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VARIATIONS IN DIAMETER MEASUREMENTS OF ROBUSTA EUCALYPTUS
due to swelling and shrinking of bark

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Abstract: Trunk diameters of *Eucalyptus robusta* trees shrink and swell as bark moisture content changes. Diameter variations from this cause as measured on six trees with a dial-gage dendrometer were less than 1 percent of trunk diameter. To compare this variation with the variation in d.b.h. measurements that can result from personal techniques of using a standard diameter tape, seven foresters each independently measured the same 40 robusta trees on the same day. Variations in diameters at breast height from personal measurement techniques exceeded d.b.h. variation due to changing bark moisture content.

Oxford: 176.1 *Eucalyptus robusta*: 521.1[–015.7 + 523.9 + 521.25].
Retrieval Terms: Eucalyptus robusta; stem diameter measurements; bark moisture content; measuring errors.

Accurate determination of tree trunk diameters with the standard diameter tape requires minimizing bias introduced by personal techniques of measurement. Measurements of diameter at breast height (d.b.h.) of the same tree by several individuals will result in slightly different values. Although this "personal bias" cannot be completely eliminated, such differences are generally small for those species having a firm bark. But they can be considerably greater in species with thick soft bark, such as robusta eucalyptus *(Eucalyptus robusta).*

In robusta, another source of bias was suspected from field observations by Survey Forester Wesley H. C. Wong, Jr., of the Hawaii Division of Forestry and other members of a Forest Survey crew. They suggested that d.b.h. measurements might be influenced by bark moisture content. Specifically, it appeared that the thick, fibrous robusta bark could swell enough from water absorbed during rainstorms to result in significantly larger d.b.h. measurements than if the same trees were measured when the bark was dry. These observations gained some support when a sample 15- by 35-mm. cylinder of robusta bark, cut from a tree with a cork borer, expanded about 15 percent in length from an ovendry to a saturated condition. If bark expansion under field conditions were of comparable magnitude, volume determinations could be biased.

I considered swelling and shrinking of the bark to be of practical importance if it caused at least a 1 percent variation in d.b.h. and was at least equal in magnitude to the diameter variations expected from "personal bias" in using the standard diameter tape for measuring d.b.h. To find out if d.b.h. variations due to bark moisture content were significant, I measured six robusta trees by using a dial-gage dendrometer especially mounted on plexiglass.

THE STUDY

The six robusta trees selected for the measurement varied in diameter from 10 to 46 inches. They were on the Honolulu Forest Reserve, next to the old Pali Highway, at 1,200 feet elevation. Annual rainfall there averages 118 inches. Wet-dry cycles ranged from 2 to 6 weeks. Measurements were begun after the weather turned dry. They were made daily during the remainder of the dry period and through a wet period that followed.

The onset of wet cycles was rapid, and rainfall was continuous enough so the transition from dry to wet bark occurred within a few hours. *Dry bark* was defined as bark that felt dry to the touch; *wet bark* was defined as that from which water could be squeezed.

At the beginning of a measurement period, I used a diameter tape to measure the "base d.b.h." of each tree to the nearest 0.1 inch. Subsequent changes in bark thickness were measured with a dial-gage dendrometer, on both the uphill and downhill sides of each tree, and added algebraically to the "base d.b.h." to determine the new d.b.h.

The technique of measuring bark thickness variation with the dial-gage dendrometer was as follows: Three nails were driven through the bark and into the wood of each tree, in a triangular configuration, on both the uphill and downhill sides. This configuration provided a fixed plane from which variations in bark thickness could be measured. About 1 square inch of bark, at the center of each triangle, was trimmed to form a vertical plane.

The dial-gage was mounted on a 1/4-inch thick plexiglass plate *(fig. 1)*. The heads of the nails driven into the trees fit into holes in the plexiglass base so bark thickness was always measured at exactly the same place. The gage was calibrated to 0.001 inch. A 1/2-inch square of plexiglass, mounted on the foot of the spindle, provided a flat surface with which to contact the prepared bark surface, thereby minimizing abrasion.

Three bolts were mounted in a second plexiglass plate so the bolt heads would fit into three holes in the base plate of the dial-gage. These bolts provided a means of insuring that the dial-gage was properly adjusted.

The null hypothesis tested was that the maximum differences between the diameters, for wet and dry bark, did not differ significantly from zero.

The second phase of the study determined the variations in d.b.h. measurements that could be attributed to differences in personal techniques of using a standard diameter tape. To carry out this phase, seven foresters independently measured d.b.h. to 1/10 inch of the same 40 robusta trees on the same day. This work was part of the normal routine for two of the seven foresters. And measuring was done during a period of dry weather. The trees varied in diameter from 6 to 24 inches.

The standard deviation of measurement differences among the seven foresters was calculated for each tree and plotted over the average d.b.h. The maximum observed d.b.h. variation due to swelling and shrinking of the bark was plotted on the same graph for comparison *(fig. 2)*.

RESULTS

The largest diameter variation due to swelling and shrinking of the bark of the six test trees was 0.139 inch. This variation occurred on a 24-inch diameter tree having 3.6-inch thick bark (double bark thickness: 7.2 inches) at breast height. The largest tree (46

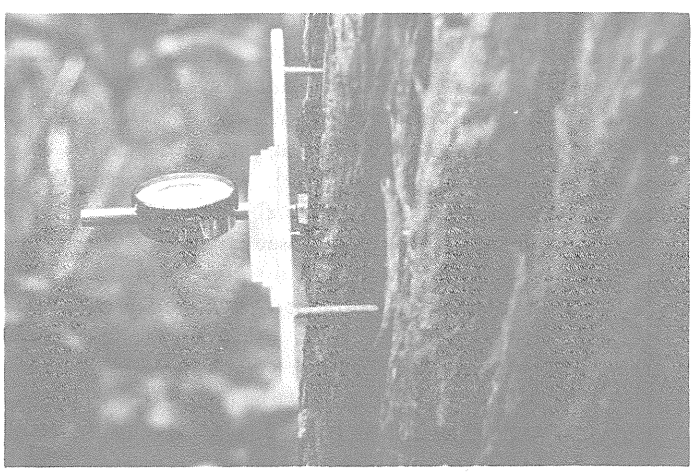

Figure 1—*A dial-gage dendrometer to measure diameter change was positioned by three nails driven into the robusta tree. The one-half-inch square of plexiglass mounted on the foot of the spindle minimized abrasion of the bark during placement and removal.*

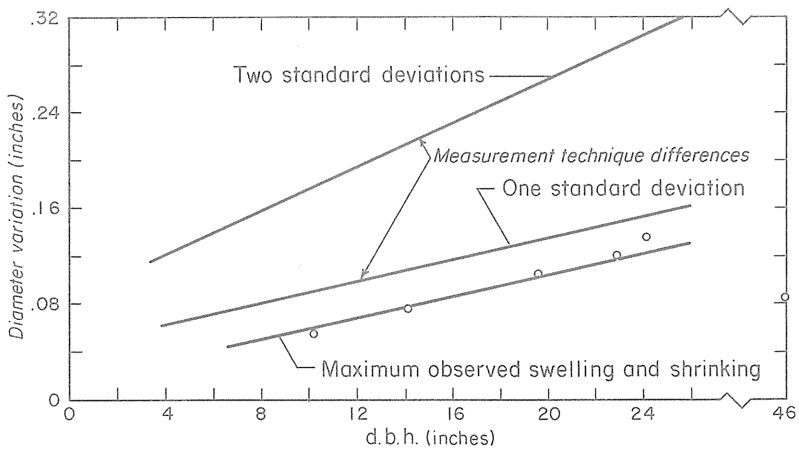

Figure 2—*Magnitude of d.b.h. variation of robusta eucalyptus trees due to swelling and shrinking of the bark compared to differences in d.b.h. measurements resulting from individual techniques of using a diameter tape.*

inches d.b.h.) had a single bark thickness of 1 inch and a maximum diameter variation of 0.085 inch.

Measurements of the 40 trees by seven foresters resulted in tree diameter differences ranging from 0.1 to 0.5 inch for 39 of the 40 trees; the diameter difference for the remaining tree was 0.7 inch. The diameter differences averaged 0.32 inch. The range of diameter differences for the two foresters who measure tree diameters as part of their normal work routine was 0 to 0.3 inch, averaging 0.12 inch. These measurement differences are due in large part to the softness of robusta bark. Some of the seven foresters pulled harder on the diameter tape than others, with the result that their diameter measurements were consistently smaller.

Maximum variation due to swelling and shrinking of the bark was less than the diameter variation due to personal measurement techniques *(fig.2)*. Diameter variation due to swelling and shrinking of the bark never exceeded *1 percent of the tree d.b.h.* This amount is much less swelling and shrinking than was observed in the drying and wetting of the 15- by 35-mm. bark cylinder. One reason for this difference is that the cylinder of bark was ovendried whereas the bark on the trees was air-dried. Another possibility is that when the bark is intact on the tree, expansion and contraction with varying moisture content is restrained by the interwoven and "interlocked" nature of the bark fibers.

Variation of robusta bark thickness with changing moisture content is statistically significant, but is not great enough to be of practical importance. If proper techniques are used, accurate d.b.h. measurements of robusta depends more on a standard pull or tension of the diameter tape than on the moisture content of the bark.

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