WALNUT WOOD CHARACTERISTICS IN RELATION TO SOIL-SITE CONDITIONS

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It takes little scanning of "Timber Trends in the United States" (U.S. Forest Service 1965) to realize that the hardwood timber of our country needs a great deal of improvement. About 27 percent of the total growing stock of the Nation is hardwoods, 90 percent of the hardwoods are eastern species, and most of them are of poor quality.

But, where does one start to improve the quality? The silviculturist can thin, weed, and prune to improve log quality but what is the effect on intrinsic quality. The geneticist may want to improve the resource, but he must first know the qualities desired, including those of intrinsic wood quality.

For the softwoods, wood quality has long been characterized by wood density. However, the uses of softwoods are generally restricted to engineering and pulp applications, where wood density is important. Hardwoods, on the other hand, have so many diverse applications that wood density loses its importance for most of them.

What then can be used as an indicator of intrinsic wood quality for the hardwoods?

A quick survey of the uses of the various hardwood species certainly gives some indication as to desired qualities. Brown *et al.* (1949) list 49 hardwood species and their uses. Furniture is the largest use, followed by millwork, veneer, and cabinetwork. Other major uses are woodenware, novelties, gunstocks, and flooring.

The first quality consideration for all of these uses is what we would call aesthetics (primarily color). Other quality considerations are texture, shrinkage, machinability, hardness, and strength properties (principally toughness).

With these quality criteria in mind the Forest Products Laboratory, in cooperation with the North Central Forest Experiment Station, initiated a study to evaluate the intrinsic wood quality of black walnut (*Juglans nigra* L.) This work was boosted by the push for increased information on black walnut after the recent symposium on walnut culture (U.S. Forest Service 1966).

This paper is a report on how we are attempting to find a quality criterion for walnut and possibly for other hardwoods. We present no results, just a fresh idea!

The Black Walnut Problem

The buyers of black walnut have long shown a preference for logs from certain areas. The reasons for this are not definitely known, although several theories have been advanced. Some claim, and with good cause, that defects such as bird peck, shake, and poor tree form are the main reasons for discrimination. These defects may be more prevalent on trees growing near the borders of the geographical range of the species or on poor sites. On the other hand, some think that discrimination by buyers of walnut logs from certain localities is from habit and without valid reason.

To investigate the passible reasons for such discrimination and to evaluate some measures of intrinsic wood quality, the study objectives became, specifically, to determine whether valid differences occur in the wood characteristics and wood properties of trees growing at various locations under different conditions.

The study is to determine whether differences exist in color and extractive, in anatomical features, and in physical and machining properties of wood. Then, if these differences exist, how do they relate to each other and to site?

The study is divided into three sections: Section I to investigate the color, extractive content, and heartwood-to-sapwood ratio of sample material as a measure of aesthetic quality; Section II to evaluate anatomical characteristics as a measure of texture and shrinkage; and Section III to evaluate the physical and machining properties. All three sections will be related to soil properties.

To provide meaningful results, material was selected from fast- and slow-grown trees from good and poor sites. Specifically, material was selected from two general areas, in Indiana and Missouri. The Indiana locations are considered to represent the best growth areas for walnut, while the Missouri locations are generally regarded as inferior.

Sample Material Selection and Handling

Selection of Sample Trees

The selection of suitable trees for analysis was coordinated through the North Central Forest Experiment Station. Station personnel[2] were responsible for obtaining logs through industrial cooperators in Indiana, and National Forests in Missouri.

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Thirty-two trees were selected to cover the following stand-site combinations:

	Number of trees Missouri	Indiana
Good site:		
Slow growth	4	4
Fast growth	4	4
Poor site:		
Slow growth	4	4
Fast growth	4	4
	16	16

Soil Sampling

At the location of each sample tree, soil samples were taken for correlation with wood properties. A composite 6-inch surface sample was taken at random points around each stump to a distance of 20 feet radially. The composite consisted of 8 borings. At two of the eight points, bulk density samples were also taken. These samples are being analyzed for chemical constituents, organic matter, pH, and physical properties.

To classify each soil on which trees were located, a pit was dug. The soils of this pit were classified and subsoil samples were taken for physical analysis.

Sample Bolts

From each of the 32 selected trees, one 5-foot bolt was taken from the 8- to 13-foot portion. These bolts were inspected carefully and all defects and blemishes on the bolt faces and ends were recorded before sawing.

The ends of each bolt were squared and a disk cut for determination of ring count and sapwood width. These disks are being retained intact for future reference.

Eight or more boards were cut from each bolt and numbered systematically, starting with the board whose face was cut first. Numbering of other boards followed the pattern shown in figure 1.

The sawing method for each bolt was marked on the small end, using a template guide. Each board was flat sawn, 1 1/4 inches thick, 4 1/4 inches wide, and 4 1/2 feet long, and has heartwood on at least one face. Sawing was done parallel to the outer surface (bark) in an attempt to keep the same growth rings throughout the board.

Selection of Test Samples

Eight boards from each bolt are being used. Random selection was utilized when more than eight boards were sawed from a bolt.

After planing to a uniform 11/2 -inch thickness, each selected board was marked off into four 1-foot samples (fig. 2) starting at the end corresponding to the top of the bolt, and numbered consecutively. One of the four 1-foot samples was selected randomly, and a 6-inch-long piece was added to the bottom end making, in total, an 18-inch piece.

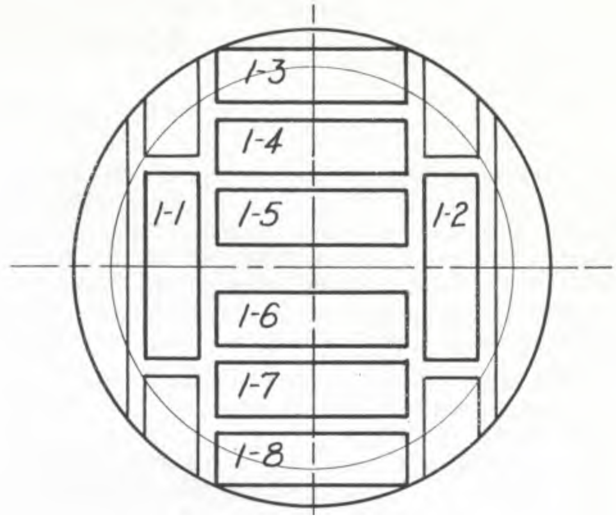

FIGURE 1. — Location of and numbering sequence for boards in the log.

The 18-inch piece was further cut into 6- and 12-inch portions. The 6-inch piece is being used in Sections I and II of the study, while the four 1-foot samples are being used in Section III.

The 6-inch piece was further processed as follows. It was sanded to a uniform 1-inch thickness; each tangential face was then divided into 8 units, 3/4 inch long, 1 inch wide, and 3/16 inch thick on the butt end (a total of 16 units per piece) as shown in figure 3. These are being used in the color, extractive, and specific gravity determinations (Section I) and for the anatomical determinations (Section II).

Further sample breakdown was followed by sawing a shrinkage specimen for Section II, 1 inch along the grain, 4 inches wide, and 1 inch in thickness.

Evaluation of Sample Material

As noted earlier, this report is on work that is now underway. All sample material has been collected and prepared. Determinations on the material are now being made to establish whether differences exist, and if so, how they relate to one another.

Section I — Color, Extractives, and Specific Gravity Determinations

Color evaluation. — The evaluation of color is especially important, for aesthetic reasons, in black walnut and some other hardwood species. Basic colors have generally, in the past, been described by qualitative terms such as dark brown, chocolate brown, etc. However, work done by Schwalbe and Ender (1934), Kollman (1939), Sandermann and Luthgens (1953), and many others has given us the opportunity to evaluate color quantitatively. Using the techniques described by Sullivan (1967a, b) the reflectance of each 3/4-by 1- by

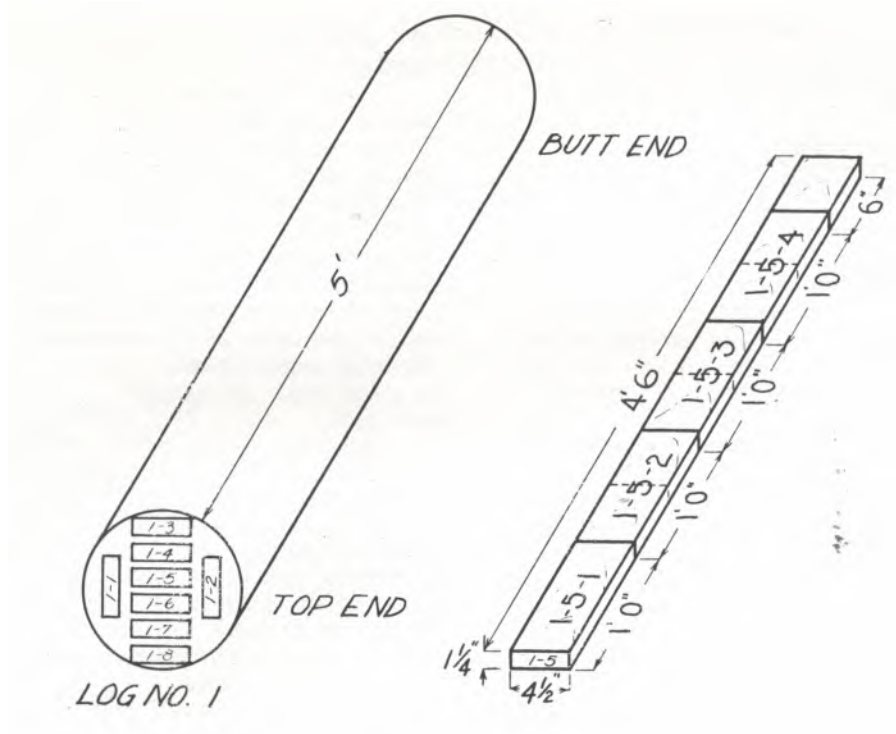

FIGURE 2. — Location of and numbering sequence for 1-foot samples in the boards.

3/16-inch piece (two per board) are being measured with a Beckman Model B spectrophotometer equipped with a reflectance apparatus. Each reflectance value is being measured as a percent of the reflectance of a standard surface, reflectance values being recorded at 10-millimicron intervals from 400 to 700 millimicrons (visible light region of the color spectrum).

These reflectance values are then utilized to derive the color's descriptive variables, i.e., dominant wavelength (millimicrons), saturation (percent of unity), and luminance (percent of unity).

Extractives and specific gravity. — After reflectance values are obtained on each 3/4- by 1- by 3/16-inch piece, the material is ovendried and weighed. The samples are than placed in a Lloyd extractor for 3 weeks with alcohol-benzene as the solvent. After extraction, the water-saturated weight is determined and the samples ovendried and reweighed. Specific gravity on an extracted and unextracted basis is being calculated by the maximum moisture method as described by Smith (1955).

Percentage of total extractives is expressed on weight per weight, and on a weight per volume basis.

Section II — Wood Anatomy and Shrinkage Determination

Wood anatomy. — The material for study consists of 512 specimens, each 1 by 3/4 by 3/16 inch. These are end matched to the color specimens and are obtained as described in Section I. The specimens are being airdried and then water saturated when measurements are to be made.

A transverse face of each specimen is being surfaced with a sliding microtome and, using a Zeiss integrating eyepiece and a 10X objective, the following are being determined :

1. Number of vessels per unit area.
2. Percent area occupied by vessel lumens.
3. Number of fibers per unit length in both the tangential and radial directions.

Using the formula for a rectangular cell model, the average cell wall thickness is being calculated according to Smith (1965), and from this, the average cell lumen diameter will be calculated.

Shrinkage and specific gravity. — The material for the study of shrinkage consists of 256 specimens, 4 by 1 by 1 inch. These are being obtained as described in Section I and as shown in figure 3.

Volumetric shrinkage and specific gravity are being determined on each specimen at 12-percent moisture content and again in the ovendry condition according to ASTM Standard D143-52. Volumetric shrinkage is being expressed as a percent of the green volume. Specific gravity is being expressed on the green volume-ovendry weight basis.

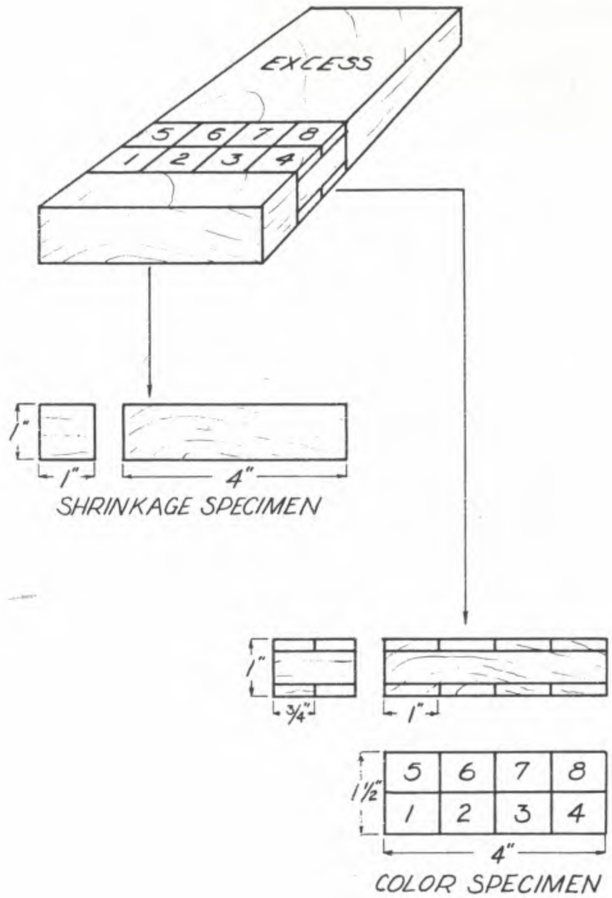

FIGURE 3. — Location of and numbering sequence showing shrinkage and color specimens.

Section III — Machining Characteristics and Mechanical Properties

Planing tests. — All of the 12-inch sample pieces are being dried to an equilibrium moisture content of 12 percent.

The samples are being planed to 1/8 inch on each face at a feed rate of 16 knife cuts per inch, after which all are examined for defects and smoothness.

Hardness and shaping tests. — One 12-inch board sample (adjacent to the 6-inch sample used in Sections I and II) was already selected for the hardness and shaping tests. One of the three remaining board samples is being randomly chosen for these same tests. The remaining two samples are used for the toughness and turning tests.

The hardness tests consist of three indentations of a ball 0.444 inch in diameter on each tangential face of the board; these are performed according to standard procedure (Amer. Soc. for Testing Materials, no date) by measuring the load to embed a 0.444-inch ball to one-half its diameter.

Following the hardness tests, the same pieces are used for the standard shaping tests (Davis 1962).

Toughness and turning tests. — The toughness and turning tests are made on 3/4- by 3/4- by 11-inch pieces cut from the remaining two 12-inch pieces. Every effort is being made to cut the toughness specimens with a tangential face and with minimum sloping grain. This may necessitate cutting the specimen diagonally from the 3/4- by 4- by 12-inch sample. The turning specimens are cut adjacent to the toughness specimens, one from each of the two selected 12-inch pieces, and are 3/4 by 3/4 by 5 inches in size.

Summary

This is a report, before completion, of a program that the Forest Products Laboratory has embarked on. It is a concentrated program to find, if possible, one or more intrinsic wood quality criteria for black walnut and hopefully for other hardwood species as well. The program attempts to cover all of the main quality attributes desired by hardwood users. Further, it covers the possibility of finding relationships of these quality criteria to soil-site conditions.

The quality attribute most evident in the hardwoods is aesthetics, or color variation; this is being quantitatively evaluated with a spectrophotometer. Wood texture is being evaluated by anatomical characteristics; and shrinkage, specific gravity, machinability, and strength are being evaluated directly.

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