Specific Gravity Variation In Mississippi Pines 1/

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Specific gravity variation--in which inheritance plays a part--is an important concern in the field of forest tree improvement. Dense wood is valued for some purposes, less dense wood for others. For most products normally made from southern pine, high density is desirable. Accordingly, new data here presented on some of the factors that affect specific gravity in southern pines are of special interest to researchers concerned with the improvement of these species.

Work on the specific gravity of southern pines was started by the Forest Survey at the Southern Forest Experiment Station primarily to obtain a better measure of pulpwood quality, since kraft pulp yield is known to increase directly with wood density. The strength of pine lumber, poles, and other products is also related to specific gravity. Such Statewide studies also show promise of yielding considerable fundamental information of value in forest management and other related fields.

In the recent cooperative Forest Survey in Mississippi, some 8, 000 increment cores were obtained to the heart center of each pine point-sampled on a 3- by 3-mile grid. The Forest Products Laboratory determined specific gravity, by the calibrated increment borer technique (2), 3/ and also tree age at breast height. These data were correlated with other tree and stand characteristics for analysis. Preliminary results are discussed in a recent

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1/ Paper presented at Fifth Southern Forest Tree Improvement Conference, Raleigh, N. C. , June 11-12, 1959.

2/ Maintained at Madison, Wis. , in cooperation with the University of Wis.

3/ Underlined numbers in parantheses refer to Literature Cited at the end of the article.

Forest Products Laboratory Report (3) and elsewhere.

In a companion study of 100 trees each of the four principal southern pines, the Forest Products Laboratory and the Southern Station, in cooperation with the International Paper Company, have related core gravity to tree gravity (4). This relationship is needed to combine the effect of volume growth with that of specific gravity to present the total effect of tree weight increase with age. The geneticist, however, is often more concerned with the variation to be expected in the individual core samples he obtains.

The Mississippi Survey core gravity data were analyzed with the Southern Station IBM 704 regression program developed by Grosenbaugh (1). Following are the nine independent variables included in the regression analysis:

Tree age at breast height (A)
Reciprocal of age (1/Age)
Tree DBH, inches (D)
DBH/Age (D/A)
Tree volume in cubic feet, i. b. , to 4-inch top (V)
Stand basal area, square feet per acre (BA)
Latitude, 3-mile units, North to South (Lat)
Longitude, 3-mile units, East to West (long)
Latitude X longitude (LXL)

Table 1 includes the means for each of the variables and the number of observations on which they were based for each of the four species.

The four species of southern pines are affected similarly by the nine variables (table 2). As we have long known, longleaf and slash pine are closely related. They have higher average core specific gravities than the less closely related loblolly and shortleaf pines. The difference between mean core specific gravity of the two groups, however, is somewhat exaggerated by species distribution in Mississippi. Loblolly and shortleaf grow over most of the State. Longleaf and slash occur only in south Mississippi where the warm-season rainfall is highest and more frost-free days occur. Ample soil moisture is known to favor sum merwood formation, and thus affect specific gravity.

By far the most important single variable tested to predict core specific gravity was 1/Age (table 2 and figure 1). For the four species tested, this variable makes up from 63 to 81 percent of the total variation explained by the nine variables. Each of the other five tree and stand variables reflect the effect of age when used as a single variable in estimating equations. However, when nine-variable regressions were computed for each species, volume, d. b. h. , and stand basal area (the latter with the exception of slash pine) did not significantly contribute to the estimating equations. Basal area probably has an effect on slash pine because, if not properly thinned, stands of this species become stagnant. Diameter is not significant when used with D/A and age, because the product of these variables equals diameter.

Because core specific gravity is so strongly correlated with age (figure 2 and table 2), the geneticist must consider the age of each tree studied. In plantation studies, where age is constant, this is not a problem. But in the selection and rating of plus trees in mixed age stands, the age factor must be taken into account when comparing an individual with its neighbors. A procedure for making such comparisons, using curves of average core gravity over age for the species and the same general geographic location, is discussed in another publication (2).

Probably an even better way to rate plus trees, especially for gross pulp yield potential, is on the basis of merchantable dry weight attained by an individual at a given age, as compared with the average for the species in the same general area. Preliminary curves of this nature are now available for Mississippi pines (fig. 3). Merchantable dry weight per tree (in pounds) is the product of net volume (in cubic feet) X tree density (in pounds per cubic foot). Tree densities are estimated from core densities with the regression equations given in figure 10 of the Wahlgren-Fassnacht report (4).

Holding constant the six variables other than latitude, longitude, and latitude times longitude, enables calculation of the effect of geographic location. It is true that geographic location includes the effects of rainfall, soil, heredity, and other factors, However, if comparison of specific gravity isograms with the warm-season rainfall chart shown in figure 4 is reasonably indicative, rainfall seems to have an effect on the specific gravity. It is most pronounced in loblolly pine (fig. 5); shortleaf (fig. 6) and longleaf (fig. 7) are less affected. If there is any effect of rainfall on slash pine, it seems to be overshadowed by what may be a hereditary trend as the species approaches the western limit of its natural range (fig. 7). Soil differences within Mississippi must also have their effect--what we do not know. We will obtain information on soil effects in the current Arkansas Forest Survey.

As shown by the isograms, core specific gravity of loblolly and shortleaf pine increases from northwest to southeast Mississippi. Therefore a superior loblolly or shortleaf tree in the northwest part of the State may have the same or only slightly higher core specific gravity than that of an average tree in the southeast.

Because age so greatly affects core specific gravity, tests for mean age differences between stands in various regions of the State were made. No significant difference was found. It seems reasonable, therefore, that isograms of core specific gravity reflect true variation.

Specific gravity also varies within the individual tree. If the exact relationship between the specific gravity of a core and the tree from which it was extracted were known, the true difference between trees might be predicted more accurately. When the variation attributable to significant variables is known, the remainder may be due to genetic factors. Some clue to the remaining unexplained variation was obtained by applying the specific gravity relationship between core and disk (found by the Wahlgren-Fassnacht study) to the variation explained by the nine variables used in the Mississippi Forest Survey regression analysis. Total inferred explained variation of the four species ranged from 69 to 73 percent. The implication is that almost one-third of the variation in tree specific gravity may be due to genetic factors.

While these estimates are only indicative, they do point out that forest geneticists have a considerable range within which to work. Further study by plant physiologists and soils scientists may narrow this range somewhat. It is certain, however, that as more variables can be studies and more data obtained for analysis, we shall all be further along toward tailoring trees to profitable products.

Literature Cited

(1) Grosenbaugh, L. R.
1958. The Elusive Formula of Best Fit: A Comprehensive New Machine Program. Southern Forest Experiment Station Occasional Paper No. 158.

(2) Mitchell, H. L.
1958. Wood Quality Evaluation from Increment Cores. TAPPI, Vol. 41, No. 4, pp. 150-156.

(3) ______ and Wheeler, P. R.
1959. Wood Quality of Mississippi's Pine Resources. Forest Products Lab. Report No. 2143.

(4) Wahlgren, H. E. and Fassnacht, D. L.
1959. Estimating Tree Specific Gravity from a Single Increment Core. Forest Products Lab. Report No. 2146.

Table 1. Means of variables, specific gravity study, Mississippi Survey, 1957 1/

Variable		Longleaf	Slash	Loblolly	Shortleaf
Core gravity Y		0.5525	0.5595	0.4877	0.5125
Long.	X_1	21.2004	16.5405	30.1778	24.5205
Lat.	X_2	90.8386	100.0991	69.2128	49.1391
LXL	X_3	1,923.5344	1,667.6901	2,254.4514	1,366.4969
BA	X_4	57.4101	82.1622	87.7081	80.8152
Vol.	X_5	10.5320	11.7953	15.5727	8.5726
Dbh	X_6	9.6356	9.1586	9.9452	8.3524
Age	X_7	31.1202	33.1892	26.0409	32.3829
$\frac{1}{A}$	X_8	0.0406	0.0396	0.0532	0.0420
$\frac{D}{A}$	X_9	0.3525	0.3137	0.4352	0.3014

1/ Number of observations: longleaf 973, slash 555, loblolly 3, 713, and shortleaf 2,711.

Table 2. Simple regressions of nine individual variables with core specific gravity for four species, with coefficient of correlation and standard error of estimate, Mississippi Survey, 1957.

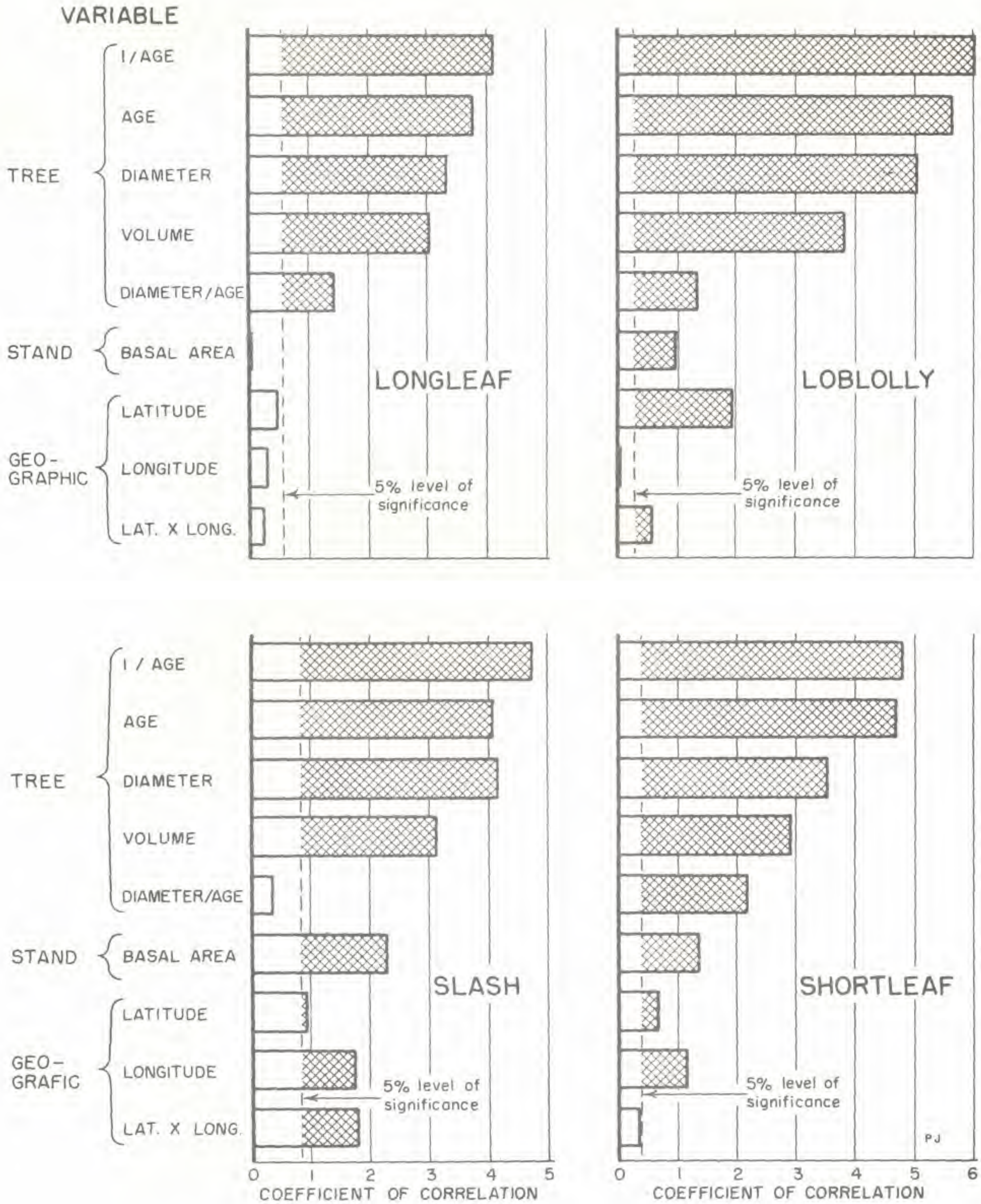
Species	Variable	Simple regression 1/ Constant	Coefficient	Coefficient of Correlation	Standard error of estimate
Longleaf	Reciprocal of age	0.6019	-1.2162	-0.4124	0.0520
	Age	.5148	+0.001211	.3784	.0529
	Diameter	.4991	+ .005537	.3333	.0539
	Volume	.5344	+ .0017180	.3023	.0545
	Diameter/Age	.5743	- .06185	- .1449	.0565
	Basal area	.5522	+ .000005061	.00316	.0571
	Latitude	.5250	+ .0003025	.0500	.0571
	Longitude	.5566	- .0001931	- .0316	.0571
	Lat. X Long.	.5557	-.000001662	- .0245	.0571

(continued)

Table 2: (continued)

Species	Variable	Simple regression 1/ Constant	Simple regression 1/ Coefficient	Coefficient of Correlation	Standard error of estimate
Loblolly	Reciprocal of age	.5561	-1.2860	- .6013	.0512
	Age	.4265	+ .002349	.5634	.0529
	Diameter	.4257	+ .006226	.5033	.0553
	Volume	.4723	+ .0009886	.3824	.0592
	Diameter/Age	.5059	- .04189	- .1338	.0635
	Basal area	.4747	+ .0001473	.0964	.0637
	Latitude	.4467	+ .0005922	.1924	.0629
	Longitude	.4871	+ .00001899	.00547	.0641
	Lat. X Long.	.4821	+ .000002457	.0600	.0639
Slash	Reciprocal of age	.6062	-1.1802	- .4754	.0493
	Age	.5164	+ .001297	.4098	.0511
	Diameter	.5054	+ .005902	.4176	.0509
	Volume	.5449	+ .001235	.3118	.0532
	Diameter/Age	.5642	- .01513	- .0387	.0559
	Basal area	.5368	+ .0002757	.2298	.0545
	Latitude	.6284	- .0006886	- .0943	.0557
	Longitude	.5834	- .001446	- .1742	.0551
	Lat. X Long.	.5829	- .00001408	- .1803	.0551
Shortleaf	Reciprocal of age	0.5636	-1.2148	-0.4799	0.0562
	Age	.4587	+0.001661	.4601	.0569
	Diameter	.4615	+ .006113	.3544	.0600
	Volume	.4999	+ .001474	.2914	.0613
	Diameter/Age	.5412	- .09507	- .2170	.0626
	Basal area	.4948	+ .0002189	.1375	.0635
	Latitude	.5047	+ .0001599	.0663	.0640
	Longitude	.5261	- .0005543	- .1166	.0637
	Lat. X Long.	.5150	- .000001845	- .0374	.0641

1/ Core specific gravity = a + bX.



VARIABLE
TREE
I/AGE
AGE
DIAMETER
VOLUME
DIAMETER/AGE
STAND
BASAL AREA
GEO-GRAPHIC
LATITUDE
LONGITUDE
LAT. X LONG.
LONGLEAF
LOBLOLLY
5% level of significance
GEO-GRAFIC
SLASH
SHORTLEAF
PJ
0 1 2 3 4 5
0 1 2 3 4 5 6
COEFFICIENT OF CORRELATION

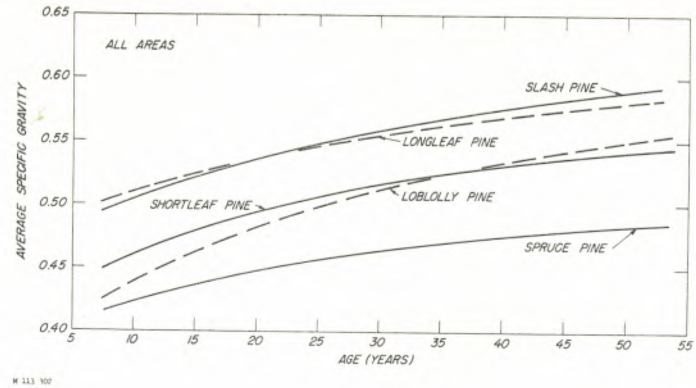


Figure 2. Relationship between age at breast height and core specific gravity for five species of pine in Mississippi.

(M113 302)

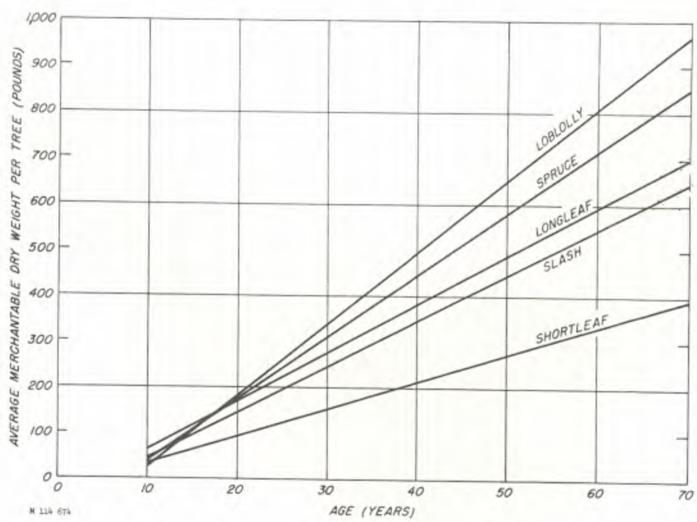


Figure 3. Relationship between age at breast height and average merchant able dry weight per tree (in pounds) for five species of pine in Mississippi.

(M 114 674)

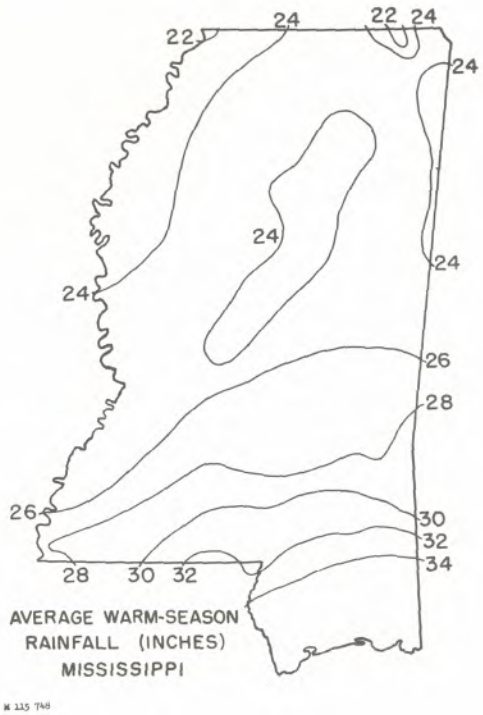


Figure 4. Average warm-season rainfall (inches) in Mississippi.

(M 115 748)

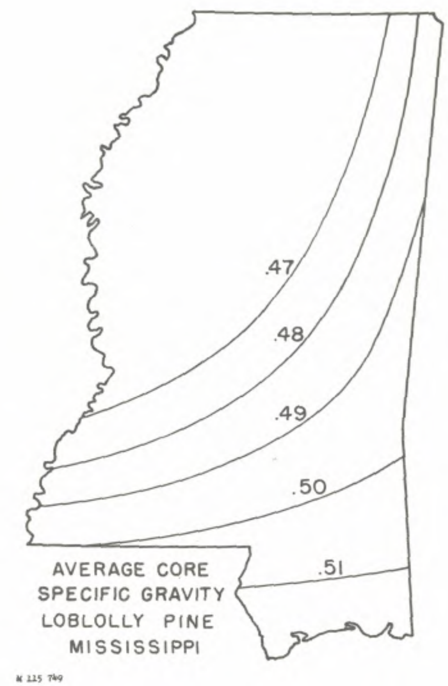


Figure 5. Isograms of average core specific gravity for loblolly pine in Mississippi.

(M 115 749)

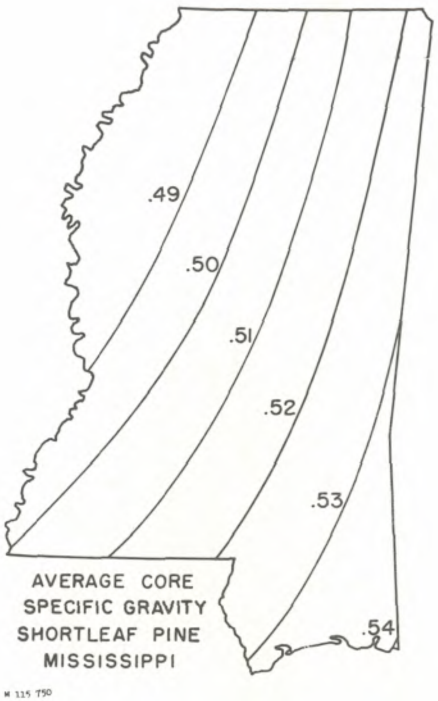


Figure 6. Isograms of average core specific gravity for shortleaf pine in Mississippi.
(M 115 750)

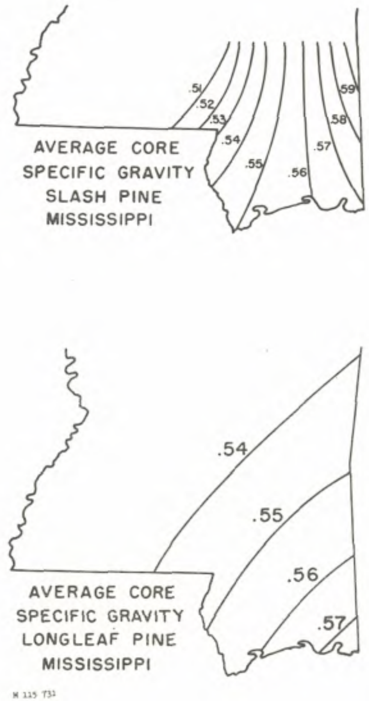


Figure 7. Isograms of average core specific gravity for slash pine (upper) and longleaf (lower) in Mississippi.
(M 115 731)