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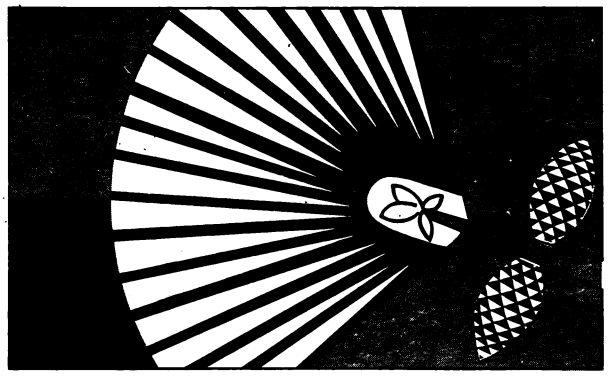

EFFECTS OF THINNING ON YOUNG SHORTLEAF PINE PLANTATIONS IN INDIANA

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Correction for: Phipps, Howard M. 1973. Effects of thinning on young shortleaf pine plantations in Indiana. USDA For. Serv. Res. Pap. NC-93, 6 p., illus. North Cent. For. Exp. Stn., St. Paul, Minn.

Page 4, "Net Volume Yield," last line of first paragraph. "1,600 cubic feet per acre" should read "600 cubic feet per acre."

Page 4, "Hardwood Invasion," lines 15 and 16 are transposed; lines 13-20 of first paragraph should read "A comparison with sampling results obtained 10 years previously in the German Ridge plantation indicates a change in species frequency. Elm and redbud in the control plots and sassafras and persinimon in the more open plots have been replaced largely by dogwood and white ash, although sassafras continues to be abundant."

Page 5, Figure 1, Designation for horizontal axis should read "Square Feet of Basal Area Per Acre."

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Howard M. Phipps

Shortleaf pine (*Pinus echinata* Mill.) has been planted in southern Indiana and neighboring areas in the Central States Region since the late 1930's; today these plantations represent an important timber resource. This species has a wide natural range and usually establishes on dry upland soils and eroded sites. It is noted for its ability to resprout, up to the age of 8 to 10 years, if the main stem should be destroyed by fire or cutting. Many of the older stands were planted at close spacings; if they are allowed to remain so, tree crowns may become too small to maintain satisfactory growth, and mortality due to overcrowding may ultimately reduce total yield.

Two studies were established on the Hoosier National Forest in southern Indiana to determine if thinning young plantations will increase growth or quality of the residual stand, and if so, what residual density may be most appropriate.

THE STUDIES

The first study was established in a 14-year-old plantation near Tell City in an area known as German Ridge during the winter of 1950-51.[1] The pretreatment spacing was 6 by 6 feet with an average basal area of 127 square feet per acre. Treatments consisted of plots thinned to 120, 100, and 80 square feet of basal area and an unthinned control. Each treatment was replicated four times on one-tenth-acre plots. Plots were thinned again to the same basal areas in 1958.

A second study was begun in 1956-57 in a 17-year-old plantation near Houston, approximately 100 miles north of German Ridge. Average basal area per acre before thinning was 165 square feet. Plots 1/5-acre in size were thinned to basal areas of 130, 110, 90, and 70 square feet, and unthinned plots were left as controls. There were two replications of each treatment. A second thinning was made in the winter of 1961-62. In 1958 permanent sample trees (dominant or codominant) were selected in each treatment plot so that the effects of various thinning treatments on potential crop trees could be evaluated. Average sample tree height in both plantations was about 48 feet at age 25, which indicates a site index of 80 at 50 years (USDA Forest Service 1929). Plots were last measured in 1969.

[1] *For early reports of this study refer to Clark (1956), Limstrom and Deitschman (1953), and Williams (1959).*

RESULTS

Mortality

Fomes annosus had caused some losses in the heavily thinned plots at German Ridge after the initial thinning, and its presence was suspected at Houston. Subsequent observations and mortality counts did not indicate that the disease was becoming more widespread or increasing in severity, but potential losses — especially of the larger trees — is a factor to be considered in thinning decisions. For the 7-year period between the first and second thinnings, mortality from all causes at German Ridge was 28, 22, 56, and 48 trees per acre for the heavy, medium, light, and control treatments, respectively. For the 11-year period after the second thinning the counts were 30, 87, 86, and 262 for the same treatments. At Houston total losses 5 years after the first thinning ranged from 20 trees per acre in the heaviest thinning to 50 trees per acre in the control, and from 14 to 146 trees per acre 8 years after the second thinning.

Basal-Area Growth

The rate of basal-area growth declined in all treatments of both plantations from the time of the first

thinning measurements (tables 1 and 2). Although differences in growth rate among the treatments were not great, there is evidence that plots thinned to 110 square feet at Houston and 120 square feet at German Ridge grew somewhat better than the other treatments. It is interesting to note that although mortality in the unthinned plots of both plantations during the last 8 years of the study was about seven times greater than in the most heavily thinned plots, the decline in average net basal area growth was similar for all treatments. The unthinned plots still maintained the largest basal areas among treatments. Thus it does not appear that plots left unthinned to age 30 are in danger of becoming stagnant or that mortality due to competition would result in a serious loss of basal-area growth.

Diameter and Height Growth

Thinning caused increases in average d.b.h. ranging from 1.9 to 0.5 inches at Houston and from 0.7 to 0.2 inches at German Ridge (tables 3 and 4). The effects of thinning on size class distribution were most evident at Houston. For example, at the last meaurement the most heavily thinned plots produced about 90 trees per acre in the 10- to 12-inch class, as opposed to about 15 trees per acre of that size in the control. However, the number of trees per acre in the 8- to 9-inch class was greatest in the control and least in the most heavily thinned plots. At German Ridge none of the thinning treatments increased the number of trees in the 10- to 12-inch class over that of the control, and thinning to 80 and 100 square feet of basal area reduced the relative number of trees in the 8- to 9-inch class. Effects of thinning on the diameter of permanent sample trees were similar to those reported above. There were small differences among treatments at German Ridge and 2.1 inches difference between the heaviest thinning and control at Houston. The average sample tree in both plantations measured 9.0 inches in 1969.

Table 1. — *Periodic annual basal area growth and residual basal area by thinning treatment at German Ridge*
(In square feet per acre)

Thinning treatment (sq. ft. of basal area per acre)	Annual basal-area growth at age: 0 to 14	14 to 21	21 to 32	Basal area at age 32
80	9.1	6.4	3.4	118
100	8.9	6.6	2.7	130
120	9.4	7.4	4.1	165
Control	8.9	7.4	2.9	208

Table 2. — *Periodic annual basal area growth and residual basal area by thinning treatment at Houston*
(In square feet per acre)

Thinning treatment (sq. ft. of basal area per acre)	Annual basal-area growth at age: 0 to 17	17 to 19	19 to 22	22 to 29	Basal area at age 29
70	9.4	7.3	6.3	4.1	99
90	9.4	6.2	6.1	4.3	123
110	10.3	9.4	7.0	5.4	150
130	9.7	8.5	6.6	4.3	162
Control	9.9	8.2	5.5	2.7	220

Table 3. — *Average stand d.b.h. by thinning treatment at German Ridge*
(In inches)

	Basal area			
	80	100	120	Control
1969	8.6	7.9	8.0	7.6
1951	5.2	5.0	5.1	4.9
Change	3.4	2.9	2.9	2.7

Table 4. — *Average stand d.b.h. by thinning treatment at Houston*
(In inches)

	Basal area				
	70	90	110	130	Control
1969	9.0	8.2	8.4	7.4	7.1
1956	5.6	5.7	5.8	5.4	5.6
Change	3.4	2.5	2.6	2.0	1.5

According to pole measurements of sample tree heights at Houston, average annual height growth from 1958 to 1969 ranged from 2.0 feet in the control plots to 1.7 feet in the most heavily thinned plots. Average tree heights on these plots in 1969 were 56 and 54 feet, respectively. Control-plot trees at German Ridge grew 1.7 feet per year as opposed to 1.3 feet in the most heavily thinned plots, with average heights in 1969 of 59 and 53 feet, respectively. Measurements taken during the first 7 years of the study at German Ridge indicated no differences in average height growth among the treatments (Williams 1959).

Volume Growth

Regardless of treatment, volume growth rate began to decline in both plantations after about 20 years. However, some thinning treatments evidently increased total cubic-foot volume or merchantable cubic-foot volume at different stages in stand development (tables 5 and 6). Generally, the first thinnings were more effective than the second thinnings in increasing growth rate. At German Ridge, thinning to 120 square feet increased merchantable volume growth after the first thinning and total cubic-foot volume after the second thinning. Thinning to 80 and 100 square feet accelerated merchantable volume growth after the first thinning but reduced both total and merchantable volume after the second. At Houston, after the first thinning both merchantable and total volume growth rates were best in plots thinned to 90 square feet, with an indication of slight benefit from thinning to 110 and 130 square feet. After the second thinning only the plots thinned to 110 square feet showed better growth than the control plots.

Table 5. — *Periodic net annual volume increase in the Houston plantation*[1]
(In cubic feet[2] per acre)

Thinning treatment (sq. ft. of basal area per acre)	Age (years)			
	0-17	17-19	19-22	22-29
70	146	174	162	129
	(126)	(166)	(181)	(133)
90	144	185	243	148
	(124)	(190)	(249)	(153)
110	158	244	197	188
	(136)	(239)	(210)	(193)
130	147	234	206	168
	(124)	(241)	(215)	(181)
Control	151	231	199	174
	(128)	(240)	(207)	(187)

1/ Thinned at ages 17 and 22.
2/ Top figure is total cubic-foot volume; lower figure in parentheses is merchantable cubic-foot volume.

Table 6. — *Net annual volume increase in the German Ridge plantation*[1]
(In cubic feet[2] per acre)

Thinning treatment (sq. ft. of basal area per acre)	Age (years)		
	0-14	14-21	21-32
80	107	158	120
	(79)	(165)	(122)
100	102	170	107
	(75)	(177)	(110)
120	106	194	174
	(79)	(203)	(155)
Control	101	204	143
	(75)	(152)	(192)

1/ Thinned at ages 14 and 21.
2/ Top figure is total cubic-foot volume; lower figure in parentheses is merchantable cubic-foot volume.

Form class[2] measurements of sample trees showed only minor differences among treatments in either plantation by the end of the study period. In the Houston plantation the form class increase in the control was .18, as opposed to .21 for the other treatments. At the end of the study form class ranged from 0.833 in the 70-square-foot treatment to 0.800 in the control. There was little difference among treatments at German Ridge, where the average form class for all densities was 0.817.

Live crown percent (i.e., the percent of total tree height in live crown) showed a definite correlation to thinning intensity in both plantations. In 1969 the higher the residual density, the shorter the live crown. Crown percents in the German Ridge plantation ranged from 36 in the most heavily thinned plots to 30 in the check control, and at Houston from 43 to 28. For satisfactory growth in the loblolly-shortleaf pine type, Westveld (1949) recommended thinning heavily enough to maintain an average live crown percent of about 40. However, results of our studies showed that thinning heavily enough to maintain a live crown percent of 40 benefited growth very little, but reduced total yield considerably.

Net Volume Yield

At German Ridge the highest productivity in terms of total cubic-foot volume[3] was obtained in the plots thinned to 120 square feet and in the control — 4,491 and 4,418 cubic feet per acre, respectively. Thinning to 100 and 80 square feet produced total yields of 3,793 and 3,922 cubic feet per acre. The light thinning and control treatments also produced the greatest merchantable volume.[4] Total yield for each of these treatments was 4,226 cubic feet per acre, which exceeded yields for the most heavily thinned treatments by about 1,600 cubic feet per acre (fig. 1).

At Houston the greatest yields in terms of both total and merchantable volume were obtained by thinning to 110 square feet. Total volume yield per acre for this treatment was 5,065 cubic feet, compared with 4,846 for the control and 4,590 and 4,220 for the plots thinned to 90 and 70 square feet, respectively. Merchantable volume yield in the control plots exceeded the yield in plots thinned to 70 square feet by about 600 cubic feet, and in plots thinned to 90 square feet by about 200 square feet. Thinning to 110 square feet produced about 180 cubic feet more of merchantable volume than no thinning. Similar results were obtained in a study in southern Illinois (Boggess *et al.* 1963), where it was found that heavy thinning in 15- to 17-year-old shortleaf pine plantations did not improve either growth or total yield during the following 5 years, and as site quality increased, thinning became less advantageous.

Hardwood Invasion

There has been considerable hardwood invasion in the study plantations, with an approximate twofold increase in number of stems in the last 10 years of the study. In the German Ridge plantation the most hardwood stems 0.6 to 5.5 inches in d.b.h. were found in the more open plots. This was not evident, however, for stems less than 0.6 inches d.b.h. In the Houston plantation, residual density had no apparent effect on number of hardwood stems. The predominant hardwood species in both plantations was dogwood. Other species frequently encountered were white ash, elm, red and sugar maple, sassafras, yellow-poplar, black cherry, and black oak. A comparison with sampling results obtained 10 years previously in species frequency. Elm and redbud in the control the German Ridge plantation indicates a change in plots and sassafras and persimmon in the more open plots have been replaced largely by dogwood and white ash, although sassafras continues to be abundant.

The more common species and their relative abundance are listed for the two plantations in table 7. In the German Ridge plantation the average number of hardwood stems per acre on the thinned plots was about 6,400 and on the control plots about 4,850. Hardwoods were somewhat more abundant in the Houston plantation, with an average of 8,550 seedlings per acre.

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[2] *Girard form class.*

[3] *Total stem volume inside bark, including stump and top.*

[4] *Volume to 3-inch top inside bark, excluding stump.*

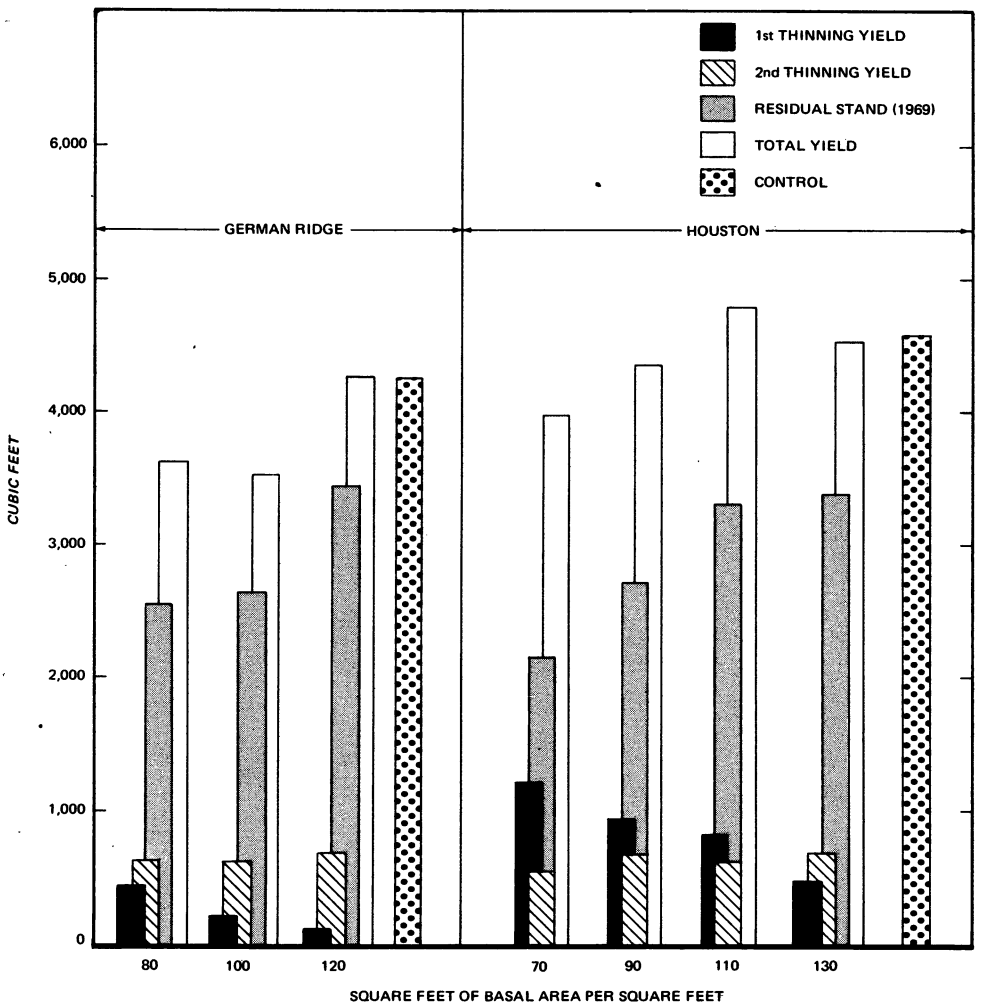

Figure 1. — *Net merchantable volume yield for the German Ridge and Houston plantations.*

SUMMARY

The results of studies in two shortleaf pine plantations in southern Indiana suggest that thinning before age 30 would be of questionable value in improving growth and yield. Thinning to 70 and 90 square feet of basal area at Houston increased average d.b.h. by 1.9 and 1.0 inches. As a result of these treatments, however, merchantable volume yields were reduced by about 5 percent and 13 percent, respectively. Yields were also substantially reduced at German Ridge by the two heaviest thinnings. Thinning lightly to 120 and 110 square feet produced slight increases in basal area growth rate and yield. Form class was changed little by thinning, but differences in live-crown ratio were evident, with the greatest reduction occurring in the unthinned plots. Thinning may increase losses due to *Fomes annosus*.

Without control measures it appears that hardwood species will succeed shortleaf pine in these plantations. If it is desired to convert these stands to hardwoods, it is likely that some level of thinning would aid in encouraging the more desirable but less tolerant species.

Table 7. — *Invasion of shortleaf pine plantations by hardwood treatments, 1968*

Species	German Ridge		Houston	
	Average stems/acre	Percent of total	Average stems/acre	Percent of total
High commercial value:				
White ash	1,193	20.2	107	1.3
Black oak	316	5.4	279	3.3
Sweetgum	304	5.2	---	---
Black cherry	276	4.7	1,011	12.0
Yellow-poplar	245	4.2	---	---
Miscellaneous	104	1.8	51	0.6
Total	2,438		1,448	
Low commercial value:				
Dogwood	1,244	21.1	4,919	58.5
Sassafras	664	11.1	338	4.0
Elm	509	8.6	103	1.4
Red maple	289	4.9	517	6.1
Sugar maple	234	3.9	395	4.7
Redbud	188	3.2	---	---
Spicebush	81	1.4	---	---
Sumac	80	1.4	199	2.4
Hazel	---	---	95	1.1
Beech	75	1.3	117	1.4
Miscellaneous	93	1.6	280	3.3
Total	3,457		6,963	

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