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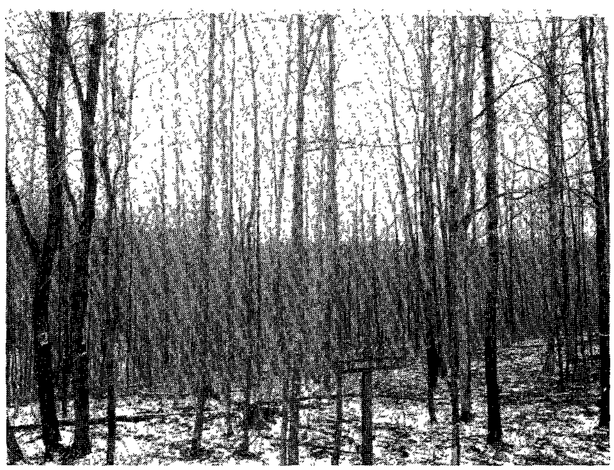
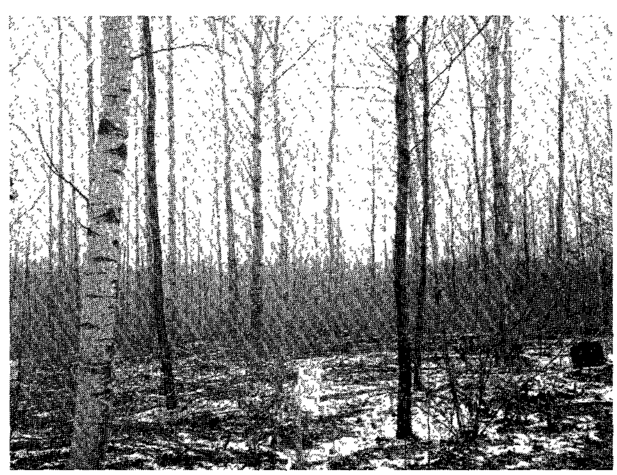
Effect of Thinning on Mixed-Oak Stem Quality

David L. Sonderman
Everette D. Rast





Abstract

Changes in limb-related stem defects were studied from 1977 to 1982 on 595 mixed-oak trees following a schedule of thinnings dating back to 1962. All of the thinnings were controlled by stocking goals rather than predetermined time intervals. Results show that heavy and moderate thinnings, as opposed to light thinnings, had an adverse effect on the number and size of live and dead limbs. The light thinnings resulted in fewer live and dead limb defects per square foot of surface area but much slower diameter growth.

The Authors

DAVID L. SONDERMAN, research forest products 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. From 1972 to 1987 he was located at Delaware, Ohio, with the Northeastern Station's project on management and utilization alternatives for nonindustrial private forests. He is currently working at the Station's Forestry Sciences Laboratory, Princeton, West Virginia, on the development of the new advanced hardwood processing and technical resource center.

EVERETTE D. RAST, research forest products technologist, received a B.S. degree in forestry from the University of Missouri in 1960 and an M.S. degree in agricultural economics from The Ohio State University in 1970. He joined the Forest Service in 1960 as a forester on the Mendocino National Forest and was located at the Northeastern Forest Experiment Station's Delaware, Ohio, laboratory from 1966 to 1987. He is currently with the Station's Forestry Sciences Laboratory at Princeton, West Virginia, working on the advanced hardwood processing and technical resource center.

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

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Introduction

The upland oak forest type is the most extensive hardwood timber type found in the United States. Growing-stock volumes of white and red oak in the Eastern United States exceed 38 billion cubic feet (USDA Forest Service 1982). To better understand the resource, a series of studies were initiated to determine potential quality in young oak trees. By regulating the stand density, researchers wanted to determine whether they could grow trees faster while maintaining wood quality. To accomplish this, a measure of the stem-related defects and their change over time under various cultural treatments was needed.

Research on bole-quality changes following cultural treatment has been neglected, though not completely ignored. An early study by Brinkman (1955) reported that individual trees in the oak type tend to inherit epicormic branch traits, but that the amount of branching is influenced by the crown position and degree of thinning. Smith (1966) found that oak trees are more prone to develop epicormic branches than yellow-poplar or white ash trees. Della-Bianca (1983) found that white oaks apparently produce and retain more branches and epicormics than most other species, even other oaks. In a more recent study, Sonderman (1984) found that the number of defects per square foot of surface area on oak species increased significantly at the heaviest thinning level, lowering potential stem quality. In a study describing changings in provisional tree grades, Sonderman and Rast (1987) also found that light thinning and crop-tree thinning produced higher quality and better grade trees than heavy thinning.

In this study, changes in limb-related stem defects were analyzed from 1977 to 1982 as a result of initial tree thinnings followed by subsequent thinnings that maintained the stocking. This situation is typical of many woodlot ownerships throughout the central hardwood region where subsequent thinnings, such as cleanings for firewood, are common. Particular attention was given to the residual stocking and its relationship to individual defect changes over time. This type of information is needed to select the best thinning methods for growing trees as defect free as possible.

The Stand

The plots selected for this study are located in southeastern Ohio. The original stand was made up of well-stocked, pole-size, even-aged, 31-year-old mixed-oak trees. Before initial thinning of the stand in 1962, basal area averaged 74 to 89 ft^2 and the stand diameter range (diameter at breast height—d.b.h.) was 3.8 to 4.5 inches. Initial thinnings were made on sixteen ½-acre plots at six stocking levels: 40, 50, 60, 70, 80, and 100 percent. Stand-density levels in this study were expressed as percent of full stocking. Stocking plots were grouped by three thinning methods: heavy (40 to 50 percent stocking), moderate (60 to 70 percent), and light (80 to 100 percent). Isolation strips were established around each plot and treated as the included plot.

Following the original thinnings in 1962, subsequent thinnings were scheduled and controlled by stocking goals rather than predetermined time intervals. The stocking goals allowed the selected plots to increase to various levels of percent stocking before being thinned back to the intended stocking level. The stocking goals were as follows: (1) short thinning interval that allowed the selected plots to be thinned to initial stocking after an increase of 10 percent; (2) an increasing stocking level that allowed plots to be thinned to 10 percent following an increase of 20 percent; (3) long thinning interval that allowed the plots to increase to 80 or 90 percent before thinning to initial stocking; and (4) no thinning after the initial treatment. These treatments generally were free thinning with consideration for species, size, form, and spacing.

In 1977, when the stand was first measured for stem quality, species composition consisted primarily of mixed oaks and a few other species (yellow-poplar, red maple, aspen, black cherry, and hickory). The diameter (d.b.h.) range at that time was between 3.6 and 11.9 inches. Only the oaks were included in the study because of the limited number of other species. There were 595 white, red, and chestnut oak sample trees.

Defect information from the study trees following the 5-year period after 1977 demonstrates the effects of heavy, moderate, and light thinnings on tree quality. Prior to and including the study period, the plots were maintained according to prescribed thinning methods that closely controlled residual stocking. These young hardwood trees, and the way they were thinned, were typical of many found throughout the central hardwood region.

Methods

Detailed measurements of the external tree characteristics were taken on each sample tree for quality determination in 1977 and 1982. Only trees 3.6 inches and larger in d.b.h. were included in the study. All branches measuring 0.3 inch in diameter and larger were tallied as limbs on the first and second 8-foot sections of the butt 16-foot log of the tree. Branches smaller than 0.3 inch were counted as epicormic branches. The variables measured and recorded were:

- D.b.h.
- 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

- Number of dead limbs on the first and second 8-foot section of the butt 16-foot log
- Diameter of the largest live limb on the first and second 8-foot section of the butt 16-foot log
- Diameter of the largest dead limb on the first and second 8-foot section of the butt 16-foot log
- Number of epicormic branches on the first and second 8-foot section of the butt 16-foot log

The number of epicormic branches was broken down into three classes: None, 1 to 6, and 7 or more. The three classes of epicormic branch measurements were grouped together for the analysis.

For comparative purposes, a relative quality index (Sonderman 1979) was computed for each tree by assigning a numerical value to individual characteristics:

Crown Class	Value
Dominant	4
Codominant	3
Intermediate	2
Suppressed	1

Sweep and Crook (Deviation in inches for 16-foot butt log)	Value
1	4
2-4	3
5-6	2
7-8	1
9+	0

If the tree has forks, rot, or seams, then the sweep and crook numerical value = 0.

Limb Count (Limbs $\geq$ 0.3 inch)	Value
1-2	4
3-4	3
5-8	2
9-16	1
17 +	0

By adding the numerical values for crown class, sweep and crook, and limb count, the relative quality index and class of a tree can be determined as follows:

Relative Quality Index (Range of individual values)	Relative Quality Class
1-7	Poor
8-9	Medium
10-12	Good

Results and Discussion

Although considerable research has been conducted on the effects of timber management practices on tree-growth rates, there has been limited work in this area on timber-quality development. In this study we have described the response of several tree-quality characteristics common to young oak stands at various levels of thinning. In dealing with these young, potentially high-quality trees, quality change over time is as important, if not more important, than growth rate.

Diameter

Differences in diameter growth due to thinning treatments were small overall with the greatest change taking place in the moderate thinning (Table 1). Increases in diameter growth for heavy, moderate, and light thinning were, respectively: 1.2, 1.3, and 0.9 inches. Given more time, the heavy thinning should have resulted in the largest increase in diameter growth.

Table 1.—Summary of average mixed-oak tree characteristics by thinning method, 1977-82

Tree characteristic	Thinning method: Heavy 1977	Heavy 1982	Moderate 1977	Moderate 1982	Light 1977	Light 1982
D.b.h. (inches)	9.6	10.8	8.3	9.6	7.7	8.6
Crown ratio (%)	36.4	36.5	32.4	32.4	29.8	32.5
Defects/ft^2 surface area (no.)	.290	.290	.340	.400	.420	.320
Relative quality index (no.)	8.1	8.5	7.5	7.6	7.5	7.8

Crown Class

All of the thinning methods affected the crown classes of the study trees (Table 2) in different ways. The heavy thinning resulted in an increase in the percentage of dominant trees. The medium thinning increased both the dominants and codominants, while the light thinning increased the percentage of codominants only. This is important to young growing-stock trees because of the number of defects that are associated with different crown classes. Normally, genetically inferior trees with intermediate and suppressed crowns tend to sprout more prolifically than genetically superior trees with dominant and codominant crown classes. By creating changes in crown class through thinnings, stem quality can be modified over time.

Crown Ratio

Crown ratio is the ratio of the length of the live crown to the total height of the tree and usually is a good indicator of tree growth and vigor. Because of thinning, the combination of additional limbs and epicormic branches that can develop sometimes causes a downward extension of the crowns on young trees, resulting in additional defects and lower quality of the section. Also, thinning methods that reach stocking goals through subsequent thinnings usually allow large amounts of light to reach the stand at different times, causing additional crown growth and large crown ratios. Therefore, response to light created by openings in the crown canopy as a result of thinnings will cause an increase in the crown ratio (Table 1). This usually means larger live limbs, additional epicormic sprouts, and a change in the crown dominance. However, results did not verify this completely because of the short study time of only 5 years. Subsequent longer-term crown ratio studies are needed to substantiate or reject this statement.

Relative Quality Index

The relative quality index is a gradient that expresses a tree or stand in terms of a numerical index of stem quality-related characteristics—the higher the index the higher the tree quality. In this study, the index increased the most in the heavy thinning, reflecting more dominant crown classes (Table 1). The index also increased in the light thinning as a result of a decrease in the number of live and dead limbs. Moderate thinning resulted in little change. None of the thinning methods resulted in a shift from one relative quality class to the next.

Moderate thinning (60 to 70 percent residual stocking) resulted in the poorest quality index, reflecting changes in both crown class and the number of live and dead limbs. Over the 5 years, heavy thinning (40 to 50 percent) had the best relative quality index, but given more time the index would have been lower because of the sprouting of the trees with epicormic branches and small live limbs. Also given more time, the opposite would have resulted in the light thinning (80 to 100 percent)—there would be fewer epicormic branches and live limbs over time because of the dense stocking maintained.

Table 2.—Mixed-oak crown classes, by thinning method, 1977-82

Crown class	Thinning method					
	Heavy		Moderate		Light	
	1977	1982	1977	1982	1977	1982
	Percent					
Dominant	17	30	18	26	24	22
Codominant	69	67	54	55	43	48
Intermediate	14	3	18	14	20	18
Suppressed	—	—	10	5	13	12

Live and Dead Limb Defects per Square Foot of Surface Area

Limb defects per square foot of surface area (Table 1) include live and dead limbs and overgrowths, but not epicormic branches. The expansion of the surface area through increased diameter growth usually results in a decrease in the number of defects per square foot of surface area if no new defects develop. Even though the number of defects per square foot of surface area in the heavy thinning appeared to remain constant from 1977 to 1982, the actual number of defects increased, offset by the large d.b.h. growth increase. For the same reasons, there was a slight increase in the number of defects per square foot of surface area in the moderate thinnings. By contrast, the light thinning showed a reduction in the number of defects per square foot of surface area, probably due to natural pruning and smaller d.b.h. growth.

Live Limbs

The number of live limbs was reduced in all thinning methods from 1977 to 1982 (Table 3). The heavy and moderate thinnings each reduced the number of live limbs by 26 percent and the light thinning by 15 percent. The high reduction in the number of live limbs in the heavy and moderate thinnings resulted from many of the live limbs dying over the 5-year period. At the same time, the remaining live limbs on the trees persisted and grew larger from the exposure to more light. In fact, increases in live-limb size in the second 8-foot section were, respectively: 0.30 inch for the heavy, 0.11 inch for the moderate, and 0.09 inch for the light thinning. We believe that the variations in limb size caused by different thinning methods resulted mainly from differences in the amounts of light.

Table 3.—Characteristics of mixed-oak limbs in butt and second 8-foot sections, by thinning method, 1977-82

Section	Thinning method: Heavy		Moderate		Light	
	1977	1982	1977	1982	1977	1982
	LIVE LIMBS (Number)					
First 8-foot	0.35	0.30	0.60	0.50	0.41	0.37
Second 8-foot	5.50	4.08	3.86	2.86	3.38	2.88
	DEAD LIMBS (Number)					
First 8-foot	3.94	3.55	4.10	4.54	2.77	2.29
Second 8-foot	8.61	10.61	10.47	13.07	8.75	8.25
	LIVE-LIMB SIZE (Inches)					
First 8-foot	.54	.70	.58	.54	.56	.64
Second 8-foot	.81	1.11	.66	.77	.62	.71
	DEAD-LIMB SIZE (Inches)					
First 8-foot	.76	.73	.62	.67	.58	.61
Second 8-foot	.77	.92	.73	.91	.69	.79
	EPICORMIC BRANCHES (Percent)[a]					
First 8-foot	27.5	74.2	31.3	68.5	21.5	64.0
Second 8-foot	44.8	77.3	47.1	84.9	37.5	87.7

[a] Percentage of trees with epicormic branches.

Dead Limbs

The number of dead limbs in the second 8-foot section increased by 23 and 25 percent, respectively, in the heavily and moderately thinned plots, and decreased by less than 1 percent in the lightly thinned plots (Table 3). The increase in the number of dead limbs in the heavy and moderate thinnings resulted from a large number of the live limbs dying. The slight reduction in the number of dead limbs in the light thinning resulted from the natural pruning of the smaller dead limbs. The smaller pruned dead limbs, if given enough time, will result as a defect (overgrowth) while the larger dead limbs will persist for years. Both are considered defects until the scar or overgrowth is covered with enough clear wood to place them out of the quality zone (Rast et al. 1973).

Epicormic Branches

Epicormic branches are less likely to develop on dominant and codominant trees than on intermediate or suppressed trees. Our study results (Table 3) show fewer epicormic branches on the heavy to moderate thinnings because they included mostly dominant and codominant trees known to sprout less. In comparison, the light thinning treatment had a substantial mix of all crowns that included intermediate and suppressed trees that are known to be more prolific sprouters. From 1977 to 1982, epicormic branching in the second 8-foot section increased by 33 percent in the heavy thinning, 38 percent in the moderate thinning, and 50 percent in the light thinning.

The mixed-crown classes, along with the varying amount of light from the thinnings, were responsible for a major portion of the epicormic branching. Because of these conditions, some new epicormic sprouts resulted and some of the existing live limbs continued to grow faster and better.

Summary and Conclusion

Limb-related defects are the greatest degraders to potential stem quality. The results show that the moderate and heavy thinnings, as opposed to the light thinnings, adversely affected the number and size of the stem defects. Moderate to heavy thinning in mixed-oak stands reduced stem quality by increasing the defects per square foot of surface area. In comparison, light thinning maintained stem quality by reducing the number of limb-related defects. Dale and Sonderman (1984) reported similar findings on 33-year-old white oak trees that showed poorer stem quality after heavy to moderate thinnings.

This study was based on trees that had been initially thinned and then subsequently thinned using stocking goals to reach specific stocking percentages. The fact that the plots were maintained over time at specific stocking levels and grouped accordingly provided a good base for comparison of limb-related defects. The trends in this study reflect a biological sequence of events that include epicormic branches changing to live limbs, live limbs changing to dead limbs, and dead limbs changing to overgrowths. All of this happens simultaneously but at different rates among the various thinning levels. Age and site are a few of the stand variables that affected the changes in this biological sequence. The full effects of thinning, whether heavy, moderate, or light, were combined and grouped by plots and treatments for this study. This, plus the fact that a subsequent thinning scheme was used, requires caution when applying this information to trees and stands in other geographic areas.

We believe that land managers are interested in knowing and recognizing the quality of their hardwood timber and that increasing profits from their investment by proper thinning is a goal. At best, full utilization of the land while maintaining good growth and quality are requirements. Other important findings were:

- D.b.h. increased as the thinning intensity increased.
- The proportion of dominant trees increased in the heavy thinning.
- The proportion of dominant and codominant trees increased in the moderate thinning.
- The proportion of codominant trees increased in the light thinning.
- The relative quality index was highest in the heavy thinning.
- Live and dead limbs were substantially larger and more numerous on the second 8-foot section of the butt 16-foot log of the tree.
- There were more epicormic branches on the second 8-foot section of the butt 16-foot log than on the first 8-foot section.
- There were fewer and smaller live and dead limbs in the light thinnings than in the heavy thinnings.

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