Compilation Sequence 3

3.1 Log Volume Calculation - Overview

See Appendix 1 for examples of detailed tree and log volume calculations.

When a tree is coded as Z-99-00 then no values will be reported for that stem.

Step 1 Set the parameters for calculating the taper and volume of a tree. These are:

1. Forest Inventory Zone.
2. DBH - Diameter at breast height (1.3 m) outside bark and above high side ground to the nearest tenth of a cm (e.g., 110.1).
3. Height - Total height to the nearest tenth in metres (e.g., 41.3).
4. Stump ht. - Stump height to the nearest hundredth in meters (e.g., 0.30).
5. Top diam. - Top diameter inside bark to the nearest tenth in cm (e.g., 10.0 or 15.0 cm).
6. Log length – individual log lengths called by cruiser. Preferred log lengths are 13, 11 and 8 m. Random lengths can be called. Maximum compiled log length is 17.9 m (13 m + 4.9 m minimum log length for a recorded last log of 99).

Step 2 Calculate tree volumes using the taper equation and volume routine (see Appendix 1).

Use the taper equation and volume routine with the above defined parameters.

These routines will determine:

1. The diameter inside bark at stump height.

2 The merchantable height of the tree.

3 The length of the last log. If top log length is less than the minimum log length for that species and grade, then the last log is combined with the second to last log and assigned the second to last log grade. The net factors are then combined. See Appendix 1 step 2.3.

4. Calculate the new net factor for the last log (only required if the last log is combined with the second to last log). See Appendix 1 step 2.4.
5. Calculate top and butt diameters for each log.
6. Calculate gross merchantable volume using Smalian's formula for

each log. Calculate Smalian's volume using a 10 cm segment length.

7. Biological volume – from high side ground to top of tree. Gross merchantable volume + stump volume + top volume.

Step 3 Apply net downs. Cruiser estimated net factors by log for decay volume, cruiser called Z grades for waste volume, CGNF lookup table for breakage volume (see Appendix 3), and NVAF corrections for taper and decay (see Appendix 4).

Terms:

Fb Breakage Factor

Ft Taper Correction Factor

Fr NVAF Correction Ratio

Fd Decay Factor

Fdc Tree Decay Factor after NVAF Correction

B Breakage Volume

D Decay Volume

W Waste Volume

V Gross Volume

VmB Gross Volume minus Breakage

VmBc Gross Volume minus Breakage after Taper Correction

VmBDc Gross Volume minus Breakage and Decay after NVAF

Correction

Vn Net Volume (Gross Volume-Breakage-Decay-Waste)

Vc Gross Volume after Correction

N Number of Logs

1. For each log, calculate the Log Breakage Volume. The NVAF process did not include breakage volume; therefore, the breakage volume must be taken out before the remainder of the volume is adjusted.

   $$B_i = V_i \; x \; Fb$$

2. Log Gross Volume minus Breakage is:

   $$VmB_i = V_i \, (1 - Fb)$$

3. Apply the Taper Correction Factor. The taper correction is used to correct the known bias in the gross volume of taper equations. These factors are corrected by species, maturity and live/dead (see Appendix 4).

   $$VmBc_i = VmB_i \; x \; Ft$$

4. The corrected Gross Volume is:

   $$Vc_i = VmBc_i + B_i$$

5. Calculate Tree Decay Factor by taking the average of logs Decay Factor weighted by the log volumes in step 3 above.

   $$Fd = \frac{\sum_{i=1}^{n} \left(Fd_i \; x VmBc_i \right)}{\sum_{i=1}^{n} VmBc_i}$$

6. Correct the Decay Factor using the NVAF coefficients from the lookup table:

   $$Fdc = Fr \times Fd^{Fp}$$

7. The log's Decay Factor is adjusted by the NVAF factor calculated in 6 above, to deduct the Decay volume:

   $$VmBDc_i = VmBc_i \times Fd_i \times \frac{Fdc}{Fd}$$

8. The Decay volume is:

$$D_i = VmBc_i \times (1 - Fd_i \times \frac{Fdc}{Fd})$$

9. If the log is of the Z grade:

$$Vw_i = VmBDc_i$$

$$Vn_i = 0$$

otherwise:

$$Vw_i = 0$$

$$Vn_i = VmBDc_i$$

10. The tree's Net Volume is:

$$Vn = \sum_{i=1}^{n} Vn_i$$

Step 4 If a percent reduction is being compiled, determine whether there is an eligible reduction for the tree. Refer to *Chapter 5* for the Percent Reduction procedures. Risk group/tree class is not used in CGNF. However, Dead/Live and Mature/Second Growth tree codes can be used.

Step 5 If both count and measure plots have been tallied in a variable plot cruise, calculate a double sampling ratio (DSR) for each tallied species. The DSR adjusts stem count, basal area, and volume estimates. Calculate a DSR for each Timber Type. Trees are not compiled if they are Z9900.

Output - Double Sampling Ratios (004b).

Example: Fir DSR for a Timber Type

$$\text{DSR}_{(\text{fir})} = \frac{\#\text{of meas plots.}}{\text{Total}\,\#\text{of plots}} * \frac{(\#\,\text{fir trees})*(\text{avg. BAF all fir trees})}{(\#\,\text{meas. fir trees})*(\text{avg. BAF meas. fir})}$$

To calculate the average BAF , sum the basal area per hectare of all the trees in the type and divide by the number of trees in the type.

Step 6 Double the volume, basal area and tree count for border plots used in cruises conducted prior to 2005.

Step 7 Calculate grade percents. Each log grade, length and net factor is assigned by the cruiser.

Spruce high grades F and G are called by the cruiser and a lookup table is used to breakout grades D and E. See Appendix 5.

3.2 Calculating Volumes Using Smalian's Formula

CGNF uses Smalian's formula for calculating log volumes. Segment length is 10cm.

To calculate a tree's merchantable volume for cruiser called grades, simply calculate and accumulate each individual called log volume. Care must be taken for the total length of the logs not to exceed the merchantable height. See Chapter 2 - 2.2.1 Validations for an example.

To calculate a tree's **merchantable height**, you can use a method resembling the binary search algorithm. Starting with an initial value for the merchantable height, calculate the DIB and compare it with the standard top diameter. If not equal, adjust the height and recalculate the DIB in a loop until the difference between the standard and the calculated diameter is negligible. See Appendix 1, step 2.2 Example #1. Version 4.1 of Kozak's taper equation is used to calculate the diameter inside bark at a given height.

Calculation of log volumes:

The log is first cut into smaller segments and the volume of each segment is calculated and summed. The segment length used is 10 cm.

The "I" subscript in the following formulas refers to a segment's attribute.

$$Vl = \sum_{i=1}^{n} Vs_i$$ Volume of the Log

$$Vs_i = \frac{Ab_i + At_i}{2} \times Ls$$ Volume of a segment, using *Smalian's Formula*

$$Ls = \frac{L}{n}$$ Segment Length

$$A = \frac{D^2 \times \pi}{4}$$ Cross section Area

Where:

Vl = Log Volume

Vs = Volume of a Segment

Ab = Area of the Segment's Bottom

At = Area of the Segment's Top

Am = Area of the Segment’s Middle

Ls = Segment Length

L = Log Length

n = Number of Segments in a Log

D^2 = Diameter squared

A = Cross section area

Last log logic:

If the compiled last log in a tree is shorter than the minimum length allowable for the species and grade assigned, then the last log is combined with the second to last log and assigned the second to last log’s grade. When the second to last log grade is N and the last log is shorter than 3.0 meters, the last log will be assigned grade Z. When the second to last log grade is N or Z and the last log is 3.0 to 4.9 m, the last log will be assigned grade Y. The log lengths are summed and the net factors are combined and weighted by length. See Appendix 1, step 2.3 and 2.4.