THINNING TO IMPROVE GROWTH AND CONTROL THE CANKER DECAY FUNGUS *INONOTUS HISPIDUS* IN A RED OAK-SWEETGUM STAND IN THE MISSISSIPPI DELTA

James S. Meadows, Theodor D. Leininger, and T. Evan Nebeker[1]

Abstract–Thinning was applied to a 55-year-old, red oak-sweetgum (*Quercus* spp.-*Liquidambar styraciflua* L.) stand in the Delta region of western Mississippi in late summer 1997. The thinning operation was a combination of low thinning and improvement cutting to remove most of the pulpwood-sized trees as well as sawtimber-sized trees that were damaged, diseased, of poor bole quality, or of an undesirable species. Special emphasis was placed on removing all red oaks infected with *Inonotus hispidus*, a canker decay fungus that causes serious degrade and cull, especially in willow oak (*Quercus phellos* L.) and water oak (*Q. nigra* L.). Prior to thinning, stand density averaged 98 trees and 125 square feet of basal area per acre. Quadratic mean diameter was 15.4 inches, while stocking averaged 102 percent across the study area. Thinning reduced stand density to 32 trees and 59 square feet of basal area per acre, increased quadratic mean diameter to 18.4 inches, and reduced stocking to 47 percent. Thinning also increased the red oak component of the stand from 47 percent of the basal area prior to thinning to 59 percent of the basal area after thinning. There has been little stand-level growth during the first 3 years following the thinning operation. Thinning significantly increased diameter growth of residual trees, especially red oaks, but has not yet produced a significant increase in quadratic mean diameter. Even trees in the dominant crown class experienced increased diameter growth as a result of the thinning operation. Epicormic branching varied widely between species groups. Thinning had no significant effect on epicormic branching in red oaks, but greatly increased the production of new epicormic branches in sweetgum. Three years after thinning, epicormic branches were most numerous on low-vigor sweetgum trees in the lower crown classes. Most importantly, thinning had no effect on the production of epicormic branches along the boles of red oak crop trees.

INTRODUCTION

A combination of thinning and improvement cutting is often used in mixed-species, southern bottomland hardwood forests to not only enhance both stand-level and tree-level growth, but also to improve both species composition and quality of the stand (Meadows 1996). These three characteristics – growth rate, species composition, and quality – are critically important for the profitable management of hardwood stands for high-quality sawtimber production.

Thinning regulates stand density and increases diameter growth of residual trees. In general, diameter growth response increases as the intensity of the thinning increases. However, very heavy thinning may reduce stand density to such a low level that stand-level growth is greatly curtailed even though tree-level growth is greatly enhanced. Stocking simply becomes so low that the stand does not fully realize the potential productivity of the site. Recommended minimum stocking levels necessary to maintain satisfactory stand-level growth have been reported to be 46 to 65 percent in upland oaks (Hilt 1979) and 45 to 60 percent in Allegheny hardwood stands (Lamson and Smith 1988). Thinning in a young water oak plantation to a residual stocking level of 33 percent created a severely understocked condition that will depress stand-level growth for many years (Meadows and Goelz 2001).

Thinning sometimes has adverse effects on the bole quality of residual trees. The production of epicormic branches along the boles of residual trees is often associated with poorly designed thinning operations. However, in stands thinned from below, the proportion of dominant and codominant trees in the residual stand increases as the intensity of the thinning increases. These vigorous, upper-crown-class trees are much less likely to produce epicormic branches than are less-vigorous, lower-crown-class trees (Meadows 1995). Consequently, the production of epicormic branches along the boles of residual trees may actually decrease after well-designed thinnings (Sonderman and Rast 1988).

This combination of thinning and improvement cutting typically used in mixed-species hardwood stands is also designed to improve both species composition and quality of the residual stand (Meadows 1996). In general, the objective is to decrease the proportion of low-value trees and thus to increase the proportion of high-value trees. The emphasis for this component of the cutting operation is on the value, or quality, of the individual trees. Trees that are damaged, diseased, of poor bole quality, or of an undesirable species are removed from the stand, whereas healthy, high-quality trees of desirable species are retained. Improvement cuttings are often performed in stands that contain a high

[1]Principal Silviculturist and Principal Plant Pathologist, USDA Forest Service, Southern Research Station, Stoneville, MS.;Professor, Department of Entomology and Plant Pathology, Mississippi State University, Mississippi State, MS., respectively.

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proportion of diseased trees in an effort to eliminate disease-causing fungi from the stand.

Hardwood stands in the Delta region of Mississippi are often infested with *Inonotus hispidus*, a canker decay fungus that causes the disease commonly known as hispidus canker. The fungus is found most frequently on willow oak and water oak, but also occurs on Nuttall oak (*Quercus nuttallii* Palmer), white oak (*Q. alba* L.), and hickory (*Carya* spp.). Hispidus canker causes serious degrade and cull in infested trees. Damage occurs primarily in the form of heartwood decay, in which the wood behind the canker becomes soft and delignified. The fungus results in the formation of a large, spindle-shaped canker usually at the site of an old branch stub 12 to 15 feet or more up the bole of the infected tree (McCracken 1978). The central part of the canker is sunken and covered with bark. In addition to the degrade caused by the heart rot, presence of the hispidus canker greatly increases the possibility of stem breakage at the site of the canker itself. Improvement cuttings to remove trees with hispidus canker have been successful in reducing spore production and dissemination within the stand, thus minimizing the possibility of the spread of the disease to adjacent trees (McCracken and Toole 1974).

The study reported here is part of a much larger research project that is investigating the relationships between silvicultural practices and insect and disease populations in southern hardwood forests. Specifically, the goals of this larger project are: (1) to better understand and to quantify the effects of stand modification on insect and disease populations in southern hardwood forests, and (2) to use this knowledge to develop pest management recommendations with respect to silvicultural practices in southern hardwood forests.

This paper reports only the silvicultural component of the overall project on one of our study sites. The specific objectives of this individual study are: (1) to determine the effects of thinning on stand growth, development, and yield, and (2) to determine the effects of thinning on individual-tree growth and bole quality. A third objective, not covered in this paper, is to determine the effects of thinning on insect and disease populations, with special emphasis on those pests that lead to degrade and/or mortality.

METHODS

Study Area

The study is located on the Delta National Forest in the Delta region of western Mississippi. The study site is adjacent to Ten Mile Bayou, within the floodplain of the Big Sunflower River, in southeastern Sharkey County. The site is nearly flat and is subject to frequent periodic flooding during the winter and spring months. Floodwaters may remain on the site for several weeks during this period.

Soils across most of the study site belong to the Sharkey series, but smaller areas of Alligator soils are interspersed with the Sharkey soils. Dowling soils also occur in small depressions. All three soils are poorly drained clays that shrink and form wide cracks when dry and expand when wet. These soils formed in fine-textured Mississippi River sediments deposited in slackwater areas of the floodplain. Broadfoot (1976) reported average site indexes of the Sharkey soils to be 92 feet at 50 years for willow oak and 91 feet at 50 years for Nuttall oak. Average site index of the Alligator soils was 88 feet at 50 years for both species. Broadfoot (1976) did not supply similar information for the Dowling soils.

The study area is contained within a 55-year-old red oak-sweetgum stand. Principal red oak species are willow and Nuttall oaks. In addition to sweetgum, other common species include sugarberry (*Celtis laevigata* Willd.), American elm (*Ulmus americana* L.), common persimmon (*Diospyros virginiana* L.), green ash (*Fraxinus pennsylvanica* Marsh.), and honeylocust (*Gleditsia triacanthos* L.).

Plot Design

Plot design was modified from the format for standard plots for silvicultural research, as originally recommended by Marquis and others (1990). Each treatment was uniformly applied across a 4.8-acre rectangular treatment plot that measured 6 by 8 chains (396 by 528 feet). Four, 0.6-acre rectangular measurement plots were established in the center of each treatment plot. Each measurement plot was 2 by 3 chains (132 by 198 feet). A 1-chain buffer strip was established around the four measurement plots. The entire study covered an area of 9.6 acres.

Treatments

Only two treatments were applied to the study area: (1) an unthinned control, and (2) heavy thinning. The thinning operation was a combination of low thinning and improvement cutting. Personnel from the Delta National Forest marked the stand to remove most of the pulpwood-sized trees as well as those sawtimber-sized trees that were damaged, diseased, of poor bole quality, or of an undesirable species. Special emphasis was placed on removing all red oaks infected with *Inonotus hispidus*.

Four replications of the two treatments were applied in a randomized complete block design to the eight plots (experimental units) in August 1997. Trees were directionally felled by a mechanized feller with a continuously running cutting head. Merchantable products in the form of longwood were removed with rubber-tired skidders.

Measurements

We conducted a preharvest survey to determine species composition and initial stand density on each 0.6-acre measurement plot. We recorded species, diameter at breast height (dbh), crown class, and tree class as defined by Meadows (1996) on all trees greater than or equal to 5.5 inches dbh. The number of epicormic branches on the 16-foot butt log was also recorded on those trees designated as “leave” trees. Log grade, as defined by Rast and others (1973), of the 16-foot butt log and sawtimber merchantable height were recorded on those “leave” trees greater than or equal to 13.5 inches dbh. Crown class, dbh, and the number of epicormic branches on the 16-foot butt log were measured annually for the first 3 years after thinning.

Table 1—Stand conditions and individual-tree diameter growth 3 years after application of two thinning treatments. Means followed by the same letter are not significantly different at the 0.05 level of probability

Treatment	Trees	Mortality	Basal area	Basal area growth	Stocking	Quadratic mean Diameter	Cumulative diameter growth
	(No./acre)	(Pct)	(Sq ft/acre)	(Sq ft/acre)	(Pct)	(In.)	(In.)
Unthinned	99 a	1.0 a	133 a	4 a	108 a	15.7 a	0.23 b
Thinned	30 b	6.2 a	60 b	1 a	48 b	19.0 a	0.60 a

RESULTS AND DISCUSSION

Stand Conditions Prior to Thinning

Prior to thinning, the study area averaged 98 trees and 125 square feet of basal area per acre, with a quadratic mean diameter of 15.4 inches. The average stocking of 102 percent exceeded the level (100 percent) at which thinning is recommended in southern bottomland hardwood stands (Goelz 1995). We found no significant differences among the plots in any of these preharvest characteristics. The stand was fairly dense, but many of the dominant and codominant trees were healthy and exhibited few symptoms of poor vigor. Unfortunately, hispidus canker was observed on approximately 24 percent of the red oaks in the study area.

The stand was clearly dominated by red oak and sweetgum. Red oaks (primarily willow and Nuttall oaks) accounted for about 47 percent of the basal area of the preharvest stand. Red oaks dominated the upper canopy of the stand and had a quadratic mean diameter of 17.2 inches. Sweetgum accounted for about 46 percent of the basal area and occurred in both the upper and middle canopies. Sweetgum quadratic mean diameter was 14.6 inches. Other species, principally sugarberry and American elm, made up the remaining 7 percent of the basal area. These trees were found almost exclusively in the lower canopy of the stand.

Stand Development Following Thinning

Thinning reduced stand density to 32 trees and 59 square feet of basal area per acre, increased quadratic mean diameter to 18.4 inches, and reduced stocking to 47 percent. It removed 67 percent of the trees and 53 percent of the basal area. Average volumes removed during the thinning operation were 3,500 board feet per acre (Doyle scale) of sawtimber and 11 cords per acre of pulpwood. Average dbh of trees removed was 13.5 inches. Thinning produced stand characteristics significantly different from the unthinned control.

This heavy thinning reduced stand density to a level approaching the minimum residual stocking level necessary to maintain satisfactory stand-level growth, as recommended for other hardwood forest types (Hilt 1979, Lamson and Smith 1988). The heavier-than-normal thinning was necessary in this stand because of the desire to remove all of the red oaks infected with hispidus canker. However, even with these additional removals of diseased red oaks, thinning improved species composition of the stand. Thinning increased the red oak component of the stand to 59 percent of the basal area and reduced the sweetgum component to 37 percent of the residual basal area.

During the 3 years following thinning, stand-level growth has been negligible in both the unthinned control and the thinned plots (table 1). In fact, cumulative basal area growth and the increase in stocking percent during the 3-year period following thinning were actually lower in the thinned plots than in the unthinned control, although these differences were not statistically significant. Apparently, this heavy thinning created an understocked stand that will require many years to fully recover from the drastic reduction in stand density.

Diameter Growth

We found significant differences between the thinning treatment and the unthinned control in cumulative diameter growth of individual trees 3 years after treatment (table 1). Thinning increased diameter growth of residual trees by 161 percent when compared to the unthinned control.

Red oaks and sweetgums were similar in their diameter growth response to the thinning treatment (figure 1). Thinning more than doubled diameter growth of both species groups. Cumulative diameter growth of residual red oaks in the thinned plots was 0.64 inches, whereas residual sweetgums in the thinned plots averaged 0.56 inches of

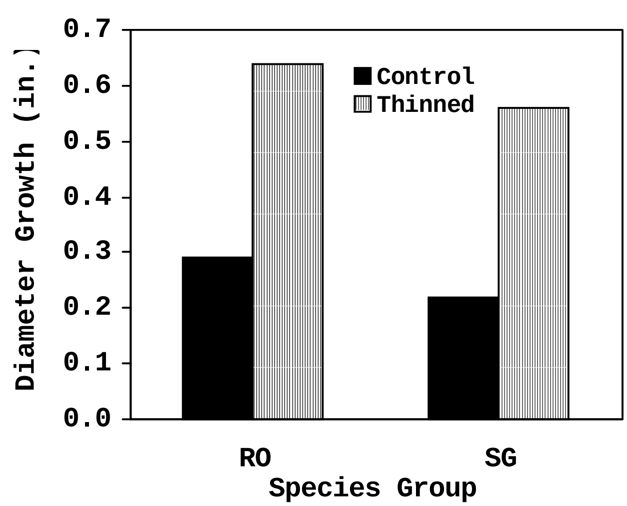

Figure 1–Diameter growth of residual trees, by species group, during the first 3 years after application of two thinning treatments (RO = red oak, SG = sweetgum).

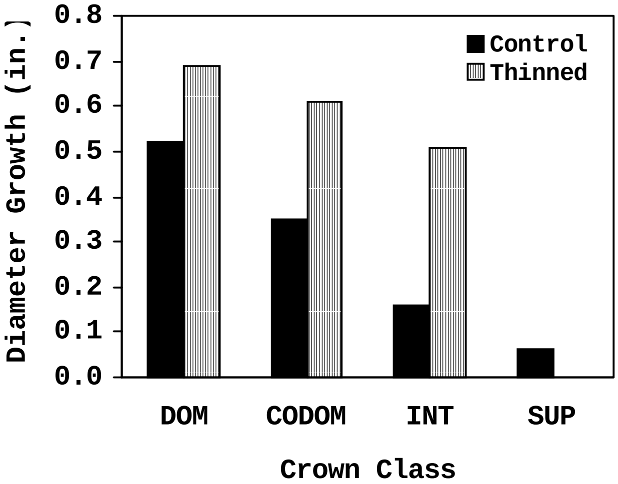

Figure 2–Diameter growth of residual trees, by crown class, during the first 3 years after application of two thinning treatments (DOM = dominant, CODOM = codominant, INT = intermediate, SUP = suppressed).

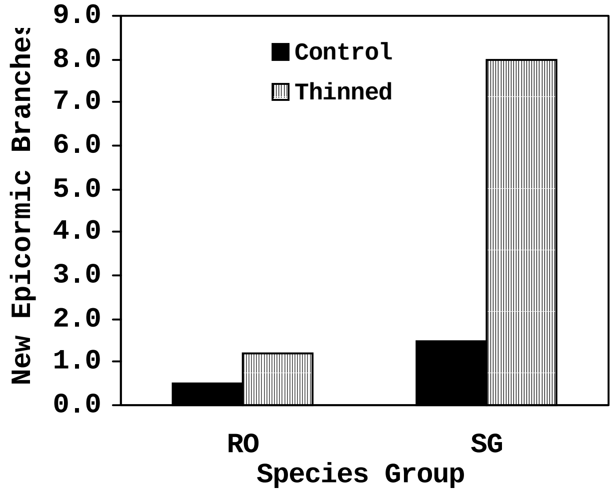

Figure 3–Number of new epicormic branches produced on the butt logs of residual trees, by species group, during the first 3 years after application of two thinning treatments (RO = red oak, SG = sweetgum).

diameter growth over the 3-year period. Cumulative diameter growth of both red oaks and sweetgums in the unthinned control averaged less than 0.30 inches.

Of particular significance in this study is the observation that thinning increased diameter growth of both dominant and codominant trees, when averaged across all species (figure 2). Thinning increased diameter growth of dominant trees by about 33 percent and increased diameter growth of codominant trees by about 74 percent over the unthinned control. Thinning also more than tripled cumulative diameter growth of trees in the intermediate crown class. No comparisons could be made for trees in the suppressed crown class because thinning removed all of the suppressed trees.

It is clear that thinning successfully increased cumulative diameter growth of residual trees 3 years after treatment. Excellent diameter growth responses were observed for both red oak and sweetgum trees in the dominant and codominant crown classes. These trees, especially the red oaks, were classified as crop trees and were considered to be the most desirable trees in the stand for high-quality sawtimber production. The thinning operation, at least through the first 3 years, has been very successful in greatly enhancing the diameter growth of the most valuable trees in the stand.

Epicormic Branching

The production of epicormic branches along the merchantable boles of residual trees can be a serious problem in thinning hardwood stands. These epicormic branches cause defects in the underlying wood and can reduce both log grade and subsequent lumber value. However, well-designed thinnings and proper marking rules can minimize the production of new epicormic branches in most hardwood stands.

In this study, thinning had no significant effects on either the total number or the number of new epicormic branches found on the butt logs of residual trees 3 years after thinning. Residual trees in the thinned plots averaged a total of 6.5 epicormic branches on the butt log; included in this total were 4.1 new epicormic branches produced on the butt log during the 3 years following thinning. On the other hand, trees in the unthinned control averaged 3.8 epicormic branches on the butt log; there were 1.0 new epicormic branches produced on the butt log of these trees during the same 3-year period. Even though residual trees in the thinned plots averaged more total epicormic branches and more new branches on the butt log than trees in the unthinned control, these differences were not statistically significant. Production of new epicormic branches on the butt log varied greatly among individual trees. Some of the high-vigor trees produced no new branches, while many other healthy trees produced only a few. Low-vigor trees, however, generally produced many new epicormic branches.

We found wide variation between the red oaks and sweetgum in the number of new epicormic branches produced on the butt log during the 3 years following thinning (figure 3). Thinning had very little effect on the production of new epicormic branches in red oak, but caused a very large increase in the number of new epicormic branches on the butt logs of residual sweetgum trees 3 years after thinning. Most of the residual red oaks in the thinned stand were high-vigor dominant or codominant trees that are generally less likely to produce epicormic branches than are trees in poor health. Consequently, we found very few new epicormic branches on the butt logs of residual red oaks, even though Meadows (1995) categorized most bottomland red oaks as highly susceptible to epicormic branching. Our observations in this study strongly support the hypothesis proposed by Meadows (1995) that healthy, vigorous trees, even of highly susceptible species, are much less likely to produce epicormic branches than are trees in poor health.

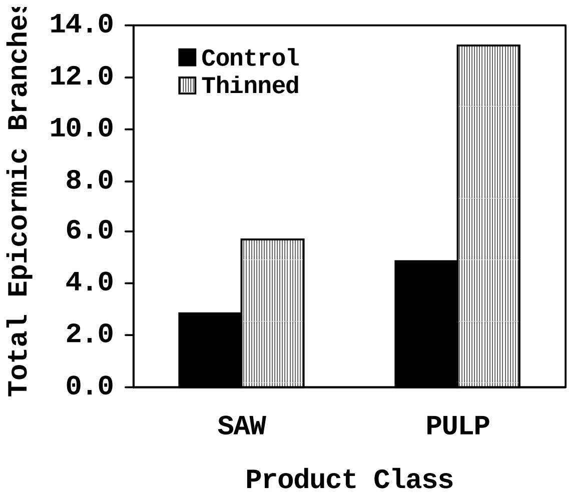

Figure 4–Total number of epicormic branches on the butt logs of residual trees, by product class, 3 years after application of two thinning treatments (SAW = sawtimber, PULP = pulpwood).

When evaluating the effects of thinning on epicormic branching, the most important consideration, however, is the total number of epicormic branches found on the butt logs of the crop trees. These trees are favored during the thinning operation and are most likely to produce high-quality sawtimber. Sawtimber trees in the thinned plots averaged 2.8 more epicormic branches on the butt log than sawtimber trees in the unthinned control, when averaged across all species (figure 4). However, this small difference was not statistically significant. On the other hand, pulpwood trees in the thinned plots had many more epicormic branches on the butt log than pulpwood trees in the unthinned control 3 years after thinning. Most of the pulpwood-sized trees in the residual stand after thinning were relatively low-vigor, lower-crown-class trees that produced many new epicormic branches following the thinning treatment.

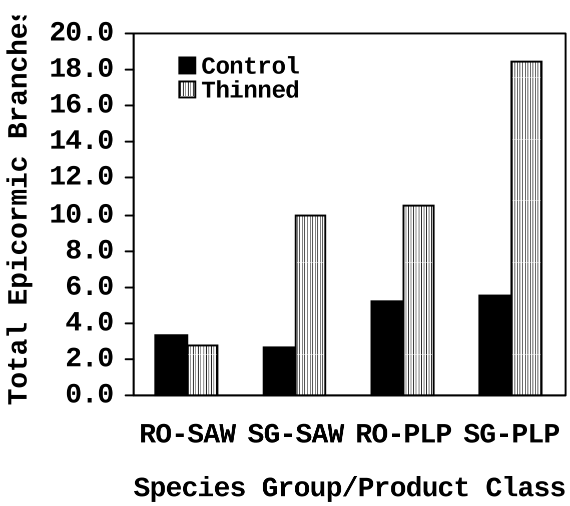

Figure 5–Total number of epicormic branches on the butt logs of residual trees, by species group and product class, 3 years after application of two thinning treatments (RO-SAW = red oak sawtimber, SG-SAW = sweetgum sawtimber, RO-PLP = red oak pulpwood, SG-PLP = sweetgum pulpwood).

Although sawtimber trees in the thinned plots had more epicormic branches on the butt log than sawtimber trees in the unthinned control (figure 4), most of this increase in the number of epicormic branches was found on sawtimber-sized sweetgum trees rather than on sawtimber-sized red oak trees (figure 5). In fact, sweetgum sawtimber trees in the thinned plots averaged 7.3 more epicormic branches on the butt log than sweetgum sawtimber trees in the unthinned control 3 years after treatment. In contrast, red oak sawtimber trees in the thinned plots actually had slightly fewer epicormic branches on the butt log than red oak sawtimber trees in the unthinned control, but this difference was not statistically significant. Consequently, we can conclude that, in this study, thinning to a low level of residual stocking had no effect on the total number of epicormic branches on the butt logs of red oak sawtimber trees, the most valuable trees in the stand.

CONCLUSIONS

1. The thinned stand has been very slow to recover from the thinning operation, with little stand-level growth during the first 3 years.

2. Thinning increased diameter growth of residual trees, especially red oaks, but has not yet resulted in an increase in quadratic mean diameter.

3. Thinning increased diameter growth of codominant trees by 74 percent and diameter growth of dominant trees by 33 percent.

4. Thinning had no effect on epicormic branching in red oak sawtimber trees, but greatly increased the production of new epicormic branches in sweetgum sawtimber trees.

5. Epicormic branches were most numerous on the butt logs of low-vigor, lower-crown-class trees; this was especially true for sweetgum.

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