



7-1983

Cubic Meter Total Tree Volume Equation for Young, Improved White Pine Plantations

University of Tennessee Agricultural Experiment Station

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STACKS

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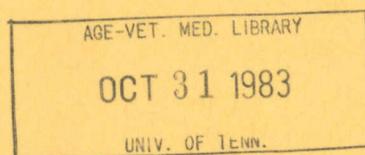
E11-2215-00-001-84

Cubic Meter Total Tree Volume Equation for Young, Improved White Pine Plantations

RR. 83-09

July, 1983

John A. Mullins, Jr.



**Department of Forestry,
Wildlife, and Fisheries**

TABLE OF CONTENTS

	Page
INTRODUCTION-----	1
MATERIALS-----	1
METHODS-----	2
RESULTS-----	4
REFERENCES-----	6

CUBIC METER TOTAL TREE VOLUME EQUATION FOR YOUNG,
IMPROVED WHITE PINE PLANTATIONS

by John A. Mullins, Jr.*

INTRODUCTION

Early evaluation of the growth potential of improved eastern white pine (Pinus strobus L.) progeny allows a more rapid planning and development of breeding schemes for future improvement. The variables generally used to evaluate growth potential are (1) total tree height, (2) diameter at breast height, (3) basal area, and (4) survival. One of the best indicators of growth potential is total tree volume. However, such available volume tables as Vimmerstedt (1961) are not suitable for the determination of the volume of young white pine because (1) initial tree sizes in the tables are either too large and/or (2) the equations available are for merchantable volume to either a 3 or 4-in. (7.44-cm or 9.92-cm) top. It therefore becomes desirable to develop a suitable volume equation for total aboveground volume. This would help evaluate the growth potential of young white pine progeny.

MATERIALS

The population utilized for this sample was from two locations of an open-pollinated white pine progeny test established in 1975 on The University of Tennessee Forestry Field Station property at Tullahoma and Oak Ridge, Tennessee. Seedlings used were the open-pollinated progeny of 22 University

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of Tennessee selections from the Cumberland Mountains (seed produced in a breeding orchard) along with seedlings grown from a preferred commercial seed source located in eastern Tennessee and western North Carolina.

METHODS

The first sample tree at each location was randomly selected. Beginning with this tree, every 30th living tree within the row was measured. The following measurements were made on each sample tree (Figure 1): (1) total tree height (THT) to the nearest decimeter using

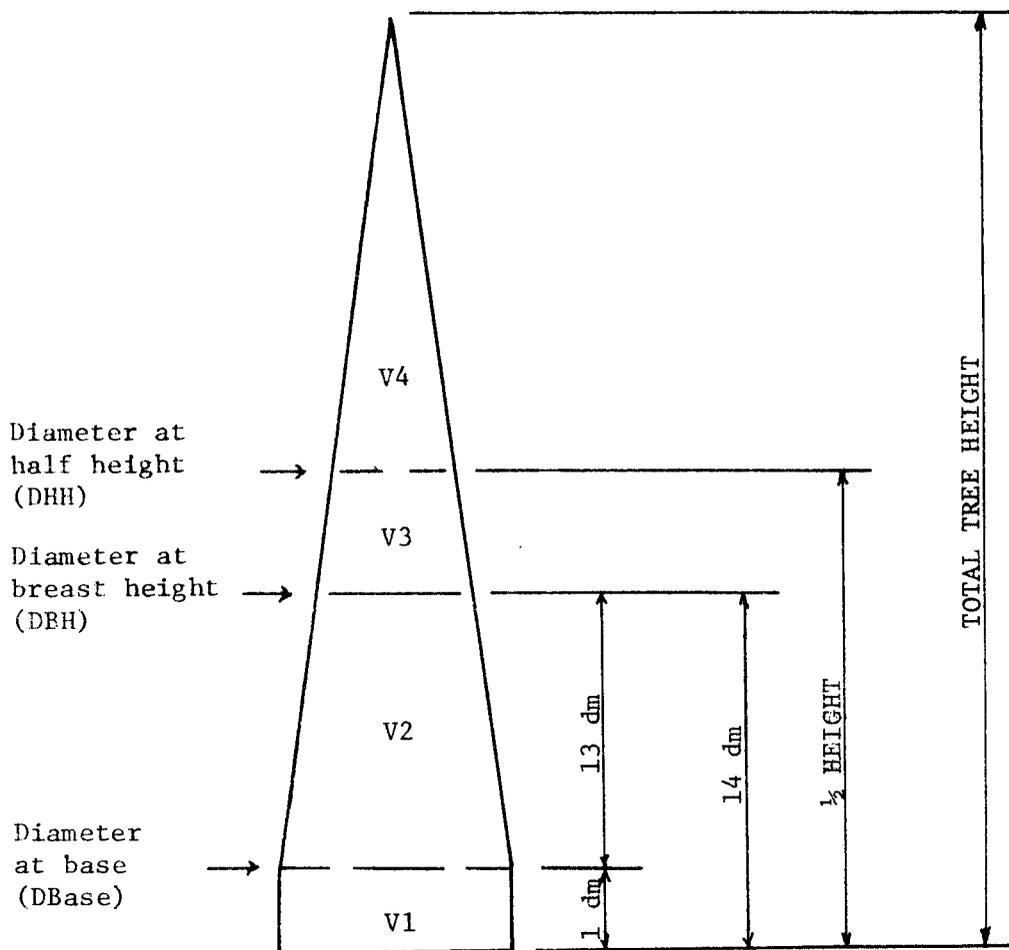


Figure 1. Diagram showing sections defined to measure height and diameters, and calculate volumes for each sample tree.

a pole; (2) diameters to the nearest half centimeter using calipers at, (a) one decimeter above the ground (DBase), (b) 14 decimeters above the ground (DBH), and (c) one-half total tree height (DHH). Using the equation:

$$A = 0.7854 D^2,$$

where

$$A = \text{cross-sectional area in cm}^2,$$

$$D = \text{diameter in cm},$$

cross-sectional areas of the stem for each diameter measurement (ABase, ABH, AHH) were calculated.

The heights at which the three diameters were measured were used to divide the tree stem into sections (Figure 1) for which the following assumptions were made to calculate volumes; section 1, (below 1 dm)= a cylinder, section 2 (above 1 dm and below 14 dm) and section 3 (between 14 dm and one-half height)=cone frustums, and section 4, (above one-half height)=a cone. Volumes in cubic centimeters of each tree section were calculated using the following equations (Husch et al. 1972):

$$\text{Volume of section 1 (V1)} = \text{ABase} \times \text{HT1};$$

$$\text{Volume of section 2 (V2)} = \frac{\text{HT2}}{3}(\text{ABase} + \sqrt{\text{ABase} \times \text{ABH}} + \text{ABH});$$

$$\text{Volume of section 3 (V3)} = \frac{\text{HT3}}{3}(\text{ABH} + \sqrt{\text{ABH} \times \text{AHH}} + \text{AHH});$$

$$\text{Volume of section 4 (V4)} = \frac{\text{HH}}{3}(\text{AHH}).$$

where

$$\text{ABase} = \text{cross-sectional area at the base in cm}^2,$$

ABH = cross-sectional area at breast height in cm^2 ,
 AHH = cross-sectional area at one-half total height in cm^2 ,
 HT1 = 10 cm,
 HT2 = breast height (140 cm) - 10 cm = 130 cm,
 HT3 = one-half tree height - 140 cm,¹
 HH = one-half total tree height.

Total aboveground tree volume in cubic meters = $(V1 + V2 + V3 + V4) / 1,000,000$. D^2H , the predictor variable for total tree volume was calculated as:

$$D^2H = DBH \times DBH \times THT,$$

where

DBH = diameter at breast height in cm,

THT = total tree height in meters

Analysis was performed on an IBM 370 model 3031 computer at The University of Tennessee, using the General Linear Model (GLM) procedures of the Statistical Analysis System (SAS 79) (Barr et al. 1979).

RESULTS

An analysis of covariance was made on the two locations using the model:

$$\text{Volume} = D^2H, \text{ Location.}$$

Since there was not a significant difference between locations the two data sets were combined. The simple regression of volume on D^2H using the 109 sample trees was highly significant (Table 1), and accounted for 95% of the variation in volume.

¹If half-height is less than 140 cm, a negative volume for section 3 results.

Table 1. ANOVA for the Regression of Volume on D^2H .

Source of Variation	df	Sum of Squares	Mean Square	F
D^2H	1	0.00572662	0.00572662	2073.27 ^a
Error	107	0.00029555	0.00000276	
Total	108	0.00602217		

^aSignificant at the 0.0001 level

The resulting equation is:

$$\text{Cubic meter volume} = 0.00246419 + 0.000046121982 (D^2H),$$

where

D = diameter of stem at breast height in cm,

H = total tree height in meters to nearest dm.

The descriptive data for the variables measured and calculated on the 109 trees are presented in Table 2.

This equation is presently being used at The University of Tennessee to predict aboveground tree volume of young white pine progeny. Its high precision enables accurate evaluation of performance of white pine under 10-years of age. Although this equation was derived from a limited population and geographic area, its utility suggests that it is a better predictor of total tree volume than that now normally determined using standard volume tables.

Table 2. Means, ranges, and standard error of means for measured, calculated, and predicted variables.

VARIABLE	MEAN	RANGE		STANDARD ERROR OF MEAN
		MIN.	MAX.	
MEASURED				
THT (m)	4.6	2.3	6.1	0.821
DBase (cm)	10.5	4.0	16.0	0.265
DBH (cm)	6.8	1.5	11.0	0.196
DHH (cm)	4.9	4.0	8.0	0.110
CALCULATED				
D ² H	250.85	5.18	701.80	15.122
VOLUME (m ³)	0.014034	0.00101	0.034737	0.000715
PREDICTED				
VOLUME (m ³)	0.014034	0.02703	0.034833	0.000698

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