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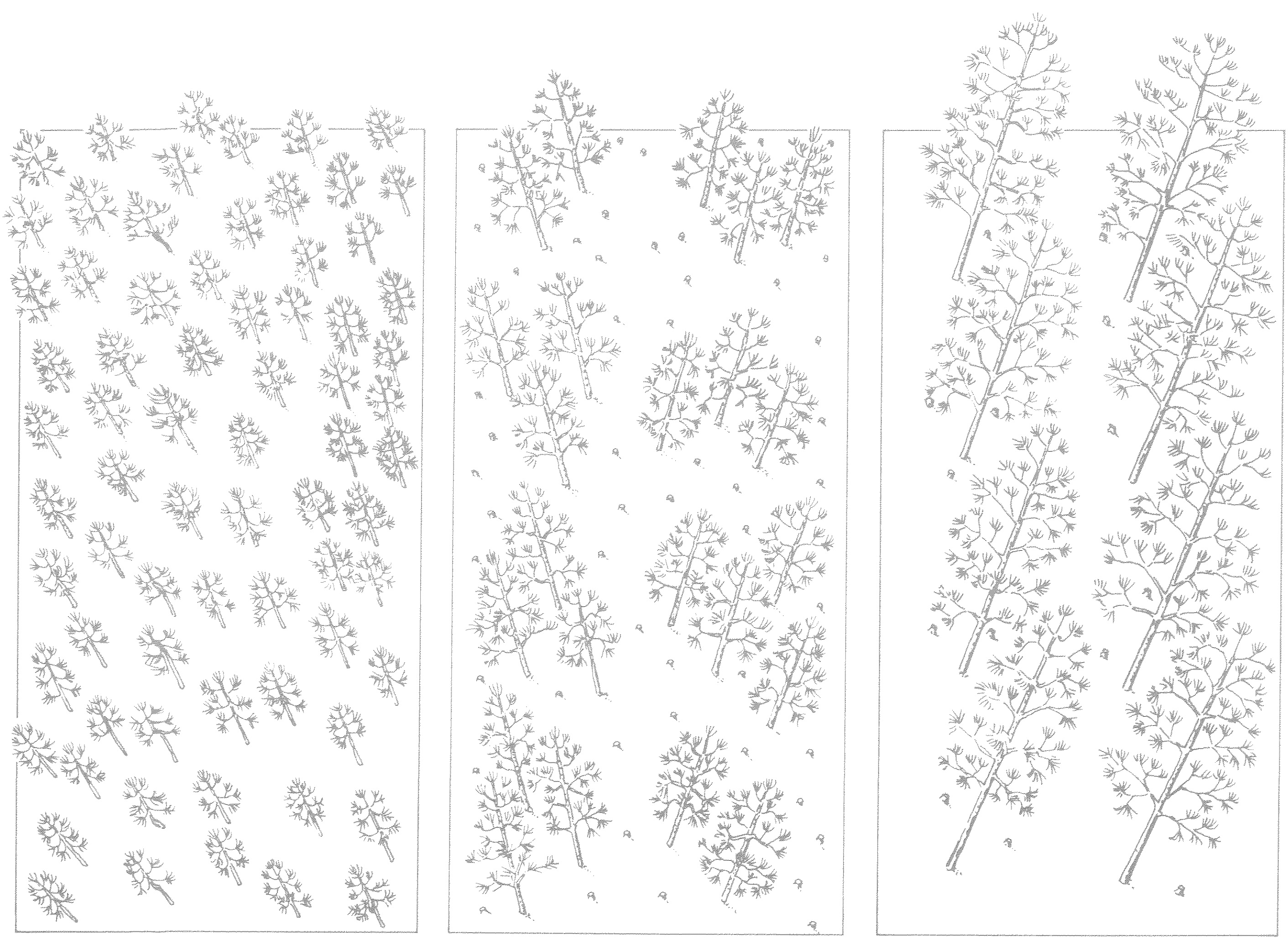

Precommercial Thinning of Naturally Seeded Slash Pine Increases Volume and Monetary Returns

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Abstract.--A naturally seeded slash pine (Pinus elliottii Engelm. var. elliottii) stand, having up to 50,000 stems per acre, was precommercially thinned at age 3. Two thinning methods left single trees spaced 10 by 10 feet, and clumps of 6 to 8 trees spaced 10 by 10 feet, compared with the unthinned original stand. At age 23, the single-tree plots averaged 28 cords per acre of merchantable wood and the clump plots 19 cords. Unthinned plots yielded less than 5 cords, which were mostly inaccessible because of numerous, submerchantable stems. Such gains in commercial volumes can justify a sizable investment in precommercial thinning. Thinning by age 5 to less than 1,500 trees per acre is recommended. Diameter and height growth were inversely related to stand density. Heights at age 23 increased about 4 feet for each 1,000-tree decrease in stocking. When evaluating or comparing slash pine site indexes over a very broad range of densities, adjustments for trees per acre may be needed. Density effects are less important when the differences between stands are no more than 1,200 trees per acre, as would normally occur in managed stands.

Keywords: Precommercial thinning, Pinus elliottii, naturally seeded stands.

Precommercial thinning seems unattractive to many foresters because it destroys established trees and has no immediate monetary return. The research reported here, however, indicates that precommercial thinning can pay handsome dividends. A natural stand of slash pine (Pinus elliottii Engelm. var. elliottii) on the Holt Walton Experimental Forest in south central Georgia was thinned at age 3. Height, diameter, and volume responses to thinning were observed through age 23. Results illustrate the depressing effect high stocking densities have on individual tree growth.

METHODS

Two farm fields divided by a stream were left untended after the fall crop harvest of 1947. That year a bumper crop of slash pine seeds was produced. Mature, sawtimber-sized slash pines nearby cast an abundance of seed across the two fields. In 1951, the area was selected for this precommercial thinning study when seedlings were 3 years old. Initial inventories revealed some milacres containing the equivalent of 50,000 stems per acre.

Soil on the study site is Gilead loamy sand. Most of the area is level, but parts have 5 to 12 percent slopes. Steeper slopes had severe sheet erosion.

The study was arranged in a split-plot design to recognize the dissimilarity between fields. There were two randomized complete blocks within each field. Treatment plots were approximately 1/4 acre, and treatments were (fig. 1):

Single tree.--Stocking was reduced to single trees spaced approximately 10 by 10 feet apart.

Clump.--Stocking was reduced to clumps of 6 to 8 stems each, with clumps spaced approximately 10 by 10 feet apart, center to center.

Check.--Stocking was left as it existed, unthinned.

Figure 1.--Study plots immediately after precommercial thinning at age 3. Treatments are (fore- to background): clump, single-tree, and unthinned.

The method used to precommercially thin this area in 1951 was not unusual for that time. A two-wheel "buggy saw" with a belt-driven circular saw blade cut 10-foot-wide swaths across the plots. For the clump treatment, additional cutting left small clumps of about 6 to 8 trees at 10-foot intervals within the narrow strip of trees. The single-tree treatment was accomplished by additional thinning with an ax or brush hook to remove all but the single best tree in each clump. The check treatment was left untouched.

Diameters and heights were measured at intervals throughout the study. Through age 8, sampling was restricted to dominant and codominant trees which represented the potential crop trees, the trees most likely to survive to the end of the study. After age 8, the diameters of all plot trees were measured, but height measurements still were confined to dominants and codominants.

RESULTS

MORTALITY

Mortality throughout the study was largely a result of competition and was greatest on the check plots. One period of severe insect attack caused heavy losses in portions of some plots. Residual densities after thinning at age 3 averaged about 435 trees per acre for the single-tree treatment and 3,000 for the clump. Density on the unthinned check probably averaged over 20,000 stems per acre, although the figure is not precisely stated in the record. Twenty years after thinning, surviving trees per acre averaged 336 on the single-tree plots; 1,298 on the clump plots; and 3,978 on the check plots (table 1). Corresponding mortality rates approximated 23, 57, and 80 percent for the single-tree, clump and check plots. Mortality on the check plots was high throughout the 20-year period, being 30 percent from age 17 to 23, compared to 9 and 10 percent on the single and clump plots.

DIAMETER GROWTH

Five years after thinning it was noted that precommercial thinning had a significant effect on the diameter growth of dominant and codominant trees; the average diameter of single-tree plots was 0.9 inch larger than the average on the check plots (fig. 2). Ten years after thinning, single-tree plots averaged 0.9 inch larger than the clump treatment, and 2.4 inches larger than the check. Diameter differences continued to increase. Twenty years after thinning, diameters of dominants and codominants averaged 8.1 on the single-tree plots, 6.6 on the clump plots, and 4.5 on the check plots.

At age 17 (Collins 1967) and age 23, the inverse relationship between diameter and density of stocking was curvilinear. A least-squares regression (fig. 3) indicates that densities below 1,500 trees per acre provide the greatest increase in the average diameter of dominants and codominants. Each 100-tree reduction in stocking below the 1,500-tree level increased the mean diameter by 0.32 inch; for a similar stocking reduction above the 1,500-tree level the mean diameter increased by only 0.05 inch.

At age 23, diameters of all slash pines were measured on all plots. All trees in the single-tree treatment had diameters large enough for pulpwood (4.6 inches and larger), compared to 43 percent in the clump treatment, and only 8 percent in the check (table 2). Also, the average diameter for all trees on the single-tree treatment was 2.8 times larger than the check, and the clump treatment was 1.6 times larger than the check (table 1).

Table 1.--Number of trees, average diameter and height, 50-year site index, and volume production on individual treatment plots at age 23, 20 years after treatment

Field	Block	Trees per acre: All	Trees per acre: Merchantable[1]	Diameter at breast height[2]	Total height[3]	Site index[4]	Merchantable[1] volume per acre
		Number		Inches	Feet		Cords
SINGLE-TREE							
I	1	401	401	7.8	56.2	78	37.54
I	2	331	331	7.7	56.1	78	30.86
II	3	331	331	7.3	51.8	72	22.46
II	4	279	279	7.3	53.0	74	20.23
Mean		336	336	7.5	54.3	76	27.77
CLUMP							
I	1	610	401	5.5	53.1	74	24.69
I	2	627	436	5.6	54.4	76	28.57
II	3	1,830	418	3.4	46.3	64	13.36
II	4	2,126	296	3.0	40.2	56	8.61
Mean		1,298	388	4.4	48.5	68	18.81
UNTHINNED							
I	1	3,415	192	2.8	39.8	55	4.49
I	2	2,128	508	3.6	46.6	65	13.40
II	3	5,802	17	2.1	33.9	47	.28
II	4	4,565	52	2.4	34.0	47	.81
Mean		3,978	192	2.7	38.6	54	4.74

[1] Trees 4.6 inches d.b.h. and above.
[2] Includes all crown classes.
[3] Dominant and codominant trees only.
[4] 50-year index age.

HEIGHT GROWTH

For the first 5 years after thinning, average height of dominants and codominants of the thinned treatments lagged behind the check, but differences were nonsignificant (fig. 4). At age 13, (10 years after thinning) the increased height growth of thinned plots was apparent. Trees averaged 26.9 feet on the check plots, compared with trees averaging 34.5 feet on single-tree plots and 31.6 on the clump plots. At age 23, trees on the single-tree plots averaged 54 feet, on clump plots 48 feet, and on unthinned treatments 39 feet (table 1). Average annual height growth for the 20 years since treatment was 2.71, 2.42, and 1.90 feet, respectively, for the single-tree, clump, and check treatments.

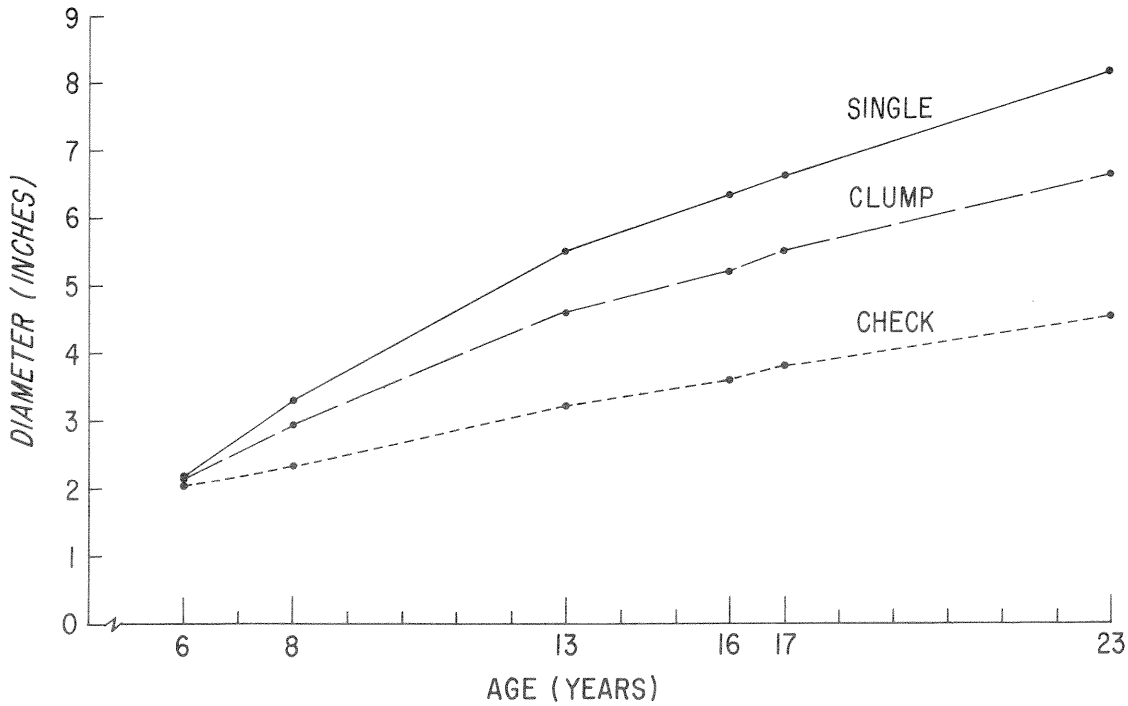

Figure 2.--Average diameters of dominant and codominant trees in each treatment, since precommercial thinning at age 3.

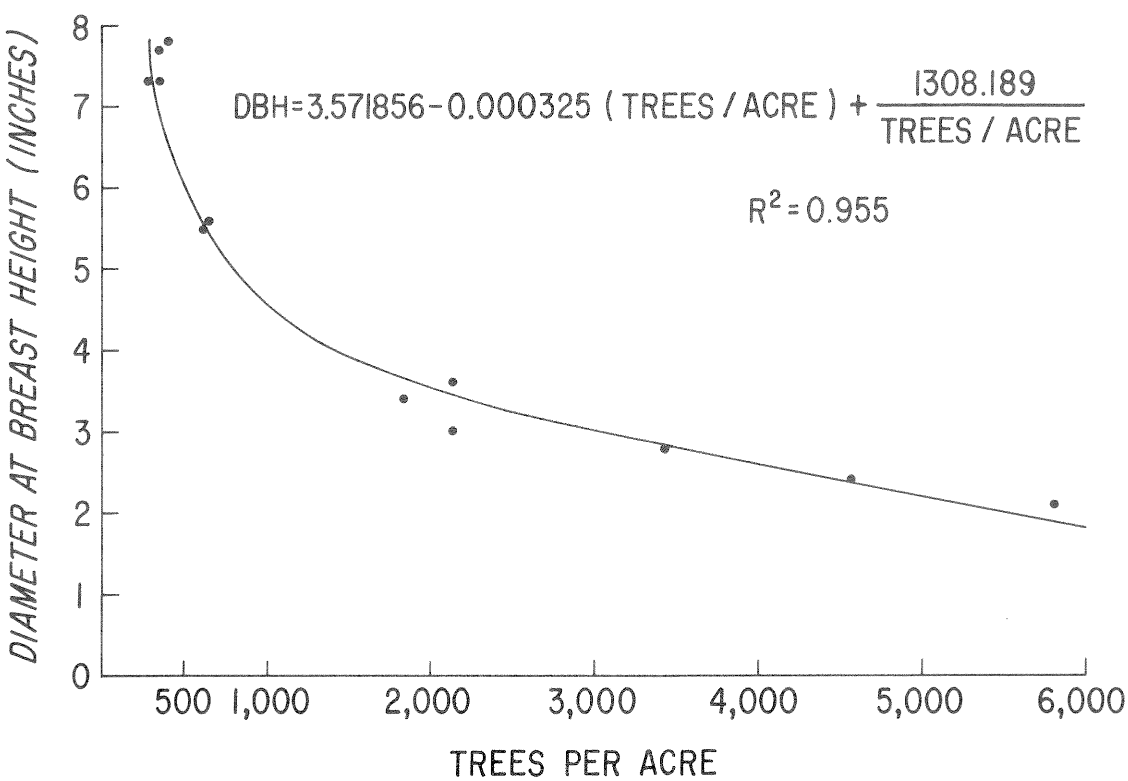

Figure 3.--At age 23, number of trees per acre sharply alters the average d.b.h. of dominant and codominant trees, especially at densities of less than 1,500 trees per acre.

Table 2.--Diameter distribution by 1-inch diameter classes, at age 23, 20 years after treatment

D.b.h. class	Single-tree	Clump	Check
	--- Trees per acre ---		
1	--	148	416
2	--	297	2,001
3	--	248	1,000
4	--	214	369
5	26	161	159
6	52	78	27
7	87	78	6
8	92	52	--
9	57	22	--
10	18	--	--
11	4	--	--
Total	336	1,298	3,978

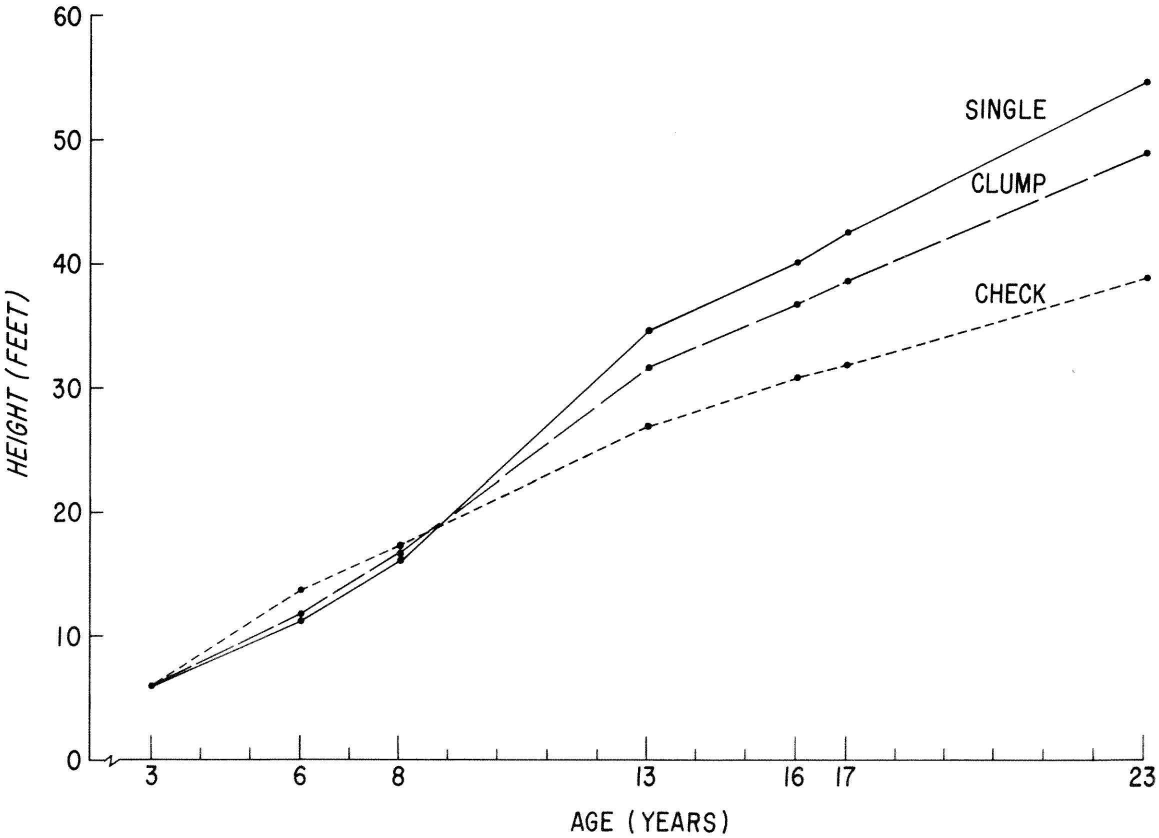

Figure 4.--Average height of dominant and codominant trees in each treatment, since precommercial thinning at age 3.

The effect of trees per acre on height growth became more critical from age 17 to 23. At age 17, the height increase was approximately 2.0 feet for each 1,000-tree reduction in stocking as reported by Collins (1967). By age 23, a 4.2-foot increase per 1,000-tree reduction was recorded (fig. 5).

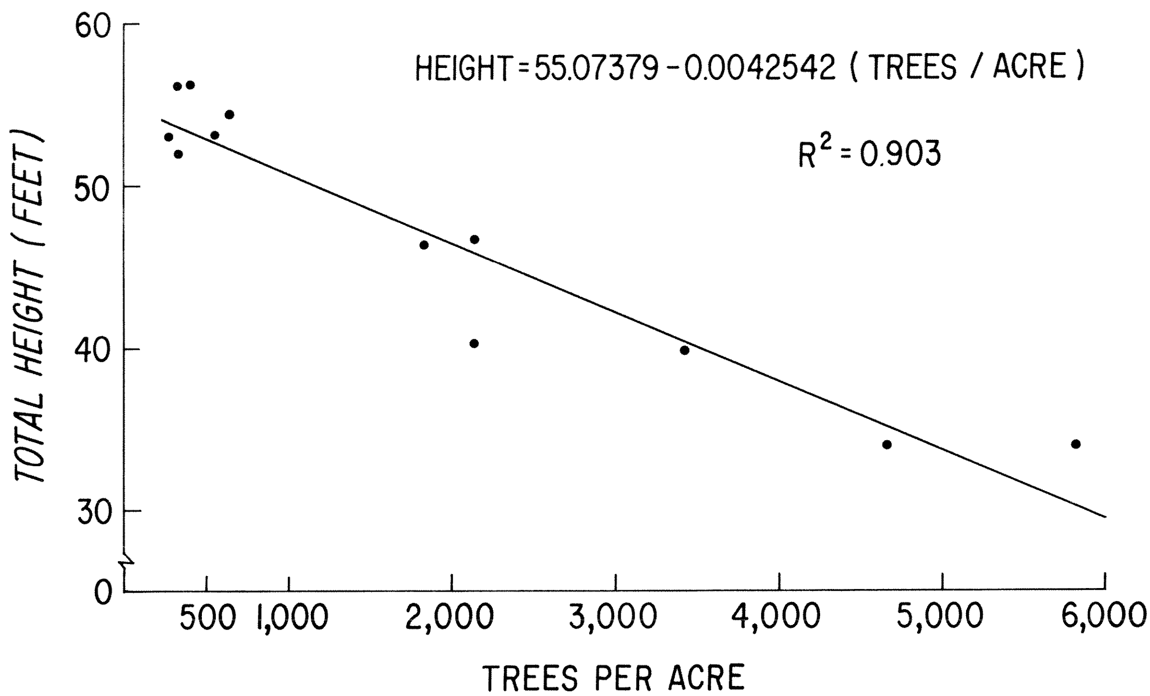

Figure 5.--The relationship between average heights of dominants and codominants and number of trees per acre indicates a 4.2-foot increase in average height for each 1,000-tree reduction in stocking at age 23.

VOLUME

Merchantable wood volume is the ultimate test of precommercial thinning. Merchantable volume resulting from precommercial thinning in this study averaged 28 cords per acre for the single-tree treatment and 19 cords for the clump treatment, compared to less than 5 cords for the unthinned treatment (table 1). Single-tree plots generally grew six times the merchantable volume of the check plots; clump-plot volumes were four times greater than check-plot volumes.

One of the unthinned plots had an unusually large volume (13.4 cords per acre), more than seven times the average of all other check plots. This plot had fewer trees than any other check plot and produced 55 percent more volume than a clump plot with almost the identical number of trees (table 1). The two plots were located in different fields. The spatial pattern of the trees in the two plots contributed to this volume difference. In the clump plot, trees were clustered with about 2 to 3 square feet of ground space per tree; in the check plot they were evenly scattered, with about 20 square feet per tree. Individual trees in the check plot had more growing space, permitting a higher percentage of merchantable stems, taller trees, and greater volume. The topsoil in the check plot was 10 inches deeper than in the clump plot and this sometimes influences growth. However, in this study the depth of topsoil had little effect on height growth, as will be reported in the discussion.

DISCUSSION

Past farming practices in the two fields studied resulted in sheet erosion in some areas. Depth to clay, or a fine textured soil horizon (DFT), was used as a covariant in the analysis of total height at age 23. Although DFT ranged from 4.4 to 17.8 inches, it accounted for less than 5 percent of the variation in height when included in the height-density relationship. Adjustments would have changed treatment mean heights by no more than 0.8 foot, so DFT was ignored and comparisons were made using unadjusted values. For plantation slash pine on an old-field site in Florida, Barnes and Ralston (1955) found a higher correlation between height growth and DFT. They found that height growth increased significantly as DFT increased to 28 inches. The naturally seeded site treatment reflected the same relationship,although height was only weakly correlated ($r = 0.35$). The differences between these results may be caused by the naturally seeded site having a smaller range in DFT values and an extreme range of stand densities.

Height comparisons illustrate the effect extreme variations in the number of trees per acre have on site index estimates. Site index at base age 50 was calculated by the equation given for natural slash pine by Bennett (1970). The comparison of these estimates as affected by stand density is dramatic--even for adjacent plots with similar DFT (fig. 6). Within Field I, the single-tree treatment plot in block 1 had 401 trees per acre and a site index of 78. In sharp contrast, the check plot immediately to the south had 3,415 trees per acre and SI 55--a 23-foot difference in site. The check plot in block 2, Field I, immediately west of the site 78 plot, had 2,128 trees per acre and site 65--a 13-foot difference. Field II, which is overall a poorer site than Field I, also had several contrasting situations. For example, compare the single-tree treatment in block 3 with 331 trees per acre and site 72 with the check plot in block 4 with 4,565 trees per acre and site 47.

Volume production resulting from early precommercial thinning can be evaluated in terms of costs and returns. A conservative gain of 15 cords per acre resulting from precommercial thinning (table 1), would amount to an increased return of $300 per acre (priced at $20 per cord). If the cost were charged at 7-percent interest over 20 years, a precommercial thinning investment of $77 would be justified. If stumpage values are as low as $8 per cord, a $30 expenditure is feasible.

Regardless of the volume of merchantable wood in an area, harvesting costs are an important factor in marketing the product. In both thinning treatments, the merchantable wood is readily accessible as there is approximately 10 feet between rows of trees (fig. 7). In the unthinned check treatment, numerous sub-merchantable stems would deter commercial logging and therefore reduce profits. A stand as dense as 3,000 stems per acre with no more

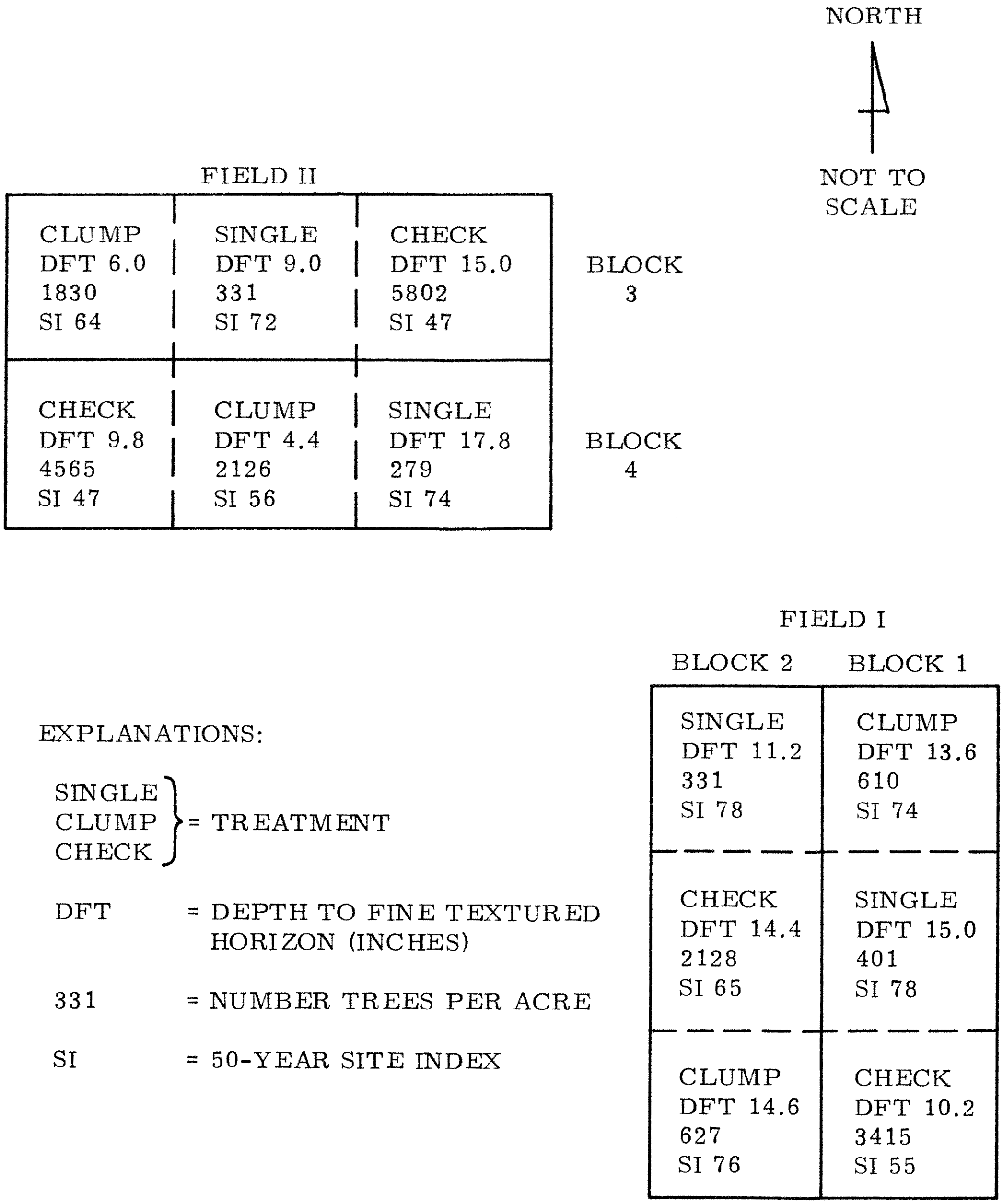

Figure 6.--Diagram of field plots showing proximity of the approximately quarter-acre treatment plots and comparing density of stocking (trees per acre) and site index among plots.

Figure 7.--The single-tree plot (left photo, foreground) and clump plot (right photo), are more accessible to harvesting and other types of forestry equipment than the unthinned plot (left, background). Contrasting the densities in the left photo, the single-tree plot had 331 trees and 22.5 cords per acre at age 23, and the unthinned plot had 5,802 trees and 0.28 cord. Also notice the conspicuously shorter heights on the unthinned plot (left, background).

than 5 or 6 cords per acre is not attractive to a commercial pulpwood enterprise. If included with sales of larger trees, small-tree stands could be utilized in total tree chipping operations. This technique ensures almost complete stem-wood utilization, as well as bark and limbs, and increases the volume harvest in small-diameter, dense stands.

There would be a limited opportunity for selling even fence posts from the unthinned check treatments. Producers generally avoid stands where the trees are less than 5 inches d.b.h., or contain less than two posts per tree. Only about 5 percent of the trees in the check treatment have diameters 5 inches or greater.

At age 23, the unthinned plots would probably benefit little from release thinning. About 80 percent of the stems are in the suppressed and intermediate classes, and the crown ratio averages 25 percent. Slash pines 23 years old with crowns this small would be very slow in responding to release.

The intensive hand labor used in 1951 preparing these study plots usually is not financially feasible today. Precommercial thinning now can be accomplished with mechanized equipment such as rotary mowers, harrows, and lightweight choppers (Balmer and Williston 1973) and other machines especially designed for the work. If thinning were done at age 3, the job could be done with relatively lightweight equipment such as a farm tractor and rotary mower. Of course, selection of equipment would depend in large part on the terrain condition. For example, cutover woodland sites with high stumps are a problem.

In comparing the two precommercial thinning methods used in this study, the cost of hand labor would rule against the single-tree method. Thinning to leave clumps can be totally mechanized and stands could be reduced to acceptable levels of density with a degree of selectivity. After the first commercial thinning of a clump treatment area, about 700 trees per acre should be left. Although mortality is difficult to anticipate, this study indicates that it is about 50 percent for the clump treatment. Compare all the clump-plot volumes (table 1); the plots with 600 to 700 surviving trees per acre at age 23 produced more than twice as much usable volume as the 2,000-tree plots. In terms of cordwood yield, low-density clump plots were very much like the single-tree plots.

Strip thinning was not used in this study, but it has been demonstrated to be an effective pattern for precommercial thinning. In a Louisiana slash pine stand thinned at age 3, Lohrey (1973) observed residual densities of 1,400 and 2,800 trees per acre and found diameter growth was comparable between strip and selective (single-tree) thinning. This led Mann and Lohrey (1974) to recommend the strip thinning practice because it is less time consuming and cheaper than selective thinning.

CONCLUSIONS

1. Young stands of natural slash pine, over-stocked with more than 2,000 stems per acre, should be identified and precommercially thinned before age 5.

2. Stocking should be reduced to less than 1,500 trees per acre; if trees are individually spaced, the stocking should be less than 700 trees per acre.

3. Cordwood yields at age 23 may be eight times as much for stands precommercially thinned early to 435 trees per acre, compared with unthinned stands carrying 3,000 or more stems per acre at age 23.

4. Thinning to single stems gives best results but requires considerable hand labor. A compromise method would be to mechanize the thinning operation and leave trees in narrow strips or clumps spaced some 10 to 12 feet apart.

5. Number of trees per acre has a significant effect on diameter and height growth. This effect was observed as early as age 17.

6. The effect of density on height growth should be considered when evaluating sites occupied by a high number of trees per acre, or when comparing site indexes based on widely different levels of stocking. However, for the range of densities normally encountered in managed stands (200 to 1,200 trees per acre), the number of trees does not seriously influence the site index estimate.

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