U.S. Department of Agriculture
Forest Service Research Paper SO-1 31

Tree Sizes Harvested In Different Thinnings -- Another look

W. F. MANN, JR., AND D. P. FEDUCCIA

Southern Forest Experiment Station

SUMMARY

In studies with loblolly and slash pine plantations, thinning increased the number of sawtimber-sized trees slightly; but it also markedly increased the number of 4- to 7-inch trees that had to be logged during the rotation. Handling large numbers of small trees can be costly.

The loblolly pine was planted on a good site at 10- by lo-foot spacing and thinned to residual basal areas of 70 (heavy), 85 (moderate), or 100 (light) square feet per acre every 5 years from age 20 to 45. Check plots were not thinned.

With an assumed rotation age of 30 years, total trees cut (those removed in thinnings plus those in the final harvest)≥10 inches dbh ranged from 128 per acre on checks to 174 on moderately thinned plots. Total stems cut in the 4- to 7-inch classes ranged from 38 per acre on checks to 80 per acre on moderately thinned plots. As rotation length was increased, the number of large stems rose slightly for all treatments, but differences among treatments stayed nearly constant from age 30 to 45. However, the differences between checks and thinning treatments in number of small stems became mom pronounced. Thinned plots produced about the same number of small stems regardless of rotation age, but on checks the number of small stems decreased as they grew into the larger diameter classes. Thus, by age 45 checks had only 6 small stems per acre, but moderately thinned plots had produced 76.

Average diameter of all trees-including those removed in thinnings-was always larger for unthinned than for thinned plots. Trees on check plots averaged 10.4 inches dbh at age 30 and 13.0 inches at age 45. Those on moderately thinned plots averaged 9.7 inches at age 30 and 11.0 inches at age 45.

Sawtimber volumes on checks were comparable to those on heavily thinned plots but somewhat lower than those on light- and medium-thinned plots. The difference between the checks and the best of the thinning treatments was only about 800 board feet per acre at age 30 and 2,500 board feet per acre at age 45. Checks had many trees just below sawtimber size; given a few more years for ingrowth into the sawtimber classes to be completed, volumes on checks would probably compare favorably with those on thinned plots.

Similar trends in diameter distribution, average diameter, and sawtimber production were observed in slash pine planted at 6- by 7-foot spacing on an excellent site and thinned every 5 years from age 17 to residual densities of 70, 85, or 100 square feet per acre.

Thinnings plus the final cut at age 32 yielded from 133 stems per acre≥10 inches dbh on checks to 156 stems on lightly thinned plots. Total cut of 4- to 7-inch trees ranged from 176 stems per acre on the checks to 375 on heavily thinned plots.

Average diameter of all trees harvested was 7.7 inches on plots thinned heavily and 8.5 inches on check plots. Net board-foot production to age 32 was highest on light thinnings (14,673 bd. ft. per acre) and lowest on checks (12,069 bd. ft. per acre).

Thus, in both these studies comparable volumes of sawtimber were obtained from thinned plots and from checks, but many more stems had to be cut on the thinned plots. The landowner should consider the effect this abundance of small trees may have on his logging costs when he is deciding whether to thin. Of course, many other considerations including the cost of marking and supervising thinning operations, the short-term returns available from thinning, and thinning's effect on disease and insect problems will also enter into his decision.

Additional keywords: Diameter distributions, average diameter, *Pinus tarda, Pinus elliottii.*

Tree Sizes Harvested In Different Thinnings -- Another Look

W. F. Mann, Jr., and D. P. Feduccia[1]

Thinning boosts diameter growth of the better trees in a stand and increases the diameter of crop trees removed in the final harvest. However, many small trees that may be uneconomical to log must be removed to achieve the gain in diameter growth. To assist landowners in appraising this factor when choosing a thinning regime, diameter distributions of trees removed in intermediate cuttings as well as the final harvests are summarized. Data for several rotation lengths were taken from plots in loblolly (*Pinus taeda* L.) and slash (*P. elliottii* Engelm.) pine plantations that were either thinned to different residual densities or not thinned.

THE PLANTATIONS

Loblolly Pine

Data were collected from a stand planted in 1928 at a 10- by lo-foot spacing in central Louisiana. Site index averaged 86 feet at age 50. Thinnings to residual basal areas of 70 (heavy), 85 (moderate), and 100 (light) square feet per acre were started at age 20 and repeated every 5 years to age 45. Thinnings were mainly from below, but large defective stems and trees in upper crown classes were removed to relieve crowding. Unthinned checks were also established and measured along with the other plots each time a thinning was made. There were five 0.4-acre plots for each thinning treatment and four for the check.

Survival at age 20, the earliest documentation available, averaged 64 percent and ranged from 59 percent on the checks to 74 percent on plots thinned moderately. Diameter distributions varied somewhat; the moderate thinnings had the most trees per acre in all but the few smallest and largest diameter classes (fig. 1). In addition, checks had 23 to 25 fewer trees per acre in the 8- and 9-inch classes than the other treatments, which may explain lower sawlog volumes at later ages.

Measurements included diameter at breast height of all trees, and merchantable length of bole to a 4-inch top (outside bark) and total height of sample trees. To age 30, local volume tables were constructed. Thereafter, volumes were determined by height accumulation.[2]

Stand data given are based on the assumption

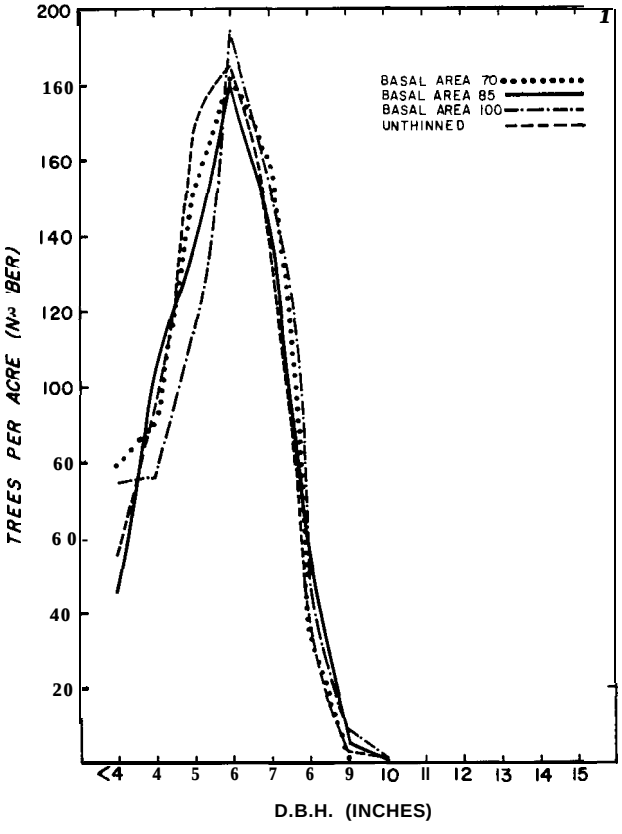

Figure 1.
Diameter distributions of loblolly pine before first thinning at age 20.

[1] W. F. Mann, Jr., is Chief Silviculturist, Southern Forest Experiment Station, Forest Service — USDA, Pineville, La.: D. P. Feduccia is Research Forester, Louisiana Forestry Commission, assigned to the Southern Forest Experiment Station, Forest Service — USDA, Pineville, La.

[2] Lohrey, R. E., and T. R. Dell. 1969. Computer programs using height accumulation for tree volumes and plot summaries. J. For. 67: 554-555.

that residual stands were clearcut at 30, 35, 40, or 45 years. A theoretical, longer rotation was not possible because the plantation was destroyed at age 47 by tornado-like winds.

Slash Pine

To help determine if the wide initial spacing in the loblolly plantation affected results, a similar analysis was made of slash pine planted at a much higher density than the loblolly. Suitable data were not available for loblolly.

The slash plantation was established in central Louisiana in 1942 on a cutover site with an index of 100 feet at age 50. Spacing was 6 by 7 feet. A very light thinning at age 16 removed small, suppressed trees for fence posts. Numbers and volumes of trees cut were determined horn stumps on each plot and were combined with data for the first scheduled thinning at age 17. On the check plots, trees removed at age 16 are tabulated as cut trees.

Thinnings were repeated at 5-year intervals after age 17. Residual densities were the same as for loblolly -70, 85, and 100 square feet per acre. As with loblolly, thinning was primarily from below. A check was also included. All treatments were replicated four times on 0.92-acre plots.

Before the first thinning, stocking was about the same among all treatments, ranging from 667 to 723 trees per acre. The number of stems by diameter classes was similar for all treatments; lightly thinned plots deviated most from the averages (fig. 2).

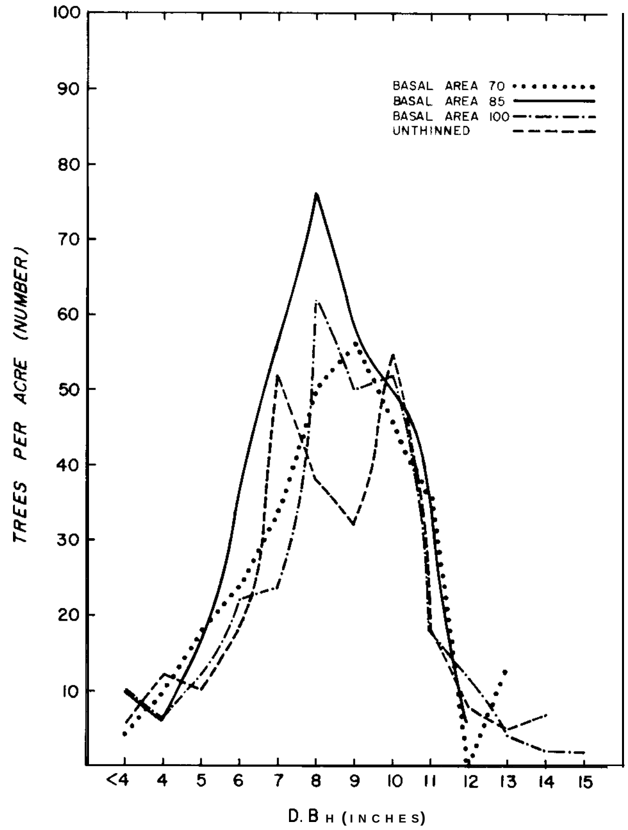

Figure *2.*

Diameter distributions of slash pine at age I7 before the first scheduled thinning.

Measurements and computations were the same as those described for loblolly, and height accumulation was used for volume determinations.

Table 1. —*Loblolly* ***pine trees per acre removed in two*** *thinnings* ***and standing at age 30 years, by l-inch dbh classes and thinning treatments***

Thinning treatment; no. of stems cut and standing	Diameter class — inches														
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18+	Total
	Number															
BA-70																
Cut at 20 and 25 yrs.	2	14	14	16	28	22	26	20	2	6	2	2	0	0	0	154
Standing at 30 yrs.	0	4	0	2	12	8	22	20	22	24	6	2	4	0	0	126
Total stems	2	18	14	18	40	30	48	40	24	30	8	4	4	0	0	280
BA-85																
Cut at 20and 25 yrs.	2	12	24	34	32	12	22	24	2	2	0	0	0	0	0	166
Standing at 30 yrs.	2	0	2	4	10	26	26	40	32	16	8	2	0	0	0	168
Total stems	4	12	26	38	42	38	48	64	34	18	8	2	0	0	0	334
BA-100																
Cut at 20 and 25 yrs.	4	10	14	10	14	18	6	8	6	2	2	0	0	0	0	94
Standmg at 30 yrs.	2	0	0	2	10	28	32	26	28	20	8	2	0	2	2	162
Total stems	6	10	14	12	24	46	38	34	34	22	10	2	0	2	2	256
Unthinned																
Standing at 30 yrs.	8	5	2	23	32	30	25	40	18	30	5	3	2	5	0	228

RESULTS

Loblolly Pine

With a rotation age of 30 years, the maximum difference in number of standing trees 10 inches dbh and larger between the check, light thinning, and medium thinning was 8 per acre (table 1). Plots thinned heavily had 28 fewer standing trees≧10 inches dbh per acre than the check; most of the difference was in numbers of 10- and ll-inch trees. Checks had 30 to 34 more standing trees per acre in the 4- to 7-inch dbh classes than thinned plots. Differences among thinning treatments in number of small trees were negligible.

To evaluate the total harvesting job, we must also consider trees removed in the thinnings at ages 20 and 25. Heavy and medium thinning removed 58 and 50 stems per acre 10 inches dbh and larger, or more than double the number removed by light thinning. Four- to 7-inch trees removed in the two thinnings numbered from 38 per acre on lightly thinned plots to 72 per acre on moderately thinned plots.

At age 30, total trees cut (those removed in thinnings plus those taken in the final harvest)' 10 inches dbh ranged from 144 per acre on lightly thinned plots to 174 on moderately thinned plots. The final cut produced the bulk of the sawtimber trees since the intermediate thinnings yielded only 17 to 37 percent of the total large-tree harvest. The checks had the fewest large trees, averaging 128 per acre. The source of most of the differences was numbers of trees in the 10- and ll-inch diameter classes. Total small trees cut over the 30-year rotation was 38, 42, 80, and 52 per acre on unthinned, light-, medium-, and heavy-thinned plots, respectively.

Thus, by age 30 check plots had produced 46 fewer trees per acre in the large diameter classes and 42 fewer trees per acre in the small diameter classes than the most prolific of the thinned plots. As rotation length was increased in 5-year steps, number and stems≧10 inches dbh increased slightly for all treatments, but differences among treatments stayed nearly constant from age 30 to 45 (tables l-4). However, the difference between checks and thinning treatments in number of small stems became more pronounced. About the same total of small stems was cut (in thinnings plus final harvest) from thinned plots whether the rotation age was 30, 35, 40, or 45 years. But the number of small stems on checks steadily decreased as they grew into larger diameter classes (mortality from suppression was only about 30 trees per acre that contained a total of about 1 cord). By age 35 checks had only 22 small trees per acre (table 2); and by age 45 they had only 6 per acre (table 4), or 70 per acre fewer than the number produced on moderately thinned plots.

Regardless of rotation age, average diameter of all trees-including those removed in thinnings-was always larger for unthinned than for thinned plots (table 5). Trees on check plots were 0.3 inch larger than those on heavily thinned plots at age 30 and 1.6 inches larger by

Table 2. — *Loblolly pine trees per acre removed in three thinnings and standing at 35 years, by l-inch dbh classes and thinning treatments*

Thinning treatment; no. of stems cut and standing	Diameter class — inches															
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18+	Total
	Number															
BA-70																
Cut from age 20 to 30	2	18	14	18	32	26	34	26	4	10	2	2	0	0	0	188
Standing at 35 yrs.	0	0	0	0	0	6	6	2	20	16	14	12	10	2	2	90
Total stems	2	18	14	18	32	32	40	28	24	26	16	14	10	2	2	278
BA-85																
Cut from age 20 to 30	4	12	26	34	38	18	32	36	6	4	0	0	0	0	0	210
Standing at 35 yrs.	0	0	0	0	4	8	14	14	22	24	12	20	6	0	0	124
Total stems	4	12	26	34	42	26	46	50	28	28	12	20	6	0	0	334
BA-100																
Cut from age 20 to 30	4	10	14	10	16	24	14	10	10	2	2	0	0	0	0	116
Standing at 35 yrs.	2	0	0	0	4	8	18	20	16	32	14	16	6	0	4	140
Total stems	6	10	14	10	20	32	32	30	26	34	16	16	6	0	4	256
Unthinned																
Standing at 35 yrs.	5	0	2	15	28	28	15	22	30	25	28	10	2	0	8	218

Table 3. — *Loblolly pine trees per acre removed in four thinnings and standing at 40 years, by l-inch dbh classes and thinning treatments*

Thinning treatment; no. of stems cut and standing	Diameter class — inches																
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+	Total
	Number																
BA-70																	
Cut from age 20 to 35	2	18	14	18	32	28	36	26	12	14	4	2	2	0	0	0	208
Standing at 40 yrs.	0	0	0	0	2	2	0	4	8	4	14	10	14	6	4	2	70
Total stems	2	18	14	18	34	30	36	30	20	18	18	12	16	6	4	2	278
BA-85																	
Cut from age 20 to 35	4	12	26	34	40	18	40	40	12	10	4	0	0	0	0	0	240
Standing at 40 yrs.	0	0	0	0	2	0	10	6	10	18	14	10	14	10	0	0	94
Total stems	4	12	26	34	42	18	50	46	22	28	18	10	14	10	0	0	334
BA-100																	
Cut from age 20 to 35	6	10	14	10	20	26	18	18	14	8	2	4	0	0	0	0	150
Standing at 40 yrs.	0	0	0	0	0	6	6	12	14	8	26	16	8	6	0	4	106
Total stems	6	10	14	10	20	32	24	30	28	16	28	20	8	6	0	4	256
Unthinned																	
Standing at 40 yrs.	2	0	0	10	13	22	18	15	35	17	32	8	7	5	0	8	192

Table 4. — *Loblolly pine trees per acre removed in five thinnings and standing at 45 years, by l-inch dbh classes and thinning treatments*

Thinning treatment; no. of stems cut and standing	Diameter class — inches																
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+	Total
	Number																	
BA-70																		
Cut from age 20 to 40	2	18	14	18	32	28	36	26	14	14	6	4	6	0	0	0	0	218
Standing at 45 yrs.	0	0	0	0	0	4	0	0	4	2	4	12	6	12	6	8	2	60
Total stems	2	18	14	18	32	32	36	26	18	16	10	16	12	12	6	8	2	278
BA-85																		
Cut from age 20 to 40	4	12	26	34	42	18	40	40	12	12	8	2	2	0	0	0	0	252
Standing at 45 yrs.	0	0	0	0	0	0	2	4	12	10	14	10	4	12	12	2	0	82
Total stems	4	12	26	34	42	18	42	44	24	22	22	12	6	12	12	2	0	334
BA-100																		
Cut from age 20 to 40	6	10	14	10	20	28	22	26	14	8	6	4	0	0	0	0	0	168
Standing at 45 yrs.	0	0	0	0	0	2	2	2	6	10	8	14	24	8	6	2	4	88
Total stems	6	10	14	10	20	30	24	28	20	18	14	18	24	8	6	2	4	256
Unthinned																		
Standing at 45 yrs.	2	0	2	2	5	20	13	15	23	25	20	23	13	8	0	2	4	177

age 45. Lightly thinned plots consistently ranked second in average diameter; and moderately thinned plots always ranked lowest, probably because these plots had the lowest average diameter at age 20 before treatments started.

Since checks had the fewest large trees at all rotation ages, it is logical to expect less sawtimber[3] production on checks than on thinned plots. However, the difference was relatively

Table 5. — *Average dbh of all loblolly pine trees removed in thinnings plus those standing at given ages, by thinning treatments*

Thinning treatment	Assumed harvest age — years			
	30	35	40	45
	Inches			
B. A. 70	19.1	10.7	11.0	11.4
B. A. 85	9.7	10.3	10.7	11.0
B. A. 100	10.3	11.1	11.5	12.0
Unthinned	10.4	11.4	12.3	13.0

[3] **Board-foot volume of trees 9.6 inches dbh and larger to a minimum top diameter of 8 inches (o.b.), International U-inch rule, is used throughout the paper.**

small (table 6). Sawtimber yield at age 30 was only 800 board feet per acre less from unthinned plots than from plots that had the highest yields. At age 45, volume on the checks was about the same as on the heavily thinned plots but 2,500 board feet per acre less than from the light thinning.

Slash Pine

Diameter distributions of slash pine removed in three thinnings plus the final cut at age 32 had many of the same trends as loblolly distributions (table 7). Numbers of trees≥10 inches dbh removed in three intermediate cuttings ranged from 16 to 22 per acre among the three thinning treatments. Large trees assumed cut at age 32 varied from 111 per acre on heavily thinned plots to 134 on lightly thinned plots; on the checks they averaged 133 per acre.

The number of 4- to 7-inch trees removed in the three thinnings varied directly with the intensity of thinning from 268 to 375 per acre. Forty-four small trees were cut on the checks in a fence-post operation at age 16. Total cut of small trees, thinnings plus final harvest, ranged from 176 per acre on the checks to a maximum of 375 on heavily thinned plots.

Assuming all stands were clearcut at age 32, average diameter of all trees harvested was 7.7 inches on plots thinned heavily, 7.8 inches on medium-thinned, 8.0 inches on light-thinned, and 8.5 inches on check plots. Differences should become larger with advancing age if results with loblolly are indicative of future trends.

Net board-foot production to age 32 averaged 13,040, 13,449, 14,673, and 12,069 for heavy, medium, and light thinnings and for the checks. As with loblolly, yields were inversely proportional to degree of thinning and lowest on the checks. The differences between the checks and thinning treatments will probably decrease in the next 5 to 10 years as ingrowth into the sawtimber size class will be heaviest on the controls; in the 8- and 9-inch dbh classes the checks had 140 trees per acre and the thinned plots had 15 to 51 trees per acre (table 7).

Table 6. — ***Sawtimber production of loblolly pine, including thinnings, at different assumed harvest ages, by treatment***

Thinning treatment	Assumed harvest age — years			
	30	35	40	45
	-- ***Bd. ft. (Int. %-inch rule)*** --			
B. A. 70	9,944	14,464	17,777	21,807
B. A. 85	10,494	16,176	19,199	23,364
B. A. 100	10,578	15,570	20,771	24,577
Unthinned	9,750	14,445	18,427	22,024

DISCUSSION

It is well established that cubic volume growth is higher on unthinned stands than on thinned stands until age 35 to 40, when mortality from suppression begins to set in. Saw-

Table 7. — ***Slash pine trees per acre removed in three thinnings and standing at age 32 years, by 1-inch dbh classes and thinning treatments***

Thinning treatment; no. of stems cut and standing	Diameter class — inches												
	4	5	6	7	8	9	10	11	12	13	14	15+	Total
	Number												
BA-70													
Cut in 3 thinnings	90	107	92	80	62	33	10	5	2	0	0	0	481
Standing at 32 yrs.	1	0	0	5	7	8	20	30	41	17	3	0	132
Total stems	91	107	92	85	69	41	30	35	43	17	3	0	613
BA-85													
Cut in 3 thinnings	89	97	88	67	50	26	7	7	2	0	0	0	433
Standing at 32 yrs.	*2*	1	4	8	18	21	30	31	32	16	7	0	171
Total stems	91	98	92	75	68	47	37	38	34	16	7	0	604
BA-100													
Cut in 3 thinnings	*65*	*63*	78	62	56	25	17	5	0	0	0	0	371
Standing at 32 yrs.	*6*	*6*	6	21	25	26	46	46	29	5	6	2	224
Total stems	*71*	*69*	84	83	81	51	63	51	29	5	6	2	595
Unthinned													
Cut at 16 yrs.	21	18	5	0	0	0	0	0	0	0	0	0	44
Standing at 32 yrs.	7	21	47	57	66	74	58	42	23	7	2	1	405
Total stems	28	39	52	57	66	74	58	42	23	7	2	1	449

timber volumes are comparable on thinned and unthinned stands until a much later age, when suppression begins to kill trees of sawlog size. Thinning, however, does shorten the rotation to obtain trees of a specified size.

In the loblolly plantation, sawtimber volumes on the checks were comparable to those on the heavily thinned plots but somewhat lower than those on light- and medium-thinned plots at all rotation ages. This difference reflected, primarily, a lag in ingrowth into the lo-inch dbh class on the checks, as evidenced by the relatively large number of trees just below sawtimber size on the checks. Given a few more years for ingrowth into the sawtimber sizes to be completed, volumes on the checks would probably compare favorably with those on thinned plots.

However, to obtain about the same total volume of sawtimber from thinned plots as from checks, many more stems had to be cut. By 45 years, total trees logged was about 50 to 100 percent more on thinned than on check plots. Differences were largely in the smaller size classes.

Initial spacing can affect results substantially, as demonstrated by the slash data. Here the planting spacing was 6- by 7-feet and 200 to 300 small trees per acre had to be cut in thinnings to obtain a few more large trees than on the check plots.

Handling such a large number of small trees is costly. But the overall effect on logging costs of having a few more Iarge trees at the expense of many small ones can only be determined by each landowner. Companies doing their own logging are apt to be more cognizant of the high costs of removing small trees than those depending on contract logging.

There are other factors the landowner must consider in deciding whether or not to thin. If he chooses not to thin, the cost of marking and supervising thinning operations is saved, there is no pressure to cut heavier than is silviculturally desirable to make logging operations economically attractive, and disease and insect problems resulting from logging are eliminated. Some major disadvantages include deferred returns, greater susceptibility of dense stands to bark beetles, and retention of high-risk and inferior trees.

Selecting a management system is complex, and alternatives must be judged in context with landowner goals. Site quality may also influence decisions. Trends given here are applicable to good and choice sites, but they may not be valid for poorer sites where crown differentiation is often slow and stagnation may occur. For these reasons, there is no universal choice for all properties.

Mann, W. F., and D. P. Feduccia.

1976. Tree sizes harvested in different thinnings-another look. South. For. Exp. Stn., New Orleans, La. 6 p. (USDA For. Serv. Res. Pap. so-131)

In loblolly planted at 10 by 10 feet, light- and medium-thinned plots had slightly more sawtimber-sized trees and board-foot volume than unthinned checks and heavily thinned plots at all ages. Average diameters of all trees were largest on checks, followed by light-thinned plots. Trends were similar for 32-year-old slash pine planted at 6 by 7 feet.

ADDITIONAL KEYWORDS : Diameter distributions, average diameter, *Pinus* taeda, *Pinus elliottii*.

Mann, W. F., and D. P. Feduccia.

1976. Tree sizes harvested in different thinnings-another look. South. For. Exp. Stn., New Orleans, La. 6 p. (USDA For. Serv. Res. Pap. so-131)

In loblolly planted at 10 by 10 feet, light- and medium-thinned plots had slightly more sawtimber-sized trees and board-foot volume than unthinned checks and heavily thinned plots at all ages. Average diameters of all trees were largest on checks, followed by light-thinned plots. Trends were similar for 32-year-old slash pine planted at 6 by 7 feet.

ADDITIONAL KEYWORDS : Diameter distributions, average diameter, *Pinus* taeda, *Pinus* elliottii.

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
SOUTHERN FOREST EXPERIMENT STATION
T-10210 POSTAL SERVICE BUILDING, 701 LOYOLA AVE.
NEW ORLEANS, LOUISIANA 701 13

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF
AGRICULTURE
AGR-101

AN EQUAL OPPORTUNITY EMPLOYER

THIRD CLASS