EXPRESSION OF FORM

Tree stem form generally approaches that of any solid revolution. Stem volume can be approximated by the formula for solid of the same basal diameter and height. Any difference in stem volume and that of solid revolution is due to the variation in stem form from the standard chose. The ratio of the 2 volumes is termed Form Factor.

$$\text{FORM FACTOR} = \frac{\text{Volume of tree}}{\text{Vol. of Geometrical Solid}}$$

Depending on the geometrical solid used which may be cylindrical or conical stem factor. The cylinder is the usual reference geometric solid is determining stem factor which is usually defined as the – coefficient by which the volume of a cylinder having the same cross-section as the tree must be multiplied to obtain tree volume.

$$\text{Form Factor} = \frac{\text{Tree Volume}}{\text{Vol. of Cylinder of same Ht \& DBH}}$$

Form factor can also be classified according to the position of basal diameter e.g. in absolute form factor, the basal diameter is taken at ground level. Basal diameter is usually taken above ground level because of the difficulties due to irregularities and buttress at ground level.

Basal diameter is usually taken at breast height which result in Breast Height Factor and sometimes at arbitrary point say 5 or 10% of the total height of the tree to obtain a normal Form Factor. The advantage of Normal Form Factor is that the basal diameters are more closely related to the tree for (in trees of different form and height). The normal form factor also describes actual tree form much more efficiently. The disadvantage in using normal for factor is the difficulty in determining the position of the basal diameter.

The portion of the tree, the volume of which is being determined can also be used in classifying form factor e.g. Merchantable Form Factor is one in which the merchantable length of the stem is used as the height while in the Stem Form Factor total height of the tree is taken. A Tree Form Factor results if the total height is used and the tree volume contains the volume of braches, wood and stump. The frustum is similar to merchantable form factor but uses the volume of the frustum of a cone.

USES OF FORM FACTOR

Form factor is used for estimating volume of standing trees from diameter at breast height and height.

$$V = S \times h \times f$$

Where V = volume

S = basal area (cross sectional area)

h = tree height

f = form factor

Note: S x h is volume of a geometric solid usually a cylinder

Form factor varies with tree species especially according to the position occupied in the canopy. Volume estimation by form factor is a circuitous and unsatisfactory approach. It is of interest essentially where the labour has already gone into the computation and presentation of statistics of form and taper of individual species.

FORM QUOTIENT

Form quotient is another expression of tree form. In contrast to form factor which is a ratio of volume, form quotient is a ratio of 2 stem diameters. The lower diameter being taken at breast height. The following are four types of form quotient:

1. Normal Form Quotient:

The original concept of form quotient is based on the diameter at ½ height to diameter at breast.

$$\text{Form Quotient} = \frac{d\,(1/2)}{d\,(bh)}$$

The defect of this form quotient is that, as the tree height becomes shorter a stage is reached when d(1/2) will coincide with diameter at breast height i.e. (d(b.h) for a tree whose height is double the breast height.

2. Absolute Form Quotient:

This is formulated to remove the defect of normal form quotient.

$$\text{Absolute Form Quotient} = \frac{d\,(1/2h.a.b.h.)}{d\,(b.h.)} \quad \text{1/2 ht after breast height}$$

3. $$\text{Girard Form Quotient} = \frac{d\,(u.b)\text{ at }17.3}{D\,(b.h.\text{ overbark})}$$

4. Gieruszynski Form Quotient

$$= \frac{A\ (0.5)}{A\ (0.1)}$$

Where A(0.5) = cross sectional area at ½ stem length
A(0.1) = cross sectional area at 0.1 stem length (starting from the base).

<u>FORM POINT</u>

This is another index of tree form. It is based on the mechanistic theory i.e. the form of trees depends on mechanical stress to which a stem is subjected e.g. dynamic stresses resulting in bending moment induced by wind and static forces due to crown weight.

It is assumed that the form of a stem is dependent on the position of the point of greatest resistance to wind pressure called the Form Point. The form point is located at the centre of gravity of the crown.

<u>FORM CLASS</u>

This is the expression of form point as a percentage of tree total height. The following procedure is used to determine the form class of a tree: The position of form point is estimated by eye. The ratio of this height (from tree base) to the total height in percentage constitutes the tree's form class:

Height of form point 100

Form Class = ------------------------ x -----
Total tree height 1

ESTIMATION OF VOLUME OF STANDS

A stand may be defined as an aggregation of trees in a specific area, and sufficiently uniform in composition, age, arrangement etc. to distinguish it from forest on adjoining areas. Stand volume estimation usually involves sampling techniques. An estimate of stand volume with an assignable error is sort.

There are 3 major approaches to Stand Volume Estimation:

(i) Sample Tree Method
(ii) Graphical or Regression Method
(iii) Volume from Aerial Photographs.

SAMPLE TREE METHOD:

Sample trees are selected. Their volumes are obtained and then extrapolated to give estimates for stand volume.

GRAPHICAL OR REGRESSION METHOD:

In the graphical method, relationship is established between individual stem volume and an easily measurable statistics (Dbh or Gbh). Graph is then plotted and used to estimate sample tree volumes which are subsequently applied to stand enumeration to obtain stand volume.

AERIAL PHOTOGRAPH VOLUME ESTIMATION METHOD:

This method entails direct estimation of stand volume from aerial photographs through prior knowledge of the relationship of air crown cover and stand volume.

SAMPLE THREE METHOD:

This approach is the oldest method of stand volume estimation in Forestry but it is being superseded by volume table method. Relatively, few trees are measured into details and stand volume is derived generally from the formula V = V(mean tree) x No. of trees in stand.
Three systems are distinguishable:

(a) Concrete/Direct-crop volume is calculated from concrete sample trees by proportion.
(b) Concrete/Graphical – (as for “a”) but graphical methods are used.
(c) Abstracts – Volume is calculated from abstract sample trees obtained from graphs and volume tables.

CONCRETE DIRECT METHOD:

(i) Selection of Sample Trees:

Sample trees are chosen from trees with diameters as near as possible to tree of mid basal area and are expected to conform in height, stem and crown shape to the mean tree. This is impossible in practice.

(ii) No. of Trees:

This is variable, general rules are impracticable because of varying circumstances of stands and growth. The more varied the stand the greater the number of sample trees required.

(iii) Measurement of Sample Trees:

Where possible sample trees should be felled for measurement and are usually selected from thinning or the surrounds.

Method 1 – Simple Sample Tree Selection.

Enumerated trees are grouped in diameter classes (1” or 2.5cm). One or more trees are selected from each class and measured for volume. There is therefore a disproportionable weight in sample in this method. Using the formula

$$V = \frac{V \times S}{s}$$

where V = volume of diameter class
v = volume of sample trees (s)
S = basal area of diameter class
s = basal area of sample tree (s)

Method 2 – Arithmetic Mean Method

Enumeration and calculation are done as in method 1. The basal area of plot mean tree is calculated from the formula

$$\frac{\text{Sum of Basal Area}}{\text{Total no. of trees}}$$

Mean basal area is concerted to diameter. Abeokuta 3 – 5 mean trees are selected and measured for volume. Volume of the plot is calculated using the formula:

$$V = \frac{V \times S}{s}$$

Method 3 – Huber’s Method.

Group enumerated trees into equal number of diameter classes. Several classes are then grouped together and a mean tree is calculated for each group. The procedure for method 1 is calculated for each group. The procedure for method 1 is then followed. This method requires fewer sample trees than method 1. Method 4 – Urich’s Method:

A more efficient method than method 3. Grouping is done is such a way that each group has the same number of trees. Equal number of sample trees are measured from each group.

$$\text{Volume of the plot} = V = \frac{V \times S}{s}$$

where v = total volume of sample tree
s = total basal area of sample tree
S = total basal area of plot.

This method is used by the British Forestry Commission for determining volume of temporary sample plots for Yield Table Construction. It is not necessary to calculate group volume in this method.

Method 5 – Hartig's Method:

This involves groups of equal basal area. It is assured that errors of volume estimates are proportional to group volumes and are compensating. Group volumes are calculated separately using the usual formula.

Method 6 – Block Method:

This method aims at removing defects in the former methods. The defects are that the same trees are not being sampled at each re-measurement of a permanent sample plot and that final crop trees are grouped in the thinnings at each measurement. In this method therefore, the largest trees are in group one, the next largest in group two etc, the number of trees increasing in the lower groups. There is therefore a selection of greater number of sample trees for groups containing the larger trees on account of the greater economic importance of the latter. The volume of each group is calculated as before from mean basal area sample trees. Not less than 2 trees are measured for each group.

<u>CONCRETE/GRAPHICAL METHODS:</u>

Sample trees are selected without regard to grouping, instead selection covers the whole range of diameter classes. A graph is prepared from the data obtained.

(i) Volume Curve Method:

Volume of sample trees are plotted against diameter and a smooth curve is drawn. The mean tree diameter is calculated and its volume read off the graph.

V (gp) = v x n
V (gp) = volume of girth class
v = volume of mean tree
n = number of trees in the group.

(ii) Form Factor Method:

This is similar to the first method but form factor diameter curve is used. Diameter/height graph is prepared. The diameter of the mean tree of each group is calculated. Its form factor and mean height are read from the graph and its volume obtained from

V = s.n.f.
S = basal area of sample tree
h = mean height
f = mean form factor.

<u>ABSTRACT METHOD</u>

Abstract sample trees are used. Any method of grouping except the arithmetic mean method is allowed. Height/diameter graph is prepared from sample trees of each group. Then for each group, calculate mean tree diameter, read height from graph, read volume from volume table using height and diameter. Obtain group volumes and then plot volumes from this abstract sample trees. This method presupposes the existence of volume tables.

CRITICISM OF SAMPLE TREE METHODS

1. They are inconvenient, though this is not peculiar to sample tree methods.
2. Methods of selection of sample trees are frequently prone to errors.
3. Sample is usually small, hence representativeness is dubious.

VOLUME TABLE METHOD OF VOLUME ESTIMATION

The volume table method was mentioned under approach (b) of the last lecture.

DEFINITION:

The tree volume table is a statement of the AVERAGE value of VOLUME of a tree of a particular DIMENSION.

AVERAGE:

Trees are irregular enfid bodies and appearances are bound to occur in volumes of trees of the same dimensions. Volume is determined by any of graphical, sectional or other methods and it provides only an estimate.

Dimensions imply limited statistic e.g. D.b.h. over bark, height and expression of taper.

The main purpose of tree volume table is for application to standing trees to give average volume of a number of trees in dimension classes.

REQUIREMENTS OF A GOOD VOLUME TABLE METHOD

1. The ideal method should be simple i.e. free of complex mathematics and should involve relatively few parameters.
2. A large number of tree measurements must be available to give well defined trends.
3. Need of special equipment should be held to a minimum.
4. It should be objective and hence graphical representation of relationship should be by straight lines rather than curves.
5. It should lead to reasonably accurate results of predictable precision.

REQUIREMENTS FOR THE CONSTRUCTION OF VOLUME TABLE

A. DIRECT CONSTRUCTION

1. The following specifications are necessary at the planning stage:
   (a) Tree statistic or statistic to be employed.
   (b) The type of volume to be estimated.
   (c) Species to be considered.
   (d) Territorial range of species selected.
   (e) Size of range covered.
   (f) Degree of precision required.

2. A Sampling Operation:

   Sufficient data within limit set by time and cost.

3. Establishment and Computation of the Volume:

Tree statistics are tested in diverge combination of variables. The best equation with lowest standard error or highest correlation coefficient should be chosen. Precision and biased are important.

Biased regression is one which overestimates younger tree volumes and underestimate volume of larger trees.

Biased Regression

4. Presentation:

The print-out should be convenient and should contain texts in identification material, descriptive materials including extent of extrapolation; comparative material in form of existing volume table for testing purposes and instruction for application and modification particularly local correction factors.

B. <u>INDIRECT CONSTRUCTION</u>

Indirect method may involve relating tree diameter and height to an indirect measure of volume like form factor or taper and the construction of the volume table as a separate step from the form factor table or taper curves.

Requirement presupposes the existence of a body of information on the tree form.

There are 2 types of Volume Tables, namely:

1. Local Volume Table: which is for a specific locality. It consists of one independent variable which is the dbh i.e. volume related to dbh.

2. Standard Volume Table: It consists of two independent variables which are the dbh and height i.e. the volume is related to dbh and height. It is used for a country or for a larger extent.

<u>TARIFF TABLE:</u>

Tariff is derived from a French word Tariff be cubage (meaning volume table) and is used in Western Europe and refers to particularly to one way volume table.

In Britain, tariff implies one of the family of one way volume tables. If the volume, basal area lines of a stand becomes older, the increase in tope heights increases the regression coefficient of volume basal area line and decreases the regression constant. The point of intersection of the volume line with the basal area axis remain approximately constant.

A tariff table may be regarded as a series of local volume table. In the U.K. Forestry Commission, tariff table provided by Humell each member of the series of the local volume in Hopus feet for a quarter girth basal area of one square foot.

The British tariff tables were originally meant for estimating the volume of thinnings before felling. The tariff tables are however been increasingly used for estimating standing volume at different ages of the stand. Tariff is not of particular interest to Tropical Forestry.