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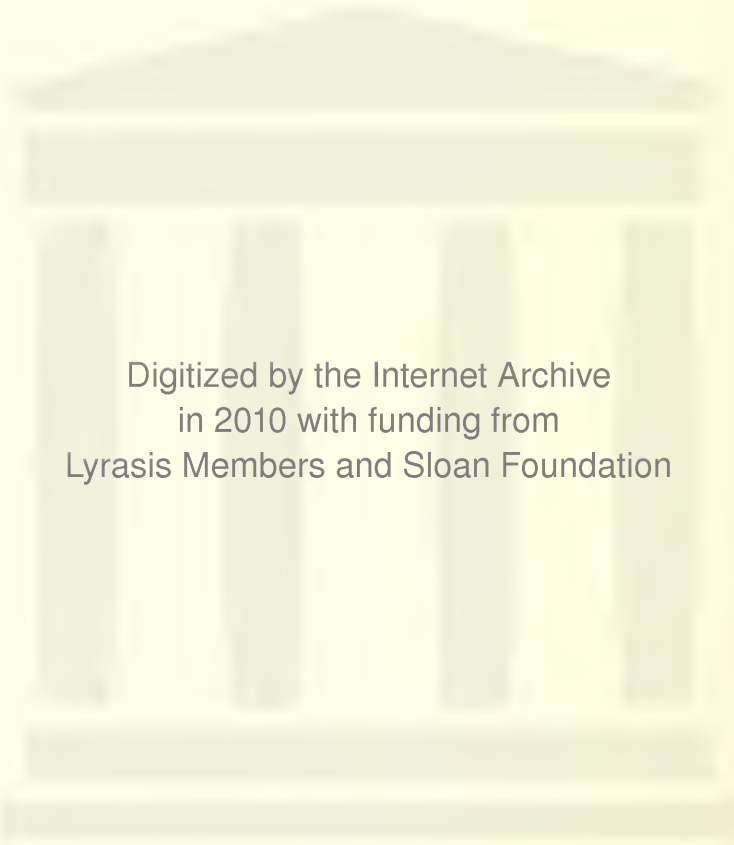
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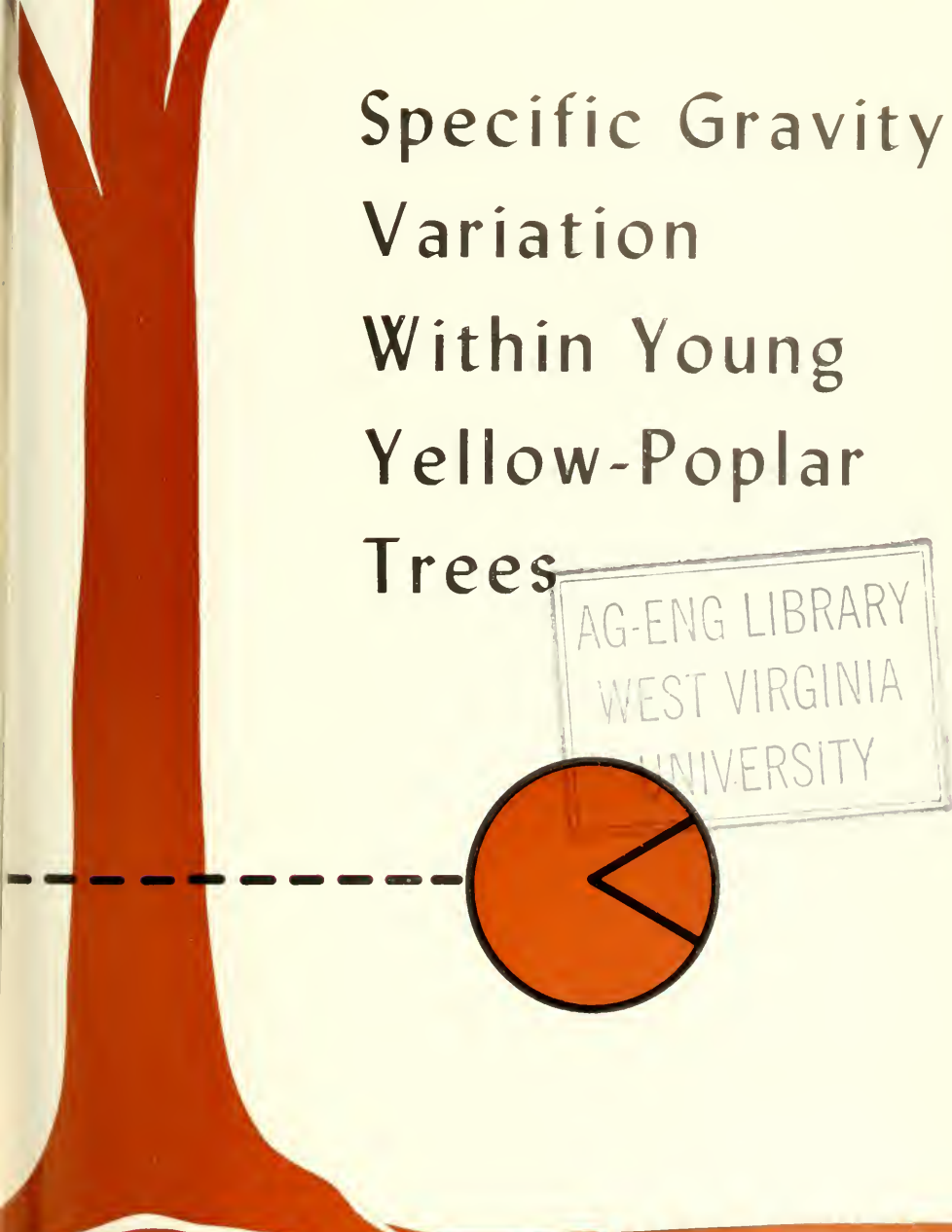
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Specific Gravity Variation Within Young Yellow-Poplar Trees

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YELLOW-POPLAR (*Liriodendron tulipifera L.*) is one of the more important hardwood species in the United States. It is widely used for such products as furniture, plywood, corestock, millwork, and increasingly for framing lumber in light construction. While old growth yellow-poplar is scarce, young timber is plentiful and is increasing in volume. In West Virginia, for example, the volume of yellow-poplar growing stock increased by more than 130 per cent between 1949 and 1964 and is now estimated to be in excess of one billion cubic feet. About one-third of this volume is made up from trees between 9 and 13 inches d.b.h. (3). Investigations of the physical properties of yellow-poplar have been primarily concerned with old-growth material, and limited information is available on the properties of wood from relatively young trees. In view of the existing volume of wood in such trees, additional information regarding its properties is needed.

Since specific gravity is closely correlated with per cent of wood substance, it is frequently used as an index of strength, dimensional stability and other properties. This report deals with the within tree variation in specific gravity of yellow-poplar stems averaging about 12 inches in diameter. Effects of both height above ground and distance from pith are considered.

Selection of Material

The trees from which the data for this study were obtained were located on the West Virginia University Forest in Monongalia County in northern West Virginia. This area was cut over about 35 years ago and is presently stocked with an essentially even-aged stand of yellow-poplar, red oak, soft maple, black cherry and associated species, primarily of sprout origin. The specific location consisted of a slope with a north exposure ranging in elevation from about 2,500 feet above sea level at the top to 1,600 feet at the base. Nine plots, each not less than 100 feet in diameter, had been previously located approximately equidistant along the slope. Six codominant trees were felled on each of these plots to provide data for the preparation of a volume table. From a total of 54 trees felled, 35 were subsequently used for the investigation of specific gravity. The average d.b.h. and age of the trees selected were 11 inches and 30

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years respectively. Corresponding ranges were 10 to 14 inches and 24 to 37 years. Site index varied from 122 at the top of the slope to 93 at the base.

Experimental Procedure

After the trees were felled, disks measuring two inches along the grain were removed at heights above ground of 1.5 ft., 4.5 ft., and at subsequent 6-ft. intervals to a height of 46 ft. The bark was removed from each disk and a pie-shaped specimen obtained by making two saw cuts which met at the pith. The angle between the cuts was approximately 30 degrees except in cases where there was obvious eccentricity of pith. In such cases, one cut was made perpendicular to the growth rings on the narrow side of the pith, the angle between the cuts being about 120 degrees.

The specimens were immersed in water until maximum volume was obtained. Green volumes were determined by calculating the difference in weight of the sections in air and in water. The specimens were then oven-dried and specific gravity computed as the ratio of oven-dry weight to green volume.

The transverse surfaces of the sections from nine trees, one from each plot, were sanded so that the individual growth rings could be delineated. Two radial strips ¼-inch wide were cut from each section. From the pith outward, one strip was split into sections of five annual increments—ie., increments 1-5, 6-10,—26-30. The material beyond the 30th increment from the pith was discarded. From the other strip, a section was obtained which contained the five annual increments nearest the bark. The sections were soaked under an intermittent vacuum until they sank. Green volumes were determined by the immersion method, and specific gravity was computed as described previously.

Results and Discussion

Table 1 shows the mean specific gravity of sections consisting of all annual rings and of only the last five annual rings at the different heights

TABLE 1

Mean Specific Gravity Values at Different Heights Above Ground

Height Above Ground (ft.)	1-1.5	4.5	10	16	22	28	34	40	46
All rings*	.499	.400	.382	.376	.376	.376	.398	.403	.403
Last five rings**	.433	.411	.376	.376	.381	.382	.399	.397	.402

*Each value is the mean of 35 observations.
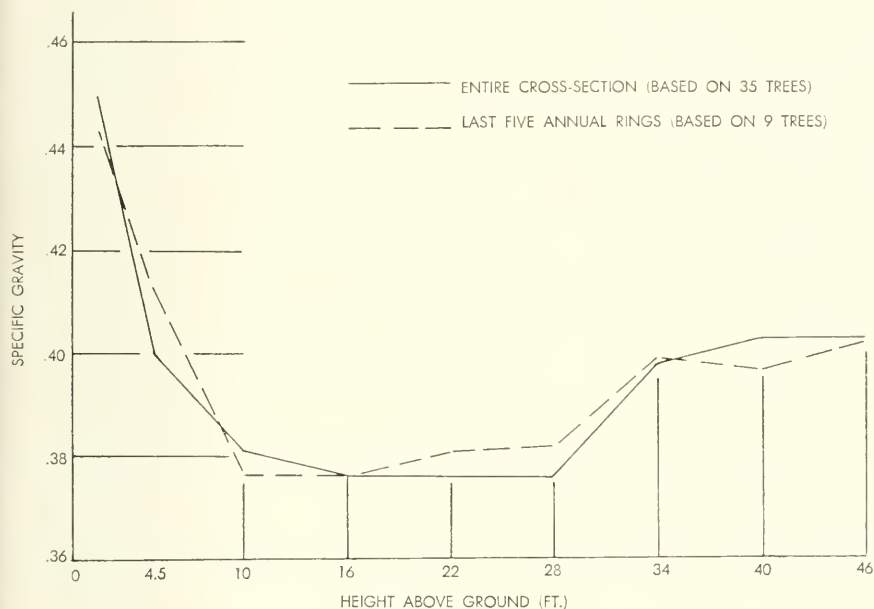**Each value is the mean of 9 observations.

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FIGURE 1. *Relationship between specific gravity and height above ground.*

investigated. The relationship between specific gravity and height is shown graphically in Figure 1. As indicated by the curves, specific gravity at stump height was considerably greater than farther up the stem. It dropped sharply to a minimum value at heights of 10 and 16 feet for the last five rings and the entire cross-section respectively, remained approximately constant to 28 feet and then increased gradually to 46 feet. Individual values for each tree exhibited essentially the same trend as the means. Analysis of variance (Tables 2 and 3) indicate the effects of differences in trees and heights to be highly significant. Multiple range tests showed the specific gravity at stump height to be significantly greater than that at any other height, while the wood from a height of 10 to 28 feet was significantly less dense than that from the remainder of the stems.

The results of the investigation of the radial variation in specific gravity are shown in Table 4 and are presented graphically in Figure 2. There was a general increase in specific gravity from the pith outward at all heights except at the stump and at 34 feet. This is in agreement with the results obtained with the same species by Thorbjornsen in an investigation of specific gravity variation at breast height (5) and by Erickson (2) at a height of 16 feet. Barefoot (1) found a similar relationship be-

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TABLE 2

Analysis of Variance of Specific Gravity of Entire Cross-Section

Source	Degrees of Freedom	Sums of Squares	Mean Squares	F
Trees	34	0.0068	0.0068	13.04**
Heights	8	0.1462	0.0183	35.29**
Remainder	272	0.1409	0.0005	
Total	314	0.5168		

**Highly significant

TABLE 3

Analysis of Variance of Specific Gravity of Five Annual Rings Nearest Bark

Source	Degrees of Freedom	Sums of Squares	Mean Squares	F
Trees	8	0.0422	0.0053	6.625**
Heights	8	0.0339	0.0042	5.250**
Remainder	64	0.0525	0.0008	
Total	80	0.1286		

**Highly significant

TABLE 4

Relationship Between Specific Gravity, Height in Tree and Distance from Pith

Height Above Ground (ft.)	Annual Rings From Pith					
	1-5	6-10	11-15	16-20	21-25	26-30
Stump	.422	.448	.449	.446	.442	.431
Dbh	.374	.379	.380	.385	.393	.409
10	.368	.371	.374	.372	.380	.385
16	.363	.369	.373	.367	.376	.385
22	.370	.373	.375	.377	.378	.386*
28	.371	.391	.375	.395	.410**	
34	.387	.389	.390	.402	.385†	
40	.382	.395	.398	.400		
46	.391	.403	.402	.402††		

*Based on three trees
**Based on six trees
†Based on five trees
††Based on four trees

tween specific gravity and age from pith as well as a decrease in specific gravity with height to 16 feet. Other diffuse porous species are reported to exhibit the same trend which is essentially opposite that reported for ring porous species (4).
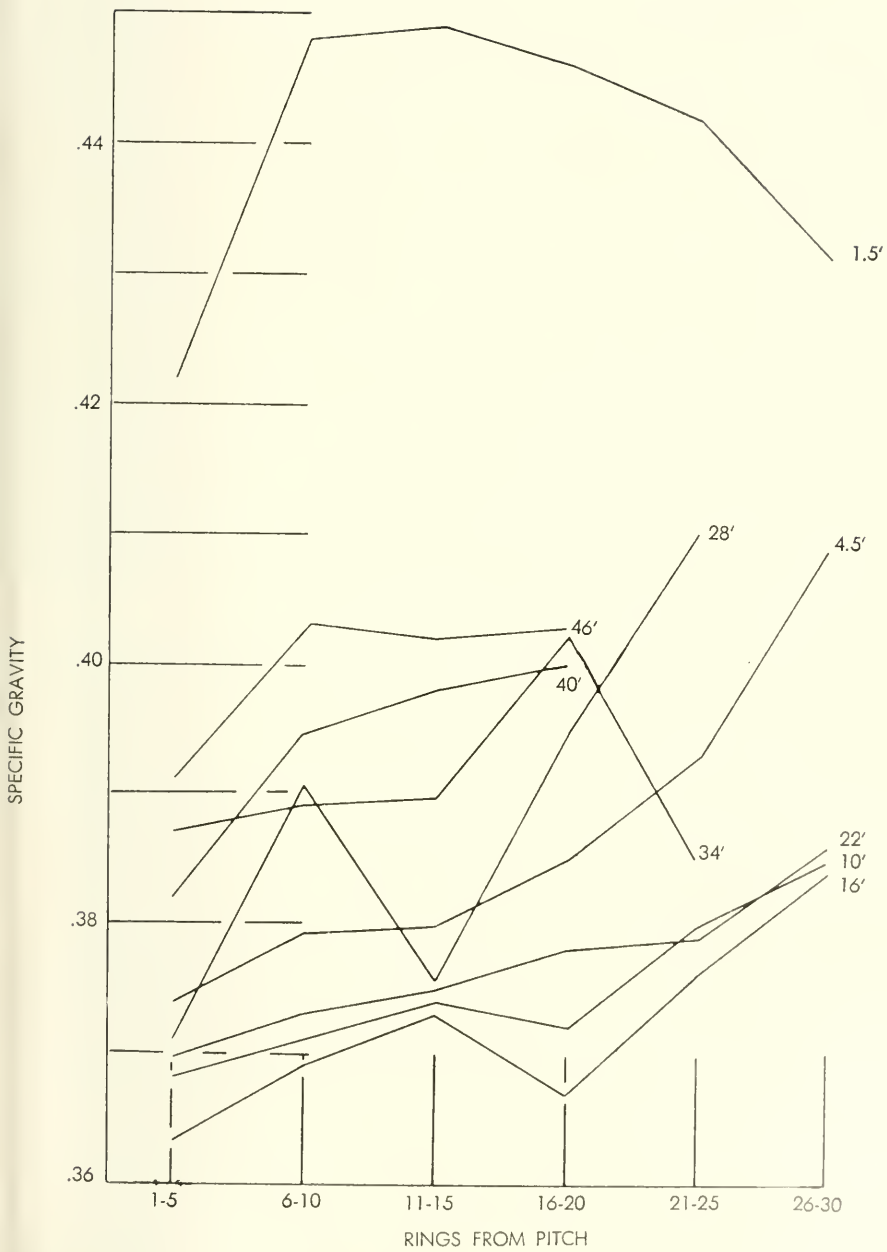
FIGURE 2. *Radial distribution of specific gravity at different heights above ground.*
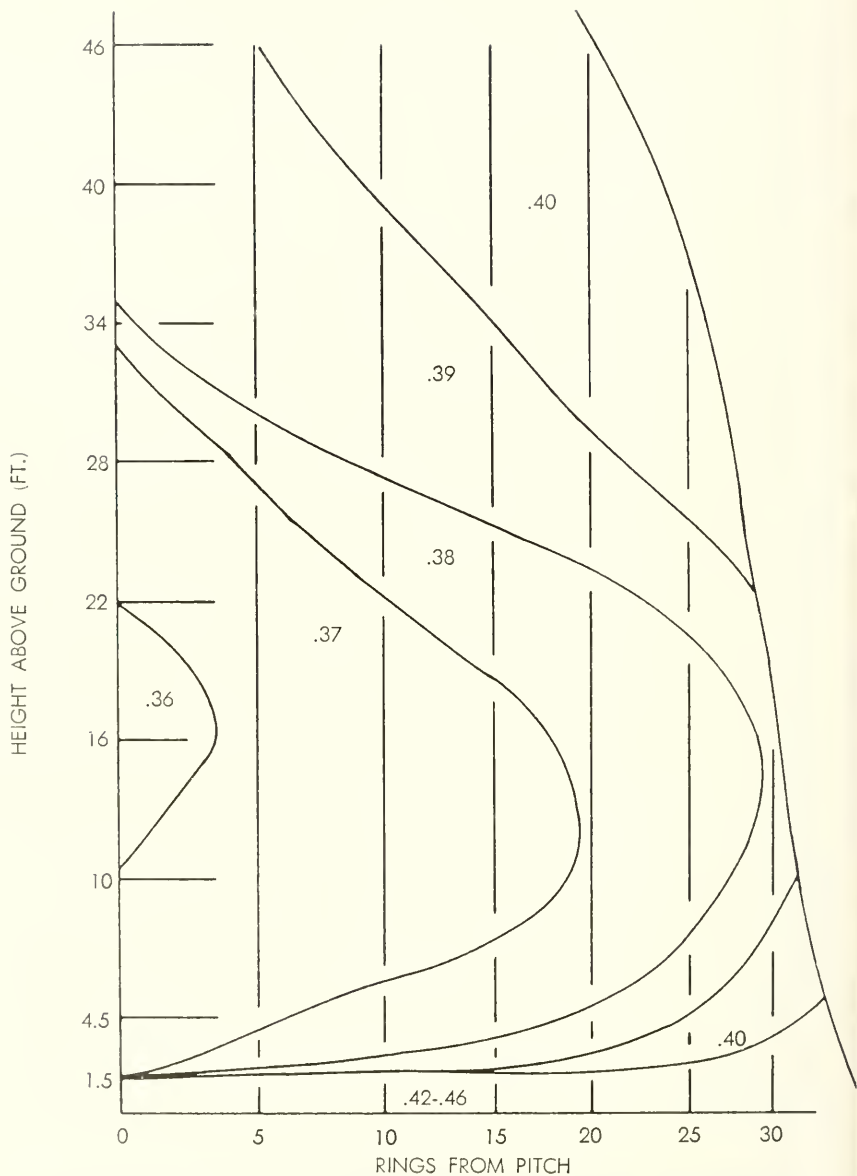
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FIGURE 3. *Radial-longitudinal specific gravity distribution.*

The results are summarized graphically in Figure 3, which shows the radial-longitudinal variation encountered within the trees investigated. Wood of maximum specific gravity occurred in a cylindrical zone at

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stump height while that of minimum specific gravity was located in an area near the pith between the heights of 4.5 and 22 feet. Overall, specific gravity decreased from the stump upward to between 10 and 16 feet and then increased. However, at the maximum height investigated (46 feet) specific gravity was still lower than that at the stump.

The Wood Handbook (6) cites a specific gravity of 0.40 as average for the species. The specific gravity of the wood from the trees investigated in this study was considerably greater than this near stump height. It was about the same near the periphery at all heights above breast height. At a height of 46 feet above the ground, it averaged 0.40 throughout the cross-section.

The fact that the maximum range in specific gravity may be expected to occur within a 16-foot butt log is of considerable significance, particularly with regard to strength and dimensional change. Based on the generally accepted relationships between strength and specific gravity (6) it would be expected that bending strength, for example, would be about one-fifth greater at the stump end of such a log than at the opposite end. The expected difference in shrinkage of wood from opposite ends of the log would be of essentially the same magnitude.

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