RESEARCH
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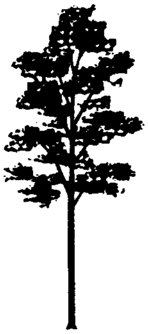

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ESTIMATING FORM CLASS IN STANDING TREES

by

James A. Johnson and Gary L. Willis

MICHIGAN TECHNOLOGICAL UNIVERSITY
FORD FORESTRY CENTER
L'ANSE, MICHIGAN 49946

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Introduction

Failure to account accurately for form class can result in a sizeable volume table error. A one percent change in form class approximates a 3 percent change in tree volume. In U.S.D.A. Technical Bulletin No. 1104, S. R. Gevorkiantz states that board foot composite volume tables, based on form classes of 78 and 79 percent, have been successfully used in the Lake States since 1943 (1). Because of compensating tendencies in factors affecting tree volume, estimates from these volume tables have seldom deviated from the gross scale by more than 6 or 7 percent. However, larger errors occasionally may occur in estimating stands of exceptionally good or poor form.

Three kinds of stands may require composite table adjustment, because of an abnormal distribution pattern and non-compensating factors. Open-grown or culled-over stands are apt to exhibit below average form, while the form in old growth stands may be above average. Another consideration is that any stand in which especially good utilization is practiced may produce top logs of excessive taper, thus causing volume overestimates. Bark thickness and oblate form may also cause error. An accurate but simple method of form class estimation is therefore necessary to provide satisfactory composite volume table adjustment.

The most commonly used measurement for volume table adjustment on standing trees is the Girard form class (2), which expresses tree form as the percentage ratio of diameter inside the bark at 17.3 feet above the ground (usually at the upper end of the first 16-foot log) to diameter outside the bark at breast height or 4.5 feet above the ground. Goebel (3) devised a procedure for estimating form class from measurements of the lower bole. Judson (4) developed regressions from Louisiana data for estimating form class with relationships that should have wide application. Their use also requires measurements of d.b.h., bark thickness at d.b.h., and diameter at outside bark at 17.3 feet. The difficulty of climbing trees, however, has discouraged adequate sampling of form class on standing trees. The recent development of optical calipers (5) makes possible the direct measurement of outside-bark taper of any portion of the tree and helps overcome this difficulty.

The Problem

Since Judson's (4) research findings were confined to the South, it was necessary to test whether the results could be applied to the northern hardwood forest. The basic principles appeared to be sound; therefore, species factor adjustments to the basic formula should provide acceptable estimates.

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[1] Assistant Professor of Forest Research and Forestry Research Assistant, respectively, Michigan Technological University.

After examination of a number of variables, Judson found the expression $\frac{d}{D+B}$ provided a close initial approximation of the form class ratio and was of a type familiar to cruisers:

d = diameter outside bark at 17.3 feet
D = diameter outside bark at 4.5 feet
B = double-bark thickness at 4.5 feet

Regression equations of the form $y = a + bx$, where y = estimated form class, and $x = 100\left(\frac{d}{D+B}\right)$, were developed for pines and hardwoods.

The equations developed were significant at the 0.01 level. The low standard of errors and the high proportion of form class variability of the regression indicated the suitability of the estimating procedure as a substitute for measurement.

Judson found it necessary to add 1 percent to the above formula for pine species and to subtract 1 percent for hardwoods to obtain an approximation within 0.5 form-class units. In the current study his method was tested on six species of trees which are common in the northern hardwood forest of the Upper Peninsula of Michigan to determine its applicability. The species investigated were sugar maple, yellow birch, American elm, red maple, black ash and basswood.

Testing Procedure

The data for testing were derived from one phase of a comprehensive tree evaluation study being conducted by the Center wherein each log of 677 standing trees was graded. The study required the measurement of the Girard form-class for each tree in conjunction with the grading study. All trees were climbed with a ladder for close inspection of upper log defects, thus providing the opportunity to obtain double-bark thickness as well as diameter inside bark at 17.3 feet. By obtaining the d.b.h. and double-bark thickness at breast height it was possible to compare the estimated form class with the actual form class. The trees were widely distributed on Continuous Forest Inventory plots in the Northern Hardwood-Hemlock cover type throughout the former Ford Timberlands in Baraga and Marquette Counties.

An IBM 360 computer was used to compute the estimated and actual form class values, limits of error, and averages for each species (Table 1). The initial testing used the formula as devised by Judson followed by empirical adjustment of the formula until the estimated form class deviated less than 0.5 form-class unit from the actual.

Results

Preliminary attempts in applying the formula $100\left(\frac{d}{D+B}\right)-1$ on the 661 tree samples failed to come within the established limits. In subsequent formula adjustments between 1 and 2 percent it was found that a minus 1.8 adjustment factor came within 0.5 form-class units for all species combined with the exception of basswood, which required a 2.8 percent adjustment factor to bring it within these limits. With the exception of basswood seventy-nine percent or greater were within ± 2 form class units, and over 90 percent within ± 3 form-class units (Table 1).

The probable reason for the variation in basswood is depicted in Figure 1, which illustrates graphically, the inherent error associated with a decreasing form class and increasing double-bark thickness such as is characteristic of the basswood, at least in the area studied. To illustrate this, double-bark thickness ranging from .5 inch to 3.5 inches, was added to a 13.5 inch d.i.b. tree at breast-height with a 11.2 inch d.i.b. at 17.3 feet above the ground. The estimated and actual form-class was computed for every addition of double-bark thickness, resulting in increasing departure of the estimated from the actual as illustrated in Figure 1.

The basswood double bark thickness averaged 1.84 inches at breast height in the study while sugar maple and yellow birch averaged only 1.38 inches. The actual form-class of basswood averaged 73.7 percent which is 3.2 percent less than the average of all species. Because of these differences an additional 1 percent must be deducted from the formula to bring basswood form-class estimations within 0.5 form-class units.

Conclusions

Adjusting Judson's formula by deducting a minus 1.8 percent resulted in a difference of less than 0.5 form-class percentage between the estimated and the actual with the exception of basswood, which requires a minus 2.8 percent adjustment factor. These results are comparable to the accuracy obtained by Judson in Louisiana. Individual form-class variability was found to be greater in the northern hardwoods than in the southern. Eighty-three percent of the southern hardwoods were within ± 1 form-class unit while only 47 percent of the northern hardwoods attained this detree of accuracy. Equivalent accuracy was obtainable only when the range was extended to ± 2 form-class units.

In the application of the formula $\frac{d}{D+B}$, D, d, and B are first measured to tenths of inches. To obtain B, two single bark thicknesses taken on opposite sides of the tree are summed. This is preferable to doubling a single measurement. Optical calipers or mechanical calipers could be used for obtaining d. With the measurements recorded, estimated form class is computed by the formula $100 (\frac{d}{D+B})$ minus 1.8 percent for all species tested, except for basswood in which 2.8 percent needs to be deducted. Providing adequate sampling is obtained, estimated values will differ from the actual by less than 0.5 form-class units.

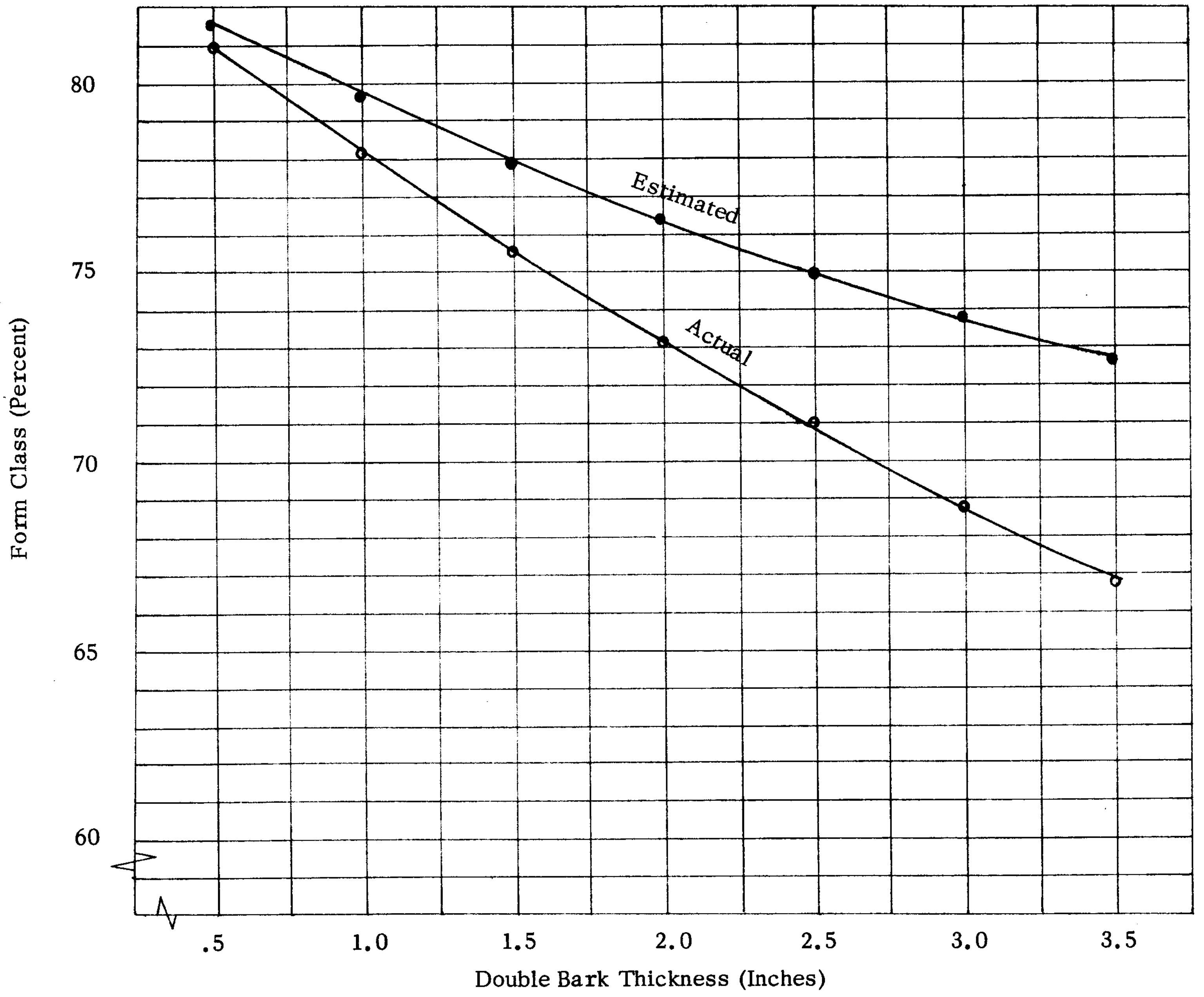
Limited sampling for other species and areas outside of the test area are reccommended for judging the reliability of the adjustment factors obtained in the test area.

TABLE 1. Northern hardwood test of estimated form classes

Species	Number in sample	Limits of error in form class units ± 1	± 2	± 3	± 4	Mean form class Actual	Estimated(1)
		Percent of sample					
Sugar Maple	396	47	81	96	98	77.5	77.4
Yellow Birch	144	43	79	90	96	75.8	76.2
Elm	9	67	89	100	-	79.7	79.4
Red Maple	51	53	80	96	98	78.5	78.3
Black Ash	15	80	93	100	-	76.7	76.6
Basswood	46	35	65	83	91	73.7	74.8
ALL	661	47	80	94	97	76.9	77.0

(1) Adjustment factor of 1.8 subtracted from formula.

Figure 1. Form class deviation with increasing double bark thickness.



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