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Early Yields Of SLASH PINE Planted On a Cutover Site At Various Spacings

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Early Yields Of SLASH PINE Planted On a Cutover Site At Various, Spacings

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Tabulates basal areas, cordwood and cubic-foot volumes, average d.b.h., and diameter distributions for 14-year-old slash pine planted in central Louisiana. Also gives regression equations developed to predict these parameters.

Since there is widespread interest in growth and yield of slash pine ***(Pinus elliottii*** Engelm. var. ***elliottii)*** plantations in the West Gulf region, it seems timely to reexamine a well-designed study that was established during 1934-35 on a cutover site in central Louisiana. The stands were destroyed by wildfire shortly after they had been measured at age 14 years. A brief account of the findings was published some years ago,[2] but improved computer programs have made possible a more thorough analysis, especially of site effects within the several spacings. In addition, volumes have been recalculated by developing local tables from measurements of individual trees on the study plots. Volumes originally reported were from tables for stands on abandoned fields in Alabama.

The resulting data are the best available for the area. Considerable information is on record for abandoned fields in the Southeast, but such sites differ from those of the West Gulf in soils, climate, and land-use history.

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[2] Russell, T. E. Spacing-its role in the growth of planted slash pine. South. Lumberman 197(2465): 115-117. 1958.

THE PLANTATION

The 40-acre plantation was about 20 miles southwest of Alexandria, Louisiana. The virgin longleaf stand had been cut in the early 1920's and the land remained idle thereafter. When planted in 1934-35, it supported mostly native grasses and a few small hardwoods and shrubs.

Soils are primarily Caddo and Beauregard silt loams, both characterized by moderately slow internal drainage. Topography is gently rolling. Several small, intermittent streams provide good surface drainage.

The plantation was in four contiguous blocks, each containing sixteen 0.6-acre plots. Planting was by hand at rates of 2,500, 1,600, 1,150, and 250 trees per acre. Each spacing, then, was replicated four times within a block. A wildfire in 1948 caused severe scorching and some mortality on approximately 7 acres in parts of two blocks. Damaged plots were dropped from the study, and the unburned plots were combined into a single block. The result was a total of 48 plots distributed by site index classes as follows:

Site index, age 50 years	Number of trees planted per acre			
	2,500	1,600	1,150	250
	------ Plots ------			
81-85	2	2	2	1
86-90	3	1	2	5
91-95	2	6	4	4
96-100	4	3	4	2
101-105	1			

Site index for each plot was determined by using the average height of dominant trees at age 14 years and the curves in figure 4 of USDA Miscellaneous Publication 50.[3] Since codominant trees were not included in the sample, site index values probably are 2 to 3 feet too high. The range in site indices is not unusual for small areas in this region. It results primarily from permeability differences that are related in a large measure to depth of the A horizon.

Survival at age 5 was about 75 percent in all spacings. A prescribed burn that killed some small suppressed trees in 1940, an ice storm in 1946, and fusiform rust (*Cronartium fusiforme* Hedgc. & Hunt ex Cumm.) reduced survival by 8 to 21 percentage points over the next 9 years, with heaviest mortality in the denser spacings. At age 14 years, survival was inversely related to number of trees planted per acre, averaging 59, 61, 63, and 78 percent.

[3] USDA Forest Service. Volume, yield, and stand tables for second-growth southern pines. USDA Misc. Publ. 50, 202 p. 1929.

MEASUREMENTS

Measurements for growth and development were taken on the central 0.1 acre of each plot. They included d.b.h. of all trees to the nearest 1 inch, and total height (to nearest 0.5 foot) and d.b.h. of 10 well-spaced dominant trees.

Local volume tables were compiled for each spacing separately by constructing curves of total height over d.b.h. and reading height values for the mean (e.g. 4.0, 5.0) of each l-inch d.b.h. class. When average total height for each l-inch d.b.h. class had been computed, volumes in cubic feet of peeled wood and standard rough cords, both to a 3-inch top inside bark, were read from tables 26 and 27 of Miscellaneous Publication 50. Total plot volume was determined by multiplying the number of trees in each diameter class by the average volume in that class.

RESULTS

Determination Of Prediction Equations

With data for individual plots at plantation age 14 years, prediction equations were developed for basal areas per acre, volume per acre expressed in cubic feet and standard rough cords, and average diameter. The equations were derived by combinatorial screening, with Grosenbaugh's REX program,[4] of eight variables:

Site index (S)
S^2
$1/S$
Number of trees planted per acre (P)
P^2
$\text{Log}_{10}\ P$
P/S
$P \times S$

Variables such as survival percent and number of living trees per acre were excluded from the screening because they cannot be estimated at the time of planting.

For all responses, variables S^2, P, $\text{Log}_{10}P$, and $P \times S$ resulted in the best-fitting equations or ones that were essentially as good as those containing other variables. For the sake of consistency, therefore, they were selected for all regressions. Given below is the equation and R^2 value for each of the stand and stocking expressions :

[4] Grosenbaugh, L. R. REX-FORTRAN-4 system for combinatorial screening or conventional analysis of multivariate regressions. USDA Forest Serv. Res. Pap. PSW-44, 47 p. Pac. Southwest Forest and Range Exp. Stn., Berkeley, Calif. 1967.

(1) Basal area per acre for all trees = -160.96340 + 0.005342-7497(%) —0.088644546(P) +69.462099($Log_{10}P$) +0.00104-16808(P×S)

$$R^2 = 0.92$$

(2) Basal area per acre for trees 3.6 inches d.b.h. and larger = -177.11316 +0.0054427554(S^2) —0.10466920(P) +76.889-573($Log_{10}P$) +0.0010955328(P×S)

$$R^2 = 0.91$$

(3) Basal area per acre for trees 4.6 inches d.b.h. and larger = -199.21865 +0.0063032989(S^2) —0.12609176(P) +84.580-910($Log_{10}P$) +0.0011525739(P×S)

$$R^2 = 0.88$$

(4) Cordwood volume per acre in trees 3.6 inches d.b.h. and larger = -39.066250 +0.0012328812(S^2) —0.020412614(P) +16.066972($Log_{10}P$) +0.00020739489(P×S)

$$R^2 = 0.92$$

(5) Cordwood volume per acre in trees 4.6 inches d.b.h. and larger = -43.747515 +0.0013686703(S^2) —0.024321895(P) +17.826795($Log_{10}P$) +0.00021688244(P×S)

$$R^2 = 0.89$$

(6) Cubic-foot volume per acre in trees 3.6 inches d.b.h. and larger = -2516.7721 +0.094093946(S^2) -1.3049391(P) +1009.2515($Log_{10}P$) +0.012905126(P×S)

$$R^2 = 0.90$$

(7) Cubic-foot volume per acre in trees 4.6 inches d.b.h. and larger = -2765.6518 +0.10135727(S^2) —1.5259729(P) +1103.1979($Log_{10}P$) = 0.013511464(P×S)

$$R^2 = 0.88$$

(8) Average d.b.h. of trees 3.6 inches and larger = 10.101858 +0.00031119382(S^2) +0.0013279826(P) —2.3618647($Log_{10}P$) —0.000013198202(P× S)

$$R^2 = 0.97$$

Basal Area

Equations 1, 2, and 3 account for 88 to 92 percent of the variation in basal areas. When the equations were solved for individual plots, estimated values were within ± 10 percent of actual on about two-thirds of the plots and within ± 15 percent on about 90 percent of the plots. Tables 1, 2, and 3 summarize calculated basal areas for 100-tree steps in planting density within site indices ranging from 80 to 105 feet in 5-foot intervals.

Table 1.--Estimated basal area per acre of all living trees at age 14

Trees planted per acre (No.)	Site index 80	85	90	95	100	105
	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.
200	32	38	43	49	55	62
300	44	50	56	62	69	76
400	52	58	65	72	79	87
500	58	65	72	80	88	96
600	63	71	78	86	95	103
700	67	75	84	92	101	110
800	71	79	88	97	106	116
900	74	83	92	102	112	122
1,000	76	86	96	106	116	127
1,100	79	89	99	110	121	132
1,200	81	91	102	114	125	137
1,300	83	94	105	117	129	141
1,400	84	96	108	120	133	146
1,500	86	98	111	123	136	150
1,600	87	100	113	126	140	154
1,700	89	102	115	129	143	158
1,800	90	104	118	132	146	161
1,900	91	105	120	135	150	165
2,000	92	107	122	137	153	169
2,100	93	108	124	140	156	172
2,200	94	110	126	142	159	176
2,300	94	111	128	144	162	179
2,400	95	112	129	147	164	182
2,500	96	113	131	149	167	186

Total basal area for all stems increased directly with planting rate on all sites, with the steepest rise at the lower rates. Overall, basal areas were almost 2½ times larger at the 2,500-tree planting density than at the 300-tree level. Site also had a strong influence; an increase of site index from 80 to 105 feet about doubled basal area values. The same overall trends were found for trees 3.6 inches d.b.h. and larger, although the differences due to planting density were slightly smaller.

Table 2.--Estimated basal area per acre of trees 3.6 inches d.b.h. and larger at age 14 years

Trees planted per acre	Site index					
	80	85	90	95	100	105
(No.)	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.
200	31	37	43	49	55	62
300	43	49	56	62	69	76
400	51	58	65	72	79	87
500	57	64	72	79	87	96
600	61	69	77	85	94	103
700	65	73	82	90	100	109
800	67	76	85	95	104	114
900	70	79	89	99	109	119
1,000	71	81	92	102	113	124
1,100	73	83	94	105	116	128
1,200	74	85	96	108	120	132
1,300	75	87	98	111	123	136
1,400	76	88	100	113	126	139
1,500	76	89	102	115	129	143
1,600	77	90	104	117	132	146
1,700	77	91	105	119	134	149
1,800	77	92	106	121	136	152
1,900	78	92	108	123	139	155
2,000	78	93	109	125	141	157
2,100	77	93	110	126	143	160
2,200	77	94	111	128	145	163
2,300	77	94	112	129	147	165
2,400	77	94	112	130	149	168
2,500	76	95	113	132	151	170

Table 3.--Estimated basal area per acre of trees 4.6 inches d.b.h. and larger at age 14 years

Trees planted per acre (No.)	Site index 80	85	90	95	100	105
	Sq.ft.	Sq.ft.	Sq.ft.	Sq.ft.		Sq.ft.
200	29	35	42	49	56	64
300	40	47	55	62	70	78
400	48	55	63	71	80	88
500	52	60	69	78	87	96
600	56	64	73	83	92	102
700	58	67	77	87	97	107
800	60	69	80	90	101	112
900	60	71	82	93	104	116
1,000	61	72	83	95	107	119
1,100	61	73	84	97	109	122
1,200	61	73	85	98	111	125
1,300	60	73	86	100	113	127
1,400	60	73	87	100	115	129
1,500	59	73	87	101	116	131
1,600	58	72	87	102	118	133
1,700	57	72	87	103	119	135
1,800	56	71	87	103	120	136
1,900	54	70	87	104	120	138
2,000	53	69	86	104	121	139
2,100	51	68	86	104	122	141
2,200	49	67	85	104	123	142
2,300	48	66	85	104	123	143
2,400	46	65	84	104	124	144
2,500	44	63	83	104	124	145

On sites 100 and 105, basal areas of trees 4.6 inches d.b.h. and larger were directly related to planting density. On sites 80, 85, and 90, basal areas reached plateaus beginning at 1,000 to 1,400 trees per acre; at densities above 1,300 to 2,000 trees a decline began. The trend of increasing basal area with increasing planting density will be evident on all sites after ingrowth of 2- and 3-inch trees progresses for a few more years.

Cordwood Volumes

Tables 4 and 5 summarize estimated cordwood volumes for trees 3.6 and 4.6 inches d.b.h. and larger. They were calculated from equations 4 and 5, which accounted for 92 and 89 percent of the variation in these volumes. Estimated and actual volumes differed by ± 10 percent on an average of 35 percent of the plots and by ± 15 percent on about 15 percent.

Table 4.--Estimated cordwood volume [1/] per acre for trees 3.6 inches d.b.h. and larger at age 14 years

Trees planted per acre (No.)	Site index 80	85	90	95	100	105
	Cords	Cords	Cords	Cords	Cords	Cords
200	5.0	6.3	7.5	8.9	10.3	11.8
300	7.5	8.8	10.2	11.6	13.2	14.7
400	9.1	10.5	12.0	13.6	15.2	16.9
500	10.3	11.8	13.4	15.1	16.8	18.6
600	11.2	12.8	14.5	16.3	18.1	20.0
700	11.9	13.6	15.4	17.3	19.2	21.2
800	12.4	14.3	16.2	18.1	20.2	22.3
900	12.9	14.8	16.8	18.9	21.0	23.2
1,000	13.2	15.3	17.4	19.6	21.8	24.1
1,100	13.5	15.6	17.9	20.1	22.5	24.9
1,200	13.7	16.0	18.3	20.7	23.1	25.6
1,300	13.9	16.3	18.7	21.2	23.7	26.3
1,400	14.0	16.5	19.0	21.6	24.3	27.0
1,500	14.1	16.7	19.3	22.0	24.8	27.6
1,600	14.2	16.9	19.6	22.4	25.3	28.2
1,700	14.2	17.0	19.9	22.8	25.7	28.7
1,800	14.2	17.1	20.1	23.1	26.2	29.3
1,900	14.2	17.2	20.3	23.4	26.6	29.8
2,000	14.2	17.3	20.5	23.7	27.0	30.3
2,100	14.2	17.4	20.6	23.9	27.3	30.8
2,200	14.1	17.4	20.8	24.2	27.7	31.2
2,300	14.0	17.4	20.9	24.4	28.0	31.7
2,400	14.0	17.5	21.0	24.7	28.4	32.1
2,500	13.9	17.5	21.1	24.9	28.7	32.5

1/ Standard rough cords to a top diameter of 3.0 inches i.b.

Table 5.--Estimated cordwood volume 1/ per acre for trees 4.6 inches d.b.h. and larger at age 14 years

Trees planted per acre (No.)	Site index 80	85	90	95	100	105
	Cords	Cords	Cords	Cords	Cords	Cords
200	4.6	6.0	7.4	8.9	10.4	12.1
300	7.1	8.5	10.1	11.6	13.3	15.0
400	8.6	10.2	11.8	13.5	15.3	17.1
500	9.6	11.3	13.1	14.9	16.7	18.7
600	10.4	12.1	14.0	15.9	17.9	19.9
700	10.9	12.7	14.7	16.7	18.8	21.0
800	11.2	13.2	15.2	17.4	19.6	21.9
900	11.4	13.5	15.7	17.9	20.2	22.6
1,000	11.5	13.7	16.0	18.4	20.8	23.3
1,100	11.6	13.9	16.3	18.7	21.3	23.9
1,200	11.5	14.0	16.5	19.0	21.7	24.4
1,300	11.5	14.0	16.6	19.3	22.0	24.8
1,400	11.3	14.0	16.7	19.5	22.3	25.3
1,500	11.2	13.9	16.8	19.6	22.6	25.6
1,600	11.0	13.8	16.8	19.8	22.8	26.0
1,700	10.7	13.7	16.8	19.9	23.1	26.3
1,800	10.5	13.6	16.7	19.9	23.2	26.6
1,900	10.2	13.4	16.7	20.0	23.4	26.8
2,000	9.9	13.2	16.6	20.0	23.5	27.1
2,100	9.6	13.0	16.5	20.0	23.6	27.3
2,200	9.3	12.8	16.4	20.0	23.7	27.5
2,300	8.9	12.5	16.2	20.0	23.8	27.7
2,400	8.5	12.3	16.1	19.9	23.9	27.9
2,500	8.2	12.0	15.9	19.9	23.9	28.0

1/ Standard rough cords to a top diameter of 3.0 inches i.b.

Volume of trees 3.6 inches d.b.h. and larger increased directly with planting density, except on site 80 where a plateau was reached at the 1,600-tree rate. On all sites, volume gains from planting an additional 100 trees were greatest at the lower densities and gradually diminished at higher levels (fig. 1).

Cordwood growth over the 14-year period was about 1.8 times greater at the 1,200-tree planting rate than at the 300-tree rate. In this array of densities, volumes ranged from 7.5 to 25.6 cords per acre. They were almost twice as great on 105-foot sites as on 80-foot sites. Within comparable stocking levels in the range of 300 to 1,200 trees planted per acre, a lo-foot rise in site index increased the yield by 2.7 to 4.9 cords.

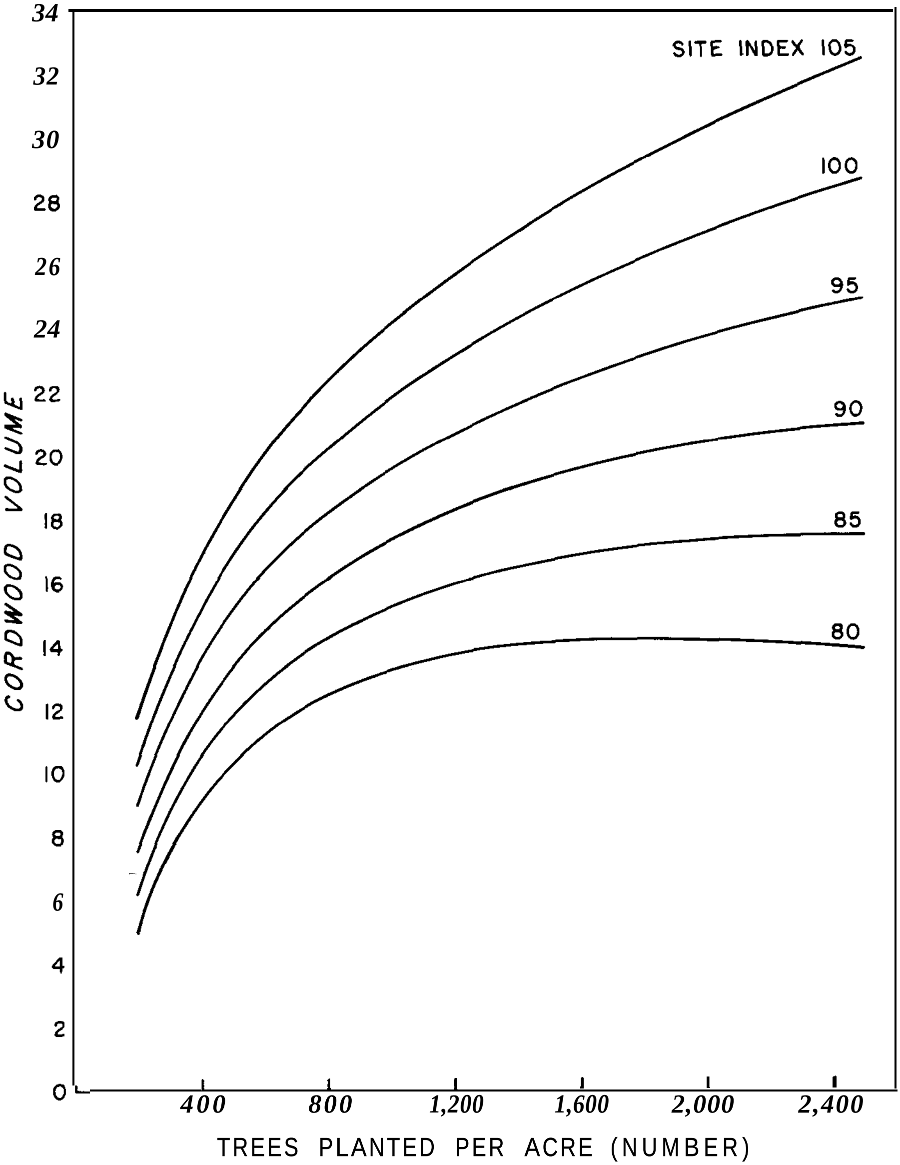

Figure 1.-*Estimated cordwood volumes per acre for slash pines 3.6 inches* d.b.h. and larger at *age* 14 years, *by* planting densities and site indices.

When 4.6 inches d.b.h. is taken as the threshold of merchantability, yields ranged from 7.1 cords at 300 trees planted per acre to 28.0 cords at 2,500 trees (table 5). Volumes on 95-foot and lower sites peaked in the range of 1,100 to 1,900 trees and then declined slightly thereafter. On better sites, they increased throughout the range of planting densities studied. Otherwise, trends in volume influenced by site index and planting density were similar to those discussed for trees 3.6 inches d.b.h. and larger. As with basal areas, ingrowth over the next few years will result in uniform trends of increasing volume with higher rates of planting.

Cubic-Foot Volumes

Equations to predict cubic-foot volumes accounted for about the same percentage of variation as did those for cordwood volumes, and the differences between estimated and actual volumes on individual plots were also comparable. Tables 6 and 7 give estimated yields at age 14 years in cubic feet per acre. Trends related to plant-

Table 6.--Estimated cubic-foot volume of peeled wood [1/] per acre in trees 3.6 inches d.b.h. and larger at age 14 years

Trees planted per acre (No.)	Site index 80	85	90	95	100	105
	Cu.ft.	Cu.ft.	Cu.ft.	Cu.ft.	Cu.ft.	Cu.ft.
200	353	444	539	639	744	853
300	504	601	702	809	920	1,036
400	603	706	814	927	1,044	1,167
500	673	783	898	1,017	1,141	1,270
600	726	842	963	1,089	1,219	1,354
700	766	889	1,016	1,149	1,286	1,427
800	797	927	1,061	1,199	1,343	1,491
900	822	957	1,098	1,243	1,393	1,547
1,000	841	983	1,130	1,281	1,438	1,598
1,100	855	1,004	1,157	1,315	1,478	1,645
1,200	866	1,021	1,181	1,345	1,514	1,688
1,300	874	1,035	1,262	1,372	1,548	1,728
1,400	879	1,047	1,220	1,397	1,579	1,766
1,500	882	1,056	1,236	1,420	1,608	1,801
1,600	883	1,064	1,250	1,440	1,635	1,834
1,700	882	1,070	1,262	1,458	1,660	1,866
1,800	880	1,074	1,272	1,476	1,684	1,896
1,900	877	1,077	1,282	1,492	1,706	1,925
2,000	872	1,079	1,290	1,506	1,727	1,952
2,100	866	1,079	1,297	1,520	1,747	1,979
2,200	859	1,079	1,303	1,532	1,766	2,004
2,300	851	1,078	1,308	1,544	1,784	2,029
2,400	843	1,075	1,312	1,554	1,801	2,052
2,500	834	1,072	1,316	1,564	1,818	2,075

1/ To a top diameter of 3 inches i.b.

Table 7.--Estimated cubic-foot volume [1] of peeled wood per acre in trees 4.6 inches d.b.h. and larger at age 14 years

Trees planted per tree (No.)	Site index 80	85	90	95	100	105
	Cu.ft.	Cu.ft.	Cu.ft.	Cu.ft.	Cu.ft.	Cu.ft.
200	332	430	532	639	751	869
300	482	586	695	809	928	1,052
400	576	686	802	923	1,049	1,180
500	638	755	878	1,005	1,138	1,276
600	681	805	934	1,068	1,208	1,352
700	710	841	977	1,118	1,264	1,415
800	730	867	1,010	1,158	1,311	1,469
900	742	886	1,036	1,190	1,350	1,514
1,000	748	899	1,055	1,216	1,383	1,554
1,100	749	907	1,070	1,238	1,411	1,589
1,200	746	911	1,080	1,255	1,435	1,620
1,300	740	911	1,088	1,269	1,456	1,648
1,400	731	909	1,092	1,281	1,474	1,672
1,500	719	904	1,094	1,289	1,490	1,695
1,600	706	897	1,094	1,296	1,503	1,715
1,700	690	889	1,092	1,301	1,514	1,733
1,800	673	878	1,089	1,304	1,524	1,750
1,900	654	866	1,084	1,306	1,533	1,765
2,000	635	853	1,077	1,306	1,540	1,779
2,100	614	839	1,070	1,305	1,546	1,792
2,200	591	824	1,061	1,303	1,551	1,803
2,300	568	807	1,051	1,300	1,554	1,814
2,400	544	790	1,040	1,296	1,557	1,823
2,500	519	772	1,029	1,292	1,560	1,832

1/ To a top diameter of 3 inches i.b.

ing density and site index are almost identical to those already discussed for cordwood volumes.

Average Diameter

Estimated average diameters were derived for 100-tree steps by solving equation 8. This equation accounted for 97 percent of the variation in average diameters. Its high accuracy is confirmed by the fact that predicted and actual values differed by more than ± 5 percent on only one plot.

Both site index and planting density affected average diameter (table 8). On site 80, trees planted at the rate of 300 per acre were 1.5 inches larger than those planted at the rate of 2,500. On site

100, the difference was 2.2 inches. Within the range of 300 to 1,200 trees per acre, which spans the practical choices today, average diameters varied by 1.1 to 1.5 inches with the greatest differences on the best sites. Between site 80 and site 105 the average diameter difference was 1.4 inches at the 300-tree planting density and 0.6 inch at the **2,500-tree** rate.

Table 8.--Estimated average d.b.h. of trees 3.6 inches d.b.h. and larger at age 14 years

Trees planted per tree (No.)	Site index					
	80	85	90	95	100	105
	Inches	Inches	Inches	Inches	Inches	Inches
200	6.7	7.0	7.2	7.5	7.8	8.1
300	6.3	6.6	6.8	7.1	7.4	7.7
400	6.1	6.3	6.5	6.8	7.1	7.4
500	5.8	6.1	6.3	6.6	6.8	7.1
600	5.7	5.9	6.1	6.4	6.7	6.9
700	5.6	5.8	6.0	6.2	6.5	6.8
800	5.4	5.7	5.9	6.1	6.4	6.6
900	5.4	5.6	5.8	6.0	6.2	6.5
1,000	5.3	5.5	5.7	5.9	6.1	6.4
1,100	5.2	5.4	5.6	5.8	6.0	6.3
1,200	5.2	5.3	5.5	5.7	6.0	6.2
1,300	5.1	5.3	5.4	5.6	5.9	6.1
1,400	5.0	5.2	5.4	5.6	5.8	6.0
1,500	5.0	5.2	5.3	5.5	5.7	5.9
1,600	5.0	5.1	5.3	5.5	5.7	5.9
1,700	4.9	5.1	5.2	5.4	5.6	5.8
1,800	4.9	5.0	5.2	5.4	5.5	5.7
1,900	4.9	5.0	5.1	5.3	5.5	5.7
2,000	4.8	5.0	5.1	5.3	5.4	5.6
2,100	4.8	4.9	5.1	5.2	5.4	5.6
2,200	4.8	4.9	5.0	5.2	5.3	5.5
2,300	4.8	4.9	5.0	5.1	5.3	5.5
2,400	4.8	4.9	5.0	5.1	5.2	5.4
2,500	4.8	4.8	5.0	5.1	5.2	5.4

Diameter Distributions

Table 9 gives the actual number of trees per acre by l-inch diameter and 5-foot site index classes at age 14. As expected, planting 250 trees per acre resulted in the greatest number of trees in the top diameter class (9 inches). For the **8-** and **9-inch** diameters combined, the low planting rate was superior on sites 81-90, but the

Table 9.--Actual average diameter and diameter distributions per acre by site index classes in each original planting density

Site index class	Average d.b.h. 1/	Trees per acre by diameter classes								
		1	2	3	4	5	6	7	8	9
	Inches	No.	No.	No.	No.	No.	No.	No.	No.	No.
	250 trees planted per acre									
81-85	6.8	--	--	--	--	60	20	80	40	20
86-90	6.8	2	2	4	4	18	50	64	32	12
91-95	7.2	--	--	5	10	5	32	62	50	22
96-100	7.4	--	--	--	--	5	55	50	45	30
	1,150 trees planted per acre									
81-85	5.4	--	65	55	130	190	125	65	5	--
86-90	5.6	40	50	85	125	160	190	85	--	--
91-95	5.6	5	50	95	135	192	165	92	175	--
96-100	5.9	--	25	42	78	85	140	230	132	17
	1,600 trees planted per acre									
81-85	5.2	10	75	180	195	180	145	50	--	--
86-90	5.1	20	70	120	230	260	190	30	--	--
91-95	5.4	60	127	135	178	263	191	88	5	2
96-100	5.6	27	97	123	150	193	220	110	10	3
	2,500 trees planted per acre									
81-85	4.8	30	165	185	345	250	105	10	--	--
86-90	5.0	130	290	343	353	250	173	47	--	--
91-95	5.0	160	280	275	380	390	190	30	5	--
96-100	5.2	120	192	202	285	350	250	47	10	--
100+	5.2	150	180	180	330	410	260	90	--	10

1/ Trees 3.6 inches d.b.h. and larger.

1,150-tree rate excelled on the higher sites. The two densest plantings had only a few 8- and 9-inch trees, but had many in the 7-inch class. On sites of 91 feet or better the 1,600-tree rate had more 7-inch trees than the 250-tree rate. When all trees 6 inches d.b.h. and larger were totaled, the 1,150-tree density ranked first and the 250-tree density ranked last.

DISCUSSION

When this plantation was installed during the mid-30's, close spacing was fairly common. Today emphasis is on wide spacing that permits easy passage of large equipment for mechanized harvesting and allows trees to reach large diameters at an early age. Consequently, that portion of the data between planting densities of 400 and 1,200 trees per acre is of greater interest under prevailing conditions.

The recent trend to wide spacing has some dangerous aspects in the West Gulf region, where summer drouths are frequent. In some years 80 percent or more of the trees survive their first year, but after a dry summer survival may be only 50 percent. On sites where bad drouths are frequent, it seems logical to adopt a planting policy that will insure a minimum stand in most years.

Yearly variations in climatic conditions in this area are quite different from those in many parts of the Southeast, where much of the information on growth and yield of slash pine plantations has been derived. Summer rainfall is usually less, and rainless periods of 4 to 8 weeks are common. The geographic difference in probabilities for high survival suggest different planting polices for the various portions of the southern pine region.

Another factor suggesting careful choice of planting density is the high susceptibility of slash pine to fusiform rust in the West Gulf region. Typically, trunk cankering ranges from 30 to 60 percent at the time of the first thinning, even after some trees have been killed by the disease. When low survival and high incidence of disease are combined in a plantation with wide initial spacing, it is difficult to leave sufficient well-spaced crop trees in an intermediate cutting.

In-this study maximum cordwood and cubic-foot volume were obtained in early years by high initial densities. Plots initially having 1,200 trees per acre yielded an average of 6 cords (the range was 4.6 to 8.7 cords) more than plots having 400 trees (in trees 3.6 inches d.b.h.). The larger differences were on the better sites.

Two factors must be considered in assessing these differences in growth. First is planting costs. But they are not in direct proportion to the number of stems planted per acre. Density can be increased by narrowing the planting interval within rows, and the cost of this increase is nominal. Second is the effect of density on diameter growth. In this study, trees planted at the rate of 400 per acre averaged about 1 inch larger in diameter than those planted at 1,200 per acre. However, interpolation strongly indicates that the higher rate had more trees per acre in the 6-inch and larger diameter classes than the 400-tree rate. With a greater number of stems in operable sizes and a higher basal area, thinnings can be started earlier with high than with low initial densities.

It is difficult to say if an added 1 inch in diameter is offset by an increase of an average of 6 cords per acre. The preference will probably vary by landowners, depending on management objectives, finances, market prices for different products, logging costs, and other factors. Then, too, average diameters must be interpreted carefully, for close spacings are penalized by having numerous trees at the lower limit of merchantability even though stocking in the larger sizes is comparable.

In regions where survival is difficult to predict and incidence of disease is high, land managers should consider the consequences of higher and lower stocking than the optimum desired. Figure 1 shows that rapid decline in volume growth starts at a lower initial stocking on poor sites than on good ones. If trees are planted at intervals of 8 by 10 feet on site 80 (about 550 trees per acre), and early survival is about 50 percent instead of the 75 percent recorded in this study, a growth loss of 2 to 3 cords per acre may result with only a small gain in diameter growth. On the other hand, if trees are planted at a 6- by 8-foot spacing and survival is better than in this study, volume growth will be higher with a minimum reduction in diameter growth. Spacing and survival are most critical on the choice sites, because the curve of volume over planting density continues upward at a high rate to the 2,500-tree level.

It is not intended to recommend a planting spacing in this paper. Instead, the purpose is to encourage landowners to consider all factors carefully before chosing a spacing, and to rely on data from a geographic region near the sites to be reforested.

Mann, W. F., Jr.

1971. Early yields of slash pine planted on a cut-over site at various spacings. South. Forest Exp. Stn., New Orleans, La. 16 p. (USDA Forest Serv. Res. Pap. SO-69)

Tabulates basal areas, cordwood and cubic-foot volumes, average d.b.h., and diameter distributions for 14-year-old slash pine planted in central Louisiana. Also gives regression equations developed to predict these parameters.