SOME FACTORS RELATED TO WOOD SPECIFIC GRAVITY OF SHORTLEAF PINE IN SOUTHERN ILLINOIS

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ABSTRACT.—Latewood percentage accounted for thirty-six percent of the variation in wood specific gravity of plantation-grown shortleaf pine (*Pinus echinata* Mill.) in southern Illinois. All other variables measured in the study only accounted for an additional five percent. Soil moisture appeared to be the factor most closely related to specific gravity.

Shortleaf pine (*Pinus echinata* Mill.) occurs naturally in the extreme southwestern part of Illinois in a few scattered stands, but it has been extensively planted throughout the southern one-third of the state using seedlings of unknown seed source. Specific gravity of wood from these naturally occurring shortleaf pines in Illinois was much lower than for shortleaf in the State of Mississippi (Gilmore, 1963). However, it was concluded that specific gravity of wood can be affected by variation in latitude only to the extent that latitude reflects differences in rainfall, soil conditions, growing season, geographic race, or some other factor or combination of them that is directly related to tree growth and wood density. Effect of geographic race on specific gravity of wood was discounted in shortleaf pine plantations in Illinois (Gilmore, 1963) because of the unlikely probability of one or even a similar geographic race occurring throughout the Illinois plantations established from seed largely of unknown origin. He states that "the variation found in specific gravity of shortleaf pine in the two states (Illinois and Mississippi) must be attributed to either physiographic or climatic factors or both."

Gilmore *et al.* (1966) also reported that forty-nine percent of the variation in wood specific gravity of loblolly pine growing in southern Illinois was accounted for by percent of latewood and to environmental factors. The effects of environment and other measured factors upon the wood specific gravity of shortleaf pine growing in the general vicinity of the loblolly pine study are discussed in this paper.

METHODS

Sixty-one 1/10-acre plots were sampled in 13- to 28-year-old shortleaf pine plantations in 21 counties of southern Illinois contained within a north-south range of 100 miles. An extensive examination of topography, drainage, position on slope, spacing, and density of canopy was made before a plot was tentatively located in a plantation. Soil wells were dug at each corner of the tentative plot to determine soil uniformity. If all of the above conditions were reasonably uniform, measurements were made of the depth to an impervious soil layer and depth that

tree roots penetrated the soil (as judged by presence of roots in soil evacuated from soil wells). A composite sample of the top six inches of soil was taken at ten locations across the diagonals of the plot. Percentages of sand, silt, and clay of this top layer were determined by the hydrometer method.

On each plot the number of trees, heights of five dominant trees, and diameter at breast height (dbh) were measured. Cores were extracted from the five dominant trees at breast height (4.5 feet) with a 0.173-inch diameter increment borer.

Total age of each tree was estimated from ring counts on the core, plus three years. The amount of latewood in the breast-height cores was determined with a dendrochronograph. Volume of the green cores was determined by the method of Gilmore *et al.* (1961), and specific gravity was computed on the basis of oven-dry weight and green volume. Site index (height of dominant trees at 25 years) was obtained for each plot from local site index curves (Gilmore and Metcalf, 1961).

The air-line distance from each plot to one of thirty weather stations used in the study area was measured. The average monthly rainfall for June, July, August, and September was calculated from long-time precipitation records (Page, 1949). Monthly rainfall for each plot was recorded as the rainfall measured at the nearest weather station. Latitude was indicated for each plot as miles north of an east-west base line located near Paducah, Kentucky.

The data were analyzed by simple and multiple regression analyses. The variables used in the study are listed in Table 1.

TABLE 1.—Correlation Coefficients between Site Index, Percent Latewood, Specific Gravity, and Latitude for Shortleaf Pine Plantations and Soil and Climatic Features

Variable	Mean	Site Index	Latewood Percentage	Specific Gravity	Miles North of Kentucky
		Correlation Coefficients[1]			
Site index	38.9	.....	.33	.39	—.59
Miles north of Kentucky	41.0	—.59	—.37	—.39	.....
Depth of root penetration	15.0	.29	.25	.25	—.37
Depth to impervious layer	24.0	.21	.10	.20	—.14
Percent silt plus clay of topsoil	90.6	—.18	.02	—.01	—.14
June rainfall	4.1	.50	.17	.10	—.33
July rainfall	3.1	.26	.10	.12	—.34
August rainfall	3.7	.05	.02	—.04	—.25
September rainfall	3.5	.26	.17	.08	—.13
No. trees per acre	901.0	—.16	—.18	—.12	.08
Total height	33.8	.80	.36	.30	—.38
Age	20.8	.03	.14	.04	.15
Latewood percentage	19.7	.33	.....	.60	—.37
dbh	7.0	.36	.23	.15	—.15
Percent slope	5.5	.37	.09	.20	—.15
Core specific gravity	0.433	.39	.60	.....	—.39

[1] Significant at 5 percent level: .25; signficant at 1 percent level: .32.

Results and Discussion

Percentages of latewood explained more of the variation in wood specific gravity than any of the other variables tested (Table 1). But the amount of latewood produced by a tree depends upon a number of genetic and environmental factors. Those variables correlated with percentage of latewood in this study were (1) miles north of Kentucky, (2) site index, and (3) depth that tree roots penetrated the soil profile. All of these variables are either directly or indirectly related to soil moisture available for tree growth. For example, as the distance from the base line in Kentucky increases, the trees are shorter, usable soil depth decreases, and rainfall during the middle of the growing season is less.

Site index is a reflection of all the environmental factors affecting tree growth such as physiographic and climatic factors. In southern Illinois there are three distinct physiographic divisions (Leighton *et al.*, 1948), and each division has a pattern of soil development which reflects the moisture and nutrients available for tree growth. Climate affects tree growth mainly through rainfall and temperature variation within a region. Rainfall during the growing season averages 14 inches in the northern part and 16 inches in the southern part of the study area. Temperatures during the growing season vary widely in the study area, but high temperatures coupled with low rainfall usually result in a drought during July. Therefore, difference in moisture available for tree growth must be a reflection of the soil and also of current precipitation.

As roots penetrate the soil to a greater depth and occupy more of the soil profile, more moisture and nutrients should become available to the tree, enabling it to lay down more cells for wood production (Gilmore *et al.*, 1968). Added increment is in both height and diameter, with diameter growth being dense latewood cells (Gilmore *et al.*, 1966).

The relationship between specific gravity and the most potent variables as computed in the multiple-linear regression are shown in Table 2. Latewood percentage, the variable most closely related to specific gravity, explained thirty-six percent of the variation in wood specific gravity. All other variables statistically related to specific gravity only accounted for an additional five percent of the variation. This is eight percent lower than that found for loblolly pine in a similar study in southern Illinois (Gilmore *et al.*, 1966).

Table 2. Correlation Coefficients between Specific Gravity and Most Potent Variables.

Variables[1]	Correlation Coefficients[2]
1	.60
1, 2	.62
1, 2, 3	.63
1, 2, 3, 4	.64

[1] Variables: 1, latewood percentage; 2, miles north of Kentucky; 3, depth to impervious layer; 4, percent silt plus clay of topsoil.

[2] Correlations for variables 1, 2, and 3 significant at 1 percent level; for variable 4, at 5 percent level.

This study substantiates earlier findings of the effects that various

factors have on the wood specific gravity of loblolly pine in southern Illinois and on conifers in different sections of the United States. About one-half of the variation in wood specific gravity is unaccounted for in these reported studies, which suggest that either the methods used in the studies were not adequate or else genetics plays a more important role in determining wood specific gravity than has been previously reported.

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