

Compilation Sequence

3

The compilation program is used to compute *quantitative* estimates for volume, basal area, average diameter and tree count statistics and other related data for a timber cruise. The estimates are reported for both stand total and 'per hectare' values. For example, the total volume and volume per hectare estimates are reported for the timber cruise. In the interior, estimates for lumber recovery and chip yield are also computed.

The estimates for these parameters are reported at the following levels:

1. Timber Type - a stratification of the cutting permit. Trees that belong to a certain type have similar characteristics with respect to species composition, age, size, quality and site index.
2. Cutting Permit - the whole cutting authority area that is compiled..
3. Block - a contiguous area within a cutting authority, made up of 1 or more Timber Types.
4. Harvesting Method - an area within a cutting authority area that is harvested by the same logging system.
5. Treatment Unit - an area of common treatment based on a silvicultural prescription.
6. Plot - an area where tree are sampled. These sampling points provide the estimates for the previous 5 levels.

For each report level, the data may be further broken down into *qualitative* categories such as species, risk group, maturity, damage type, and log grades. The reporting levels are specified in Chapters 8 - 14.

3.1 Compilation Sequence

3.1.1 Step-by-Step Compilation Instructions

- Step 1 Perform Edits and Load Data - Inspect each input card from the input file and compare to the list of edits in Chapter 2. If a fatal error is found, stop the compilation and edit the input file. Remove un-compiled trees and load the data for use by subsequent processing. A sample data model relating the input data elements is given in Section 3.4.
- Output - Edit Error Report (001a)
 - Scattergram of card type 2s and 3s (001b)
- Step 2 If there are any trees with no height, then determine the Height-Diameter curves from the sample trees and apply heights as outlined in Chapter 7.
- Output - Regression coefficients (003a)
 - Scattergram of predicted heights (003b)
- Step 3 Calculate Volume - refer to Section 3.3.1 for step-by-step instructions on calculating volumes.
- Step 4 Produce Reports - for each of the selected reports, refer to the specific Chapters 8 - 14, which defines the report.

3.1.2 Compilation Dataflow Diagram

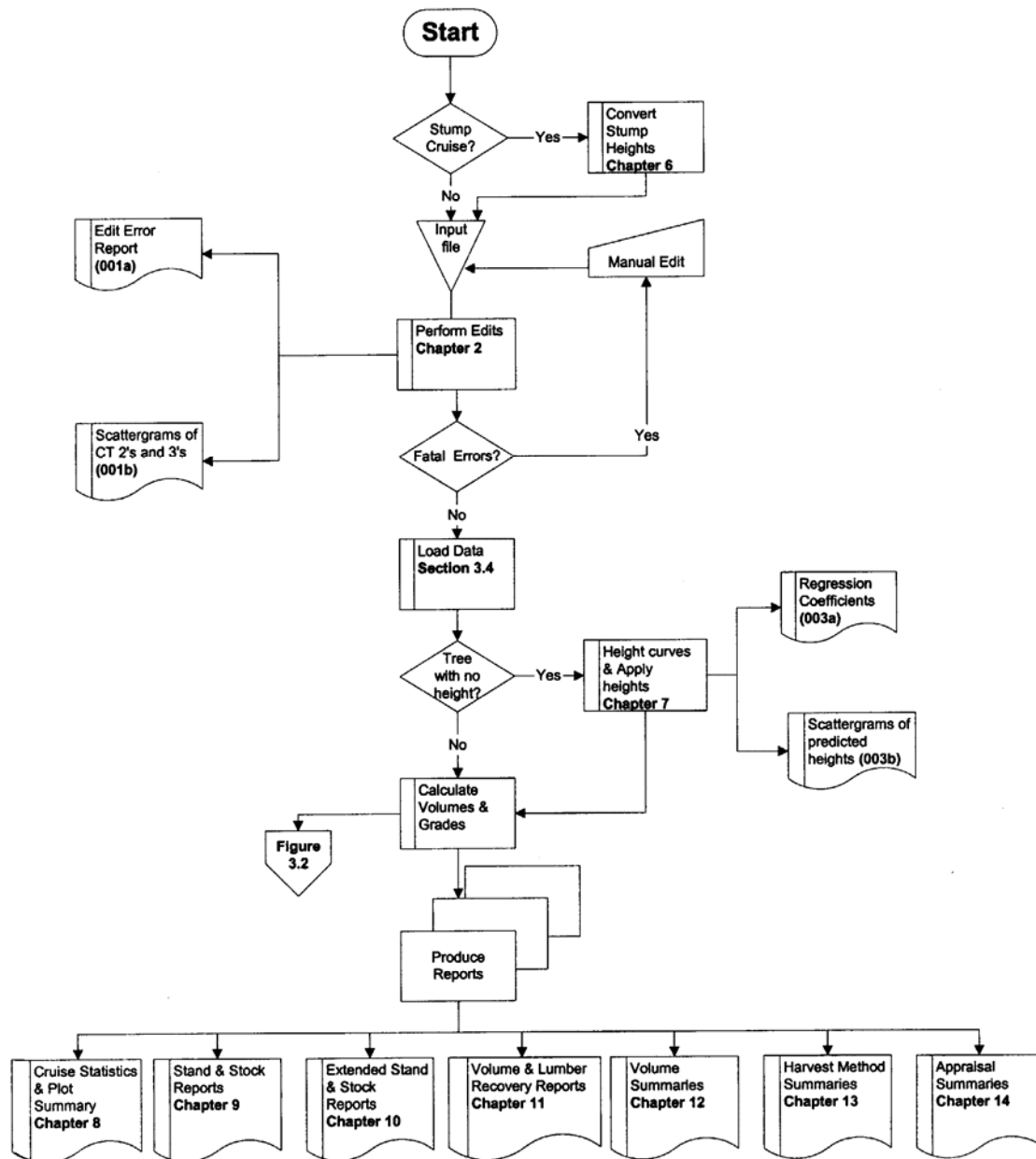


Figure 3.1 Cruise Compilation Sequence.

3.2 Log Volume Calculation - Overview

3.2.1 Step-by-Step Log Volume Calculation Instructions

Only compile the stem count for Western Yew.

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

1. Forest Inventory Zone.
2. DBH - Diameter at breast height (1.3 m) outside bark in cm to the nearest tenth (e.g., 110.1).
3. Height - Total height in meters to the nearest tenth (e.g., 41.3).
4. Stump ht. - Stump height in meters to the nearest hundredth (e.g., 0.30).
5. Top diam. - Top diameter inside bark in cm to the nearest tenth (e.g., 12.5).
6. Log length - log length in meters to the nearest tenth (e.g., 5.0).

Step 2 Calculate tree volumes - taper equation and volume routine (see Appendix 13).

Use the taper equation and volume routine with the above-defined parameters. This routine will determine:

1. Number of logs in the tree.
2. Volumes for each log.
3. Top diameters for each log.
4. Length of top log.
5. Butt diameter for 1st log.
6. Gross merchantable volume - from stump height to top diameter.
7. Biological volume - from ground to top of tree.

Step 3 Determine loss factor table.

1. Use FIZ tables unless a local loss factor exists for the Unit. All local factors apply only to mature volumes (i.e., 121 years or greater). Refer to Table 17 of the [Cruising Manual](#).
2. Determine maturity based on tree class and age. Refer to the Tree Class Modification of Loss Factors in Table 17 of the *Cruising Manual* at the above URL.
3. Determine Risk Group based on tree class and Section 3.5.6, pathological remarks, and damage.

Tree Class - Tree classes 3, 4, 6, 7 & 9 automatically go to highest Risk Group. The exception being Tree Class 7 Lodgepole Pine in the Interior. These stems will be classed as Risk Group 2. Conk, Blind conk, fire code C and blowdown code G will move these stems into Risk Group 3.

Pathological Indicators - Tree class 1, 2, 5 & 8 trees start at the lowest risk group and are then placed into a higher risk group, depending on pathological indicators. Refer to Table 18 in the [Cruising Manual](#).

Damage Codes - trees are further moved into higher risk groups depending on the damage codes associated with them.

Insect Damage

If the Risk Group is not 2 or 3, then increase the Risk Group by 1 for insect damage codes 1, 2, 3, 4, 6, 7 and 8.

Fire Damage

There is no change in Risk Group for fire damage code A.

If the Risk Group is not 2 or 3, and the tree class is 1, 2, 5 or 8, then increase the Risk Group by 1 for fire damage code B. For other tree classes, use the highest Risk Group.

Use the highest Risk Group for fire damage code C.

Blowdown Damage

There is no change in Risk Group for blowdown code E.

For blowdown damage code G, use the highest Risk Group.

For cedar loss factor table 296, the Risk Group is based on the average height from card type 9. If the average height ≤ 40 , then the risk group is 2. Otherwise, the Risk Group is 1.

4. Determine diameter class, based on DBH. Refer to Appendix 14.

Step 4 Apply loss factors - refer to the "Cruise Compilation Loss Factor Table Manual", 1976, for the specific table. Reduce the tree volume by the specified percentages. Apply the loss factors individually and in the order {Decay $\rightarrow$ Waste $\rightarrow$ Breakage}.

For mature coast cottonwood, a flat rate of 15 percent is applied in lieu of the loss factors.

For interior Lodgepole Pine addition breakage factors are reduced from gross volume based on insect damage codes and/or tree classes.

The additional breakage factor for all risk group 3 stems is zero (0).

Tree Classes	Damage Code	Breakage Factor Add On
1, 2, 5, 8	No insect code	0
1, 2, 5, 8	1	0
1, 2, 5, 8	2	7.5
3, 7, 9	3	20.0
3, 7, 9	No insect code	20.0

Step 5 If a percent reduction is being compiled, determine whether there is an eligible reduction for the tree. Refer to Chapter 5 for Percent Reduction handling.

- Step 6 If count and measure plots have been tallied, calculate the double sampling ratios (DSR) for each tallied species. The DSR adjusts stem count, basal area, and volume estimates. When using the Average Line method, calculate a DSR for each Timber Type. When using the Block method, calculate a DSR for each Timber Type, each Timber Type within Block and each Timber Type within Harvesting Method.

For tree classes 4 & 6, use 1.0 (i.e., no adjustment in volume).

Use 1.0 for Western Yew (i.e., no adjustment in stem count).

Output - Double Sampling Ratios (004b)

Example: Fir DSR for a Timber Type

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

To calculate the average BAF, sum the basal area factors of all the trees in the type and divide by the number of trees in the type. Refer to Section 3.5 for a detailed explanation of the calculation of number of trees and basal area factors.

Example 3.4 - Double Sampling Ratio

Refer to Figure 3.4 for a sample Double Sampling Ratio Report.

In Block 2, Type 2 there are 2 measure plots and 2 count plots. One measure plot is a border plot and has a BAF of 8. The other measure plot is a full plot with a BAF of 10. Both count plots are full plots with BAFs of 8 and 10.

There was 1 cedar tallied in each of the plots. The cedar tallied in the border plot would count as 2.

The average basal area for all cedars is $(8 + 8 + 8 + 10 + 10) / 5 = 8.8$

The average basal area for all measured cedar is $(8 + 8 + 10) / 3 = 8.66$

$$DSR_{(cedar)} = \frac{2}{4} * \frac{5 * 8.8}{3 * 8.66} = 0.84615373$$

- Step 7 Double the volume, basal area and tree count for border plots.

- Step 8 Calculate grade percents (Appendices 9 and 10).

Each log is graded and the volume for that log is reported for that grade.

3.2.2 Calculate Volumes and Grades

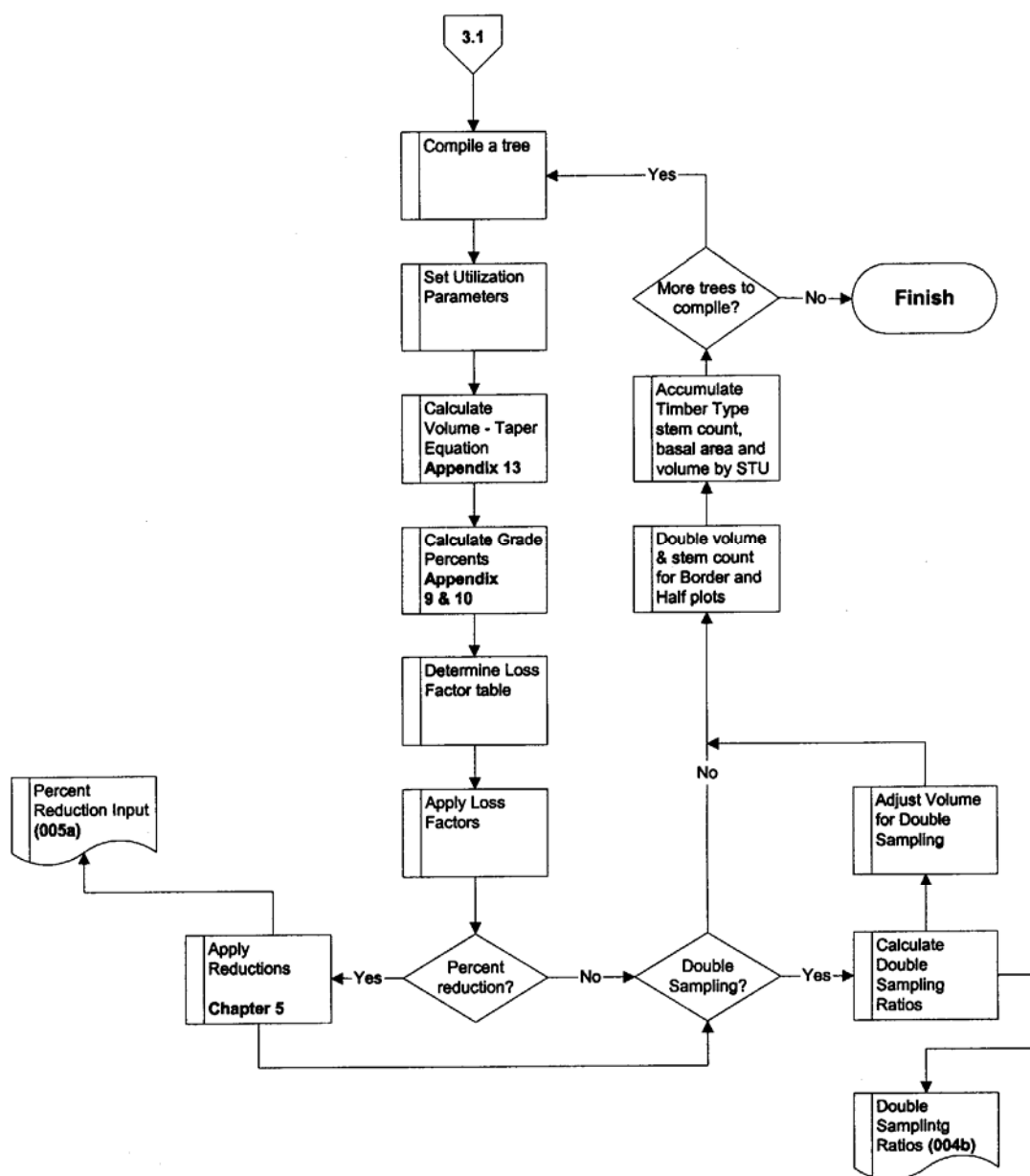


Figure 3.2 Log Volume Calculation.

This diagram is only a sample of the input data relationships. Many different views would be required to perform all the reporting calculations.

Read the cardinality rules as: "1 Cruise Compilation CONTAINS 1 or many Harvesting Methods", "1 Tree can be USED FOR 1 Height Sample Tree" etc.

3.4 Plot Types

There are two methods of plot sampling, which correspond to the *type* of plot being cruised. The types of plots are fixed area plots and variable plots, also known as prism plots. Both of these plot types have associated methods for estimating the following quantitative values (as well as any other 'per hectare' value required for a compilation):

1. Volume per hectare.
2. Basal area per hectare.
3. Number of trees per hectare.

Further, each of the plot types can identify a sub-plot, which will alter the calculations of the above parameters for certain trees in the plot, depending on the specified DBH of the tree.

Generally speaking, the two types of sampling cannot be mixed. However, in a stratified stand with more than one Timber Type, it is permissible to use fixed area plots for one Type and prism plots for another Type.

3.4.1 Prism Plots

Prism plots are identified by the presence of a BAF in columns 32 - 35 of card type 9. The BAF may change between plots in a Timber Type.

A prism plot may be a measure plot or a count plot, as indicated by an "M" or a "C" in column 25 of card type 9. The presence of count plots indicates "double sampling" which requires a method of adjusting the plot estimates despite recording only the species of each tree. Plot estimates are adjusted using a factor called the Double Sampling Ratio, described in Section 3.3.1.

If a species is tallied in a count plot, it must also occur in a measure plot.

Count plots cannot be border plots.

Tree classes 4 and 6 are not permitted in count plots.

For count plots, the DBH lower limit specified in columns 37 - 39 of card type 9 must be the same as the DBH lower limit from card type B.

The plot sweep for prism plots may be "F" (full) or "B" (border) and is located in column 36 of card type 9. For border plots, each tree tallied will contribute double to the estimates of the plot parameters, i.e. volume, basal area and tree count.

Use the following methods for calculating the plot estimates. The tree class 4 and 6 trees (snags) will be estimated independently from the other trees (stems).

3.4.1.1 Number of Trees per Hectare

Each tree contributes:

$$S_t = \frac{BAF_t * 12732.39545}{DBH_t^2} * DSR_t * R_t$$

To the number of stems (or snags) per hectare. So,

$$S_p = \sum_{t=1}^{n_p} S_t$$

Example 3.1

Plot 1, Type 1 has two (2) Spruce trees in it. Spruce is reduced by 30 percent in all diameter classes. BAF = 10. Tree one has a DBH of 56.0 and tree two has a DBH of 51.1. The Double Sampling Ratio is 1.

$$\text{Tree 1} \quad S_{t,1} = \frac{10 * 12732.39545}{56.0^2} * 1 * (1 - 30 / 100) = 28.4 \text{ stems per hectare}$$

$$\text{Tree 2} \quad S_{t,2} = \frac{10 * 12732.39545}{51.1^2} * 1 * (1 - 30 / 100) = 34.1 \text{ stems per hectare}$$

$$S_p = 28.4 + 34.1 = 62.5 \text{ stems per hectare}$$

Where:

S_t = Stems per hectare estimate for tree t.

S_p = Stems per hectare estimate for plot p.

n_p = Number of trees in plot p.

BAF_t = Basal area factor for tree t in plot p.

DBH_t = Diameter at 1.3 m outside bark for tree t.

DSR_t = Double Sampling Ratio for tree t (see Section 3.3.1).

R_t = Post-reduction percent for tree t (1 - reduction percent / 100).

Double this estimate if the plot is a border or a half plot.

3.4.1.2 Basal Area per Hectare

$$BA_p = \sum_{t=1}^{n_p} BAF_t * DSR_t * R_t$$

Where:

BA_p = Basal area/hectare estimate for plot p.

n_p = Number of trees in plot p.

BAF_t = Basal area factor for tree t in plot p.

DBH_t = Diameter at 1.3 m outside bark for tree t.

DSR_t = Double Sampling Ratio for tree t (see Section 3.3.1)

R_t = Post-reduction percent for tree t (see Example 5.5).

Double this estimate if the plot is a border plot.

3.4.1.3 Volume per Hectare

Each tree contributes:

$$V_t * \frac{BAF_t * 12732.39545}{DBH_t^2} * DSR_t * R_t$$

To the volume per hectare.

$$V_p = \sum_{t=1}^{n_p} V_t$$

Where:

V_p	=	Gross merchantable volume per hectare estimate for plot p.
n_p	=	Number of merchantable trees in plot p.
BAF_t	=	Basal area factor for tree t in plot p from card type 9.
DBH_t	=	Diameter at 1.3 m outside bark for tree t.
V_t	=	Gross merchantable volume for tree t (see Appendix 13).
DSR_t	=	Double Sampling Ratio for tree t (see Section 3.3.1).
R_t	=	Post-reduction percent for tree t (see Example 5.5).

The procedure for calculating the merchantable volume of a tree is described in Section 3.3.

Double this estimate if the plot is a border plot.

Sub-plots may be used for prism plots and are detected by the presence of a sub-plot basal area factor in columns 44-48 of card type 9, which differs from the main plot DBH. There will be a corresponding DBH lower limit for the sub-plot in columns 50-52, which will also differ from the main plot DBH lower limit.

If the sub-plot DBH is smaller than the main plot DBH, then the smaller trees in the plot will use the sub-plot BAF and plot sweep in the above calculations. Conversely, if the sub-plot DBH is larger than the main plot DBH, then the larger trees in the plot will use the sub-plot BAF and plot sweep.

For example, if the main plot DBH lower limit is 17.5 and the sub-plot DBH lower limit is 27.5, then trees with DBH between 17.5 and 27.4 would be processed using the main plot BAF and plot sweep. Trees with DBH of 27.5 or more would be processed using the sub-plot BAF and plot sweep. Together, the main plot and sub-plot count as 1 plot.

3.4.2 Fixed Area Plots

Fixed area plots are identified by the presence of a plot size, in hectares, in columns 27-30 of card type 9. The plot size must be the same for all plots in a timber type. Unlike prism plots, fixed area plots cannot be count plots.

The plot sweep for fixed area plots must be full or border.

Use the following methods for calculating the plot estimates. The tree class 4 and 6 trees (snags) will be estimated independently from the other trees (stems).

3.4.2.1 Number of Trees per Hectare

Each tree contributes:

$$S_t = \frac{\text{Area one hectare}}{\text{Plot Size}} * R_t$$

Each species contributes:

$$S_p = \sum_{t=1}^{n_p} S_t$$

Example 3.2

Plot 1, Type 1 has two (2) Spruce trees in it. Spruce is reduced by 30 percent in all diameter classes. The area of the plot is 400 m². Tree one has a DBH of 56.0 and tree two has a DBH of 51.1. There is no Double Sampling Ratio because count plots are not used with fixed area sampling.

Tree 1 $S_{t,1} = \frac{10\,000}{400} * (1 - 30 / 100) = 17.5 \text{ stems per hectare}$

Tree 2 $S_{t,2} = \frac{10\,000}{400} * (1 - 30 / 100) = 17.5 \text{ stems per hectare}$

$S_p = 17.5 + 17.5 = 35.0 \text{ stems per hectare}$

Where:

S_p = Stems per hectare estimate for plot p.

n_p = Number of trees in plot p.

R_t = Post-reduction percent for tree t (1 - reduction percent / 100).

S_t = Number of trees per hectare tree t represents.

Area one hectare = 10,000 m²

plotsize = Area of plot from card type 9.

Double this estimate if the plot is a border plot.

3.4.2.2 Basal Area per Hectare

The basal area for each tree is calculated as $\pi (\text{DBH}/200)^2$ (i.e., the area of a circle whose diameter is the DBH for the tree).

$$\text{BA}_p = \frac{\sum_{t=1}^{n_p} \pi \left(\frac{\text{DBH}_t}{200} \right)^2}{\text{plot size}} * R_t$$

Where:

BA_p = Basal area (m^2) per hectare estimate for plot p.

n_p = Number of trees in plot p.

DBH_t = Diameter (cm) at 1.3 m outside bark for tree t.

π = 3.14159

R_t = Post-reduction percent for tree t (1 - reduction percent / 100).

Double this estimate if the plot is a border plot.

3.4.2.3 Volume per Hectare

$$V_p = \sum_{t=1}^{n_p} S_t V_t$$

Where:

V_p = Gross merchantable volume per hectare estimate for plot p.

n_p = Number of trees in plot p.

V_t = Gross merchantable volume for tree t.

S_t = Number of trees per hectare that tree t represents.

Double this estimate if the plot is a border plot.

The procedure for calculating the volume of a tree is described in Section 3.3.

Sub plots are also permitted for fixed area plots and are detected by the presence of a sub-plot size in columns 40-43 of card type 9. There will be a corresponding DBH lower

limit in columns 50-52, which will also differ from the main plot DBH lower limit. Use the same logic as is used for prism plots to determine which trees use the sub-plot parameters and which trees use the main plot parameters.

3.5 Double Sampling Ratio - Sample Listing

Report 004b - Sample listing (partial).

Double Sampling Ratios - required.

FOREST REVENUE BRANCH - 2001.0 NOT FOR APPRAISAL PURPOSES DUE TO NON-STANDARD UTILIZATION LICENCE: CF7080 - 000 BLOCK NUMBER - 002		RATIOS FOR DOUBLE SAMPLING CRUISE TIMBER TYPES		(004b)	PAGE	4
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C	1.00000000	.84615373				
H	1.00000000	.84615373				
HW						
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B	1.00000000	.84615373				
BA						
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Figure 3.4 Report 004b.