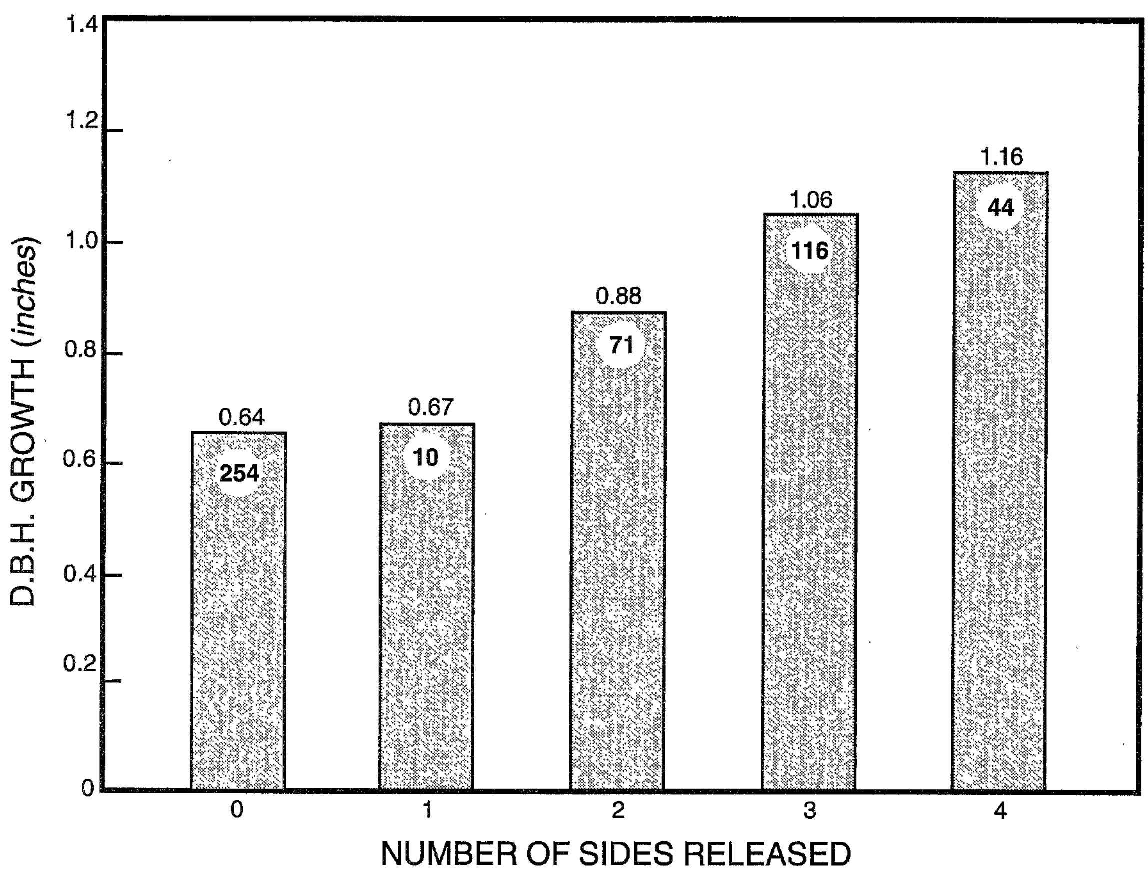

Figure 3.--Five-year d.b.h. growth of black cherry crop trees as related to sides of crown released. Number of trees is shown in boldface.

branches occurring as a result of the study treatments. Due to available samples, black cherry was the only species evaluated.

When released, black cherry trees are susceptible to the development of epicormic branches along their tree boles (Smith 1966). However, crown class is an important factor when considering trees for release. Trees in the dominant-codominant crown classes are not as susceptible to epicormic branching as trees in the intermediate-overtopped crown classes. In this crop-tree release study, all crop trees were dominant-codominant and free of epicormic branches along the tree bole before the thinning treatment.

After 5 years, epicormic branching resulting from any of the crop-tree-release treatments did not reduce butt-log grade for most of the black cherry trees. Only 4 (2 percent) of the 241 released black cherry crop trees had a degraded butt log due to epicormic branches. A total of 42 trees (17 percent) produced at least one epicormic branch on the lower portion of the tree bole (1 to 33 feet). However, only 16 (7 percent) had one or more epicormic branches on the butt log. For both control treatments, 4 of 254 (2 percent) trees produced epicormic branches along the tree bole (17 to 33 feet). No sprouts occurred on the butt log.

Due to the limited development of epicormic branches, it was not necessary statistically to evaluate the results of individual treatments. Released trees did produce more epicormic branches than trees on the nonreleased (control) areas, but the degrade on the butt log was insignificant. After 5 years, growth of the understory is developing rapidly and shading the butt log. No additional epicormic branches as a result of the crop-tree-release treatments should occur. Shading will induce natural pruning (the branches will die) and any additional butt-log degrade due to epicormic branching is not expected to occur.

Summary

In this study, six crop-tree treatments were applied to a 65-year-old black cherry-maple stand. Three crop-tree crown-release overstory treatments were used—selecting and releasing 40 crop trees per acre, 60 crop trees per acre, and no release of crop trees. Three additional treatments were similar except all trees less than 7.0 inches d.b.h. (saplings and small pole-size trees) were felled. Before treatment, stands averaged approximately 180 square feet per acre in trees 1.0 inch d.b.h. and larger. The average height and d.b.h. of the crop trees at time of release was 80 feet and 12.5 inches d.b.h.

A crown-touching technique was used to release crop trees. The release provided an average of 13 feet of growing space from the edge of the crop-tree crown to the edge of adjacent trees. Most trees (71 percent) were free to grow on three or four sides of their crowns. Residual stands include both crop trees and other trees not selected as crop trees. Criteria were developed for choosing crop trees to produce high-quality sawlogs and veneer products with key points related to crown class, stem quality, and vigor.

For the released black cherry crop trees, the average d.b.h. growth was 1 inch during the 5-year period after release, while d.b.h. growth for the nonreleased crop trees was significantly lower, averaging about 0.6 inch. The same response was found for the 40 largest trees per acre. Five-year data from a nearby study in which 60-year-old stands were thinned using SILVAH, indicated a similar response to the crop-tree crown-release thinning. The 50 largest d.b.h. black cherry trees per acre (not crop trees) in the SILVAH thinned stands averaged about 1.2 inches in d.b.h. growth. Trees on the control plots averaged 0.8 inches in 5 years (Lamson and Smith 1988).

Removing trees 1.0 to 6.9 inches d.b.h. had no significant effect on residual tree d.b.h. growth for any treatment. Black cherry crop trees that were free-to-grow on three or four sides of their crowns responded more (5-year d.b.h. growth 1.1 inches) than similar trees released on one or two sides of their crown (0.85 inch).

Five-year growth for basal area, volumes, and relative densities was summarized for each treatment. Data also were summarized for mortality and, depending on the variable, ingrowth into the 1.0, 5.0, and 11.0 inches d.b.h. classes (sapling-, pole-, and sawtimber-size trees). In general, for the crop-tree treatments, net basal-area growth averaged 12.5 square feet per acre compared to 9.2 square feet for the control areas. Net cubic-feet growth averaged 291 for the crop tree treatments and 304 for the control plots. Net board-feet growth for the crop-tree treated plots averaged 2,340 per acre while the controls averaged 2,565 per acre. The control plots had more trees than the released plots and, thus, growth by individual trees is more meaningful. For example, the 5-year growth per tree for the crop-tree plots averaged 43 board feet while the crop trees on the control areas averaged 28 board feet of growth per tree. Five-year relative density net growth for the crop-tree treatment plots averaged 9.2 percent while the control plots averaged 1.5 percent.

When using this crop-tree release method, one-half to two-thirds of the basal area was removed from the 65-year-old previously unmanaged cherry-maple stands. About 35 percent of the crop trees had some degree of exposed sapwood wounds due to logging. Also, 80 percent of damaged crop trees had exposed sapwood wounds that were 50 square inches or less in size. It is anticipated that wounds of this size will be closed after 10 years and for black cherry, little or no degrade will occur in the butt log. However, this initial damage to the residual trees was much higher than expected. There are several ways to minimize the damage such as leaving fender trees along skid roads or reducing tree length winching-skidding to a maximum length of 32 feet. Loggers also can anticipate where damage can occur and try to avoid the problem. Where damage is going to occur, the loggers can consider damaging the less desirable than more desirable residual trees. Of course, paying for residual trees damaged during

logging or receiving a bonus for little to no damage are other ways of minimizing damage.

Black cherry is susceptible to the development of epicormic branching. All crop trees were in the codominant crown class and trees in the dominant-codominant crown class are less susceptible to branching. After 5 years, only 4 of 244 (2 percent) black cherry trees had a reduced butt-log grade due to epicormic branching. However, the growth of the understory reproduction was developing rapidly and shading the butt log. We expect all epicormic branches resulting from the crop-tree treatments to die. Thus, epicormic branching was not a serious problem in this study.

A vigorous commercial stand remains where 40 to 60 crop trees per acre were selected. After 5 years, the individual trees are responding to release as evident by d.b.h. growth and basal area and volume growth. At this point we expect the future stands to be of significantly higher quality and of average tree size compared to the uncut control areas. As a result, released trees will mature faster (based on tree size—d.b.h.) and provide wood products in a shorter period.

A significant amount of black cherry reproduction was established for both the 40 and 60 crop-tree-per-acre treatments where all trees less than 7.0 inches d.b.h. were felled. In most cases, the reproduction will continue to respond and develop. After 5 years, ingrowth, or reproduction, into the 1.0 inch d.b.h. class averaged about 250 trees per acre. Thus, the crop-tree treatments were setting the stage for a future shelterwood overstory removal. In some instances, a form of two-age management could be considered too, but black cherry will not have the life expectancy compared to species such as beech and maples. Where trees less than 7.0 inches d.b.h. were not felled, little to no black cherry reproduction was established.

It is important to recognize that crop trees can be selected for many purposes. Though the timber resource was the primary objective in this study, other objectives such as wildlife, esthetics, or combinations easily could be selected. In using this crop-tree approach for thinning of forest stands, landowners and forest managers have an opportunity to become more satisfied with the results. Landowners will become more aware of ecological concepts, while forest managers will be able to use another tool to satisfy landowner desires and gain confidence in forest management practices.

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Crop-tree release was applied to a 65-year-old cherry-maple stand in north central West Virginia. Criteria were developed for selecting crop trees for high quality sawtimber and veneer products. Five-year stand growth, mortality, and ingrowth using basal areas, volume, relative density, and number of trees were discussed for the treatments.

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