A NOTE ON THE INFLUENCE OF SOIL PARENT MATERIAL ON NORTHERN RED OAK SPECIFIC GRAVITY[1]

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ABSTRACT

Soil parent material was found to affect the specific gravity of northern red oak wood (*Quercus rubra* L.). The unextracted specific gravity of wood grown on limestone soils was 0.597 and that of wood grown on sandstone soils was 0.581. Site quality within a soil type had no significant effect. The relationship was independent of both rate of growth and latewood percentage.

Keywords: *Quercus rubra*, specific gravity, growth rate, latewood percentage, limestone, sandstone, site quality.

INTRODUCTION

The mineralogy, texture, and structure of the underlying parent rock all affect properties of the soil mantle and these in turn affect the vegetation present in many ways. For example, plant geographers have observed patterns in species distribution and ecologists have noted differences in biomass production attributable to soil parent material. The Appalachian Mountains present an unusual opportunity to contrast the effects of two fundamentally different parent materials—limestone and sandstone—which occur in extensive contiguous formations.

The premise that there are differences in properties of the wood of trees growing on soils derived from limestone or sandstone parent material has been the subject of a continuing series of investigations by the Division of Forestry, West Virginia University (Davis 1973; Percival et al. 1973). This note reports one phase of a comprehensive study of the relationship between a number of wood properties and site characteristics conducted by Litwin (1969).

Of interest here is the relationship between the specific gravity of northern red oak wood (*Quercus rubra* L.) and soil geology. Wood specific gravity was studied because in lieu of specific tests it is the best available index of many physical properties. Although not of primary interest, radial growth rate and latewood percentage were also examined because of the interdependence of the three factors. Ash content was studied to a limited degree.

PROCEDURE

The wood produced on dry, low-quality and moist, high-quality sites on both limestone and sandstone derived soils was sampled by extracting an increment core, at breast height, from twenty randomly selected northern red oak trees at each of four locations in West Virginia representing each of the combinations of site characteristics of interest. The number of locations was restricted by the availability of suitable sites.

Both the dry and moist sandstone sites, located on the West Virginia University

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TABLE 1. *Values for four wood properties together with their standard deviations in parenthesis, for high- and low-quality sandstone and limestone sites. Determinations based on 20 randomly selected trees at each site except for ash content, which was based on four trees.*

Site description	Wood property			
	Specific gravity	Rings-per-inch	Latewood percentage	Ash content
Sandstone				
High-quality	0.581	6.54	60.53	0.25
	(0.029)	(1.46)	(3.20)	(0.097)
Low-quality	0.582	6.38	61.17	0.32
	(0.021)	(1.61)	(4.66)	(0.048)
Average	0.581	6.46	60.85	0.28
Limestone				
High-quality	0.591	6.71	61.39	0.36
	(0.022)	(1.16)	(5.29)	(0.063)
Low-quality	0.602	7.64	61.71	0.38
	(0.025)	(1.75)	(3.76)	(0.085)
Average	0.597	6.67	61.55	0.37

Forest in Monongalia County, were occupied by pole-size stands of mixed upland oaks, yellow-poplar, and black cherry ranging in age from 35 to 45 years. The site index for upland oak was 75 for the dry sandstone site and 94 for the moist sandstone site (Schnur 1937). The moist limestone site, located on the Fernow Experimental Forest in Tucker County, supported a stand of mixed hardwoods ranging in age from 52 to 58 years. The site index was 80 for upland oak. The dry limestone site, located on the Monongahela National Forest in Randolph County, was covered by mixed hardwoods ranging in age from 51 to 59 years of age. The site index was 63 for upland oak.

Unextracted specific gravity was determined using the maximum moisture content method (Smith 1954); increment width and latewood percentage were determined to the nearest 0.1 mm using a dual-linear-micrometer (Hamilton 1963); and ash contents were determined using a muffle furnace. These data were collected from a six-year-segment taken between the twentieth and twenty-fifth year from the pith. In the case of specific gravity, increment width, and latewood percentage, measurements were made on twenty trees at each location; whereas four trees at each location were used for ash determinations.

Segments the same number of years from the pith were selected because each was formed by cambium of the same age at a time when within-tree nutrient gradients were the same and, perhaps more importantly, increment formation

TABLE 2. *"F" ratios and significance for the three sources of variation for the three major wood properties.*

Source of variation	Specific gravity	Rings-per-inch	Percentage latewood
Parent material	7.91**	4.45*	0.24
Site quality	1.10	1.24	0.53
Interaction	0.70	2.60	0.03

**—Significant at the 99% level of probability.
*—Significant at the 95% level of probability.

TABLE 3. *"F" ratios for the analysis of covariance for specific gravity with rings-per-inch as the covariate.*

Source of variation	Specific gravity
Parent material	12.51**
Site productivity	1.56
Interaction	2.05

**—Significant at the 99% level of probability.

was subject to variations in site factors as well as tree vigor and not by differential growth rates that occur over time in trees of dissimilar ages. The influence of year-to-year environmental vagaries was overcome by randomly selecting the study trees from the entire population of northern red oaks (usually 35 to 40 acceptable stems) at each study location. The size and age of the selected trees was such that all six-year segments were located in the heartwood.

RESULTS AND DISCUSSION

Significant variation in specific gravity and rate of radial growth was found to be associated with soil parent material (Tables 1 and 2). Specific gravity of the wood of trees growing on limestone soils averaged 0.597, a value 3% greater than that for wood grown on sandstone soils. Rate of growth was only slightly greater on sandstone soils than on limestone soils. Rates of growth averaging 6.5 rings-per-inch and 6.7 rings-per-inch were observed in material from sandstone and limestone soils, respectively. Differences noted in latewood percentage were not significant.

No significant effect of site quality on either of the three wood characteristics was demonstrated. The sites were carefully selected and were obviously different in many respects, a fact attested to by their site index—75 and 94 for the low and high quality sandstone sites and 63 and 80 for similar limestone sites. This was not completely unexpected, for Wilde and Benson (1951) failed to find any clear relationship between soil composition and specific gravity in *Populus tremuloides* notwithstanding a wide range in soil fertility and site index.

Because there was a difference in the rate of growth attributable to soil parent material the possibility existed that the differences in specific gravity observed to be associated with soil parent material were actually a reflection of differences in rate of growth. A covariate analysis with rings-per-inch as the covariate indicated that soil parent material had an effect on specific gravity that was independent of rate of growth (Table 3).

Wood specific gravity is primarily a function of the relative amount of solid

TABLE 4. *Simple correlation coefficients associated with the three major wood properties. High and low quality sites are combined for each parent material.*

	Sandstone		Limestone	
	Latewood percentage	Rings-per-inch	Latewood percentage	Rings-per-inch
Specific gravity	0.249	−0.065	0.326*	−0.323*
Rings-per-inch	−0.419*		−0.398*	

* Significant at the 95% level of probability.

wood substance in a sample, but it often may reflect the presence of organic or inorganic extraneous materials. In order to approximate the influence of the latter, ash content as a percentage of the oven-dry wood was determined and averaged for the limestone and sandstone sites. Ash content of samples from the sandstone sites averaged 0.28%, as compared to 0.37% for samples from limestone sites. Results of a *t*-test ($t = 2.47$) indicated these means to be significantly different at the 0.05 probability level. Although differing by 32%, the difference in ash content of the samples accounts for only a small part of the difference in specific gravity.

Of peripheral importance to this study, but of general interest, is the interrelationship between the three wood characteristics. In red oak, as is the case with other ring porous woods, a strong relationship between ring width, acting through the percentage of latewood, and specific gravity is often noted. Wide increments usually have large percentages of latewood, and this results in a high specific gravity. Examination of the correlation coefficients for our data (Table 4) indicates this to be true for the samples from the limestone soils but not for the samples from the sandstone soils. This discrepancy may be a reflection of the small sample size we used.

The results presented here indicate that the wood of northern red oak trees growing on soils derived from limestone parent material has a somewhat greater specific gravity than wood grown on sandstone derived soils. Since this difference is independent of both growth rate and latewood percentage, more fundamental relationships are suggested. Our results suggest that differences in ash content may make a small but significant contribution but there are obviously other contributory factors. The results may be due to anatomical differences such as the relative proportions of different cell types, or cell wall thicknesses, or they may be due to chemical differences such as extractive content.

The differences in specific gravity reported here are quite small and although of academic interest have little practical significance.

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