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The unthinned 10 x 10 plots contain large amounts of wood, but much of it is in trees of poor form.

GROWTH OF 40-YEAR-OLD PLANTED LOBLOLLY PINE

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The best-known pine plantation in Louisiana probably is a 40-acre stand on the Alexander State Forest near Woodworth, known as the loblolly pine spacing-and-thinning study. One of the oldest plantations on the Forest, it has been visited by most foresters in the State. For the past 20 years it has provided valuable information about the effects of tree spacing and thinning methods on growth and yield.

The plantation is also familiar to regular readers of *Forests & People*. Data after 25 and 30 years were summarized in articles appearing in the Second Quarter issues of 1954 and 1960. Reported here is the performance after 40 years, by which time most of the pines were large enough for veneer bolts or saw logs.

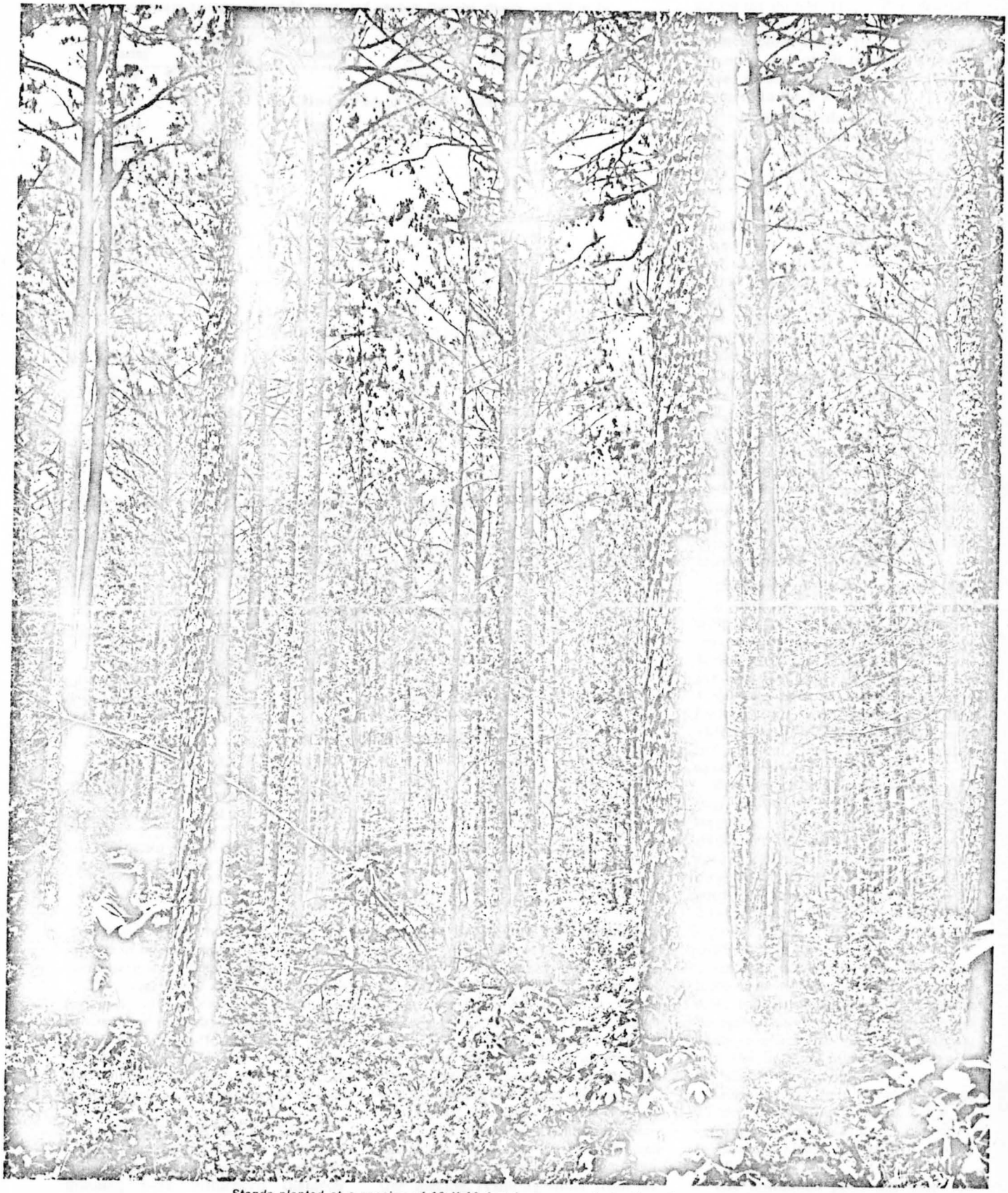
ESTABLISHMENT

The plantation was established by the Louisiana Forestry Commission in 1927-28, when forest planting was still in its infancy. It was divided into four 10-acre blocks so that four spacings could be compared. The spacings were 4 x 4, 6 x 6, 8 x 8, and 10 x 10 feet—equivalent to planting about 2,700, 1,200, 680, and 435 trees per acre.

The area originally had a stand of longleaf pine that was clearcut in the early 1920's. The soil is classed as a Muskogee silt loam, which has good drainage even though the subsoil is a heavy clay. Terrain varies from flat to gently rolling. Site index (expected height, in feet, of trees at age 50 years) ranges from 71 to 93 feet and averages 76, 81, 82, and 85 feet for the four spacings.

In 1948, when the stands were 20 years old, a series of 0.4-acre plots were established for a comparison of thinning treatments. Light, medium, and heavy thinnings, later defined as cutting back to 100, 85, and 70 square feet of basal area per acre, were made in all spacings at age 20. (The basal area of a tree is the cross-sectional area of its bole at 4½ feet above groundline.) In addition, on one set of plots in each of the three widest spacings, the medium thinning was deferred to age 25 years. Some plots in the 10 x 10 spacing have never been thinned. All thinning treatments are replicated.

The thinnings have been repeated at 5-year intervals. Especially in the earlier years they were mainly from below—that is, the trees cut were chiefly those that were growing more slowly than their competitors. Domi-



Stands planted at a spacing of 10 X 10 feet have grown faster than those spaced more closely. Here, medium thinnings have removed most of the low-quality trees for pulpwood. Growing potential of the site is now concentrated on trees suitable for sawtimber and plywood.

Table 1.—Average diameter at age 40 years, and periodic diameter growth, age 20 to 40

Spacing	Heavy thinning	Medium thinning	Light thinning	Deferred thinning	Unthinned
Feet			Inches		
			Average d.b.h. of trees 3.6 inches and larger		
4 x 4	12.2	10.6	9.2	—	—
6 x 6	12.0	10.3	11.4	11.2	—
8 x 8	13.5	12.5	12.0	11.7	—
10 x 10	14.8	13.8	14.1	13.0	12.6
			Periodic diameter growth of merchantable trees		
4 x 4	4.6	3.4	2.4	—	—
6 x 6	4.0	2.8	3.6	3.0	—
8 x 8	4.8	4.0	3.6	3.6	—
10 x 10	5.0	4.4	4.0	3.6	3.0
			Periodic diameter growth of 50 largest trees per acre		
4 x 4	6.0	5.2	3.8	—	—
6 x 6	5.6	4.4	4.6	4.4	—
8 x 8	5.4	4.8	4.4	4.4	—
10 x 10	5.8	5.2	4.6	4.6	4.0

Table 2.—Total cordwood volume growth per acre to age 40 years, and periodic cubic volume growth, age 20 to 40 years

Spacing	Heavy thinning	Medium thinning	Light thinning	Deferred thinning	Unthinned
Feet			Cords 1/		
			Total cordwood volume growth per acre		
4 x 4	62.1	62.4	54.7	—	—
6 x 6	59.5	51.9	64.1	57.2	—
8 x 8	63.1	65.8	66.4	64.9	—
10 x 10	61.1	66.3	68.4	61.3	60.9
			Periodic cordwood volume growth per acre 2/		
4 x 4	34.1	35.6	29.0	—	—
6 x 6	31.7	25.3	34.3	31.3	—
8 x 8	32.9	36.6	37.5	36.6	—
10 x 10	34.0	37.5	41.8	36.4	36.8

1/ Standard rough cords, 76.3 cubic feet inside bark per cord of wood.
2/ Growth includes mortality.

nant trees have, however, been removed in all spacings when they were competing with better trees.

The basal areas and cord volumes reported here are for trees 3.6 inches in diameter at breast height (4½ feet above the ground) and larger to a 4-inch top outside the bark. Sawlog volumes include trees 9.6 inches in diameter and larger to an 8-inch top.

GROWTH AND YIELD

Tree size and diameter growth.—Initial planting spacing and degree of thinning have influenced diameter growth. Before the first thinning at age 20 years, there were differences of about 1 inch in average diameter between each successive spacing. The range was from 5.5 inches in 4 x 4 spacing to 8.7 inches in 10 x 10 spacing. The advantage gained by planting fewer trees prevailed at age 40; the difference between the closest and widest spacing increased slightly during the last 20 years.

For the thinning treatments, average diameters at age 40 ranged from 9.2 to 14.8 inches (see table 1). Wide tree spacing, resulting either from initial planting or heavy thinning, produced the largest trees. It is interesting that average diameter on the unthinned plots in the 10 x 10 spacing exceeded that of all treatments in the three closer spacings except heavy thinning in the 8 x 8 spacing.

Diameter growth between ages 20 and 40 years ranged from 2.4 to 5.0 inches. Unthinned 10 x 10 plots grew a total of 3 inches in the 20 years. Heavily thinned plots averaged 1.2 inches more diameter growth than lightly thinned plots. In the 8 x 8 and 10 x 10 spacings deferring the first thinning to age 25 resulted in an overall loss of about 0.5 inch of diameter growth. It appears that thinnings stimulated diameter growth more in the close than in the wide spacings.

Diameter growth of the 50 largest trees per acre followed the same general trend as with all trees.

It should be noted here that both diameter and volume growth in the medium thinning of the 6 x 6 spacing have consistently been below general trends. The reasons are unknown, but the deviation of these plots makes it invalid to compare regular and deferred thinning at this spacing.

Cordwood growth.—Total production over the 40 years has ranged from 52 to 68 standard rough cords per acre, or the equivalent of average annual growth of 1.3 to 1.7 cords per acre (table 2). Except in the 4 x 4 spacing, light thinnings resulted in better yields than heavy thinnings. Differences between spacings were not clearcut, though the two widest appeared superior.

Between the twentieth and fortieth year, growth for each major thinning treatment was directly related to stand density, except in the 4 x 4 spacing. On the average, light thinnings excelled heavier thinnings by 5 cords per acre. The differences were 2.6 cords per acre in the 6 x 6 spacing, 4.6 cords in the 8 x 8, and 7.8 cords in the 10 x 10.

Growth on lightly thinned 4 x 4 plots was substantially less than on plots thinned moderately or heavily. By age 20 the 4 x 4 plots had become badly overcrowded, and it is believed that the light thinning did not open the stands sufficiently.

Delaying the first thinning to age 25 decreased growth in the 10 x 10 spacing by about 1 cord per acre. It had no effect on growth in the 8 x 8 spacing.

The unthinned plots did well. In

cordwood growth between ages 20 and 40 they were excelled only by the lightly thinned 8 x 8 and 10 x 10 plots and by the moderately thinned 10 x 10. Forty-year growth of the unthinned plots also was good.

Mortality was small on all plots. The unthinned stands had the most loss—about 4.4 cords per acre. Nearly three-fourths of this occurred in the last few years, when suppressed trees began to die.

Board-foot growth.—Total sawlog volumes to age 40 ranged from 6,600 to 21,000 board feet per acre (table 3). They were influenced by initial spacing and degree of thinning, and followed the same general trend as cordwood growth.

Among spacings, the 10 x 10 averaged almost 5,000 board feet per acre more than the 8 x 8. Differences between other spacings were less marked but still notable.

Light thinning resulted in higher yields than heavy thinning, except in the 4 x 4 spacing. The differences between thinning intensity increased from the 6 x 6 through the 10 x 10 spacing. In 4 x 4, heavy thinning produced about twice as much board-foot volume as light thinning.

Delaying thinning to age 25 years decreased sawlog volume growth 1,000 to 2,000 board feet in the two widest spacings. The unthinned plots averaged 19,860 board feet per acre and were excelled only by the lightly thinned 10 x 10 plots.

Board-foot content of the average sawlog-size tree at age 40 was greatest with heavy thinning and wide spacing (table 3). The average on the unthinned 10 x 10 plots was as high as or higher than on the heavily thinned plots of the three closer spacings.

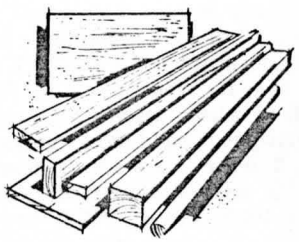
Value of total production.—At a stumpage price of $35 per thousand board feet and $4 per cord for pulpwood, the average value of the total growth to age 40 ranged from $492 per acre for the 4 x 4 spacing to $773 for the 10 x 10 (table 4). The value on the unthinned plots was $765. Heavy thinning increased value most on the 4 x 4 plots, and light thinning was best at all other spacings.

Table 3.—**Total sawlog volume growth per acre and average board-foot content per tree, age 40 years**

Spacing	Heavy thinning	Medium thinning	Light thinning	Deferred thinning	No thinning
Feet	Bd. ft. (Int. ¼-inch rule)				
	Total board-foot volume growth per acre				
4 x 4	11,865	10,368	6,624	—	—
6 x 6	13,844	8,285	14,539	11,171	—
8 x 8	14,015	14,293	15,506	13,173	—
10 x 10	18,197	19,199	21,028	16,984	19,862
	Average volume of sawlog-size trees				
4 x 4	117	87	67	—	—
6 x 6	137	77	123	103	—
8 x 8	138	109	104	101	—
10 x 10	203	157	171	140	136

Table 4.—**Value of total production to age 40 years**

Spacing	Heavy thinning	Medium thinning	Light thinning
Feet	Dollars	Dollars	Dollars
4 x 4	560	522	393
6 x 6	602	425	638
8 x 8	621	638	673
10 x 10	722	770	826



CONCLUSIONS

What does the Woodworth study tell the forest manager?

One of the most interesting aspects is total growth and yield on sites that are about average for loblolly pine in Louisiana. Volume of timber now standing, plus volume removed in thinnings, ranges from 52 to 68 cords.

But cordwood volumes do not indicate the full value of these stands. Many of the trees are suitable for sawlogs, which are more valuable per unit of wood than pulpwood. For example, sawlog volume makes up nearly two-thirds of the total volume in the 10 x 10 spacing, and ranges from 17,000 to 21,000 board feet per acre.

Translating growth to dollars, at very conservative stumpage prices, indicates values of $393 to $826 per acre. The highest value exceeds $20 per acre yearly.

Initial planting spacings were not replicated, and comparisons therefore are risky. However, the 10 x 10 spacing has excelled in diameter growth and in cordwood and sawlog production. Its total earnings thus have also been high. One disadvantage to this spacing is stem quality. Trees are rougher and taper more than those in other spacings. Only a few have been suitable for poles, whereas many trees in the 8 x 8 and 6 x 6 spacings are of pole quality.

The 8 x 8 spacing has been more productive than the 6 x 6 or 4 x 4. But trees in the 6 x 6 are of potentially higher quality than those at 8 x 8. The 4 x 4 spacing is impractical because planting costs are excessive and trees become overcrowded before they are large enough to thin.

The choice between spacings will hinge largely on the land manager's objective. If pole quality is not important, the 10 x 10 seems preferable. The 6 x 6 or 8 x 8 is probably best when poles, plywood bolts, and sawlogs are sought.

Heavy thinnings have resulted in the fastest diameter growth but the least volume growth. The gain in diameter has averaged about 1 inch in the last 20 years but the loss in volume has been about 5 cords per acre.

The unthinned 10 x 10 plots should not be overlooked. In diameter growth they were considerably slower than many of the thinning treatments at all spacings, but in cordwood and sawlog volume, as well as in dollar returns, they ranked near the top. When thinning costs are high or large volumes must be removed to make a sale feasible, this treatment has some merit even though many of the trees are rough and crooked.