Slash, Loblolly, and Shortleaf Pine in a Mixed Stand; A Comparison of Their Wood Properties

DONALD E. COLE, BRUCE J. ZOBEL, AND JAMES H. ROBERDS [1/]

INTRODUCTION

Differences have been reported among the major southern pines[2/] with regard to disease resistance, form and rate of growth although there are conflicts, particularly regarding differences in growth rate. In addition, differences have been reported for such characteristics as wood specific gravity, extractive content, and total yield (see Mitchell, 1963; Johnson and Roth, 1896; Chidister et al, 1938; Robinson, 1956; and Bray and Curran, 1937). In many of the studies of growth rate and in most of the wood property and pulping studies, a direct comparison of different species has not been made in which site, age, and spacing are comparable. If one is interested in the real productive potential of slash and loblolly pine, a comparison of slash pine in north Florida with loblolly pine in central South Carolina, for example, is quite meaningless. There are many reports in the literature which do just that and often it is then concluded that species differences exist. It is essential to compare trees of the same age, growing under the same conditions, in order to make a really meaningful comparison between species.

Such a comparison, in which differences between species could be isolated from differences due to geographic origin, age, site, or other confounding variables, would be of considerable practical importance as a guide in forest management planning, in interpreting reported differences in growth rate, and in situations where a choice could be made between

[1/] Respectively: Research Forester, Continental Can Company, Savannah, Ga.; Professor of Forest Genetics, and Liaison Geneticist, North Carolina State University, Raleigh, N. C.

[2/] Slash pine (*Pinus elliottii* var. *elliottii* Englm.), loblolly pine (*Pinus taeda* L.) and longleaf pine (*Pinus palustris* Mill.).

the species.

In order to clarify the wood property relationships among loblolly, slash, and longleaf pine, a study was initiated cooperatively by Continental Can Company, Inc., Savannah, Georgia, and the Cooperative Tree Improvement Program at North Carolina State University, Raleigh, N. C.

The present paper reports the results of the work done on the breast height increment cores; the data from the felled trees, from which wedges and cores were obtained and on some of which pulping studies were made, will be reported in a more complete paper at a later date.

The objectives of the study were:

A. To compare the wood properties of slash, loblolly and longleaf pine by analyzing wood samples from a mixed even-aged stand on a relatively uniform site.

B. To determine which species produces the most wood substance under these conditions.

METHODS

A. Field Procedures:

The study was conducted on a fifteen-acre old field stand in Bulloch County, Georgia. It is remarkably uniform with virtually no relief and less than 1% slope. It is a soil of the Kley series; after a careful examination, it was found that the soil site index for a given species varied less than five feet within the stand; site index at 50 years was 71' for longleaf and pond pine, 80' for slash pine and 90' for loblolly pine. There has been one very light improvement cut in the stand but otherwise it has been undisturbed. The stand is about 40% slash pine with loblolly and longleaf pine each making up about 30% of the volume. A very few pond pines are growing throughout the area, and nine were large enough to include in the study. Although the pond pine sample size is too small to permit us to draw definite conclusions, it does give some basis for comparing this species with the other three species. All three major species grow intermixed throughout the stand.

Fifty dominant or co-dominant sample trees were chosen for each species. Trees with excessive lean, crook, or large fusiform stem cankers were avoided. The loblolly and longleaf sample trees, being least abundant, were marked first and then the slash sample trees were chosen in the vicinity of the other two species; thus sample trees were grouped in the same areas of the stand. Each sample tree was paint-marked, bark-scribed with a number, and described externally by a series of measurements of height, diameter, crown size, and bole straightness. The mensurational data is summarized in Table 1. In addition, a record was made of all sample trees located within 50' of any other sample tree so comparisons of sample trees growing adjacent to each other could be made. A bark-to-bark 10 mm. increment core was taken at 4.5' from each sample tree. Cores which contained knots or pitch pockets or which missed the pith by more than two rings were rejected and these trees were re-bored until a satisfactory core was obtained.

These double cores were used for the determination of specific gravity, extractive contant, tracheid length, & cellulose content; this phase of the work was done during December, 1963, and January, 1964. Later it was decided that additional data on these trees was needed, including moisture content of the wood. Therefore in May & June, 1964, an additional bark-to-pith core was pulled from each sample tree and weighed in the field; these cores were obtained with an electric drill powered by a portable gasoline generator.

At the same time, ten trees of each of the three major species were felled; each bolt was weighed, and cores and wedges were taken from each bolt for the determination of wood properties. Finally, two trees from each species were sent to the Research and Development Laboratory of Continental Can Company's Paperboard and Kraft Paper Division, in Augusta, Georgia, for pulping studies; the details of this phase of the study will be reported later. To obtain moisture content of the wood, the cores were weighed in the field using the following procedure; after the reversible drill was backed out of the tree, the bit was removed from the drill and carried (with

Table 1. Mensurational Data.

Species	No. Trees	DBH	Total Height	Rings @ BH	CW Years	Cu. Vol. 2" Top*
Lob.	50	10.2"	56'	16	7	13.3
L. L.	50	10.8"	58'	21	7	11.8
Sl.	50	10.0"	54'	17	7	11.6
P. P.	9	11.0"	50'	21	7	--

* - Adjusted to a common age.

the core inside) to the field laboratory. There the core was removed from the bit, the bark was removed and the whole core was weighed. Then the core was separated into outerwood (mature wood) and visual corewood _/and each segment was weighed separately. Next, the segments were labeled, the length and number of rings per segment was recorded, they were put into plastic bags, and sent to N.C. State University for laboratory analysis. The cores were weighed on a Mettler K7-T Balance which weighs to 1/100th gram with an accuracy of ± 3/100 grams. This accuracy corresponds to about 1/10% of the weight of the average corewood segment (outerwood segments were heavier) and about 1% of the weight of the smaller corewood segments. The accuracy of the rapid-reading balance was checked each time it was set up and it gave very little trouble in use. Cores were stored prior to analysis under running water to prevent molding. All field work was done as rapidly as possible to avoid loss of moisture by evaporation.

B. Laboratory Analysis

Wood property determinations made in the North Carolina State University laboratory included:

1. Specific gravity before and after extraction.
2. Extractive content (alcohol- benzene soluable.)
3. Moisture content.
4. Tracheid length.
5. Cellulose content.

Moisture content is the ratio of weight of water lost on drying to unextracted dry weight of the wood. It is important to note that the basis is dry wood weight because often moisture content is reported as the ratio based on wet weight.

Specific gravity is determined by the ratio of dry weight to green volume; from the difference in dry weight of the cores before and after extraction, the extractive content is calculated and expressed as a percentage of the dry weight of the extracted wood. Extractive content here refers only to those substances extractable by alcohol-benzene; this is not a complete extraction although most of the resinous materials are removed.

Tracheid lengths determined are average values for uncut tracheids. Forty tracheids were measured for each segment of each core.

Cellulose yields were obtained by a method developed by Yundt and Bradway (see Zobel and McElwee, 1958). It is a survey method, involving a chloriting procedure to obtain the water resistant carbohydrates (loosely referred to as holo-cellulose). In addition, alpha cellulose was determined. The data on cellulose content and tracheid lengths is summarized in Table 2; the data on specific gravity, extractive content, and moisture content is summarized in Table 3.

Table 2. Cellulose content and tracheid length data.

SPECIES	CELLULOSE CONTENT %				TRACHEID LENGTH	
	HOLO		ALPHA			
	CW	OW	CW	OW	CW	OW
Lob.	81.59	83.27	54.62	61.33	2.58	3.45
L. L.	74.74*	79.65	51.44	60.26	2.88**	3.81**
Sl.	78.07	81.13	55.28	62.14	2.62	3.55
P. P.	79.67	82.33	54.70	61.55	2.60	3.50
Avg.	78.13	81.35	53.78	61.24	2.69	3.60

* - Differs significantly at the 5% level.
** - Differs significantly at the 1% level.

Table 3. Specific gravity, extractive content, and moisture content data.

SPECIES	SPECIFIC GRAVITY						Extractive Content %			Moisture Content % *		
	Unextracted			Extracted								
	CW	OW	Wt'ed.	CW	OW	Wt'ed.	CW	OW	Wt'ed.	CW	OW	Wt'ed.
Lob.	.430	.553	.541	.413	.540	.527	3.06	2.67	2.71	126.8	102.0	104.5
L. L.	.503	.542	.538	.442	.529	.520	13.57	2.42	3.53	95.2	98.1	97.8
Sl.	.462	.538	.530	.439	.526	.517	4.99	1.78	2.10	99.2	97.2	97.4
P. P.	.420	.481	.475	.396	.468	.461	-	-	-	-	-	-

* - Adjusted for differences in age and extractive content.

3/ Corewood has a characteristic "lifeless" appearance because of difference in light reflectivity. It is often "cheesy" in consistency and has very little summerwood. There is no sharp line of demarcation between corewood and outerwood, but usually the separation comes at the 7th to 10th ring from the pith. Corewood must not be confused with heartwood which may or may not be present.

RESULTS AND DISCUSSION

A. Cubic Volume

Adjustment of the volumes of the different species to a common age by co-variance analysis showed that there were differences between the species in cubic volume to a 2" top; the differences were significant at the 5% level and the average volume of the loblolly was significantly higher than either the slash or longleaf sample trees.

Rings at breast height was used to estimate age for this analysis which gives a conservative or low estimate of the age of the longleaf sample; if rings at breast height plus three had been used for the loblolly and slash sample trees and rings at breast height plus five for the longleaf sample trees, the differences in cubic volume between species would have been more marked. It is surprising, and important, that on this typical flatwoods slash pine site the average volume of the loblolly sample is 15% greater than that of the slash sample.

B. Specific Gravity

Probably the most important single finding of this study is that there were no significant diferences between the outerwood specific gravity, extracted or unextracted, of the slash, loblolly, and longleaf pine sample trees in this stand where all three species were growing together in a natural stand (see Table 3). Although the specific gravity of the loblolly pine was somewhat higher than that of the other two species the differences were not statistically significant.

These results are quite different from the idea held by most foresters and should prompt a very close scrutiny of our opinions as to the merits of these species.

There were small differences between species in corewood specific gravity but they will have only a small net effect. An average of 90% of the total merchantable volume of these trees was outerwood based on measurements of the 31 trees which were felled and sampled intensively. If a 0.02 difference in specific gravity is equal to a change of 100 pounds in the dry weight of a cord of wood (see Mitchell, 1963) the difference of 0.03 between the extracted corewood specific gravity of the loblolly sample trees and that of the slash and longleaf sample trees would indicate a difference in dry weight of only 15 pounds per cord between species.

There were so few pond pine sample trees that the data on these trees were not included in the general analyses. However, the differences in specific gravity between pond pine and the other species are so marked that there would undoubtedly be reduced yields from such wood.

C. Moisture Content Percent

Moisture content data adjusted to a common age (as measured by rings at breast height) for all species showed some differences between species (see Table 3). However, these differences were not statistically significant

D. Extractive Content

Surprisingly, all species were nearly alike in the extractive content percent of the outerwood. The corewood was much more variable with the loblolly and slash sample trees being significantly lower and the longleaf sample trees being significantly higher than the average. Total extractive content, corewood and outerwood, followed the same pattern as the corewood extractive content, with the longleaf being highest at 3.54%; this was 27% greater than the average weighted extractive content at breast height for all three species and would probably be of some economic significance.

It appeared from the samples studied that the longleaf pine had a greater amount of heartwood formation than the other two species.

E. Age (Rings at Breast Height)

The loblolly and slash pine sample trees did not differ significantly from one another in age. However, the longleaf sample trees differed significantly (at the 1% level) from the others when age was expressed as rings at breast height, being an average of 5.5 years older than slash or loblolly pines. As was noted earlier, total age would have shown even greater differences. Even though the range was from 16 to 21 rings at breast height the stand sampled was considered to be essentially even-aged.

F. Core Wood Years at Breast Height

This analysis showed no difference among the three major species in the number of years (or rings) of corewood formation at breast height; it was about seven years for all three species.

The range of years of corewood formation was also very nearly the same for all species, from a low of four years to a high of eleven years. That there were no differences between species is especially surprising because these values were based on an independent ocular estimate for every tree and it is commonly thought that the duration of corewood formation would vary considerably between species.

G. Tracheid Length, Corewood and Outerwood

Analysis of the tracheid length data showed that the longleaf sample trees had longer tracheids, both in the corewood and the outerwood, than the other species; this was significant at the 1% level. The differences in tracheid length between the slash and loblolly were not significant.

The differences between longleaf and the other species are of such low magnitude (about 3/10 mm.) that their effect on paper properties is questionable; however, this data indicates that there are real differences between longleaf and the other two species, at least in this population.

H. Cellulose Content Percent 4/

There were no significant differences betweenthe species in alpha cellulose content, either in the corewood or the outerwood, nor in the holo-cellulose content of the outerwood.

However, the holo-cellulose content percent of the corewood of the longleaf sample trees was significantly lower (at the 5% level) than that of the other species in spite of the fact that its corewood specific gravity was higher (these determinations were made on extracted wood). But the effect of this low cellulose content on pulp yields would be negligible because of the low proportion of corewood in these trees.

I. Form Class (Fogelberg's)

There were no significant differences among the species in this stand in form class as determined on the standing trees by Fogelberg's method. This also was somewhat surprising since it is commonly felt that both slash and longleaf pine have better form than loblolly pine.

CONCLUSIONS

The results of this study, based on data from 10 mm. increment cores at breast height, indicate that where loblolly, longleaf and slash pine are grown together in natural stands there are no significant differences among them in (1) outerwood specific gravity, extracted or unextracted; (2) moisture content; (3) years of corewood formation; (4) cellulose content (except for corewood holo-cellulose content); and (5) form class (Fogelberg's).

Differences were found in tracheid length, corewood specific gravity and corewood holo-cellulose content but they were of such low magnitude that they probably would have little effect on pulp yields or paper properties when total yields per acre are considered.

There were important differences between the species in rate of growth and extractive content. The loblolly sample trees were significantly larger in cubic volume (15%) than the longleaf and slash in spite of the fact that the estimate of age used in the analysis (rings at breast height) was probably biased in favor of the longleaf sample trees. The longleaf sample trees had the highest total extractive content at breast height (27% more extractives than the average of the slash and loblolly sample trees); this would probably be a factor of economic significance.

4/ Cellulose yields are the ratio of cellulose obtained to the dry weight of the wood used.

The results cited here apply with certainty only to this particular stand and this data, should not be applied to other areas until such time as these results have been tested and confirmed in other mixed stands.

However, we believe that the results are significant enough to warrant further investigation; if these results are confirmed, we should adjust our thinking about these species in the light of this new information on wood properties and growth.

LITERATURE CITED

Mitchell, H. L., 1963. Specific gravity variation in North American conifers. Sect. 41, For. Products, I.U.F.R.O., Sept. 11-13, 1963; Madison, Wisconsin.

Johnson, J. B. and F. Roth, 1896. Southern pines; mechanical and physical properties. U.S.D.A. Div. For. Circ. 12, pp. 12.

Chidister, G. H., J. N. McGovern, and G. C. McNaughton, 1938. Comparison of sulphite pulps from fast-growth loblolly, shortleaf, longleaf, and slash pine. Paper Trade Journal 107:36-39.

Robinson, J. M., 1956. Pulping evaluation of six pine species. 6th Alkaline Pulping Conference, New Orleans, La., Nov. 14-15, 1956. 16 pp.

Bray, M. W. and C. E. Curran, 1937. Sulphate pulping of southern yellow pines: Effect of growth variables on yield and pulp quality. Paper Trade Journal 105:39-46.

Zobel, B. J. and R. L. McElwee, 1958. Variation of cellulose in loblolly pine. Tappi 41: 167-170.