EFFECT OF INITIAL SPACING ON MECHANICAL PROPERTIES OF LUMBER SAWN FROM UNTHINNED SLASH PINE AT AGE 40

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ABSTRACT

The effect of initial planting density on strength and stiffness of slash pine (*Pinus elliottii* Engelm. var *elliottii)* from a 40-year-old plantation on the Georgia Coastal Plain was examined. A stratified random sample of trees with diameters at breast height ranging from 8 to 16 inches from replicated stands representing tree spacing of 6 by 8, 8 by 8, 10 by 10, and 15 by 15 feet was processed into lumber. Visually graded No. 1 and No. 2, 2 by 4 and 2 by 6 lumber from the study was tested for stiffness (modulus of elasticity) and strength (modulus of rupture) according to the provision of American Society for Testing and Materials Standard Method D 198. Only the modulus of rupture of the No. 2 grade 2 by 4's showed a significant (p = 0.05) decrease with increased tree spacing. All spacings tested produced dimension lumber with excellent mechanical properties.

Initial planting densities and thinning are silvicultural tools that can be used to control the proportion of juvenile wood, size and number of knots and, thus, the quality of the lumber produced from managed plantations. Results of a loblolly pine (*Pinus taeda* L.) spacing-thinning study (6) show that planting at initial densities of greater than 538 trees per acre (TPA) and thinning at age 18 can yield lumber of greater grade and value compared to planting at densities less than 538 TPA and thinning to the same basal area. Information on the effect of initial spacing on slash pine is also needed.

The completion of a spacing study provided the opportunity to examine the effect of initial planting density of an unthinned, 40-year-old slash pine (*Pinus elliottii* Engelm. var *elliottii)* plantation on lumber strength and stiffness. Repeated tree measurements were collected over the life of the spacing study to determine the response of slash pine planted at eight different spacings and unaltered by thinning or other silvicultural treatments. Interim growth and volume data have been widely published (2-4,7). Jones (8) reported that the only significant difference in stem volume per acre at ages 15 and 20 was that the cubic foot volume in the 15- by 15-foot spacing was significantly below that found in the other planting densities. The difference in merchantable stem volume between planting densities was not statistically significant at ages 25 and 30.

In 1989, Clark and Saucier (5) reported that the slash pine in this spacing study produced juvenile wood for the first 10 rings at all planting densities. Analysis of collected increment cores showed that the diameter of the juvenile core was significantly related to the initial tree spacings and averaged 4.0 inches for the trees spaced 6 by 6 feet; 4.6 inches for the trees spaced 8 by 8 feet; 5.5 inches for the trees spaced 10 by 10 feet; and 6.3 inches for the trees spaced 15 by 15 feet. Analysis of wood specific gravity (SG) based on increment cores collected from trees planted at the various spacings showed no significant difference in SG among planting densities (5).

OBJECTIVE

The objective of this study was to determine the effect of initial planting density on modulus of elasticity (MOE) and modulus of rupture (MOR) of visually graded No. 2 dimension lumber sawn from unthinned 40-year-old slash pine.

MATERIALS AND PROCEDURES

The study plantation was established in an old cultivated field in January 1952 on the Holt Walton Experimental Forest in Dooley County, Ga. The slash pine spacing study had a randomized block design with two replications. The soil is loamy sand, mostly of the Lakeland and Gilead series. In this study, four spacings

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Forest Prod. J. 47(7/8):107-109.

were selected from the original eight installed: 6 by 8 feet (908 TPA), 8 by 8 feet (681 TPA), 10 by 10 feet (436 TPA), and 15 by 15 feet (194 TPA).

SAMPLE TREES

In 1992, a stratified random sample of four to five trees per 2-inch diameter at breast height (DBH) class between 8 and 16 inches was taken from each of the four spacings in each replication. Stratifying the sample trees by diameter class permits extending the lumber grade yield data to other timber stands with similar spacing characteristics. A total of 132 trees were selected for harvest. These trees were felled and bucked into tree-length logs to a 7-inch-diameter outside bark (d.o.b.) top or sawlog merchantable top. The tree-length logs were trucked to a cooperating sawmill in central Georgia where they were bucked into 10- to 16-foot log lengths. All logs were numbered and tagged to identify the tree and the log number within the tree. The logs were sawn into nominal 4/4 and 8/4 lumber on a circular saw with a computer-controlled setworks headsaw and vertical gang resaw. Lumber cut from each log was identified and graded green by certified Southern Pine Inspection Bureau lumber graders. Each piece of lumber was tallied by mill number, thickness, width, length, and grade. Green grades were assigned solely on the basis of defect (9). Warp and twist were not considered.

SAMPLE LUMBER

The number of 2 by 4 and 2 by 6 dimension pieces produced from the 132 study trees and selected for testing are shown in **Table 1.** A sample of dimension lumber for mechanical testing was selected randomly from the lumber produced. The goal was to test 20 to 30 No. 1 and No. 2 grade 2 by 4's and the same number of 2 by 6's from each planting density. No attempt was made to select lumber by DBH class. We did try to limit the number of boards selected from individual logs to two. We were unable to select 20 to 30 pieces from all lumber grade and size cells **(Table 1).** The selected pieces were taken to Athens, Ga., where they were kiln-dried to 12 percent moisture content, planed to thickness, and ripped to width. The research dry kiln allows a maximum length of 12 feet. All test pieces were trimmed to a 12-foot length immediately before stacking and drying. A total of 282 sample 2 by 4 and 2 by 6 boards were tested. The number of specimens tested in each spacing and grade is not representative of the grade yields by spacing.

SAMPLE TESTING

The dimension lumber was tested in static bending with third-point loading over a 138-inch span. Using a 120,000-pound capacity hydraulic universal test machine, testing followed the specifications of ASTM D 198 (1). Load/deflection data were collected and recorded using electronic sensors and an analog/digital board in a portable computer. Load was applied at the rate of 100 to 140 pounds per minute until failure. Deflections were taken to approximately 1.5 inches; then the deflection sensor was removed without interrupting the loading.

DATA ANALYSIS

The effect of initial spacing on the proportion of lumber tested that met the required bending strength for its lumber grade and size was examined. The MOR of each board was compared to the required bending strength for its size and grade. The required bending strength value was calculated by multiplying the required bending design value F_b (9) for each grade and lumber size by an adjustment factor of 2.1 for safety and duration of load.

The MOE and MOR data for No. 2, 2 by 4 and 2 by 6 boards were analyzed using the SAS General Linear Model and Tukey's test (10).

RESULTS AND DISCUSSION

The average MOE and MOR of No. 1 grade 2 by 4's and 2 by 6's did not vary consistently with tree spacing, probably because of the low number of pieces tested **(Table 2).** The average MOE and MOR for the No. 1 grade 2 by 4's and 2 by 6's tested exceeded the average values specified by the grading rules for southern pine (9).

TABLE 1. - Number of pieces of No. 1 and No. 2 grade 2 by 4 and 2 by 6 lumber produced from the 132 slash pine trees and number of pieces tested for stiffness and strength.

	Pieces of lumber			
	Produced		Tested	
Spacing	No. 1	No. 2	No. 1	No. 2
(ft.)				
2 by 4's				
6 by 8	60	90	12	26
8 by 8	45	115	11	25
10 by 10	23	83	9	24
15 by 15	26	99	8	27
2 by 6's				
6 by 8	10	41	10	22
8 by 8	3	32	3	23
10 by 10	18	94	11	31
15 bv 15	16	67	12	28

TABLE 2. — Average MOE and MOR for visually graded No. 1 grade 2 by 4's and 2 by 6's by tree spacing for unthinned slash pine in the Georgia Coastal Plain.

		MOE		MOR	
Soacine	Pieces tested	Average	SD"	Average	SD
(ft.)	(No.)	- (million psi) - ---		(psi)_______	
2 by 4's					
6 by 8	12	1.98	0.61	6,920	2,691
8 by 8	11	2.33	0.46	7,065	2,661
10 by 10	9	2.40	0.68	7,442	2,894
15 by 15	8	1.89	0.54	6,048	2,116
2 by 6's					
6 by 8	10	2.03	0.33	6,700	1,572
8 by 8	3	1.71	0.29	4,140	700
10 by 10	11	1.98	0.34	6,827	2,121
15 by 15	12	1.81	0.42	4,827	2,121

[a] SD = standard deviation.

TABLE 3.— Average MOE and MOR for visually graded No. 2 grade 2 by 4's und 2 by 6's by initial tree spacing for unthinned slash pine in the Georgia Coastal Plain.

Spacing	Pieces tested	MOE Average	MOE SD[a]	MOR Average	MOR SD[a]	Proportion in compliance for F_b
(ft.)	(No.)	- (million psi) - - - - -		- - - - - - - - (psi) - - - - - - - - -		(%)
2 by 4's						
6 by 8	26	1.94	0.57	6,464	2,313	96
8 by 8	25	1.99	0.52	5,754	2,603	84
10 by 10	24	1.97	0.53	5,721	1,662	96
15 by 15	27	1.81	0.42	4,827	2,121	81
2 by 6's						
6 by 8	22	1.96	0.41	5,882	2,095	100
8 by 8	23	1.86	0.35	5,817	1,950	96
10 by 10	31	1.72	0.35	5,193	1,942	90
15 by 15	28	1.73	0.43	5,075	1,901	96

[a] SD = standard deviation

The average MOE and MOR of No. 2 grade 2 by 4's and 2 by 6's generally decreased with increased tree spacing **(Table 3).** The average MOE of the No. 2 grade 2 by 4's did not vary significantly with spacing (p = 0.57). However, the average MOR of the No. 2 grade 2 by 4's was significantly different among spacings at the 0.07 level. Based on the Tukey test at the 0.05 level, the MOR of the lumber from the 15- by 15-foot spacing was significantly lower (25%) than that of the 6- by 8-foot spacing, but there was no difference among the 6- by 8-, 8- by 8-, or 10- by 10-foot spacings. Even though the MOR of the No. 2 grade 2 by 4's from the 15- by 15-foot spacing was significantly lower than that of the lumber from the 6- by 8-foot spacing, 81 percent of the No. 2 grade 2 by 4's from the 15- by 15-foot spacing was in compliance with F_b **(Table 3).**

The average MOE of the No. 2 grade 2 by 6's among spacings was significantly different at the 0.09 level. However, the Tukey test showed no significant difference between spacings at the 0.05 level. Average MOR of the No. 2 grade 2 by 6's did not vary significantly (p = 0.33) with tree spacing.

The proportion of No. 2 grade 2 by 4's and 2 by 6's that was in compliance for F_b was high (92%) for the study and the proportion in compliance did not vary consistently with increasing tree spacing **(Table 3).**

CONCLUSIONS

Tree spacing had a minimal effect on strength and stiffness of dimension lumber sawn from unthinned 40-year-old slash pine growing in the Georgia Coastal Plain. Average MOE and MOR of No. 2 grade 2 by 4's and 2 by 6's generally decreased when tree spacing increased from 6 by 8 feet (908 TPA) to 15 by 15 feet (194 TPA). However, only the MOR of No. 2 grade 2 by 4's showed a significant decrease (p = 0.05) between trees planted at spacings of 6 by 8 feet and 15 by 15 feet. The unthinned 40-year-old slash pine from all spacings sampled produced dimension lumber with excellent mechanical properties.

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