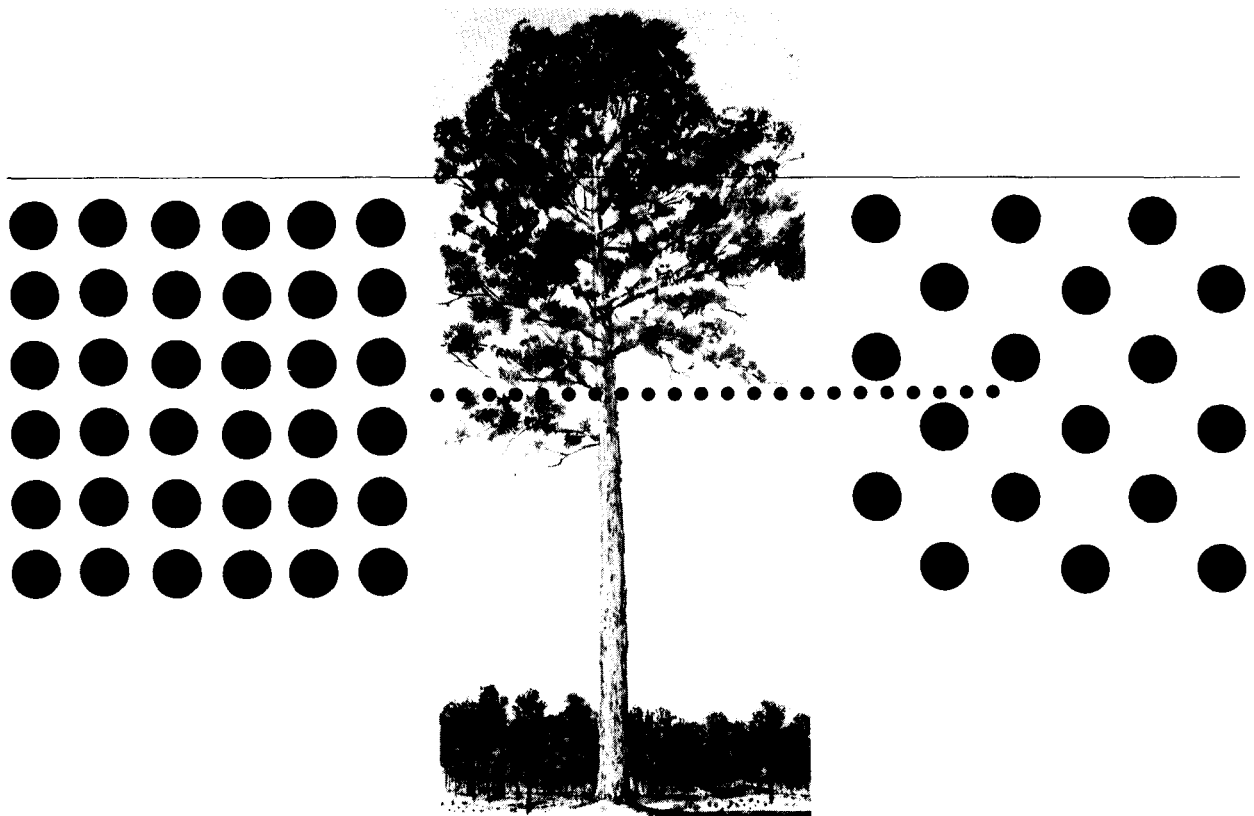


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WOOD QUALITY OF LOBLOLLY PINE AFTER THINNING



ABSTRACT

This study provides a comparison of loblolly pine wood produced 4 years after heavy thinning and pruning of 9-year-old stands with wood of unthinned stands of the same age.

A three-fold increase in radial growth was found to be accompanied by a significant increase in specific gravity and percentage of latewood in response to heavy thinning and pruning. A change in the relationship between specific gravity and percentage of latewood suggested that there were fundamental changes in the wood structure associated with thinning and pruning.

WOOD QUALITY OF LOBLOLLY PINE AFTER THINNING

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PREFACE

A review of inservice reports prompted the publication of this study, conducted in 1958, because it furnishes information in an area long neglected, but of current concern.

INTRODUCTION

In 1954, the Crossett Research Center² of the Southern Forest Experiment Station undertook a study to determine the shortest rotation required to produce loblolly pine sawtimber of good quality. The stand treatments combined heavy early thinnings with pruning. Although detailed analyses of wood quality, lumber grade, and yield will be made at final harvesting, the Center desired some preliminary examinations of the wood characteristics after 4 years of treatment to guide further thinning practices.

TREATMENTS STUDIED

The original study was established in the winter of 1953-54 to compare four thinning treatments applied to a 9-year-old stand of loblolly pine planted at a spacing of 6 by 6 feet along the contours. Study plots were 1/4 acre, surrounded by a 1/2-chain-wide isolation strip. There were three plots per treatment.

In this exploratory study of wood properties only two of the original four treatments were

¹ Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

² In cooperation with the Crossett Lumber Co., Crossett, Ark.

sampled. These are:

Treatment 1.--At 9 years of age (winter of 1953-54) remove all but 100 crop trees per acre; prune every 3 years to not more than 50 percent of total height.

Treatment 4. --No thinning at age 9. At 12 years of age (winter of 1956-57) select 100 crop trees per acre; thin stand to leave 85 square feet of basal area per acre, favoring crop trees; no pruning.

SAMPLING PROCEDURES

On April 14 and 15, 1958, five trees were selected at random from each of the three replications of treatments 1 and 4. Two standard increment cores (0.168 inch in diameter) that included the pith were taken from opposite radii at breast height in each tree. The cardinal direction of the cores in the trees was ignored, but in the case of leaning trees, cores were taken perpendicular to the direction of lean.

The wood characteristics studied were: annual ring width, percentage of latewood, specific gravity, and the number of earlywood and latewood cells laid down radially in each annual increment.

LABORATORY TECHNIQUES

Upon arrival at the Forest Products Laboratory, the cores were extracted with pure benzene for 3 days. This treatment removed resins and allowed specific gravity to be determined on the basis of actual wood substance.

For the comparisons of wood structure, the cores from both treatments were separated into three growth periods:

1. 1951-53 growing seasons, before the original study started.

2. 1954-56 growing seasons, which covered the 3 years of post-thinning growth on treatment 1 trees and 3 years of prethinning growth on the trees of treatment 4.

3. 1957 growing season, after the plots under treatment 4 had been thinned for the first time.

The first period of 3 years served as a uniformity trial to establish the initial comparability of plots assigned to the two treatments. The second 3-year period allowed a determination of the response to the heavy thinning and pruning of treatment 1. The third period of one growing season allowed a comparison of the wood produced during the first year after thinning of the plots under treatment 4 with that of the fourth year after thinning and the second pruning under treatment 1.

Ring width and percentage of latewood were measured for individual annual rings by the standard Forest Products Laboratory method.³ Concurrently, a record was made of the number of earlywood and latewood tracheids laid down radially within each annual ring. The within-ring values obtained for both cores were averaged to provide a value that was representative of the cross section.

In the case of specific gravity, a different procedure was followed--growth periods of the two increment cores from each tree were combined to give a direct average specific gravity by periods for each tree. Specific gravity was determined by the maximum moisture method.⁴

RESULTS

From the grower's point of view, the first question about wood quality might be, "Have the extreme thinnings of treatment 1 seriously lowered the specific gravity of the resulting fast-grown wood?"

To answer this question the growth period 1951-53 was considered first as it serves to establish the initial agreement between plots assigned to the two treatments. Analysis of variance indicated that there was no significant difference between the means (table 1) of the two treatments. The combination of heavy thinning and pruning of treatment 1 at the beginning of the 1954-56 growth period produced wood

³ Smlth, Diana M. Comparison of Two Methods of Estimating Summerwood Percentage in Wide-Ringed, Second-Growth Douglas-fir. U.S. For. Prod. Lab. Report No. 2033. 1954.

⁴ Smith, Diana M. Maximum Moisture Content Method for Determining Specific Gravity of Small Wood Samples. U.S. For. Prod. Lab. Report No. 2014. 1954.

Table 1.--The effect of treatments 1 and 4 on the average ring width, percentage of latewood, and specific gravity of loblolly pine

Treatment	Plot No.	1951-53			1954-56			1957		
		Ring width	Late-wood	Specific-gravity	Ring width	Late-wood	Specific-gravity	Ring width	Late-wood	Specific-gravity
		Mm.	Pct.		Mm.	Pct.		Mm.	Pct.	
1	2	6.61	22.4	0.373	9.35	35.7	0.455	11.28	37.9	0.472
	6	6.66	20.6	.350	8.43	39.0	.452	9.80	37.6	.456
	11	8.16	20.5	.371	11.04	33.2	.436	11.39	39.7	.460
Average.....		7.15	21.2	.365	9.61	36.0	.448	10.82	38.4	.463
4	3	6.45	25.0	.385	3.24	30.6	.424	4.15	55.2	.521
	5	6.58	21.7	.369	3.62	25.4	.409	4.17	54.4	.541
	8	6.63	24.3	.393	3.82	28.0	.423	4.38	53.9	.537
Average.....		6.55	23.7	.382	3.56	28.0	.419	4.24	54.5	.533

having a significantly higher (5 percent level) specific gravity than the unthinned plots of treatment 4. During this period trees on the thinned plots had ring-widths averaging nearly three times that of trees on the unthinned plots. In the final growth period, 1957, the wood produced during the fourth year after thinning and the year following the second pruning in treatment 1 was significantly lower in specific gravity (1 percent level) than that produced during the first year after thinning in treatment 4.

Differences in percentage of latewood between treatments followed trends similar to those observed for specific gravity. This is not surprising in view of the strong association known to exist between specific gravity and percentage of latewood in loblolly pine. For each treatment and each time period straight lines were fitted relating specific gravity to percentage of latewood (fig. 1). It is interesting to note that prior to thinning (1951-53), the slopes of these lines were about the same for the two treatments; in the period after the thinning in treatment 1, the slope for the thinned trees was significantly lower than that of the unthinned trees. This change in the relationship between specific gravity and percent latewood suggested that there were fundamental changes in the wood structure associated with thinning.

Considering the annual rings as a whole (fig. 2 and table 2) the average radial tracheid count for the pretreatment years shows fairly close

agreement between plots assigned to the two treatments. The small, but consistently higher, tracheid counts of treatment 1 can be attributed to plot 11 that produced generally wider annual rings throughout (table 2). As we would expect, ring width and radial tracheid count curves followed one another very closely (fig. 2, A and B). The response to the heavy thinning and pruning of treatment 1 in the winter of 1953-54 was a marked increase in ring width and number of tracheids laid down radially. The minor fluctuations probably reflect moisture conditions during the growing seasons that have become accentuated under treatment 1. For instance, the drought years of 1954 and 1956 and the more abundant rainfall of 1955 are clearly reflected in the curves. In 1957, the response in ring width and tracheid count in treatment 4 trees, thinned for the first time, was similar to treatment 1.

Percentage of latewood (fig. 2, C) increased generally from 1951 to 1957 with one interesting feature--an increase of 20 to 25 percent in latewood production for each treatment during the year immediately following thinning. Past studies have shown that heavy thinnings often produce compression wood that has a high proportion of latewood in the annual rings. Therefore, in this study an attempt was made to determine whether this was the case.

To assess quantitatively the occurrence of compression wood, the radial surfaces of the increment cores were smoothed with a microtome

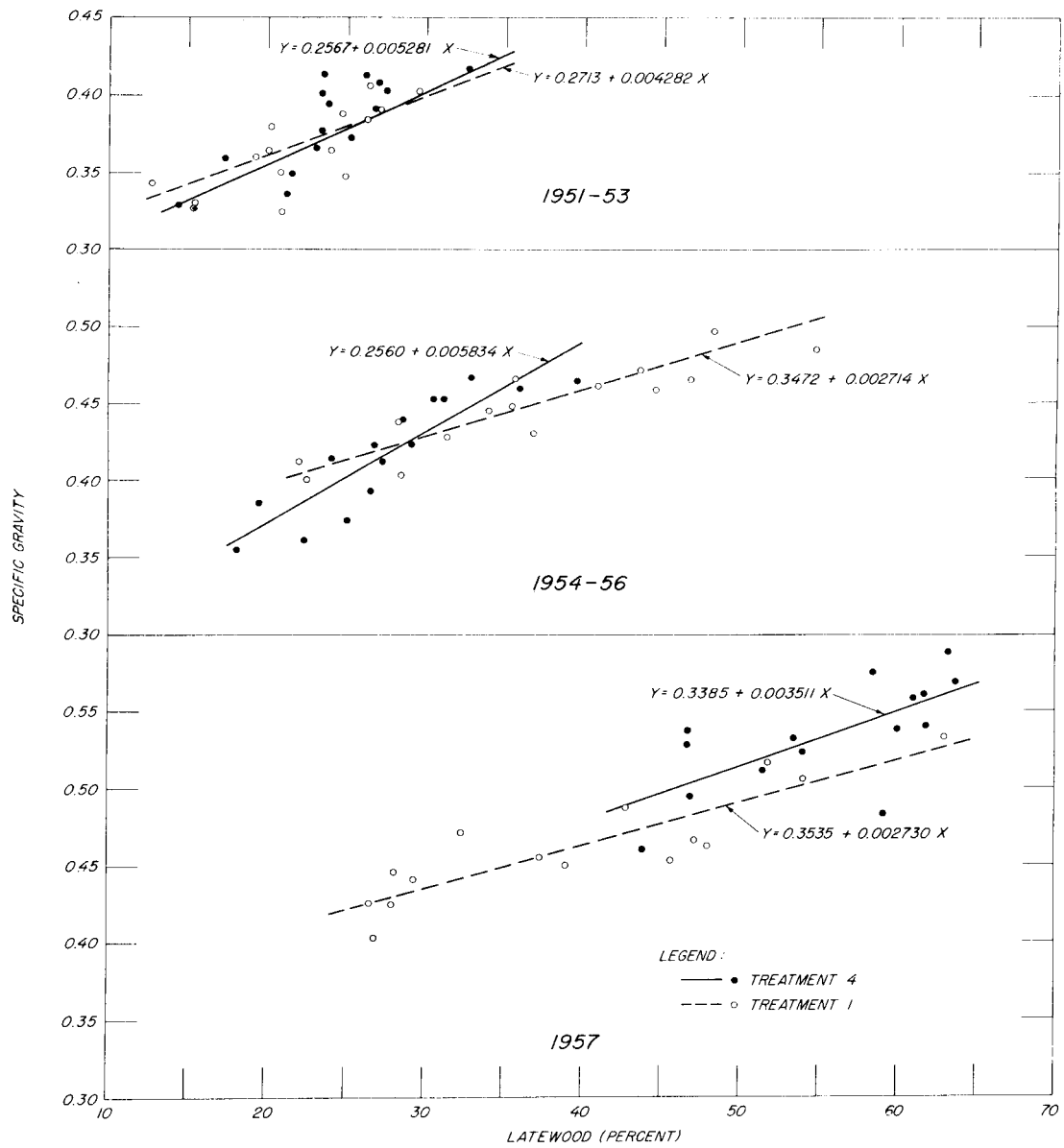


Figure 1.--Relationship between specific gravity of loblolly pine and percentage of latewood in the annual rings.

Each point represents a tree.

1951-53: Before treatment

1954-56: First thinning and pruning, treatment 1
Treatment 4, unthinned

1957: Second pruning, treatment 1
First thinning, treatment 4

(M 113 818)

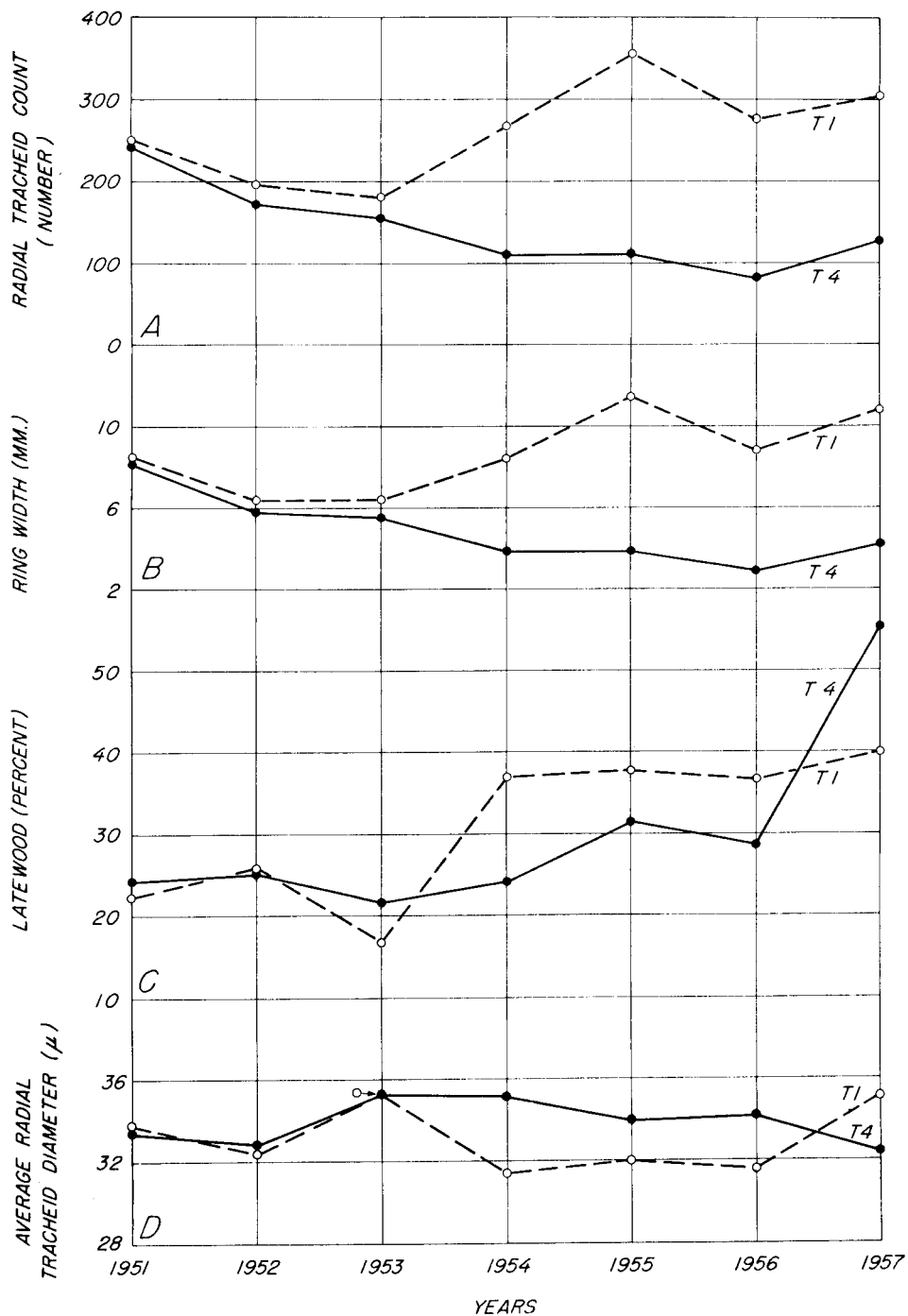


Figure 2.--Annual development of loblolly pine growth rings under treatments 1 and 4.

1951-53: Before treatment

1954-56: First thinning and pruning, treatment 1
Treatment 4, unthinned

1957: Second pruning, treatment 1
First thinning, treatment 4

(M 113 819)

Table 2.--Anatomical structure of earlywood and latewood of loblolly pine showing response to treatments 1 and 4. All determinations made in the radial direction.

Growth period	Treatment	Plot No.	Tracheid count			Width of zone			Proportion of latewood in annual ring	Average tracheid diameter	
			Early-wood	Late-wood	Annual ring	Early-wood	Late-wood	Annual ring		Early-wood	Late-wood
			No.	No.	No.	Mm.	Mm.	Mm.	Pct.	μ	μ
1951-53	1	2	134	61	195	5.13	1.48	6.61	22.4	38.0	23.9
		6	133	57	190	5.29	1.37	6.66	20.6	40.3	23.6
		11	179	71	250	6.49	1.67	8.16	20.5	36.2	23.3
Average.....			149	63	212	5.64	1.51	7.15	21.2	38.2	23.6
	4	3	123	67	190	4.84	1.61	6.45	25.0	39.7	23.8
		5	131	64	195	5.15	1.43	6.58	21.7	39.6	22.4
		8	132	67	199	5.02	1.61	6.63	24.3	38.6	23.8
Average.....			129	66	195	5.00	1.55	6.55	23.7	39.3	23.3
1954-56	1	2	165	130	295	6.01	3.34	9.35	35.7	36.4	25.3
		6	135	127	262	5.14	3.29	8.43	39.0	38.5	25.6
		11	203	146	349	7.38	3.66	11.04	33.2	36.4	25.5
Average.....			168	134	302	6.18	3.43	9.61	36.0	37.1	25.5
	4	3	51	43	94	2.25	.99	3.24	30.6	44.0	23.0
		5	63	41	104	2.70	.92	3.62	25.4	42.9	22.5
		8	66	46	112	2.75	1.07	3.82	28.0	41.8	22.5
Average.....			60	43	103	2.57	.99	3.56	28.0	42.9	22.7
1957	1	2	172	143	315	7.00	4.28	11.28	37.9	39.7	30.0
		6	155	122	277	6.12	3.68	9.80	37.6	39.7	30.2
		11	174	153	327	6.87	4.52	11.39	39.7	39.5	29.5
Average.....			167	139	306	6.66	4.16	10.82	38.4	39.6	29.9
	4	3	41	83	124	1.86	2.29	4.15	55.2	45.2	27.3
		5	45	86	131	1.90	2.27	4.17	54.4	42.2	26.2
		8	47	86	133	2.02	2.36	4.38	53.9	43.3	27.0
Average.....			44	85	129	1.93	2.31	4.24	54.5	43.6	26.8

knife and examined microscopically for the presence of checks in the walls of the tracheids that are indicative of compression wood. Five classifications of compression wood were recognized:

- (0) Compression wood absent
- (1) Isolated compression wood tracheids
- (2) Narrow bands of compression wood tracheids
- (3) Broad bands of compression wood tracheids
- (4) Compression wood tracheids only

Results of the examination are shown in table 3 separately for the duplicate increment cores taken from each tree under treatments 1 and 4 and for the annual ring sequence 1951-1957. Since the numerical designations are approximately in order of the magnitude of the occurrence of compression wood, these values were averaged for each plot and treatment. Within a

single annual ring, results are quite erratic. However, there is some indication that the trees under treatment 1 tended to produce compression wood for the period of 3 years (1954-1956) following heavy thinning and pruning; whereas the lighter thinning of treatment 4 (1957) did not result in the formation of compression wood.

Of particular interest is the average radial diameter of the earlywood and latewood tracheids (fig. 3, C) that were computed from the measured width of the respective zones and the cell counts. The earlywood tracheids were narrower, and the latewood tracheids wider, in treatment 1 than in treatment 4. The differences were trivial in the pretreatment period but became quite large after treatment. Of interest also is the apparent correlation between tracheid diameter and the number of tracheids laid down radially within the zones (fig. 3). In

Table 5.--Occurrence of compression wood¹ in the latewood of loblolly pine in response to treatments 1 and 4

Treatment 1								Treatment 4									
Plot No.	Tree No.	1951	1952	1953	1954	1955	1956	1957	Plot No.	Tree No.	1951	1952	1953	1954	1955	1956	1957
2	2	0	0	0	0	1	1	0	3	4	0	0	0	0	2	1	0
		2	1	2	3	0	2	0			1	0	0	1	0	0	0
	9	2	1	1	2	3	3	0		5	0	2	2	2	4	0	4
		0	0	2	2	2	2	0			1	0	0	0	0	0	1
	10	2	2	1	4	4	4	0		13	0	0	0	0	0	0	0
		2	1	0	2	4	4	3			3	2	0	0	0	0	0
	16	1	0	3	0	4	4	2		19	0	1	2	3	0	0	0
		1	1	0	4	2	2	0			1	2	0	0	0	0	1
	18	2	1	1	4	1	1	0		20	4	2	2	1	0	4	0
		2	0	1	1	1	0	0			1	0	0	1	0	1	0
Plot Av.		1	1	1	2	2	2	0	Plot Av.		1	1	1	1	1	1	1
6	7	0	0	0	4	3	2	3	5	3	4	1	0	0	0	0	0
		0	0	0	0	1	0	0			0	0	0	0	0	0	0
	13	0	0	0	1	0	0	0		10	0	0	0	0	0	0	0
		3	4	0	1	1	0	0			0	0	0	0	0	0	0
	21	0	0	1	3	2	2	1		12	0	0	0	0	0	0	0
		0	0	0	0	0	2	0			0	0	0	0	0	0	0
	23	0	0	0	0	0	0	0		17	1	0	0	0	0	0	0
		3	2	0	0	0	0	1			0	1	0	0	0	0	0
	25	1	1	0	3	3	1	0		23	2	2	1	1	1	0	0
		4	2	1	0	1	0	0			0	0	0	0	0	0	0
Plot Av.		1	1	0	1	1	1	0	Plot Av.		1	0	0	0	0	0	0
11	7	0	0	2	1	0	1	0	8	1	2	2	2	0	1	0	0
		2	0	1	3	2	0	1			2	0	1	0	0	0	0
	10	2	1	0	1	2	0	0		4	0	0	0	0	0	0	0
		2	2	0	2	2	3	2			2	0	0	0	0	0	0
	14	4	0	2	4	3	2	0		7	2	0	0	0	0	0	0
		0	0	1	3	2	2	0			4	3	0	0	4	0	0
	21	4	4	4	3	4	4	1		11	4	3	3	1	4	0	0
		0	0	1	4	4	2	0			2	0	1	0	0	0	0
	25	4	4	4	3	4	4	2		16	1	1	0	0	0	1	0
		0	0	2	1	2	2	1			2	0	2	0	0	0	1
Plot Av.		2	1	2	2	2	2	1	Plot Av.		2	1	1	0	1	0	0
Treatment									Treatment								
Average		1	1	1	2	2	2	1	Average		1	1	1	0	1	0	0

¹0 = compression wood absent; 1 = isolated compression wood tracheids; 2 = narrow bands of compression wood tracheids; 3 = broad bands of compression wood tracheids; 4 = compression wood tracheids.

the case of earlywood, the correlation is negative, whereas for latewood the correlation is positive. The nature of these correlations becomes even more evident when average cell diameter is plotted against the number of cells within the zone as in figure 4.

From figure 4 it is apparent that different mechanisms of growth control the development of these two zones within the annual increment.

The positive relationship observed for latewood may be associated with soil moisture availability which has been shown to affect both the diameter and number of tracheids laid down in the latewood zone. The negative relationship observed for earlywood is obviously related to factors of growth (other than moisture availability) that control the rate of cell division and differentiation.

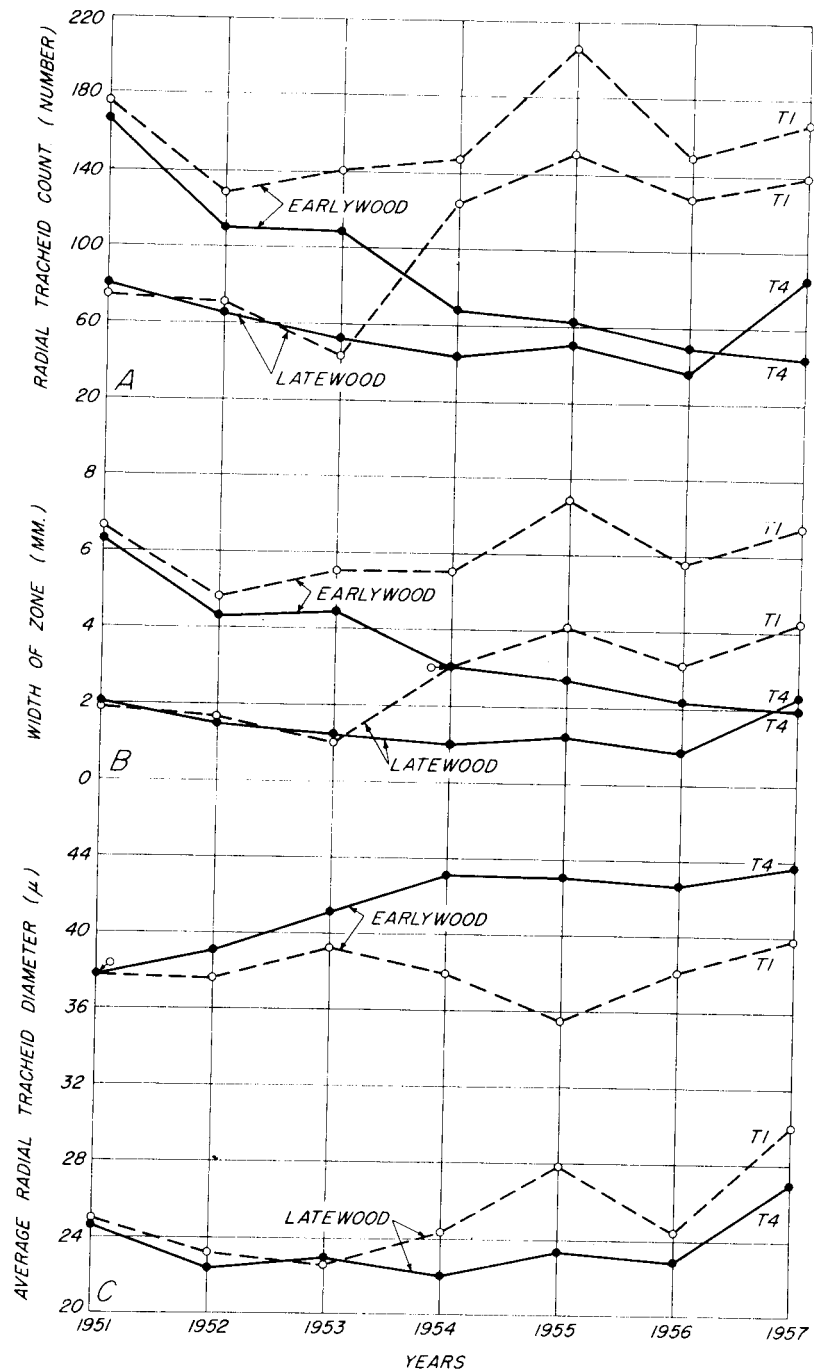


Figure 3.--Annual development of earlywood and latewood of loblolly pine under treatments 1 and 4.

1951-53: Before treatment

1954-56: First thinning and pruning, treatment 1
 Treatment 4, unthinned

1957: Second pruning, treatment 1
 First thinning, treatment 4

(M 113 820)

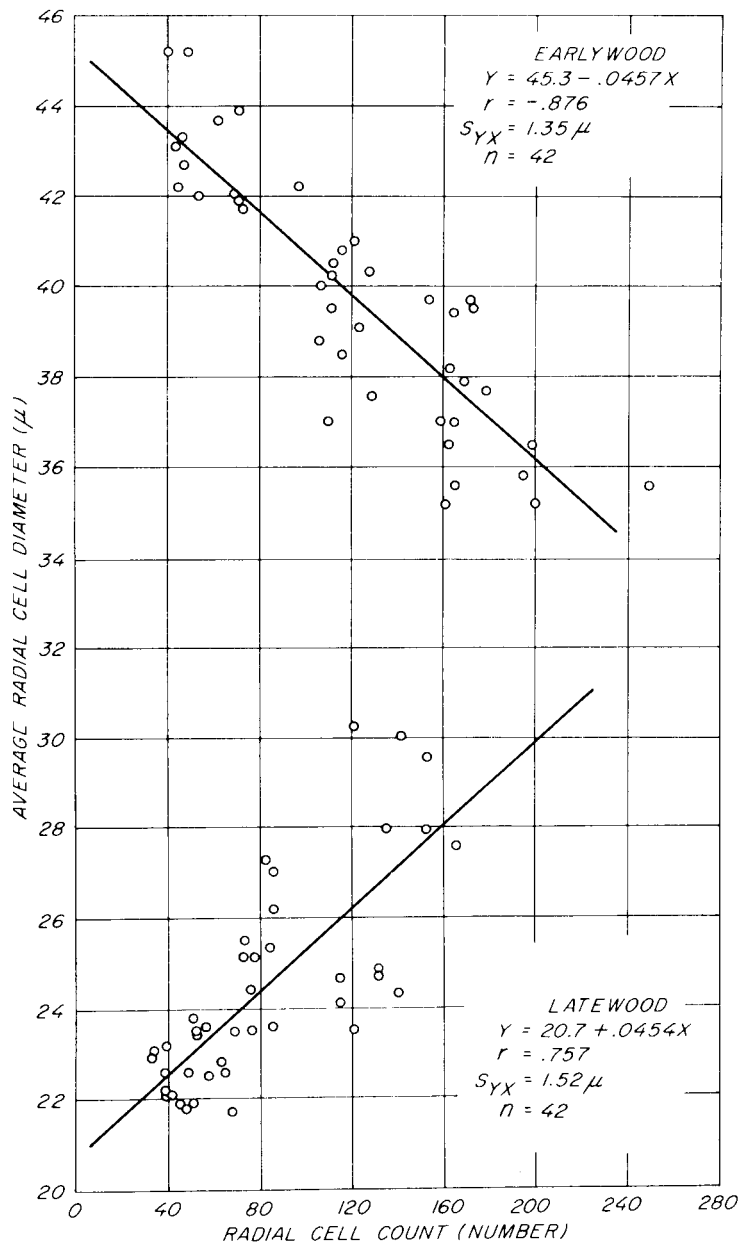


Figure 4.--Correlation between average radial tracheid diameter and the total number of tracheids laid down radially within the growth zone. Each point represents a plot average for a given year's growth.

(M 133 892)

CONCLUSIONS

The trend in wood structure of loblolly pine as influenced by thinning and pruning after 4 years of treatment has been shown in this preliminary study. On the basis of increment cores taken at breast height, results indicate that:

1. Initially, heavy thinning and pruning at age 9 years produced wide-ringed wood having a significantly higher specific gravity than that of the unthinned stands of the same age.

2. Light thinnings, delayed until the 12th year, produced wood of specific gravity significantly higher than the earlier thinned stands. This is on the basis of only 1 year's growth, during which treatment coincided with heavy autumn rainfall, making it impossible to predict whether this initial advantage can be maintained.

3. On the basis of individual annual rings, response to thinning is reflected in a striking increase in percentage of latewood for the year following thinning.

4. Thinning produced earlywood tracheids that were narrower and latewood tracheids that were

wider than those found in the unthinned stands. Superimposed on this trend is the influence of water relations--for instance the more abundant rainfall of 1955 is reflected in a decrease in cell size within the earlywood zone and an increase in cell size within the latewood zone.

5. In general agreement with the above, the relationship between specific gravity and percentage of latewood in the annual rings is also influenced by thinning and pruning. It is expected that for the thinned stands the narrower tracheids of earlywood would have a higher specific gravity and the wider tracheids of latewood a lower specific gravity than the unthinned stands; this phenomena may have contributed to the trend in the specific gravity-percentage of latewood relationship.

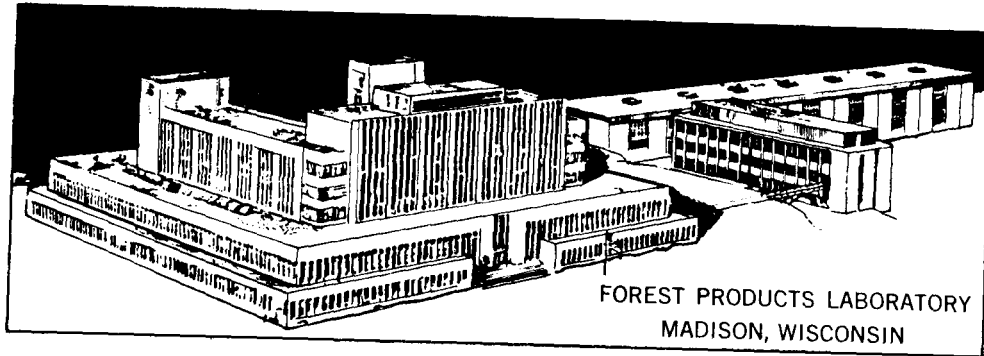
Future investigations should be expanded to ascertain whether increase in percentage of latewood immediately following thinning is due to the formation of compression wood, and to explore the variations in specific gravity of earlywood and latewood as indicated by tracheid dimensions.



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