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Applying a Crop-Tree Release in Small-Sawtimber White Oak Stands

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Abstract

Small-sawtimber white oak crop trees in Kentucky were released by a crown-touching technique. In two cutting treatments, 20 and 34 crop trees were released per acre at a total cost of $35 and $42, respectively. Both treatments yielded commercial volumes of cut material. Total mean merchantable volume ($>$ 5.0 inches d.b.h.) in cut trees was 693 cubic feet/acre, with approximately 2,400 board feet/acre in sawtimber ($\geq$ 11.0 inches d.b.h.). On the basis of early crop-tree stem response, the released trees are growing 0.16 inch/year compared with 0.13 inch/year for the unreleased trees.

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Introduction

Since upland oaks are a significant component of eastern forests, there has been considerable research on their management. Much effort has been focused on the manipulation of stand density (Roach and Gingrich 1968) and its effect on growth and yield following intermediate cutting treatments in upland oak forests (Dale and Hilt 1986). Resulting management guides recommend maintenance of growing stock (stand density) at certain minimum levels. In general, poorer quality trees are removed and higher quality trees are retained. However, in many cases this approach has not resulted in the highest quality trees being cultured adequately in the residual stand. The importance of emphasizing individual trees in identifying silvicultural alternatives is discussed in DeBald and Mendel (1976).

This study tested the concept of maximizing timber-value production per unit area by applying crown-touching release to individual crop trees with the potential for yielding high-quality, high-value sawtimber and veneer logs. In this approach, stands with low stocking by some standards may have potential for continued management. Also, potentially high-value trees in adequately stocked stands will receive more attention than would normally be afforded by area-wide treatments. Concentration on release of only potentially high-value trees can simplify and reduce costs of cultural work. The crop-tree approach concentrates treatment benefits from intermediate cutting treatments on trees with the highest potential value increase. With area-wide thinnings, trees are more likely removed without considering the benefits to the residual stand.

In this paper we present initial results of a crop-tree release, including treatment costs, volume of removals, and preliminary, 3-year growth data. This information can be used to help determine costs of treatments designed to release individual trees as well as felling costs for predetermined volumes in intermediate cuts. Cost data coupled with yield-response data will enable managers to formulate guides for selecting crop trees and determine the cost effectiveness of intermediate treatments.

Study Description

The study was conducted at the University of Kentucky's Robinson Forest located in Breathitt, Knott, and Perry Counties in eastern Kentucky. Two cutting treatments, releasing 20 and 34 crop trees per acre, and a control treatment were replicated 4 times and randomly distributed among 12 stands selected for study. The number of crop trees released per acre was determined by realistic goals for the merchantable stand at final harvest. Our goal was to have a fully stocked stand in which codominant trees averaged 22 to 24 inches d.b.h. at final harvest and occupied approximately 80 percent of full stand stocking (Gingrich 1967). The remaining 20 percent stocking is occupied by understory trees. In managed stands, 80 percent stocking in 24-inch trees is achieved with 22 crop trees per acre. In unmanaged stands, where tree crowns are smaller, 80 percent stocking in 24-inch trees is achieved with 34 crop trees per acre. Thus, the two release treatments bracket the minimum number of crop trees needed to promote a stand at final harvest made up of 24-inch codominant trees. Our objective was to give crop trees enough canopy space to allow unhindered growth throughout the remainder of the rotation. No additional treatments are planned before final harvest.

Crop trees were released using a crown-touching treatment; that is, any tree touching or overlapping the outer edge of the crop tree crown was eliminated unless the competing tree was another crop tree. It is important to note that only trees in direct competition with crop trees are removed. Some canopy trees not competing directly with the crop trees are retained and also benefit from the release treatment.

Stand Description

The 12 stands in this study consisted primarily of white oak, which occupied an average of 58 percent of the total 111 ft^2 of basal area/acre (stems $\geq$ 1.0 inch) in each stand (Fig. 1).

Figure 1.—Small-sawtimber white oak stand, 70 to 75 years old, in eastern Kentucky.

These stands averaged 67 dominant and codominant trees/acre and could be considered large poles or small sawtimber with an average d.b.h. of 13 inches. Canopy trees consisted primarily of white oak with scattered black oak, yellow-poplar, American beech, and hickories. White oak site index (base age = 50 years) of the stands ranged from 65 to 83 feet, averaging 73 feet, with an average age of 73 years. The average stem diameter and the number of stems per acre for all stems $\gtrsim$ 1.0 inch before treatment were 5.2 inches d.b.h. and 760, respectively (Table 1). It should be noted that acccording to Gingrich's upland oak stocking chart, these stands are overstocked. When eliminating trees $<$ 3.0 inches, as suggested by Roach and Gingrich (1968), the stands are understocked.

Methods

In each of the 12 stands selected for study, a 2-acre treatment area was established with a 1/2-acre growth and yield plot located within each treatment area. All trees $\gtrsim$ 1.0 inch d.b.h. in the growth and yield plots were tagged according to Lamson and Rosier (1984). The entire 2-acre treatment area was used to obtain time data for determining treatment costs and the merchantable volume of cut trees, and to provide a buffer area for the growth and yield plot. The growth and yield plot was used to monitor quantity and quality changes of individual trees and to determine crop-tree volume and damage to the residual stand from the release treatments. Pretreatment data recorded in the growth and yield plots included species. d.b.h., crown class, and remarks on stem condition for each plot. Crop tree selections were made on both the treated and control plots according to the following criteria:

1. Crown class--only dominant or codominant trees.
2. Species--white oak preferred.
3. Quality--trees with potential butt log grade 1 or 2.
4. Spacing--even distribution where possible.
5. All things equal, trees with larger d.b.h.

Crop trees were released by felling competing trees with a chain saw. To determine costs associated with each treatment, time-study data were collected during felling operations. Time data were recorded according to productive and nonproductive activities. Productive activities included felling unwanted stems and walking from tree to tree. Nonproductive activities included refueling, routine saw maintenance, personal breaks, and machine downtime. These data were summarized to determine average total time per crop tree and average total time per acre for each treatment. Immediately after the treatments, merchantable volume cut in the treatment areas was measured. In the growth and yield plots, crop-tree butt-log grade, crown dimensions, and distances to crown of nearest neighbor were recorded. After three growing seasons, the d.b.h. and butt-log grades of the crop trees were remeasured.

Table 1.—Stand per-acre characteristics for two crop-tree release treatments in pole and small sawtimber white oak stands

Crop tree treatment	Stand	No. of stems	Percent stocking	Basal area	Ave. stem diameter	Merchantable volume[a] Cubic feet	Board feet
				ft²	*Inches*		
34	Initial	786	110	111.5	5.1	2,114	6,187
	Cut	56		33.7	10.5	764	2,360
	Damage	18		1.5	3.9	19	74
	Residual	712	80	77.1	4.5	1,331	3,753
	Crop trees	34	20	25.2	11.7	584	2,407
20	Initial	735	104	107.9	5.2	2,122	6,799
	Cut	38		27.1	11.4	622	2,462
	Damage	18		2.5	5.0	50	189
	Residual	679	79	78.3	4.6	1,450	4,148
	Crop trees	20	15	20.1	13.3	505	2,311
Control	Initial	451	104	112.6	5.7	2,356	10,154
	Crop trees	28	25	31.4	14.1	777	4,187

[a]International 1/4-inch rule, form class 78.

Results

Time and Cost Data

The average time required to select and mark crop trees prior to actual felling operation averaged 0.7 hour/acre for the 20-tree plots and 1.0 hour/acre for the 34-tree plots, increasing as more crop trees were selected per acre (Table 2). The felling operation required an average of 3.7 hours/acre for 20 crop trees and 4.7 hours/acre for 34 crop trees. Marking and productive times were both greater per crop tree for the 20-tree versus the 34-tree plots.

Two primary factors, the number and the size of trees being removed, influenced the amount of time needed to release an individual crop tree. Total felling time generally increases as d.b.h. increases. Cut trees in the 20-tree areas were an average of 1 inch larger in d.b.h. than in the 34-tree areas (Table 3). The 20-tree plots also had a greater number of cut trees per crop tree, 1.9 cut trees/crop tree compared with 1.6 cut trees/crop tree in the 34-tree plots.

Both of these factors are a function of the number of crop trees released per acre. Under normal circumstances, the trees with high crop-tree potential tended to be the largest trees in the plots. The selection of crop trees tended to proceed in descending order of size as is evident from the average crop-tree sizes in Table 1. As additional crop trees were selected per acre, the average size of both crop trees and cut trees decreased. Also, as the number of crop trees per acre increases, the likelihood that cutting one tree may lead to the release of more than one crop tree also increases. Thus, the number of trees cut per crop tree decreases as the number of crop trees increases.

The total treatment cost, including marking crop trees and the actual release operation, was $35 for 20 crop trees and $42 for 34 crop trees/acre (Table 2). Releasing additional crop trees lowered the average cost per crop tree. The average treatment cost decreased from $1.77 to $1.24/crop tree as the number of crop trees increased from 20 to 34/acre.

Table 2.—Estimated cost per acre for two crop-tree release treatments in 70-year-old white oak stands in Kentuckv

Crop tree treatment	Release time	Marking time	Total	Labor[a] cost	Machine[b] cost	Total	Total cost/ crop tree
	Hours/acre			*Dollars/acre*			*Dollars*
34	4.7	1.0	5.7	37.34	4.98	42.14	1.24
20	3.7	0.7	4.4	28.82	3.92	35.36	1.77

[a] Wage rate = $5.00/hour plus 31 percent mandatory fringe benefits including Social Security, workmen's compensation insurance, and unemployment compensation — $6.55/hour.
[b] Machine cost = $2.12/operating hour; operating hours = 50 percent of release time (Miyata 1980).

Table 3.—Summary of time-study data for two crop-tree release treatments in 70-year-old white oak stands in Kentucky

	Time study						Ave. total time per:	
Crop tree treatment	Crop trees observed	Trees cut	Average d.b.h. of cut trees	Productive time	Delay time	Total time	Crop tree	Cut tree
	Number		*Inches*	*Minutes*				
34	114	180	10.5	651	291	942	6.1	5.2
20	73	133	11.4	623	191	814	11.2	6.1

[a]Includes refueling, saw maintenance, personal time, and repairs.

Volume of Removals

Crown release of 20 crop trees/acre resulted in removing about 27 percent of the initial basal area (1.0 inch d.b.h. and larger). The residual stand stocking was 70 percent of full stocking defined by the upland oaks stocking guide (Gingrich 1967). Merchantable volume included in the cut averaged 2,462 board feet/acre in 14 sawtimber trees (11.0 inches d.b.h. and larger) per acre. Total merchantable volume in cut trees (5.0 inches d.b.h. and larger) averaged 622 ft^3/acre (Table 1). Crown width of crop trees averaged 23.7 feet. Following release, selected crop trees were free-to-grow with an average crown growing space of 10.1 feet, as defined by the average distance from the edge of the crop tree crowns to the closest adjacent tree crown (Table 4).

Releasing 34 crop trees per acre resulted in removing 31 percent of the initial stand basal area. Residual stocking averaged 68 percent of full stocking (Gingrich 1967). Merchantable volume included in the cut averaged 2,360 board feet/acre in 17 sawtimber trees per acre. Total merchantable volume in cut trees averaged 764 ft^3/acre (Table 1). Average crown width of residual crop trees was 21.5 feet. Following release, selected crop trees were free-to-grow with an average crown space of 12.4 feet (Table 4).

Three-Year Growth Response

Diameter-growth response for all released trees was pooled for comparison with unreleased potential crop trees. The d.b.h. growth of released trees after three growing seasons averaged 0.16 inch/year, significantly higher than that of unreleased trees (0.13 inch/year ($p = 0.01$)). The d.b.h. growth for released trees ranged from 0.14 to 0.21 inch/year and for unreleased trees ranged from 0.11 to 0.17 inch/year.

Discussion

In earlier studies, white oak poletimber occupying a codominant crown position responded to crown release. Minckler (1967) found that a partial crown release increased diameter growth of white oak crop trees for at least 10 years after treatment. In another study, white oak crop trees released on one or two sides of the crown grew faster than their unreleased counterparts for 20 years following treatment (Schlesinger 1978). Research results indicate that the d.b.h. of codominant white oak poletimber trees can be increased by 1.5 to 2.0 inches in about 10 years following one partial crown release. In this study, crop trees received a full crown-touching release. On the basis of the success of previous studies involving partial crown release of white oak poletimber, we expect the crown-touching release in this study to maximize potential diameter growth. Beyond the period of faster growth, released trees are expected to be at least 2 inches larger and have higher stumpage values than unreleased trees.

The d.b.h. growth of unreleased crop trees averaged 0.13 inch/year. Released trees, however, did show a significant difference between crown sizes. Released crop trees with relatively large and medium-size crowns maintained a higher growth rate (0.17 inch/year) than trees with relatively small crowns (0.13 inch/year). Thus, trees with the largest crowns exhibited the greatest growth differential, 0.04 inch/year, between released and unreleased trees.

The potential quality of white oak crop trees can be reduced by heavy thinning. Moderate or light area-wide thinnings, where residual basal area is above 50 ft^2, do not result in significant losses in crop-tree stem quality (Dale and Sonderman 1984; Sonderman 1984). In this study, average basal area was reduced to about 77 ft^2/acre in both release treatments. This could be considered a light thinning, though cut trees were concentrated around the crop trees. Changes in stem quality will have to be monitored to determine if the crown-touching release has the same detrimental effects as heavy, area-wide thinnings.

Table 4.—Data summary for crop-tree release treatments

Crop-tree treatment	Trees selected	Trees destroyed	Trees released	Average crop-tree d.b.h.	Average crop-tree crown width	Ave. crown growing space after release	No. of trees cut per acre	Average d.b.h.
	----------Number/acre-----------			Inches	------------------Feet---------------			Inches
34	34	2	32	11.8	21.5	12.4	56	10.5
20	20	1	19	13.2	23.7	10.1	38	11.4

In precommercial operations, the cost per crop tree increases as fewer trees are released. In addition, crop-tree selection will influence the composition of the stand at final harvest. It is important to focus investment dollars on the best available trees. We select the trees we want from the residual stand. The more we select, the fewer nature selects for us. Also, selecting fewer trees allows more of the final harvest to be determined by chance. In this study, cut volumes were similar for both 20 and 34 residual crop trees per acre. In the latter treatment, however, we were able to culture a larger proportion of trees that will develop into final harvest trees.

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