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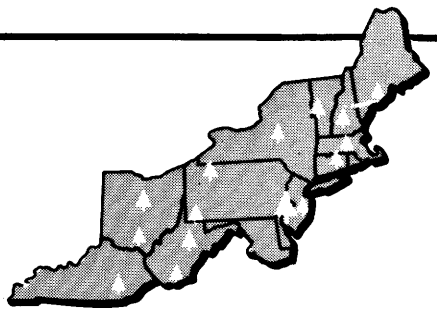

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FOREST SURVEY CUBIC-FOOT VOLUME EQUATIONS

Abstract.—The cubic-foot volume equations used in the regionwide Forest Survey are presented, and their development is discussed. An example of the use of an equation is given.

How does the Forest Survey estimate tree volume? This question is often asked by users of these data. Other people who make their own inventories often wish to calculate their tree volumes by using the same equations that are used in the regionwide forest survey. This note was prepared to provide this information.

Background

In the late 1940's, C. Allen Bickford (*1951*) worked on form-class and volume tables for tree species in the northeastern United States. This work was based on tree diagrams and average taper rates. He developed three volume tables.

One table gave the cubic-foot volume in the sawlog portion of the tree; one gave the volume in the upper-stem portion; and the third gave the volume in trees of less than minimum sawlog size. These tables segregated volume according to butt class and Girard form class (*Mesavage and Girard 1946*). Butt class is based on the ratio between stump diameter and d.b.h. Four butt classes were recognized:

1. Softwoods.
2. Hardwoods with a low ratio of stump diameter to d.b.h.
3. Hardwoods with a high ratio of stump diameter to d.b.h.
4. All other hardwoods.

To determine the total cubic-foot volume of a tree, volumes from several of these tables had to be combined.

In the early 1950's many trees in Connecticut, Maryland, New York, Vermont, and West Virginia were measured for Girard form class by forest-survey crews. The data were analyzed to test the hypothesis that, for each species, all Girard form-class measurements are from a single homogeneous population. The results showed no significant difference within a species due to location.

Some species within each of the four butt-log classes had the same average Girard form class. When these were combined, a total of 17 different species groups existed. The groups and the species in each are given in table 1.

Table 1.—*Seventeen species group cubic-foot volume equations*

General form of equation:
Gross cubic-foot volume = a + bX
where X = d.b.h.^{2} times height to 4-inch top in feet.

Species group	Species	Intercept (a)	Slope (b)
1	White, red pine	3.5142	0.00236
2	Red, white, black spruce	2.1998	.00257
3	Balsam fir	1.4793	.00272
4	Hemlock	2.4784	.00242
5	Hard pines, tamarack, Norway spruce	−0.0496	.00303
6	Cedar species	1.5817	.00259
7	Sugar maple	1.6823	.00310
8	Soft maples, yellow-poplar	1.1763	.00310
9	Ash species, aspen species	1.0067	.00293
10	Black cherry	1.1809	.00292
11	Birch species	1.1339	.00281
12	Beech	1.2851	.00326
13	Basswood	.8976	.00349
14	Red oaks, sweet gum, black gum	1.2027	.00301
15	Chestnut oak	1.0009	.00300
16	Hickory	1.4438	.00316
17	Other hardwoods	.8591	.00309

Cubic-Foot Volume Equations

Several years later, cubic-foot volume estimates and other data for trees measured on forest-survey plots throughout the Northeast were available. The volumes had been determined by combining sawlog and upper-stem volume estimates based on the tables. The total volume of the tree was the volume in the main stem from a 1-foot stump to a flexible top diameter outside bark of either 4 inches or more when taper, knots, or other limits to merchantability occurred below the 4-inch point.

These volume, diameter, and height data were used to predict total volume. The best equation for predicting total volume was $Y = a + bX$, with X being d.b.h.^{2} times height. Table 1 gives the intercept (a) and slope (b) for each species group.

In a recent study at the University of Vermont (*Myers 1972*), these equations were tested along with several others. The volumes estimated by the various equations were compared with the volume of the felled tree as determined by a water-displacement technique. The forest-survey equations were found to give the estimate closest to that determined by displacement.

Here is an example of the use of these volume equations for calculating the volume of a tree:

Given:

A red spruce with d.b.h. of 18.6 inches, estimated height to a 4-inch top of 41 feet, and 21 percent cull material in the main stem.

What are the estimated gross and net cubic-foot volumes?

Red spruce is in species group 2. The intercept and slope are 2.1998 and 0.00257.

$$X = 18.6^2 \times 41 = 14184.36.$$

Gross cubic-foot volume = 38.6536 cubic feet.

Net volume in cubic feet = 30.53 cubic feet.

References

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