Salahaddin University
College of agriculture science
Department of forestry

Comment [r1]: College of Agricultural Engineering Sciences

Effect log formula on the accuracy of volume estimates of *Populus nigra* L. (black poplar) species

Researched by
Alan Esmahil

Supervisored by
Halmat A. Sabr- Assistant professor

Introduction

The Estimation or tree Volumes with accuracy and precision is vital to efficient forest inventory and management (Wiant and wood 1993). Log volume estimates

are often made using log formulae like Huber's, Samalian's and Newton's. The choice of any of these formulae is decided by(i) the ease of taking measurements, (ii) the simplicity in calculating log volumes using the formula, and (iii) the accuracy obtained using the formula (Alemdag 1978).

Comment [r2]: Need more information

Aim of the Research

The aim of the study the purpose of this investigation was to assess the impact of log formula on the accuracy of volume estimates obtained for black poplar (*Populus nigra* L.) in Erbil City.

MATERIALS AND METHODS

Mensuration techniques A common procedure for estimating tree volumes during forest inventories in Erbil city is that described in FAO (1981).

Measurement

By this method either felled trees are sectioned into 4 m bolts and sectional diameters measured with a diameter tape or caliper, diameters are measured at these intervals (Figure l). Bolt or section volumes are then calculated using a chosen log formula (Huber, Smalian, Bruce or Newton) and summed to give total volume for the whole tree bole. Newton's formula was used to calculate bolt volumes for the standard method since it is said to give "exact' results with frustums of cylinder, paraboloids, neiloids and conoids (Rondeux 1993, Philip 1994). The standard method seems cumbersome and time consuming since so many measurements have to be made, hence an alternative method, in future this Method, has been favored by some foresters. It requires only three diameter measurements on logs: a diameter at log base (db), one at small end or upper cross-cut (ds) and a third at log midpoint (dm) (Figure 1). A chosen log formula is then used to estimate volume for the whole tree bole; considered as a single log if Huber's or Newton's formulae are used and as two logs if Smalian is used.

Data

Data used for this study were based on felled tree measurements. Measurements were made according to Method on felled trees. From these data sets 32 logs with 4 m logs were obtained.

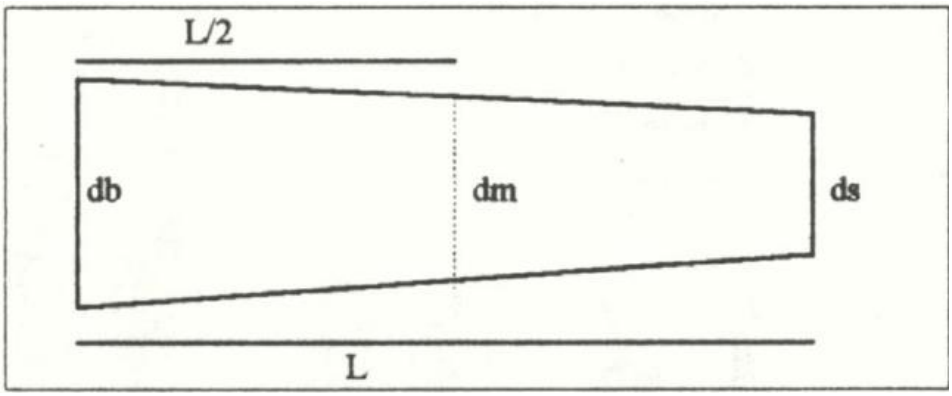

Figure 1: Diagrams illustrating the volume estimation with method of only three diameters (db = diameter at large end of log, ds = diameter at small end of log, dm = diameter at midpoint of logs).

Log formulae tested

Five log formulae, Huber, Smalian, Newton, Average of end-diameters formulae (Avend) and Bruce formulae (cf. Alemdag 1978), were tested. The formulae are as follows:

Bruce's formula	$V_i = f * L * (0.25(dB)^2 + 0.75\,(dA)^2)$

$V = \pi d_m^2 L/4$	Huber's Formula.
$V = \pi (d_b^2 + d_s^2)L/8$	Smalian's Formula.
$V = \pi (d_b + d_s)^2 L/16 = \pi d_{av}^2 L/4$	Average of end-diameters formula
$V = \pi (d_b^2 + 4d_m^2 + d_s^2) L/24$	Newton's formula.

where:

V = log volume (m^3),
d_b = diameter at large end of log,
d_s = diameter at small end of log,
d_m = diameter at midpoint of log,
d_{av} = average of end diameters,
L = log or bolt length (m).

Accuracy assessment

From the volume estimates obtained, the accuracy of the methods were evaluated using the following criteria:

Bias, defined as the average deviations between the estimated volume and the 'standard' value obtained using method A with Newton's formula.

Precision deviations as follows was estimated by the variance of the and the standard deviation (STD) was derived from the Variance.

Mean square error (MSE), a composite criterion, which combines bias and precision (variance) was used as an estimate for the overall accuracy of each method. The relationship between MSE, bias and precision is as follows (cf. Cochran, 1977):

$MSE = Bias^2 + Var$

MSE was converted to root mean square error (√MSE) so as to present results in the same measurement units.

Results and discussion

Table 2: bias, variance, STD, MSE, RMSE and mean for (4m) log sectional length.

	Bruce	Average end	Simalian's formula	Huber
bias	-11.9983	3.589330729	5.390660417	-2.69533
variance	2126.884	2211.006872	2222.867211	2502.303
std of variance SQRT OF VARIANCE	46.11815	47.02134486	47.14729272	50.02303
MSE	2270.842	2223.890167	2251.926431	2509.568
RMSE	47.65336	47.15813999	47.45446692	50.09559
Mean	193.9427	215.0429	200.9914	212.4249