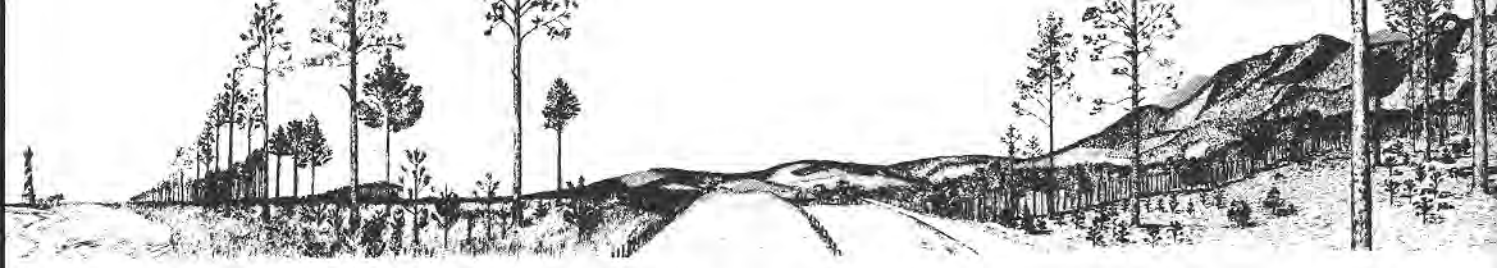

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EFFECTS OF VARIOUS SPACINGS ON LOBLOLLY PINE GROWTH 15 YEARS AFTER PLANTING

Abstract.--Four spacings of loblolly pine trees (6 by 6 ft, 8 by 8 ft, 10 by 10 ft, 12 by 12 ft) were studied for 15 years at the Calhoun Experimental Forest near Union, South Carolina. The two wider spacings at 15 years produced trees of greater height, larger diameter, and more sawtimber volume while the two narrower spacings favored basal area growth and total cubic volume production. More merchantable cord volume was produced at the 8 by 8 ft spacing. The study results should offer some guidance to the landowner in the Piedmont in choosing a spacing for planting to meet his specific production needs.

INTRODUCTION

Of all the decisions foresters and landowners face at tree planting time, one of the most important is to select the best spacing. Species, site quality, local survival patterns--all influence the final decision, but another key factor is the landowner's objectives. What products does he want to grow--sawtimber, pulpwood, plywood stock, or a combination? What rotation length is he planning?

A guide to making this decision for planting loblolly pine (Pinus taeda L.) in the Piedmont is offered by a spacing study established on the Calhoun Experimental Forest near Union, South Carolina, by the Southeastern Forest Experiment Station. The study established during the winter of 1956-57 involves four spacings--6 by 6 ft, 8 by 8 ft, 10 by 10 ft, and 12 by 12 ft--and was replicated four times in a randomized block design.

BACKGROUND OF STUDY

The planting site was a field that produced a cotton crop during the 1955 growing season. The soil, in the Helena series, is characterized by a layer of sandy loam overlying a compact mottled yellow and red clay. Site quality is very good; site index at 25 years is approximately 75.

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All planting stock was nursery run 1-0 loblolly pine obtained from the South Carolina Commission of Forestry. Each plot was 0.6 acre in size, with the total number of trees per plot varying according to the spacing. Interior plots of nine rows of nine trees each were established for measurement purposes. Trees that died the first year within the nine-row plots were replaced at the end of the first year, bringing survival in the measurement plots to 100 percent. To ameliorate the effects in interplanting, transplants consisted of original stock that was planted on the site for replacement purposes. Care was taken to move as much soil as possible with the replants.

In February 1972, after 15 growing seasons, measurements of diameter breast height (d.b.h.), total height, and merchantable height were made on all surviving trees in the 81-tree interior plots. All data were then computed on a per-acre basis.

RESULTS

Survival.--After 15 years the average number of surviving trees per acre range from 1,027 for the 6- by 6-ft spacing to 285 for the 12- by 12-ft spacing. Only the 6- by 6-ft spacing showed the adverse effect of stand density on survival (table 1). Survival in that spacing was 85 percent while in the other spacings survival was 94 to 96 percent. No apparent effects of the interplanting at age one on survival could be detected.

Table 1.--Effect of spacing on survival after 15 years

Spacing (feet)	Trees planted per acre	Surviving trees per acre	Survival
	------ Number ------		Percent
6 x 6	1,210	1,027	85
8 x 8	681	637	94
10 x 10	436	421	96
12 x 12	302	285	94

Diameter.--Average diameters were strongly affected by spacing (fig. 1). At age 15, the average diameter increased approximately 20 percent for each 2-foot increase in spacing from 6 by 6 ft to 12 by 12 ft. Between ages 11 and 15, diameter growth decreased in rate in all spacings, but more so in the 6- by 6-ft spacing than in the others.

Measurements for age 7 and age 11 were based on 64 trees per spacing. The age 15 measurements were from all surviving trees in the measurement plots.

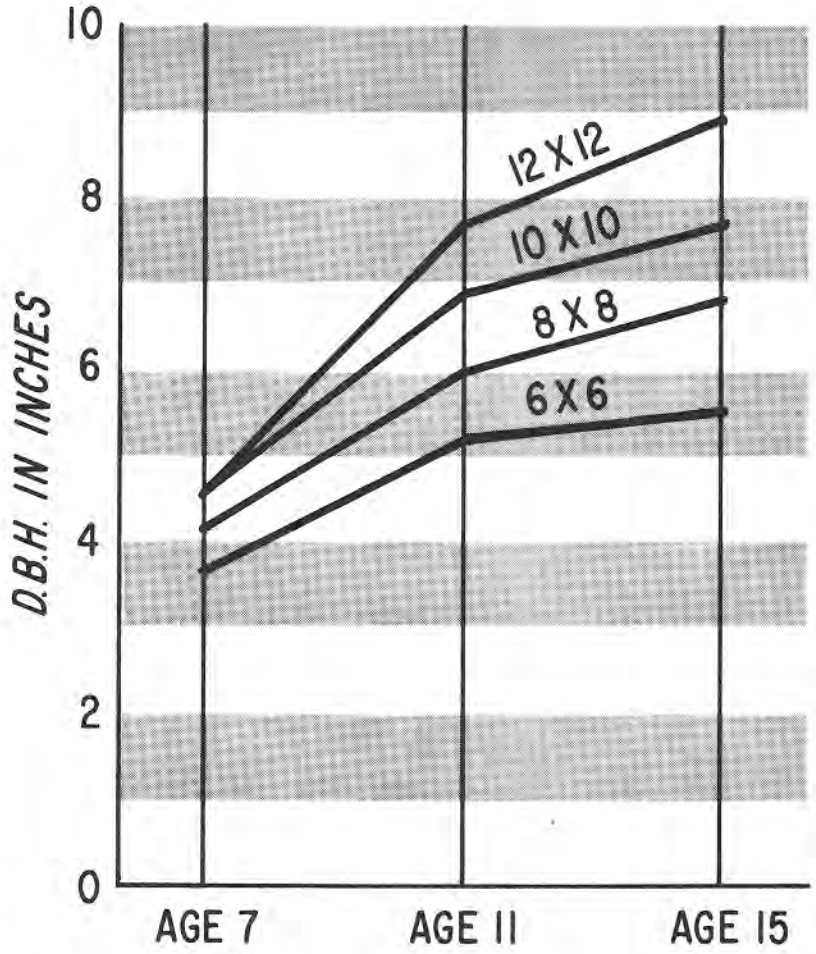

Figure 1.--Average diameter as related to spacing and stand age.

Measurements for age 7 and age 11 were based on 64 trees per spacing. The age 15 measurements were from all surviving trees in the measurement plots.

Distribution of tree diameters at age 15 was related to spacing (table 2). Only the 12- by 12-ft spacing had a significant number of trees (nearly 100 per acre) with diameters large enough for sawtimber (9.6 inches d.b.h. or larger). Nineteen percent of the trees on the 6- by 6-ft spacings were less than 4.5 inches d.b.h., but in the other three spacings only 1 to 2 percent of the trees in the spacing were of this size.

Height growth.--Average total heights (fig. 2) for the 6- by 6-ft spacing were significantly less at age 15 than for other spacings, with no significant difference shown among the three wider spacings. Through age 7 there was no significant difference in average height. A trend began to appear by age 11 and, if it continues as it had through age 15, the difference in average height between the 6- by 6-ft spacing and the wider spacings will become greater.

Table 2.--Number of trees at age 15 by diameter class and initial plantation spacing

D.b.h. class (inches)	Spacing (feet)			
	6 x 6	8 x 8	10 x 10	12 x 12
	Number per acre			
3	34 (3)[1]	2	--	--
4	161(16)	14 (2)	5 (1)	2 (1)
5	277(27)	57 (9)	10 (2)	5 (2)
6	324(32)	164(26)	35 (8)	1
7	187(18)	197(31)	109(26)	22 (7)
8	41 (4)	153(24)	129(30)	66(23)
9	4	48 (8)	117(28)	98(34)
10	--	--	15 (4)	75(26)
11	--	--	3 (1)	20 (7)
12	--	--	--	1
No. living	1,028	635	423	290
No. dead	183	44	15	18
Total[2]	1,211	679	438	308

[1] Numbers in parentheses indicate percentages.

[2] Because of rounding procedure, totals per acre vary slightly from those in table 1.

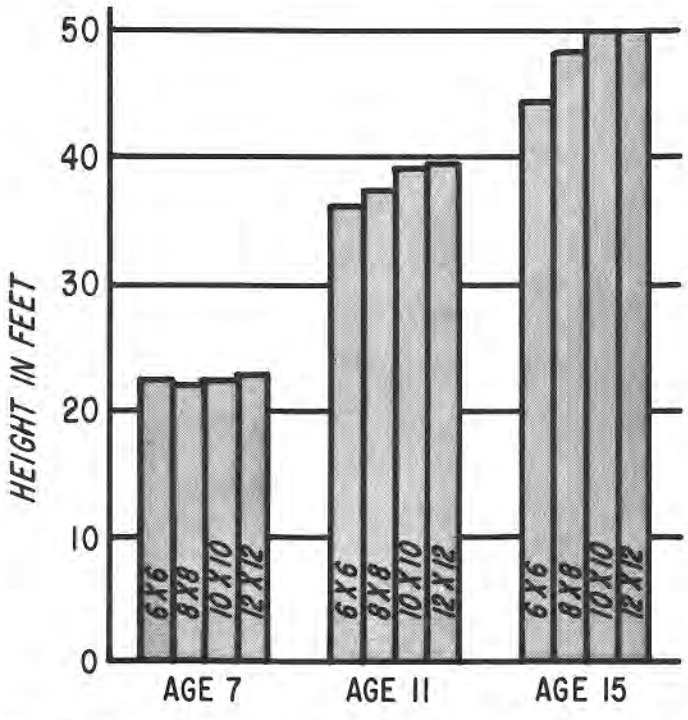

Figure 2.--Average heights by spacing and stand age.

Not only was average height affected by spacing, but total height of dominant trees was also affected (table 3). Wider spacing produced taller dominant trees. The 10- by 10-ft spacing had the most trees in the 55- and 60-ft class whereas the 12- by 12-ft spacing had the highest percentage of trees in these height classes.

Table 3.--Number of trees at age 15 by height class and initial plantation spacing

Height class (feet)	Spacing (feet)			
	6 x 6	8 x 8	10 x 10	12 x 12
	Number per acre			
25	4	--	--	3 (1)
30	12 (1)[1]	6 (1)	4 (1)	1
35	123(12)	10 (2)	2	2 (1)
40	213(21)	36 (6)	9 (2)	18 (6)
45	340(33)	177(28)	71(17)	50(17)
50	276(27)	302(47)	228(54)	112(39)
55	60 (6)	104(16)	106(25)	97(34)
60	--	--	3 (1)	7 (2)
No. living	1,028	635	423	290
No. dead	183	44	15	18
Total[2]	1,211	679	438	308

[1]Numbers in parentheses indicate percentages.

[2]Because of rounding procedure, totals per acre vary slightly from those in table 1.

Basal area and volume growth.--Basal area increased as spacing decreased (table 4). The greatest volume of pulpwood was produced on the 8- by 8-ft spacing and the least on the 12- by 12-ft spacing. At the 6- by 6-ft spacing, overcrowding and the resultant smaller diameters and shorter stems produced less merchantable volume than the 8- by 8-ft spacing despite an initial planting of 77 percent more trees per acre. At the 8- by 8-ft and wider spacings, essentially all trees were of merchantable

Table 4.--Basal area and merchantable and total cubic-foot volumes at age 15 (inside bark) by initial plantation spacing

Spacing (feet)	Basal area	Merchantable volume[1]		Total volume
	Square feet/acre	Cubic feet/acre	Cords/acre	Cubic feet/acre
6 x 6	178	2,484	27.6	2,940
8 x 8	166	2,764	30.7	2,971
10 x 10	140	2,392	26.6	2,584
12 x 12	125	2,110	23.4	2,325

[1] Minimum merchantable diameter was 4.6 inches d.b.h. The equations used to compute the merchantable cubic feet (inside bark) and total cubic feet (inside bark) are from: McDonald, R. B., J. H. Bamping, and C. S. Brightwell. 1963. Southern pine cubic foot formulae for the Southeastern United States. USDA For. Serv. Southeast. Area, State & Priv. For., Atlanta, Ga.

size and quality. At the two wider spacings, however, the number of trees was apparently not sufficient to fully utilize the site in these early years.

CONCLUSIONS AND RECOMMENDATIONS

At this Piedmont site, it appears that the 6- by 6-ft spacing is too close. Mortality because of suppression is high and seems to be increasing. Only the 6- by 6-ft spacing had a significant number of trees (19 percent) below 4.5 inches d.b.h. (considered minimum merchantable size), and many of these smaller trees appear to have little chance of ever producing merchantable wood. Too, average height for the 6- by 6-ft spacing was significantly less than for the other three spacings.

The 8- by 8-ft spacing had the greatest merchantable volume, though only statistically greater than the 12- by 12-ft spacing. The 8- by 8-ft spacing had few trees that will not meet present merchantability specification for pulpwood.

Therefore, if one of the landowner's objectives is to thin at an early age and have as few sub-merchantable trees as possible, the 8- by 8-ft spacing appears best on such sites.

The wider spacings (10 by 10 ft and 12 by 12 ft) offer the advantage of larger trees, but at the expense of some early pulpwood volume production. At age 15 the 10- by 10-ft spacing had produced little merchantable sawtimber volume. The large trees of sawtimber size are generally too rough to be of merchantable quality. Nevertheless, this spacing has numerous trees approaching sawtimber size and within a few years will have substantial volume.

Therefore, the 10- by 10-ft spacing may offer the landowner, who anticipates good survival and prefers early production of large material, a desirable alternative between the widest spacing and those that produce considerable numbers of small trees.

The effects of competition on survival, diameters, and heights on this good site are evident and appear to be increasing with time. A comparison of the number of trees by diameter and height classes for each of the spacings gives an indication of the time required to reach merchantable size and the potential for reaching varied sized products within a given rotation. Only the 12- by 12-ft spacing had trees sufficiently large to make sawtimber, but even on these plots the average volume on a per acre basis was less than 2,000 board feet per acre (International $\frac{1}{4}$-inch scale).

On poorer sites, where available moisture and nutrients generally would be less, wider spacings may be necessary to grow trees to merchantable size within an acceptable period of time. However, any spacing of 10 by 10 ft or wider should be used with caution for areas where good survival is not expected. A few trees lost through mortality will leave substantial amounts of under-used land.

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