Simple and Inexpensive Method for Extracting Wood Density Samples From Tropical Hardwoods

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A method for extracting wood density samples from living trees with high-density wood is described. A carpenter's auger is used to extract wood chips from a hole of known dimensions. The chips are dried and weighed, and the standard formula — ovendry weight divided by green volume — is used to calculate density. For illustrative purposes, a comparison is made with a water immersion method for samples collected from four tree species with woods of varying densities. The auger method, if used correctly, appears to yield an accurate measurement of wood density. Moreover, it is rapid, simple to use, and employs very inexpensive equipment. Tree Planters' Notes **45(1):10-12;1994.**

Wood density is an important characteristic that is selected for by tree geneticists. Destructive sampling tends to be counterproductive. Determining wood density— the weight in grams per cubic centimeter of wood at a given moisture content— is accomplished in four steps. These are extraction of the sample, determination of its volume, drying of the sample, and calculation. Wood density can be determined by several methods, principally variations in the method of extraction of the sample from the tree trunk and in how the volume of the sample is determined. A few other systems estimate density indirectly. An example is the pilodyn system, a type of penetrometer. Density is estimated from the hardness of the wood as indicated by resistance to penetration. The system may be used in the field but can only give an indication of the density of the surface layer.

The most common method for determining wood density is to saw samples from boards after a tree is milled. The volumes of the samples are determined by measuring them or immersing them in water and noting the rise in water volume. The weight at a standard moisture content (usually ovendry) is used to complete the calculation. This is obtained by drying the sample until no further loss of moisture occurs.

To collect samples from living trees within studies or protected areas has required the use of an increment borer. The increment borer extracts a small cylindrical piece of wood of known diameter, and the length of this piece is measured to calculate the volume of the sample.

The increment borer is a useful tool for collecting samples from living trees, although it has a few drawbacks. Increment borers with smaller diameters may compress some of the samples, but this can be avoided by using the largest (12-mm) bits available. Although samples from increment borers come just from the more dense lower trunk, and often over-represent the heartwood and under-represent the sapwood, Wahlgren and Fassnacht (1959) conclude that increment cores extracted at breast height can be safely used to estimate whole-tree density of southern pines. Field sampling of tropical hardwoods presents problems not encountered with pines. Trees with hard and dense woods are very difficult to sample with an increment borer, which must compress the wood in a ring around the core in order to enter. Also, increment borers are often too expensive for many foresters in developing countries where tropical hardwoods grow.

In response to this problem, I developed a simple method for extracting wood density samples from living trees with inexpensive equipment. I believed it to be original and could find no other forester or scientist aware of it. However, reviewing old references on the use of increment borers for wood density, I found the theory for the method described and suggested as an alternative to the increment borer for extracting samples from southern pines (Paul and Baudendistel 1956). Those authors apparently did not test the method.

Materials and Methods

The samples are collected with a carpenter's auger ("brace and bit"). Auger bits are available at hardware stores in a wide variety of sizes and lengths. Any convenient diameter bit may be used. A brace and bit of good quality costs about US $20. The pieces of equipment used for field collection of samples are shown in figure 1. A ventilated oven is also necessary for ovendry determinations. Airdry determinations, which are much less precise, can be obtained without such equipment. A balance capable of weighing to the nearest 0.1 g (0.003 ounce) is also required.

The point within the tree to be sampled is accessed by boring through the bark to a previously decided standard depth in the wood. Depending on the demands of the study or the peculiarities of the species, this may be the surface of the sapwood, some point within the sapwood, or the start of the heartwood (as noted by a color change). Chips produced in boring the preparatory hole are discarded. The preparatory hole is brushed out and its depth measured with a ruler. This is the starting depth of the sample. To catch the chips for the sample, a plastic bag should be tucked on one of its sides into a string or ribbon tied around the tree, tacked to the tree, or held by an assistant underneath the hole. As the chips are caught in the bag, the borehole is extended to another previously decided depth such as the pith. After the auger is withdrawn, the chips remaining in the hole are collected using a flattened stick or thin spatula and added to the sample. It is important to withdraw all the chips (and also not to lose any), because any chips not included in the sample will bias the results. The ending depth of the hole is noted. The chipped sample is placed in a cloth or paper bag or in a pan and dried in a ventilated oven until no further weight loss is noted. The final weight is recorded to the nearest 0.1 g.

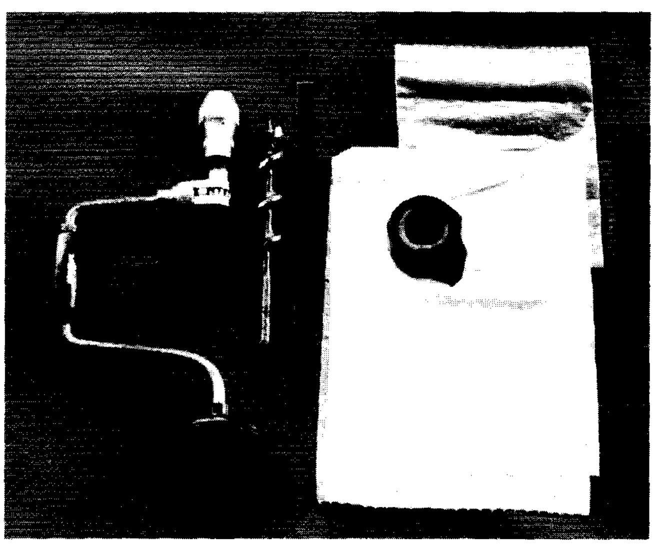

Figure 1—*The equipment required for collecting wood density samples by the auger method.*

The density of the sample is calculated by the formula:

$$\text{Density} = \frac{\text{Sample weight (g)}}{\text{Volume of the hole (cm}^3\text{)}}$$

The volume of the hole, or the volume formerly occupied by the sample, is calculated using the formula:

$$\text{Volume} = (3.1416\ D_b^2/4)\ (D_e - D_s)$$

where:

D_e = ending depth
D_s = starting depth
D_b = diameter of the bit.

Comparison With Standard Methods

The auger method and the increment core method are conceptually similar and should give comparable results. The core method takes its volume from an undisturbed core; the auger method uses a chipped sample extracted from an undisturbed hole (the sides of the hole are not compressed by the slicing action of the bit). The tiny holes created by the guide screw of the auger bit could be a source of error; however, the holes are present at the start and at the finish and, in effect, cancel one another.

To illustrate some advantages and cautions in using the auger method, a comparison was made with the water immersion method, a standard method for determining wood density of sawn samples (American Society for Testing and Materials 1967). Four species of trees that exhibit a range in wood density — *Anthocephalus cadamba* (Roxb.) Miq., *Dialium guianense* (Aubl.) Sandwith, *Pinus caribaea* Morelet, and *Tabebuia heterophylla* (DC.) Britton — were selected.

Replicated samples for both methods were taken from a single tree of each species. Ten auger samples using a 2.54-cm (1.0-in) diameter bit were withdrawn in a close-spaced, vertical row of holes beginning at about 1.5 m and ending at about 1.2 m (4 to 5 ft) above the ground. Samples were taken beginning at 10 to 15 mm (0.4 to 0.6 in) in from the cambium and going approximately to the center of the tree. The tree was cut down, and a rough board on the radial section adjacent to the auger holes about 0.5 m (20 in) long and 1.5 cm (5/8 in) thick was cut with a chainsaw, also from near breast height. Generally, 20 samples for the water immersion method were cut from this board with a table saw. The samples were cubes about 1.5 cm (0.6 in) on an edge, from a position roughly midway between the bark and the pith, and spaced along the 0.5-m (20-in) piece. The volume of the solid samples were determined by first soaking them in distilled water and then immersing them in a graduated cylinder and noting the change in water level. Afterwards, both the solid and the chipped samples were dried at 105 /C (221 /F) in a ventilated oven and reweighed on an analytical balance until no further weight reduction was noted.

Mean densities (10 to 20 samples) for the four species measured by the two methods with their standard deviations and coefficients of variation are presented in table 1. The coefficients of variation are low (3 to 10%) for both sample methods. The variances of the two methods were homogeneous at the 5% level of confidence using the F-test for equality of two variances (Snedecor and Cochran 1967). An unpaired t-test showed that the means of densities measured by the two methods were not significantly different at the 5% level of confidence, with the tree species pooled.

Discussion

The auger method gave mean densities that were comparable to, though not identical with, those obtained by the water immersion method. The numerical differences in the results, particularly within species, almost certainly arose because the water immersion method essentially measured density at a point midway between the cambium and the pith whereas the auger method measured a rough average across most of that radius. Differences in density between sapwood and heartwood and the presence of soft cores due to rapid juvenile growth inject additional variation both within and between species. Any sampling procedure should be designed to measure the desired portion or portions of a tree in a representative fashion. Many methods and variations are available for determining wood density. Because there are often difficulties in comparing results from different methods, it is always best to use only one method within a study or survey.

Table 1 - *Comparison of ovendry wood densities in four trees of four species obtained by the water immersion method and the auger method*

Species & method	n	Mean	Standard deviation	Coefficient of variation (%)
Anthocephalus cadamba				
Immersion	20	0.26	0.009	3.3
Auger	10	0.34	0.036	10.5
Dialium guianense				
Immersion	20	0.88	0.056	6.3
Auger	10	0.84	0.035	4.2
Pinus caribaea				
Immersion	18	0.48	0.028	5.8
Auger	10	0.40	0.015	3.8
Tabebuia heterophylla				
Immersion	20	0.49	0.018	3.7
Auger	10	0.54	0.017	3.1

Conclusions

The auger method, used correctly, appears to accurately measure wood density. The new method is rapid-field collection time is about 10 minutes per sample-and it is capable of extracting samples from hard hardwoods. Moreover, it is simple to use, and the equipment is very inexpensive.

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