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Experiment Station

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EFFECTS OF SPACING ON LOBLOLLY PINE IN HAWAII AFTER 11 YEARS

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The optimum spacing interval at which to plant loblolly pine *(Pinus taeda* L.*)* is being studied on Maui, Hawaii. Four spacings are being tried: 6, 8, 10, and 12 feet. Measurements 11 years after the plots were set up show that (a) survival rates exceeded 94 percent, (b) average d.b.h. ranged from 6.4 inches at the 6-foot spacing to 9.8 inches in the 12-foot spacing; (c) basal area ranged from 168 sq. ft. per acre in the 12-foot spacing to 278 sq. ft. per acre in the 6-foot spacing; (d) spacing did not markedly affect height growth; and (e) percent of stem in live crown ranged from 44 percent, in the 6-foot spacing, to 63 percent, in the 12-foot spacing.

Oxford: 174.7 *Pinus taeda* (969): 223.43: 181.65.
Retrieval Terms: Pinus taeda; Hawaii; species trials; spacing; seedling survival; diameter increment; basal area; height increment.

Loblolly pine *(Pinus taeda* L.*)*, a species valued for pulpwood, poles, and piling in the southern United States, grows well in Hawaii. On the island of Maui, a trial is underway to determine the growth response of this species planted at four spacing intervals: 6, 8, 10, and 12 feet. The trial was started in January 1961, near Olinda, by the Hawaii Division of Forestry[1] in cooperation with the U.S. Forest Service. Measurements in 1968 suggested that the growth and survival rates of the trees compared favorably with that of loblolly pine grown in the Southeast.[2] The latest measurements in November 1971—nearly 11 years after planting—indicate that the growth rates in this plantation equal or surpass those of most planted loblolly pine stands in the Southeast. In this trial, the wider spacings continued to produce substantially larger average diameters, but less total basal area.

This experimental planting is just beginning to yield information that may be interpreted in terms of products. Individual trees reach sawtimber size fastest at wide spacings, but do not fully use the available growing space during the first decade—unless survival remains near 100 percent. The loss of any tree at a spacing of 12 by 12 feet creates a large opening in such stands. This spacing will probably not give an adequate number of desirable crop trees, and would provide low-quality lumber.

If the objective is to grow loblolly pine sawtimber fast, an initial spacing of 10 by 10 feet should produce high total dollar returns.[3] This spacing would require pruning the crop trees to improve wood quality. Brender[4] recommended pruning loblolly pine in Georgia to a height of 17 feet in one operation (when the trees were between 4 and 6 inches d.b.h.) as the most economical. If the landowner interested in producing sawlogs also has a market for posts, pole, or fuelwood a spacing of 8 by 8 feet may be found most profitable. Early thinnings in the closer spacings would increase growth rate and improve the quality of the residual stand.

STUDY SITE

The elevation of the site is 3,740 feet, at latitude 20° 49′ N. and longitude 156° 17′ W. Aspect is generally northwest, with a slope of 10 to 15 percent, except in a small steep gulch. Annual rainfall averaged 54 inches for the 11-year period—20 percent higher than the mean annual rainfall of 45 inches. Mean annual temperature is 57° F; January temperature averages 54° F; and July temperature averages 60° F.

The soil is Olinda loam, subgroup Entic dystrandepts (formerly the Latosolic Brown Forest great soil group). Typically the surface layer is a dark reddish-brown granular loam about 6 inches thick. The subsoil is a dark reddish-brown and yellowish-red subangular blocky silty clay loam about 36 inches thick. The parent material is volcanic ash over andesite or basalt. This soil is well-drained, runoff is medium, and permeability is moderately rapid. The soil is slightly acid (pH 6.2 to 6.4) in both the surface layer and subsoil.[5]

METHODS

The 1-1 loblolly pine planting stock was grown from seed purchased from a commercial seed supplier, and the seed source is not known. The seedlings were graded, and only thrifty trees with 8- to 12-inch tops and well developed root systems were planted. The grass was grazed heavily just before planting. The sod was removed at each planting spot, and holes were dug 1 foot deep.

The experimental design is a Latin square of four replications. The treatments consist of four spacings, on 4.3 acres: 6, 8, 10, and 12 feet. The 16 major plots are each 0.27 acre, with the central 25 trees forming the measurement plots.

In both 1962 and 1965, the heights of all trees in the 25-tree plots were measured, whereas heights of only nine randomly selected trees in each plot were measured in 1968[2] and in November 1971. The diameters at breast height of all trees in the 25-tree plots were measured each time.

RESULTS AND DISCUSSION

Survival—Twenty-one seedlings of the 400 planted in the plots died during the first year. These were replaced with seedlings of the same planting stock. No other replantings were made.

Survival remained exceptionally high at the end of the 11 years. Mortality did not exceed 5 percent at any one spacing *(table 1)*. No trees in the 12-foot spacing plots died during this period. During the first 4 years of the trials 1 percent of the trees in the 10-foot spacing and 4 percent in the 8-foot spacing died, but none since then. Five percent of the trees in the 6-foot spacing have died, all within the period 1968 through 1971. Increased mortality, especially at this spacing, is anticipated when competition becomes more severe.

Diameter Growth—Comparisons of mean diameters for trees in each spacing showed a direct relationship with spacing before the end of the seventh year, and such differences were statistically significant at the 5 percent level. By then the average d.b.h. of the trees at the 12-foot spacing was 43 percent greater than that of the 6-foot spacing *(fig. 1)*. This difference increased to 53 percent by the end of the eleventh year. At age 11, all trees had a mean diameter of 8.5 inches. The trees with the largest diameters were in the wider spaced plantings. Average diameter increased 1 inch with each 2-foot linear increase in spacing. There were 178 trees with d.b.h. of

Table 1—*Survival and diameter growth in a 11-year-old loblolly pine planting, by four spacing intervals and age at time of measurement, Maui, Hawaii*[1]

Spacing	Trees per acre				Survival			Average diameter			Basal area		
(feet)	Initial	Age 4	Age 7	Age 11	Age 4	Age 7	Age 11	Age 4	Age 7	Age 11	Age 4	Age 7	Age 11
	Number				*Percent*			*Inches*			*Sq. ft./acre*		
6	1,210	1,210	1,198	1,150	100	99	95	3.0	5.3	6.4	60	193	278
8	681	654	654	654	96	96	96	3.2	6.2	7.6	37	138	219
10	435	431	431	431	99	99	99	3.2	6.8	8.7	26	114	187
12	302	302	302	302	100	100	100	3.5	7.6	9.8	21	98	168

[1] Ages computed from time of outplanting, in 1961. Data based on measurement in four 25-tree plots for each spacing.

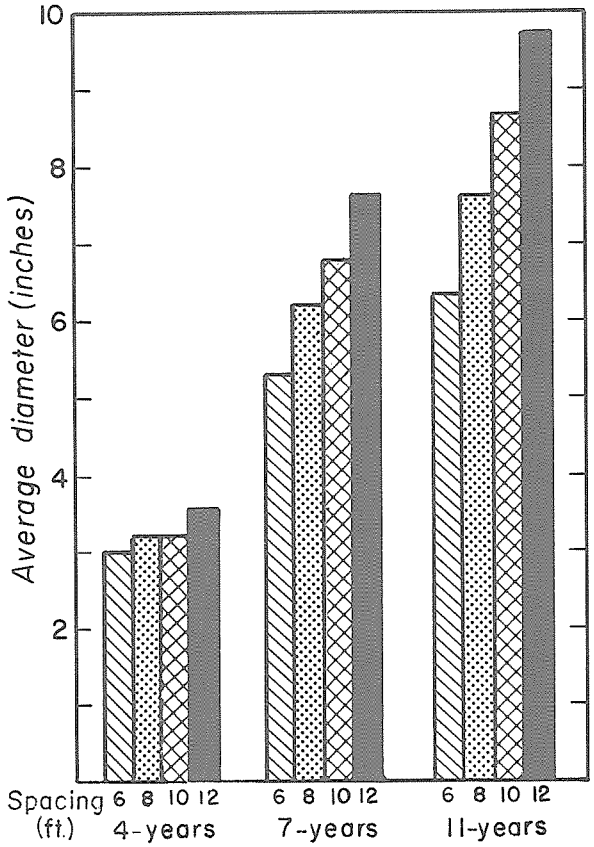

Figure 1—Effect of initial spacing on diameter (breast height) of loblolly pine at ages 4, 7, and 11 years, outplanted in 1961 near Olinda, Maui, Hawaii.

Table 2—*Average total and merchantable heights and crown ratio in 11-year-old loblolly pine plantings,*[1] *by four spacing intervals and age at time of measurement, Maui, Hawaii*

Spacing (feet)	Average total height			Aver. merch. height[2]	Stem in live crown	
	Age 4	Age 7	Age 11	Age 11	Age 7	Age 11
	Feet				*Percent*	
6	15	30	38	22	64	44
8	14	28	39	23	72	55
10	14	30	41	26	78	61
12	15	30	42	29	81	64

[1]Planted in 1961.
[2]Height to 4-inch top d.o.b.

9.6 inches or greater per acre at the 12-foot spacing. This number decreased to 166 per acre at the 10-foot spacing, to 109 at the 8-foot interval, and to only 73 at the 6-foot interval. Nevertheless, on a per-acre basis, the number of trees with a d.b.h. exceeding 9.5 inches were not statistically significant between spacings. The largest d.b.h. measured was that of a 15-inch tree, 57 feet tall, in a 12-foot spacing plot.

Basal Area Growth—Closely related to initial spacing, basal area increased as spacing decreased. In basal area, the trees ranged from 98 square feet per acre in the 12-foot spacing to 193 square feet per acre in the 6-foot spacing, at age 7; and from 168 square feet in the 12-foot spacing to 278 square feet per acre to the 6-foot spacing, at age 11. The mean annual increment during the 11-year period ranged from 15.5 square feet (12-foot spacing) to 25.7 square feet (6-foot spacing). The periodic annual basal area increment for the last 3½ years ranged from 20.0 square feet (12-foot spacing) to 24.3 feet per acre (6-foot spacing).

Height Growth—Height growth was not correlated with stand density. The average total height of the plot trees was 40 feet at age 11 *(table 2)*, a mean annual increment of 3.7 feet. The periodic annual increment during the last 3½ years was only 2.9 feet, compared to 4.5 feet for the previous 3½ years.

The dominant and co-dominant trees in this spacing trial failed to surpass the height growth made in the 10-year-old "wonder" plot in South Carolina.[6] The Hawaii-grown trees averaged 42 feet, falling short of the South Carolina plot by 5 feet. However, growth has exceeded that of most loblolly pine plantations in the southeastern United States.[4, 7, 8]

Merchantable heights, estimated to a 4-inch top diameter outside bark, ranged from an average of 22 feet for the 6-foot spacing to 29 feet for the 12-foot spacing at age 11; the differences were not statistically significant.

Crown Development—Crown closures occurred by the fourth year in the 6-foot spacing, by the seventh year in the 8-foot and 10-foot spacings, and was nearly completed after 11 years in the 12-foot spacing. Trees in the 12-foot spacing plots had 56 percent (10 feet) more live crown length than did those planted at the 6-foot spacing (a statistically significant difference at the 5 percent level), compared with 27 percent more just 3½ years earlier. Natural pruning of the lowest limbs was observed to begin around age 10, but only in the 6-foot spacing plots.

NOTES

[1]This spacing study was started by Karl Korte and Gerald D. Pickford, formerly with Hawaii Division of Forestry, and now retired.

[2]Whitesell, Craig D. *Early effects of spacing on loblolly pine in Hawaii.* USDA Forest Serv. Res. Note PSW-223. Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif. 3 p. 1970.

[3]Englehardt, H. G. *Growth of 40-year-old plantation loblolly pine.* Forests and People 20(3): 38-41. 1970.

[4]Brender, E. V. *Silviculture of loblolly pine in the Georgia Piedmont.* Georgia Res. Council Rep. 33. 74 p. 1973.

[5]U.S. Department of Agriculture. *Soil survey of the islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii.* Soil Conserv. 232 p. 1972.

[6]Langdon, O. G., G. E. Hatchell, and W. P. LeGrande. *Can you top this loblolly pine growth.* South. Lumberman 217(2704): 197. 1968.

[7]Brender, E. V. *Initial spacing in loblolly pine.* In, *A guide to loblolly and slash pine plantation management in southeastern U.S.A.* Georgia Forest Res. Council Rep. 14. p. 40-47. 1965.

[8]Ware, L. M., and R. Stahelin. *Growth of southern pine plantations at various spacings.* J. For. 46: 267-274. 1948.

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