United States
Department of
Agriculture

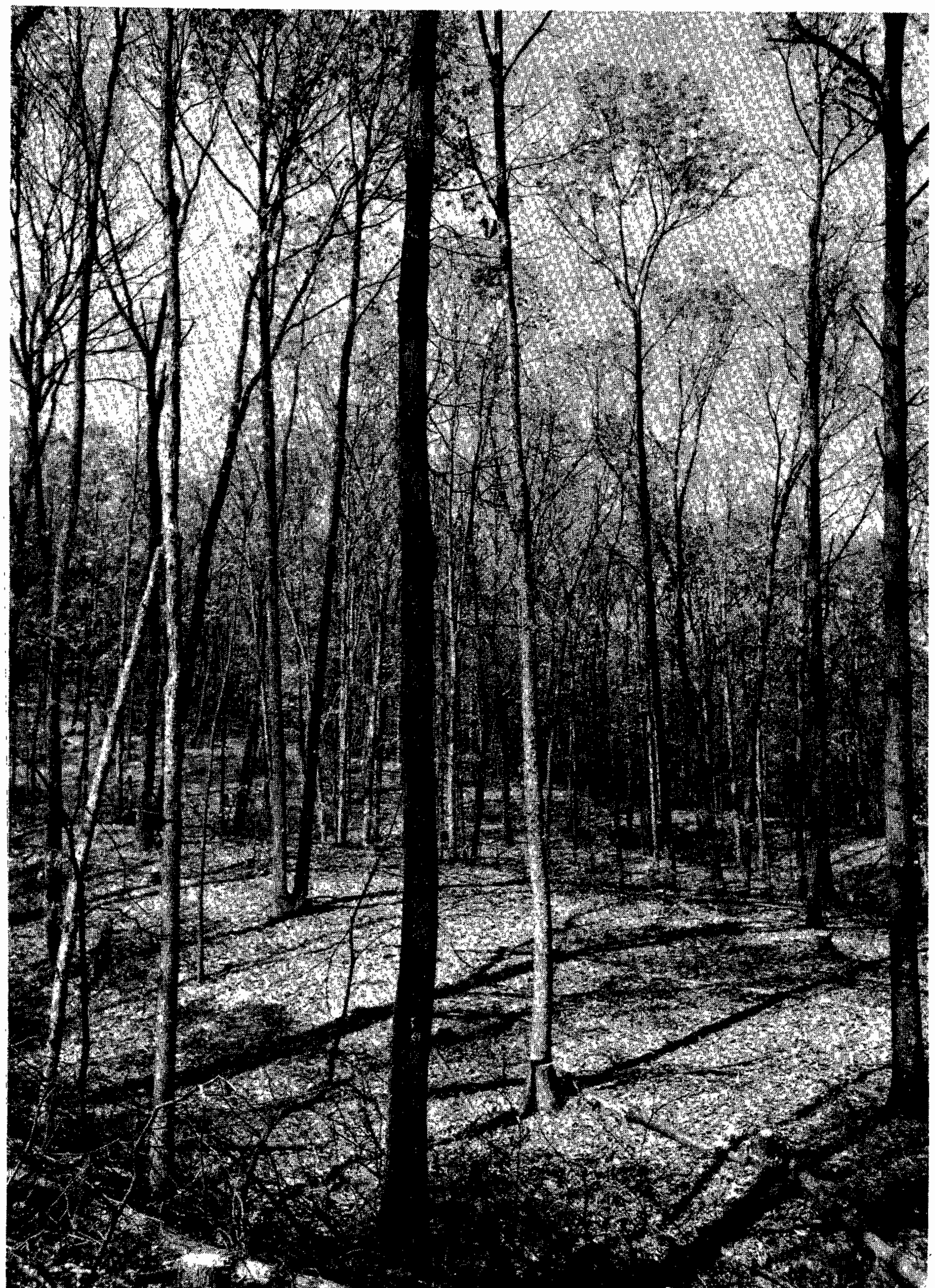
Forest Service

**Northeastern Forest
Experiment Station**

NE-RP-597

Stem-Quality Changes on Young, Mixed Upland Hardwoods After Crop-Tree Release

David L. Sonderman



Abstract

Relative change of several types of stem defects was studied over an 8-year period to determine the effects of crop-tree thinning on the development of tree quality. Special interest was given to changes in relative quality associated with defect indicators of crop trees compared to trees in unthinned plots. The relative quality classes of the crop trees went from "poor" to "medium" for red maple and "poor" to "good" for aspen. The oaks stayed in the poor classification and yellow-poplar remained unchanged in the medium classification. Results showed a decrease in the number of epicormic branches on the crop trees, and an increase in the size of live limbs.

The Author

DAVID L. SONDERMAN, research forest product technologist, joined the Northeastern Forest Experiment Station in June 1962, and was on the staff of the eastern softwood timber quality project until June 1972. He is currently located at Delaware, Ohio, with the Station's project on management and utilization alternatives for nonindustrial private forests.

Manuscript received for publication 2 June 1986

Northeastern Forest Experiment Station
370 Reed Road, Broomall, PA 19008
April 1987

Introduction

Forest managers need information on stem quality to better assess young hardwood trees. Quantifying limb-related defects is one method of evaluating how young growing stock stands should be thinned to grow the best possible defect-free stems. Little work has been done on developing the methodology for relating limb-defect changes over time to different thinning practices, particularly crop-tree release. However, one study showed that thinning young white oaks to low density levels resulted in severe epicormic branching (Dale 1968). It was found that quality losses more than offset gains from increased volume when stocking was reduced below 50 percent. In a more recent study of a young mixed-oak stand, the number of live and dead limbs increased substantially more in the heavily thinned plots than in the unthinned plots (Sonderman 1985). This confirms the common belief that stand density affects stem quality after only a few years. Additional research has shown that heavy thinning in young white oak stands has delayed, if not substantially reduced, the potential to develop high-quality stems.

In this study, various types of limb-related defects were examined on a 17-year-old mixed upland hardwood stand that had been thinned by a crop-tree release. The potential crop trees were selected on the basis of tree form, crown position, and spacing. The stands were thinned to free the crowns of the selected crop trees on all sides without leaving large gaps in the canopy. These data, combined with other hardwood quality information (Dale and Sonderman 1984; Sonderman 1984a, b; Sonderman 1985, 1986), comprise an important data base for future reference and analysis of limb-related defects.

The Stand

The 3-acre stand in this study is located on the Vinton Furnance Experimental Forest in southern Ohio. The original stand, which was clearcut in 1959, contained mature, even-aged, fully stocked, mixed-oak species on a good site. In 1977, the young stand was divided into two treatment areas—one thinned as a crop-tree release and the other left as a control. The crop-tree release contained seven 1/10-acre plots and the control eight 1/10-acre plots. A 1/2-chain-wide isolation strip was left around each treatment. All plots were about the same in density, age, site class, species, and quality. Species composition consisted of aspen, red maple, sugar maple, mixed oaks, yellow-poplar, black cherry, blackgum, butternut, beech, red elm, and hickory. From these plots, 259 study trees were selected and measured. Potential crop-tree selection was based on crown position, vigor, spacing, size, and apparent quality. Six groups were used in the analysis: oak, yellow-poplar, red maple, aspen, miscellaneous, and "all" species. Red maple was the most common species, accounting for 38 percent of the total trees in the stand.

Methods

All trees 3.6 inches or larger in diameter at breast height (d.b.h.) were graded by the quality classification system developed by Sonderman and Brisbin (1978). This system measures limb-related external defects on both the first and second 8-foot section of the butt 16-foot log on each tree. Measurements were made before thinning in 1977 and again in 1985. Limbs are branches 0.3 inch or larger in diameter. Branches smaller than 0.3 inch are classed as epicormic branches. Various stem characteristics and limb-related defects were identified and classified on each selected tree. The following tree characteristics were measured:

- d.b.h.
- total height
- crown class
- crown ratio
- sweep and crook
- number of live limbs on the first and second 8-foot section of the butt 16-foot log
- size of the largest live limb on the first and second 8-foot section of the butt 16-foot log
- number of dead limbs on the first and second 8-foot section of the butt 16-foot log
- size of the largest dead limb on the first and second 8-foot section of the butt 16-foot log
- number of epicormic branches on first and second 8-foot section of the butt 16-foot log

Epicormic branches were grouped into three categories to make counting easier: (1) trees with no epicormic branches, (2) trees with one to six epicormic branches, and (3) trees with seven or more epicormic branches.

As part of the quality classification system, a relative quality index was used to measure gross quality changes. This was done by assigning a numerical value to selected tree characteristics to be used as indexes:

Crown Class	Value
Dominant	4
Codominant	3
Intermediate	2
Suppressed	1
Sweep and Crook (Deviation in inches)	Value
1	4
2–4	3
5–6	2
7–8	1
9+	0
Fork, Rot, or Seam	0
Limb Count (Limb ≥ 0.3 inch)	Value
1–2	4
3–4	3
5–8	2
9–16	1
17+	0

By adding the individual values, the relative quality class of a tree was determined as follows:

Sum of individual values	**Relative quality class**
1–7	Poor
8–9	Medium
10–12	Good

Determining relative quality was the first step in quantifying tree characteristics that are important for growing quality trees. In-dept analyses and comparison of individual tree characteristics by species groups are included in this report. Additional information on the measurement of individual tree characteristics was published by Sonderman (1979). Computations were made using weighted averages.

Results and Discussion

Relative Quality Index

The relative indexes (Fig. 1) showed that aspen increased most in quality in the crop-tree release, going from the "poor" to "good" classification. However, in the control, aspen stayed in the "poor" quality class. Yellow-poplar's performance showed the least change, remaining as a "medium"-quality tree in both treatments. Figure 1 shows that crop-tree thinning had a positive effect on red maple and aspen, but little effect on yellow-poplar or oak.

Diameter and Height Growth

Crop-tree release had a greater effect on diameter growth than the control. Table 1 shows an overall increase in average tree diameter of 2.6 inches for "all" species combined in the crop-tree plots versus only 1.4 inches in the control plots for the 8-year period. Yellow-poplar in the crop-tree release was the fastest growing, increasing 4.3 inches in diameter from 1977 to 1985. The oak group had the slowest diameter growth of all the species.

Height growth (Table 1) was best for yellow-poplar in the crop-tree treatment, but second to aspen in the control plots. Height growth for the oak group, as with diameter, was slowest of all the species measured. There were virtually no differences between the oak trees in the control plots and those in the crop-tree release plots. Comparing the data for "all" species, the crop-tree treatment outgrew the control in height by 2.7 feet.

Crown Ratio

Crown ratio is the ratio of live crown length to total tree height (Table 1). Thinning around a tree in a crop-tree release provides additional light, which can cause an increase in limb growth. This results in a downward extension of the crown and an increase in crown ratio. This was true in the crop-tree treatment which increased by 1.2 percent when analysed by "all" species. When individual species were analyzed, the crown ratios for aspen and yellow-poplar increased by about 15 percent in the crop-tree plots, but only by about 2 percent in the control plots. Similar crown-ratio results were found in relation to thinning in an earlier study by Sonderman (1984b).

Limb Defects per Square Foot of Surface Area

As a tree grows, the surface expands, causing an increase in surface area. If there are no changes in the number of defects on the surface, then the number of defects per square foot of surface area will decrease. Changes in limb defects per square foot of surface area are shown in Table 1. There was an overall reduction in the number of defects per square foot of surface area between 1977 and 1985 in both the crop-tree treatment and control on the butt 16-foot log of the study trees. Neither the crop-tree treatment nor the control appeared to vary much when analyzed for "all" species, but because the crop trees had greater diameter growth than the control trees, they had more surface area and developed more limb-related defects.

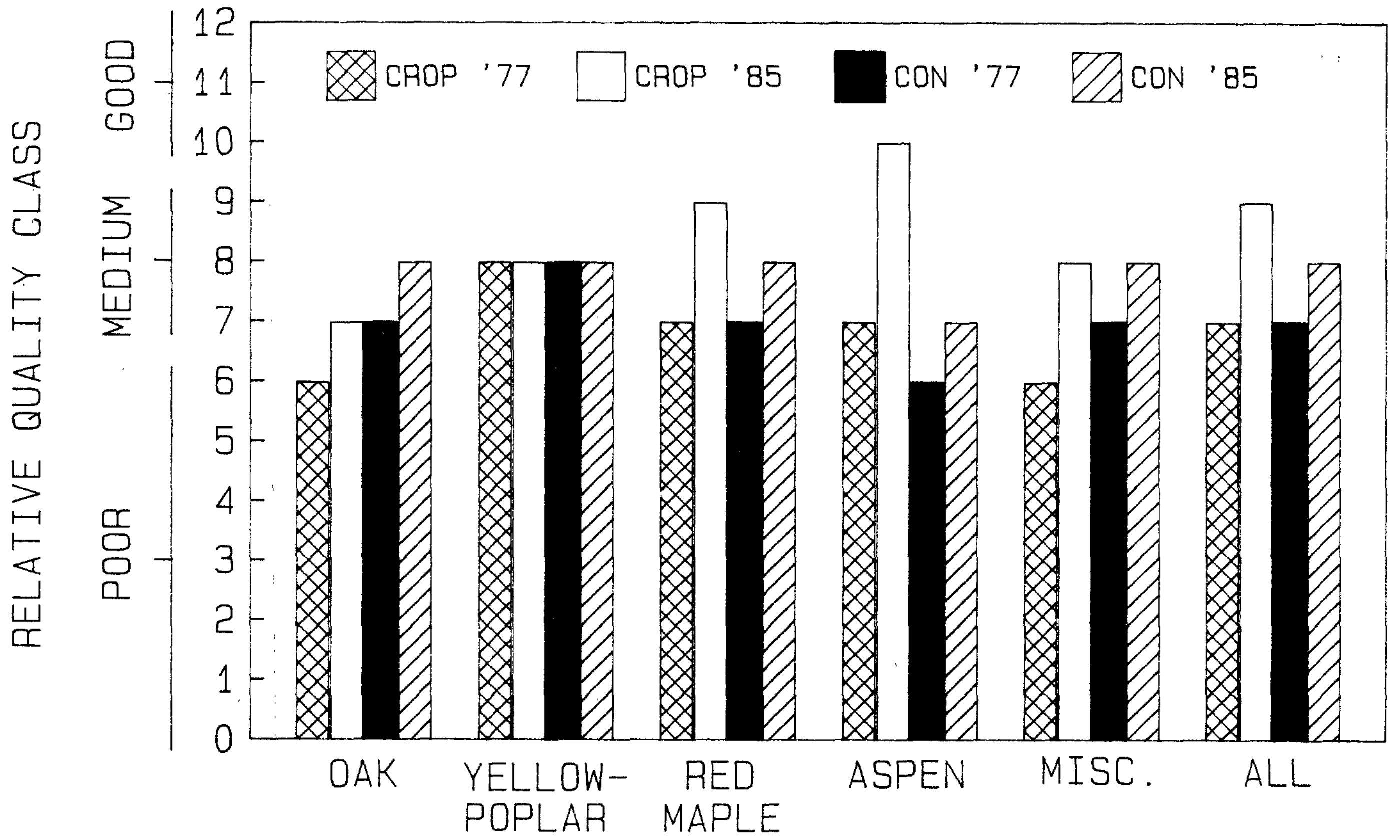


Figure 1.—Average relative quality index by species and treatment, 1977–85.

Live Limbs

Generally, there were more live limbs (Table 2) on the second 8-foot section of the butt log of the tree than on the first. There also was a reduction in the number of live limbs on the second 8-foot section for both the crop-tree release and control from 1977 to 1985. However, on the second 8-foot section in 1985, oak showed an increase in live limb frequency for both the crop-tree and control treatments. By contrast, the number of live limbs on red maple decreased dramatically for both treatments. Red maple live limbs stayed on the tree longer and reached a size of 3 to 4 inches in diameter before dying. Few new live limbs developed during that time. The result was a decrease in the number of live limbs and an increase in the size of dead limbs (Table 3).

Dead Limbs

The average number of dead limbs for "all" trees (Table 2) was reduced substantially from 1977 to 1985, but the difference between treatments was small. The full stocking of the control plots caused some natural pruning, resulting in fewer but larger dead limbs remaining on the stems over the 8-year growth period. Size was the reason for dead limbs hanging on, because large limbs usually do not prune off easily or quickly. The average diameter (Table 3) of the dead limbs in the secnd 8-foot section for "all" species in 1985 was 2.92 inches for the crop-tree treatment and 3.03 inches for the control.

Table 1.—Summary of average tree characteristics in 1977 and 1985, by species group and treatment

Species group	Crop-tree release 1977	Crop-tree release 1985	Control 1977	Control 1985
		D.B.H. (inches)		
Oaks	5.1	6.5	4.8	5.6
Yellow-poplar	5.1	9.4	4.9	7.6
Red maple	5.3	8.1	5.4	6.8
Aspen	5.0	7.8	4.3	6.8
Miscellaneous[a]	5.4	7.4	4.9	6.0
All	5.3	7.9	5.1	6.5
		HEIGHT (feet)		
Oaks	44.0	46.2	43.0	46.3
Yellow-poplar	47.5	63.8	47.9	60.7
Red maple	47.6	59.3	46.5	54.3
Aspen	51.0	64.5	49.2	71.1
Miscellaneous[a]	44.1	52.4	44.8	50.5
All	46.2	56.8	46.0	53.9
		CROWN RATIO (percent)		
Oaks	35.0	26.0	30.0	22.1
Yellow-poplar	26.8	41.4	25.7	28.1
Red maple	49.1	48.2	38.3	35.6
Aspen	30.0	45.0	26.4	28.6
Miscellaneous[a]	37.8	37.6	27.5	25.4
All	41.0	42.2	31.4	29.4
		DEFECTS/FT^2 SURFACE AREA[b] (number)		
Oaks	0.270	0.165	0.452	0.191
Yellow-poplar	.100	.116	.147	.060
Red maple	.387	.070	.396	.092
Aspen	.812	.179	.836	.608
Miscellaneous[a]	.447	.130	.411	.107
All	.373	.104	.383	.120

[a]Includes sugar maple, black cherry, blackgum, hickory, butternut, beech, and red elm.

[b]Live and dead limbs, butt 16-foot section.

Table 2.—Average number of live and dead limbs in butt and second 8-foot sections, 1977–85, by species group

Species group	Crop-tree release 1977 Live	Crop-tree release 1977 Dead	Crop-tree release 1985 Live	Crop-tree release 1985 Dead	Control 1977 Live	Control 1977 Dead	Control 1985 Live	Control 1985 Dead
				BUTT 8-FOOT SECTION				
Oaks	—	1.70	2.23	0.39	—	4.08	1.03	1.17
Yellow-poplar	—	0.55	—	1.82	—	1.02	—	0.33
Red maple	0.04	2.43	0.03	.29	0.19	2.65	0.22	.39
Aspen	—	7.17	—	—	—	6.57	—	6.64
Miscellaneous[a]	—	2.91	—	1.55	.09	2.39	.32	.78
All	.04	2.40	.17	.94	.09	2.57	.28	.84
				SECOND 8-FOOT SECTION				
Oaks	—	8.96	3.57	1.68	0.93	11.61	1.83	4.00
Yellow-poplar	0.74	2.74	0.20	6.34	.63	3.90	1.67	1.61
Red maple	3.44	9.95	1.41	2.74	3.21	10.33	0.85	3.43
Aspen	—	23.73	—	11.27	1.28	19.98	—	25.25
Miscellaneous[a]	.54	15.38	1.08	4.73	1.06	12.21	.76	2.99
All	1.76	11.17	1.28	4.03	1.71	10.57	.98	3.89

[a]Includes sugar maple, black cherry, blackgum, hickory, butternut, beech, and red elm.

Table 3.—Average diameter, in inches, of largest live and dead limbs in butt and second 8-foot sections, 1977–85, by species group

Species group	Crop-tree release 1977 Live	Crop-tree release 1977 Dead	Crop-tree release 1985 Live	Crop-tree release 1985 Dead	Control 1977 Live	Control 1977 Dead	Control 1985 Live	Control 1985 Dead
				BUTT 8-FOOT SECTION				
Oaks	—	0.83	0.50	2.50	—	0.55	1.50	2.90
Yellow-poplar	—	.50	—	1.35	—	1.03	—	2.25
Red maple	1.50	.67	2.00	1.55	0.95	.62	1.75	1.84
Aspen	—	.50	—	—	—	.50	—	1.37
Miscellaneous[a]	—	.54	—	1.80	1.00	.59	0.83	2.18
All	1.50	.61	1.25	1.62	.96	.62	1.28	2.06
				SECOND 8-FOOT SECTION				
Oaks	—	0.62	1.00	5.41	0.91	0.82	1.50	3.00
Yellow-poplar	1.00	.56	5.00	2.20	.75	.64	1.70	1.35
Red maple	1.01	.74	4.00	3.27	.98	.75	3.68	3.45
Aspen	—	.50	—	2.00	.75	.53	—	2.53
Miscellaneous[a]	1.20	.87	3.41	2.46	1.25	.69	1.47	2.99
All	1.04	.77	3.71	2.92	1.00	.71	2.41	3.03

[a]Includes sugar maple, black cherry, blackgum, hickory, butternut, beech, and red elm.

Yellow-poplar was the only species to increase in the number of dead limbs in both 8-foot sections of the crop-tree treatment, while aspen was the only species to increase in the number of dead limbs in both 8-foot sections of the control. The oak group had the largest dead limbs, averaging 5.4 inches in diameter in the second 8-foot section of the crop-tree treatment. Aspen and yellow-poplar had the smallest dead limbs in that same 8-foot section.

Epicormic Branches

Study results show that the percentage of epicormic branches increased the most in the control plots (Table 4). An increase in light around the crop trees caused the existing limbs on the stem to continue to grow larger. This resulted in little new epicormic branch activity. Natural variation in sprouting ability among species also was a factor. When the data were analyzed by individual species, red maple and oak were the most prolific sprouters, while yellow-poplar and aspen barely sprouted. Smith (1977) found similar effects on 60-year-old yellow-poplars following thinning. Another study (Brinkman 1955) showed that dominant and codominant trees had a tendency to "feather out" less with epicormic branches than intermediate or suppressed trees. Since this way a crop-tree release that favors dominant and codominant trees in the residual stand, one would anticipate less epicormic branching. Although some epicormic branching may be species related, a large amount of branching was influenced by the degree of thinning and the residual stocking of the stand.

Table 4.—Percentage of trees with epicormic branches, 1977–85, by species group

Species group	Crop-tree release		Control	
	1977	1985	1977	1985
	BUTT 8-FOOT SECTION			
Oaks	0.0	40.0	7.1	71.9
Yellow-poplar	0.0	0.0	0.0	3.7
Red maple	5.8	38.0	0.0	45.2
Aspen	0.0	0.0	0.0	0.0
Miscellaneous[a]	3.7	7.4	0.0	26.0
All	3.7	22.5	0.5	32.3
	SECOND 8-FOOT SECTION			
Oaks	0.0	40.0	7.1	85.6
Yellow-poplar	0.0	18.1	7.4	18.5
Red maple	11.6	44.0	3.0	49.9
Aspen	0.0	0.0	0.0	0.0
Miscellaneous[a]	3.7	7.4	0.0	39.9
All	6.2	32.3	2.7	42.4

[a]Includes sugar maple, black cherry, blackgum, hickory, butternut, beech, and red elm.

Results of a previous study showed that heavily thinned stands with low residual stocking and open canopys resulted in heavy epicormic sprouting (Dale and Sonderman 1984).

Summary and Conclusion

Tree quality is not markedly affected by residual stand-density levels that are maintained above C-level stocking. The crop-tree release in this study resulted in many changes in stem-quality and growth characteristics. The average diameters (d.b.h.), heights, and crown ratios increased in the crop-tree treatment, as did the number of limb defects per square foot of surface area. This study showed an increase in live and dead limbs in the crop trees, and a decrease in epicormic branches. The additional live and dead limbs occurred because the expanded growing space around each tree that resulted from thinning allowed existing live limbs to develop (grow) and curtailed natural pruning of the dead limbs. For this reason, fewer epicormic branches formed.

In some instances, opening the canopy around crop trees may be a greater stimulus to the growth of already established branches than to the formation of new epicormics. Fewer epicormics would, over time, mean a reduction in the number of new stem defects on the prime grading section (butt 16-foot log) and result in improved tree quality in the future. The fact that dominant trees, which were left for the final crop trees, were known to sprout less than codominants and intermediates may have contributed to fewer epicormic branches. All of this information will help evaluate the quality of young growing-stock trees and serve as a basis for selecting silvicultural treatments. Other important findings were:

- Epicormic branches increased most on the second 8-foot section of the butt 16-foot log.
- The oaks had the most epicormic branches of all the species.
- The number and size of the live and dead limbs were greatest on the second 8-foot section of the butt 16-foot log.
- The oak species in the crop-tree release plots had the largest number of live limbs in both the first and second 8-foot sections of the butt 16-foot log. They averaged more than 3.5 limbs per tree in the second 8-foot section.
- Yellow-poplar was the only species to increase in the number of dead limbs in the crop-tree release plots during the 8-year growth period.

- The oak trees in the crop-tree release plots had the largest dead limbs. The average number of these large dead limbs was fewer than 2 per tree.

Because this study was limited to a crop-tree thinning, a single site class, and one age group, caution should be used when applying these data to other trees and stands.

Acknowledgment

I thank forest technicians John Beaton and Deloris Weiss for assistance in collecting the data.

Literature Cited

Brinkman, K. A. 1955. **Epicormic branching on oaks in sprout stands.** Tech. Pap. 146. Washington, DC: U.S. Department of Agriculture. 8 p.

Dale, Martin E. 1968. **Growth response from thinning young even-aged white oak stands.** Res. Pap. NE-223. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 9 p.

Dale, Martin E.; Sonderman, David L. 1984. **Effect of thinning on growth and potential quality of young white oak crop trees.** Res. Pap. NE-539. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 12 p.

Smith, H. Clay. 1977. **Changes in tree density do not influence epicormic branching of yellow-poplar.** Res. Note NE-239. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 3 p.

Sonderman, David L. 1979. **Guide to the measurement of tree characteristics important to the quality classification system for young hardwood trees.** Gen. Tech. Rep. NE-54. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 12 p.

Sonderman, David L. 1984a. **Quality response of even-aged 80-year-old white oak trees after thinning.** Res. Pap. NE-543. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

Sonderman, David L. 1984b. **Quality response of 29-year-old, even-aged central hardwoods after thinning.** Res. Pap. NE-546. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 9 p.

Sonderman, David L. 1986. **Changes in stem quality on young thinned hardwoods.** Res. Pap. NE-576. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 9 p.

Sonderman, David L. 1985. **Stand density—a factor affecting stem quality of young hardwoods.** Res. Pap. NE-561. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Sonderman, David L.; Brisbin, Robert L. 1978. **A quality classification system for young hardwood trees—the first step in predicting future products.** Res. Pap. NE-419. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

Sonderman, David L. 1987. **Stem-quality changes on young, mixed upland hardwoods after crop-tree release.** RP–NE 597. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

Relative change of several types of stem defects was studied over an 8-year period to determine the effects of crop-tree thinning on the development of tree quality. Special interest was given to changes in relative quality associated with defect indicators of crop trees compared to trees in unthinned plots. The relative quality classes of the crop trees went from "poor" to "medium" for red maple and "poor" to "good" for aspen. The oaks stayed in the poor classification and yellow-poplar remained unchanged in the medium classification. Results showed a decrease in the number of epicormic branches on the crop trees, and an increase in the size of live limbs.

ODC 228.1:242:851:852:11

Keywords: Stand density; thinning; stem quality

Headquarters of the Northeastern Forest Experiment Station are in Broomall, Pa. 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, Morgantown.
- Orono, Maine, in cooperation with the University of Maine, Orono.
- 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, Syracuse.
- University Park, Pennsylvania, in cooperation with the Pennsylvania State University.
- Warren, Pennsylvania.

☆U.S.GOVERNMENT PRINTING OFFICE:1987-748-076:40017