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# Vegetation Resources Inventory

## Sample Data Compilation Process

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# Abstract

This document describes the functions that have been developed to process Vegetation Resources Inventory (VRI) ground sample data.

Described in this document are:

- Methods to derive tree values.
- Methods to derive sample (group) values.
- Methods to calculate volumes of coarse woody debris and stumps.
- Methods to calculate ecology and range values.

This document is intended for use by technical persons with an understanding of the VRI process and experience in data manipulation.



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# 1. Introduction

## 1.1 Background

The Vegetation Resources Inventory (VRI) is designed to answer two questions:

1. Where is the resource located?
2. How much of a given vegetation resource (for example, timber or coarse woody debris) is within an inventory unit?

The VRI is carried out in two phases:

- **Photo Interpretation** - estimating vegetation polygon characteristics from existing information, aerial photography, or other sources. No sampling is done in the photo interpretation phase.
- **Ground Sampling** - provides the information necessary to determine how much of a given characteristic is within the inventory area.

The ground measurements resulting from the ground sampling process are used to estimate the proper totals for the population. The relationship between the polygon estimates and ground samples is then used to adjust the photo-interpreted polygon estimates.

The sample data compilation process is performed after ground sampling data measurements have been made and involves using the ground data to derive sample data that cannot be measured directly.

## 1.2 Purpose

This document describes the functions that have been developed to process VRI ground sample data. These functions include:

1. Methods to derive tree values:
  - Age adjustments
  - Projected heights for broken top trees
  - Per hectare factor
  - Basal area
  - Basal area increment
  - Volume
2. Methods to derive sample (group) values:
  - Number of plots
  - Mean age
  - Mean height
  - Site index

## Sample Data Compilation Process

- Quadratic mean diameter
  - Basal area per hectare
  - Tree volume
  - Volume per hectare
  - Species composition
  - Proportion of dead trees
  - Small tree summary
3. Methods to calculate volumes of coarse woody debris and stumps.
  4. Methods to calculate ecology and range values:
    - Total herbaceous production
    - Range summary data

This document does not discuss the results data management processes, the preparation and editing of raw data and the process for compiling the data. The task of editing input data is outside the scope of the compilation process.

## 2. Derivation of Individual Tree Values

The basic inputs for the data compilation process are tree measurements. The majority of tree measurement data are collected at the ground sampling stage of the VRI. Those values that cannot be measured in the field, but are required for sample statistics, must be computed. These values include tree volume, age and basal area.

### 2.1 Tree age

Tree age is measured on all site trees (first and second leading species as determined by the field crew), one randomly selected tree and one top height ('T') tree.

For trees of sufficient size, age is measured by taking ring counts from increment cores usually taken at breast height (1.3 metres).

For trees that are too small to measure by increment cores, there are two methods to determine age:

1. Whorl counts, or
2. A suitable out-of-plot tree is cut down and the rings on the stump are counted.

#### Correction for ages not taken at 1.3 m

Tree age, determined by counting the rings at 1.3 metres (m) above the germination point, is required for calculating mean age, site index and total age. The breast height age must be calculated where it is not possible to measure age at 1.3 m. The boring height, the height at which the actual ring count was taken, is used to adjust the boring age to estimate the breast height age.

The adjustment procedure uses the breast height to total age relationship ('correction') derived from the SITE TOOLS site index program. The correction is calculated by prorating the SITE TOOLS value by the boring height to breast height ratio.

The adjustment function is:

$$\text{Breast height age} = \text{boring age} - \left[ \left( \frac{1.3 - BH}{1.3} \right) \bullet \text{SITE TOOLS} \leftrightarrow \text{total age conversion} \right]$$

where BH = boring height

The calculation is done iteratively as the SITE TOOLS program requires site index as well as species and age to generate the correction and the SITE TOOLS program must be used to derive the site index.

The following example illustrates the adjustment method.

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#### Inputs:

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Species

Coastal Douglas-fir

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## Sample Data Compilation Process

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Boring height (BH)	0.9 m
Boring age	91 years
Total tree height	32 m

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### Initial iteration:

SITE TOOLS site index 23.7 m (@50 years BH)

BH ↔ total age	9.4 years
BH Age (est.) =	$91 - ((1.3 - 0.9)/1.3) \bullet 9.4 = 87.2$

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### Second iteration:

SITE TOOLS site index 23.5 m (@ 50 years BH) - using BHA estimate from iteration 1

BH ↔ total age	9.3 years
BH Age (est.) =	$91 - ((1.3 - 0.9)/1.3) \bullet 9.3 = 87.3$

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No further iterations are required as the BH age for both iterations round to the same year.

## Trees with incomplete ring counts

In cases where it is not possible to count all the rings to the tree centre, the missing ring count must be computed in order to determine the total ring count at boring height.

The estimation method is based on the assumption that average basal area growth is reasonably constant over time. The adjustment procedure extrapolates the average basal area growth rate calculated from the existing ring count to the missing part of the core.

The calculation includes the following steps:

1. Calculate the total basal area from the diameter measured inside the bark (ib).
2. Calculate the basal area from the length of the intact core.
3. Calculate the inverse of the basal area annual growth rate from 2 and the existing ring count (years/cm<sup>2</sup>).
4. Calculate the total boring height age from 1 and 3.

The following example illustrates the procedure.

### Inputs:

#### 1. Total inside bark basal area

Diameter (outside bark) at boring height	60.0 cm
Single Bark thickness at boring height	5.0 cm
Diameter (inside bark)	50.0 cm

Total basal area (inside bark)	1,963.5 cm <sup>2</sup>
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## 2. Basal area from intact core

Length of intact core	15.0 cm
Length of missing core	10.0 cm
Missing basal area	314.2 cm <sup>2</sup>
Intact basal area	1,649.3 cm <sup>2</sup>

## 3. Years/cm<sup>2</sup> basal area growth from intact core

Ring count of intact core	60
Years/cm <sup>2</sup>	.0364

## 4. Total boring height age (1) • (3) = 71.5 years

### Total age

Tree total age is derived in the SITE TOOLS program during compilation.

Input values are tree species, site index, breast height age (adjusted as described above, if necessary) and Coast / Interior indicator.

## 2.2 Tree basal area

The basal area (BA) for a tree is calculated by the area formula for a circle, using the diameter at breast height (dbh) as input. Basal area is expressed in square metres.

$$\text{Equation: } \textit{Tree Basal Area} = \pi \left( \frac{\textit{dbh}}{200} \right)^2$$

Note: dbh is in cm and must be divided by 100 to convert to metres.

## 2.3 Tree basal area growth rate

Annual basal area growth rates are calculated at intervals of 5, 10 and 20 years previous to sampling. The input data used are the measured lengths taken from increment cores at the three time intervals, the dbh and bark thickness.

Growth rate is calculated based on the compound increment function:

$$\textit{Current BA} = \textit{Previous BA} (1 + \textit{growth rate})^{\textit{time}}$$

$$\text{Therefore: } \textit{Growth rate} = \exp \left[ \ln \frac{(\textit{current BA} / \textit{previous BA})}{\textit{time}} \right] - 1$$

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$$Growth\ rate = \exp \left[ \ln \frac{(current\ diameter^2 / previous\ diameter^2)}{time} \right] - 1$$

Where: current diameter = dbh - (2 • bark thickness)  
previous diameter = current diameter - diameter growth over 5, 10, 20 years  
time = 5, 10 or 20 years

## 2.4 Tree per hectare factor (PHF)

The per hectare factor (PHF) is the multiplier used to derive per hectare statistics from sample data. It is more efficient to calculate PHF for each sample tree as a first step as it allows the subsequent statistical computations to be independent of the sampling method (variable radius or fixed area). Also, documentation of statistical algorithms is made simpler.

The PHF is calculated using one of two methods, depending on the sampling method.

1. For fixed area plots, PHF is the inverse of the plot area. The value is the same for every tree in the plot.

Equation: 
$$PHF = \frac{1}{plot\ area} * plotweight$$

2. For trees selected with a variable radius plot method, the factor is based on tree diameter and relascope characteristics (Basal Area Factor (BAF)). The PHF varies for each tree in a variable radius plot.

Equation: 
$$PHF = \frac{BAF \bullet plot\ weight}{tree\ BA}$$

Note that in both cases, for half and quarter swept plots, PHF is 2 and 4 times the value of full plots of the same radius or BAF. This is denoted as 'plot weight'.

## 2.5 Tree volume

Individual tree volumes are calculated for each full-measured tree using Kozak's taper functions (currently version 5.0) and input field data. Kozak functions are available for 16 tree species by Biogeoclimatic zone (BEC). Bec based volumes are the current standard. A species without a unique equation is assigned to an appropriate function. There are adjustment factors for 3 areas of the province, which further adjust the calculated volumes.

The algorithm adds volumes of small (10 cm) slices (truncated conic sections) of the height/diameter shape produced by the Kozak function. This method is used so that volumes of logs of varying lengths can be calculated.

Net volumes are calculated using the net factor for each log estimated during sampling.

Both living and dead trees are processed as described here with the same outputs.

**Inputs:**

Tree dbh

Total tree height (from field data)

Tree species (input code converted to Growth and Yield (G&Y) old standard set (16 species)

Bec zone, subzone and variant (current standard) Utilization standards:

- Minimum top diameter (10 cm current standard)<sup>1</sup>
- Stump height (0.3 m current standard)
- No minimum log length<sup>2</sup>

Field estimated percent sound (net factor), grade and length of each log

Pathology indicators

**Major Outputs:**

1. Tree whole stem volume
2. (1) less stump and top
3. (1) less percent unsound
4. (2) less percent unsound
5. (4) less calculated waste (W2), and breakage as per BEC based loss factors

Other outputs include the volume of broken top portion, the volume and top diameter of the stump, diameters at log tops, log volumes and the height at which merchantable diameter limit (10 cm) occurs.

**Volumes of broken top trees**

A special procedure is required to calculate volumes for broken top trees. A projection of the total (unbroken) tree height is required as input into Kozak's volume function.

In some cases, projected heights are provided in the field data and these values are used in the volume function. Otherwise, the projected height must be calculated using the field-estimated diameter at the break, as follows:

1. Using Kozak's equation, compute a diameter at the break height given an initial guess at the tree height.
2. Calculate the difference between the computed and field-estimated diameter.
3. Iterate steps 1 and 2 with changing height values to converge on field estimated diameter.
4. Stop when one of the following occur:
  - The difference between computed and actual broken top diameters is less than 0.5 cm.
  - Iterations exceed 33 (error condition warning).
  - Projected tree heights exceed 65 m (height is then set to 66.6 m).

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<sup>1</sup> Minimum top diameter is changeable if required.

<sup>2</sup> This is changeable.

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The resulting height/diameter profile (taper) is then applied in the volume computation algorithm to get the volume of the intact bole.

Projected heights are used only for the purpose of volume derivation. They are not used in calculating mean height or site index.

## 2.6 Tree volumes for non-enhanced trees

At one time, a ratio of volume/basal area ( $vbar$ ) was used to estimate the volume of the non-enhanced trees. The current method involves regression analysis and ratio adjustment.

Regression coefficients are computed for live and dead trees separately within each of 16 species groupings within a project grouping. Project grouping is defined as all projects located in the same geographic area (e.g. a TSA). Multiple projects within a geographic area might exist for reasons such as keeping track of a particular sampling emphasis or to indicate different sampling years. Once the project data is grouped appropriately, the regression model is fit as

$$\log (WSV) = b0 + b1 * \text{Log}10(Ba)$$

Regression equations are also fit for live and dead trees separately within a deciduous and a coniferous category. Similarly, another set of equations are fit for the two broadest groupings of live and dead trees. These more general equations are used if there are insufficient trees in a species grouping to provide a good regression fit. Insufficient is defined as less than 2 trees in a group, or an  $r\_square$  statistic of less than 0.3. For example, if a project grouping contained only 1 dead measured douglas-fir, then this tree would have to use the regression equation for dead conifers.

Once the set of equations are calculated, they are applied to all non-enhanced trees (live and dead) in the project grouping.

Whole stem volume for enhanced trees is computed as:

$$\text{Whole stem volume} = 10^{b0 + b1 * \log_{10}(\text{basalarea} + \frac{\text{mean square error}}{2})}$$

A ratio is computed for each of the netted volumes as described in Section 2.5.

$$\text{ratio} = \frac{\sum \text{netted volume}}{\sum \text{whole stem volume}}$$

Similar to the regression equations, ratios are computed by project grouping for: live and dead; live and dead within deciduous and coniferous; and live and dead within each of 16 species groupings. Only trees with a DBH  $\geq 10$  cm are used in the computation of ratios. As with the regression equations, if there are

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<sup>3</sup> Mean Square Error – computed by the regression process

2 or fewer trees available for a ratio, the next most generalized ratio must be used (e.g. if there are only 2 dead douglas-firs, these trees would use the ratio for dead conifers).

These ratios are applied to the whole stem volume for each tree, thereby computing all required netted volumes.

### 3. Derivation of Tree Group Values

Tree group statistics are values calculated for a sample or for a selected group of trees within a sample.

The input data used may be:

- Raw (field) data.
- Tree derived data discussed in the previous section.
- Values from supporting tables.

The VRI compilation program calculates and reports on statistics at the cluster (sample) level. Statistics are often broken down into sub-levels (such as species) where appropriate.

#### 3.1 Number of plots

The number of plots in a sample cluster is used in the final averaging that produces per hectare statistics. This count is the total number of plots in a sample and includes plots devoid of trees.

The number of plots is not used in the calculation of dead tree per hectare values as dead trees are only recorded on the integrated plot except for :

- NVAF plots where dead trees may be recorded on auxiliary plots., and
- Samples collected in 2007 and on, when the samples standards changed ot include measurement of dead trees on auxiliary plots,

#### 3.2 Mean age

Ages are collected for site trees and one randomly selected tree. Site trees are identified as ‘L’ (leading species in the sample) and ‘S’ (second species in the sample). Out-of-plot (‘O’) and extra (‘X’) site trees may be sampled. Also, the largest diameter tree in the integrated plot is measured and designated as ‘T’. Before 1999, site trees were designated as ‘T’ (primary) or ‘S’ (secondary). From 1999, site trees are designated as suitable or not suitable for use as age trees. If a tree is “not suitable”, then it is excluded from the following calculations.

Mean total age and breast height age are calculated for the following groups:

- All ‘T’ and ‘S’ (pre-1999) or ‘T’, ‘L’ and ‘S’ (1999) by species.
- The above groups, but including any ‘X’ and ‘O’ site trees.
- The above groups by sample – all species combined.

Data sources for age measurements may include:

- Total age reported in the field data.
- Breast height age reported in the field data.

- Derived tree age.

Whatever the source of data, either breast height age or total age is calculated using SITE TOOLS so that both are available for averaging.

For each group of trees described above, both breast height age and total age means are calculated as:

$$\text{Mean age} = \frac{\sum \text{ages}}{\text{number of trees in group}}$$

Only one random tree and one top height tree are measured in a given sample. Ages for these trees are carried over and stored in the final results database.

### 3.3 Mean tree heights

The compilation program calculates various mean height values:

**Lorry Height** – the average stand height weighted by tree basal area, not grouped by species code. Two values are derived: one for all living trees, the other for only live, intact trees (living broken top trees excluded).

**Site height** - the average height of the selected site trees in the sample. Heights are collected for site trees and one randomly selected tree.

Mean heights are calculated for the following groups if the tree is “suitable” as indicated on the field cards starting in 1999:

- All ‘T’ and ‘S’ (pre-1999) or ‘T’, ‘L’ and ‘S’ (1999) by species.
- The above groups, but including any ‘X’ and ‘O’ site trees.
- The above groups by sample – all species combined.

Two methods are used to derive site height:

1. An average height is calculated for each of the above groups.
2. Site index is used as follows:
  - a) Site index is calculated for each tree using SITE TOOLS.
  - b) A mean site index is derived for each group:
    - Using SITE TOOLS, the mean height is derived for each group from the mean site index and mean age (by species only).

### 3.4 Site index

Site index is a measure of site quality expressed as the site height in metres at a breast height age of 50 years. A site index value is calculated for each species selected for site height estimation in the field. All site trees have height and age estimates, though some trees may be deemed to be “not suitable” for age and / or height.

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Site indexes are calculated for the following groups:

- All 'T' and 'S' (pre-1999) or 'T', 'L' and 'S' (1999) by species.
- The above groups, but including any 'X' and 'O' site trees.

Two methods are used to calculate site index:

1. Site index is derived for each site tree using the SINDEXT program. Site indexes are averaged for the above groups.
2. Mean site height and age calculated as described in the above sections are input into SINDEXT, which returns site index.

### 3.5 Quadratic mean diameter (QMD)

The quadratic mean diameter (QMD) is the diameter (dbh) of the tree of average basal area within a group. This can be calculated from tree per hectare factor (Section 2.4) as follows:

$$QMD = \sqrt{\frac{\sum (dbh^2 \cdot PHF)}{\sum PHF}}$$

All trees within a sample that have a dbh measurement are included in the calculation. QMD is derived for:

- All live trees by species.
- All live trees within the sample.
- All dead trees within the sample.

### 3.6 Stems per hectare

Stems per hectare is the total estimated number of trees per hectare for:

- Live trees by species.
- All live trees.
- All dead trees.

All in-plot trees with measured dbh are included in the calculation.

Stems per hectare is calculated at five standard utilization levels (dbh limits):

1. All trees
2. 7.5+ cm
3. 12.5+ cm
4. 17.5+ cm
5. 22.5+ cm

The calculation for stems/ha is:

$$\frac{\sum PHF}{\text{number of plots}}$$

### 3.7 Basal area per hectare

Basal area per hectare is calculated as:

$$\frac{\sum (\text{tree BA} \bullet PHF)}{\text{number of plots}}$$

This value is computed at five utilization levels for the following groups of trees:

- Live trees by species within the sample.
- Total live trees within the sample.
- All dead trees within the sample (recorded on the integrated plot only except for NVAF plots)

Basal area/ha is calculated for the following utilization levels (dbh limits):

1. All tallied trees
2. 7.5+ cm
3. 12.5+ cm
4. 17.5+ cm
5. 22.5+ cm

### 3.8 Tree volume per hectare

Volume per hectare is derived by summing the individual volumes times the per hectare factor for each unique tree. The total volume per hectare is the sum of individual species values. Separate estimates are computed for living and dead trees.

$$\text{Equation: } \text{Volume/ha} = \sum \text{tree volume} * \frac{phf}{\text{no of applicable plots}}$$

Where applicable plots varies if the volume is for live trees (all plots included), or dead trees (1 if not an NVAF plot).

For each tree species and the total, the following values are derived:

1. Whole stem volume/ha.
2. Volume/ha less top and stump (current standards: top - < 10 cm diameter, stump - 0.3 m high).
3. Volume/ha less decay only (from field data).
4. Volume/ha less top, stump and decay (from field data).
5. Volume/ha less top, stump and decay, waste (from field data) and breakage from loss factor table.

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6. Volume/ha less top, stump and decay, waste (from field data) and breakage from loss factor table, adjusted by the net volume adjustment factor (NVAF).

The above values are calculated for the following utilization levels (dbh limits):

1. All tallied trees
2. 7.5+ cm
3. 12.5+ cm
4. 17.5+ cm
5. 22.5+ cm

### 3.9 Volume by log grade

The VRI call grading procedure assigns a Ministry of Forests (MOF) statutory grade to each log of a sampled 'volume' tree. Recorded also for each log are the estimated length and percent sound wood. The VRI compiler uses these inputs and the calculated net log volume to compute the percentage volume per hectare by species and log grade.

The procedure includes the following steps:

1. For each species, compute percent net log volume by grade.
2. For each species, apply the results of (1) to the species total net volume per hectare.
3. Divide the results of (2) by the sample total net volume per hectare and express as a percentage.

### 3.10 Timber value

Timber value is calculated for a species and log grade and expressed as dollars per hectare. Value is derived by multiplying the net volume/ha by species and log grade by the log market value (\$/m<sup>3</sup>) which is determined by species and log grade. The total dollar value/ha is the sum of the species/log grade values. The dollar values are supplied in a table created in 1999. It is not intended to be a reflection of market price, but an indicator of relative values.

### 3.11 Damage agents

Damage agents are collected and stored for reporting purposes.

### 3.12 Proportion of dead trees

Dead trees are recorded only on the integrated plot (except for NVAF samples or samples measured in 2007 and later). Therefore, only the relevant plot data is used in this calculation (primarily the integrated plot data). The proportion of dead trees is computed from basal area.

The procedure is as follows:

1. Compute total basal area of all live and dead trees on the relevant plots.

2. Compute total basal area of dead trees.
3. Calculate:  $proportion\ dead = \frac{basal\ area\ of\ dead\ trees}{total\ basal\ area\ of\ all\ trees}$

### 3.13 Mean annual increment (MAI)

The mean annual increment is the average annual growth rate of a group (often a stand) of trees. The compilation algorithm calculates volume/ha MAI for each species in the sample.

$$\text{Equation: } MAI = \frac{volume/ha}{mean\ total\ age}$$

### 3.14 Species composition

Species composition is a ranking of species by percentage of basal area per hectare (standard) or volume per hectare. All live trees tallied in the sample are included in the calculation. The attribute value is a table consisting of genus/species codes occurring in the field data and percentage composition values.

The percent by basal area for a species is calculated as follows:

$$\frac{species\ basal\ area/ha}{total\ basal\ area/ha} \cdot 100$$

By volume this value is calculated as:

$$\frac{species\ whole\ stem\ volume/ha}{total\ whole\ stem\ volume/ha} \cdot 100$$

### 3.15 Mean bark thickness by species

Bark thickness (BT) at boring height is recorded for all site trees (prior to 2008) measured for age (top height and random trees). In 2008, the standards were changed to only measure bark for trees with an incomplete ring count. The VRI compiler uses this data to calculate the bark thickness percentage (%BT) of the outside bark (ob) diameter at the boring height. An average is then computed for each species in the sample. Random height trees are totaled separately. Note: Bark thickness is in millimetres.

Equations:

$$Average\ tree\ \%BT = \left( \frac{BT \cdot 2}{ob\ boring\ diameter} \right) \cdot 100 \cdot 10$$

$$Mean\ species\ \%BT = \frac{\sum tree\ \%BT}{number\ of\ trees\ in\ calculation}$$

### 3.16 Small tree summary

Trees less than 4 cm in dbh are sampled on the fixed area subplot. Dot tallies record the number of small trees by species and height class. This field is weighted by plot size (i.e., if it is a 1/2 plot, then the result is multiplied by 2).

There are three height classes:

- 0.1 m to 0.3 m
- 0.3 m to 1.3 m
- Greater than 1.3 m (less than 2 cm dbh)

The equation to calculate the number of small trees per hectare by species and height class is:

$$Trees/ha = \frac{\text{number of trees/species/height class} \cdot 10,000}{\pi \cdot \text{plot radius}^2}$$

### 3.17 Stump volumes

A stump is recorded as such if it is less than 1.3 m in height. Stumps are recorded only on the fixed area subplot.

The volume equation for a cylinder is used to calculate the volume of a stump. Data inputs are the inside-bark diameter (dib) and the length of the stump. Stump volume/ha is the sum of stump volumes on the plot divided by the plot area (ha).

Equations:

$$\text{Stump volume (m}^3\text{)} = \left(\frac{\text{dib}}{200}\right)^2 \cdot \pi \cdot \text{length of stump}$$

$$\text{Stump volume/ha} = \frac{\sum \text{stump volumes}}{\text{plot area}}$$

## 4. Coarse Woody Debris (CWD)

Coarse woody debris (CWD) comprises all types of woody material found on the ground and in various stages of deterioration, such as fallen trees, broken tree tops, large branches, and overturned stumps with no roots attached. It is defined as downed or suspended (not self-supported) woody material greater than 7.5 cm in diameter. It is measured in the field using the line intersect sampling method.

Two methods are used to calculate volumes of CWD depending on whether the distribution of the debris is scattered or in accumulated in piles.

### 4.1 Scattered CWD

Volume/ha is calculated for each of five decay classes.

$$\text{Equation: } CWD \text{ Volume/ha} = \frac{1.234}{L} \cdot \sum \left[ \frac{D^2}{\cos(A)} \right]$$

**Number of pieces / ha is also calculated when the optional data – length of piece is present.**

$$\# \text{ of pieces / ha} = \left( \frac{1000 * \pi}{2 * L} \right) * \left( \frac{1}{\text{length of piece} * \cos(A)} \right)$$

where: L = length of total transect (horizontal distant in meters combined for RS and RT (field card types))

D = diameter of each piece of CWD (cm)

A = tilt angle from horizontal for each piece (degrees)

### 4.2 Accumulated CWD

Volume/ha is calculated for each accumulation along the transect line by decay class. Volumes are then summed to get the total volume/ha. Note: Height and width are captured in the field in centimetres, but stored in ORACLE database in metres.

$$\text{Equation: } CWD \text{ Volume/ha} = \left( \frac{H * W}{L} \right) * 10,000$$

where: H = height of pile (m)

W = width of pile (m)

L = transect length (horizontal distance in metres)

### 4.3 Totals and classes

The equation for total CWD is:

$$Total\ CWD/ha = \sum scattered\ and\ accumulated\ volume/ha\ CWD$$

An optional field in the VRI data compilation process is piece length. Introduced in 1997, this class length variable is used with decay class to provide subset totals. Length class is in multiples of 6 m, as seen below.

<b>Length (m)</b>	<b>Length Class</b>
0.1 to 6.0	1
6.1 to 12.0	2
12.1 to 18.0	3

Diameter classes, introduced in 1998, are also used:

<b>Diameter (cm)</b>	<b>Diameter Class</b>
7.6 - 12.4	1
12.5 - 17.4	2
17.5 - 25.0	3
25.1 - 50.0	4
50.1 - 75.0	5
75.1 - 100.0	6
100.1 - 125.0	7
125.1 - 150.0	8
150.1 and greater	9

## 5. Ecology & Range Derivations

Ecology and range information collected during ground sampling includes detailed descriptions of all types of vegetation consumed by livestock and wildlife. As not all ecology and range data can be measured directly, some compilation is necessary to produce the attributes required for the VRI. The purpose of this data is to estimate the production of forage (i.e., grasses, forbes, and shrubs) and its utilization by animals. These attributes are also summarized to show quality and quantity of vegetation cover.

In addition to the summaries described below, the ecological data is destined to be stored as an MS Access database format called VENUS, which is the approved standard for sharing data with the other branches of Ministry of Sustainable Resource Management (formerly Ministry of Environment, Lands and Parks).

### 5.1 Forage compilation

#### Total herbaceous production

The steps to calculate the total herbaceous production and the sample average utilization class are:

1. Calculate the sample average for forbs (kg/ha):

$$\text{Equation: } \frac{\text{total grams of forbs} / (0.5 \text{ m}^2 \bullet 20 \text{ kg/ha})}{\text{number of subplots with data}}$$

2. Calculate the sample average for graminoids (kg/ha):

$$\text{Equation: } \frac{\text{total grams of graminoids} / (0.5 \text{ m}^2 \bullet 20 \text{ kg / ha})}{\text{number of subplots with data}}$$

3. Calculate the total average herbaceous production :

$$\text{Equation: } \text{graminoids kg/ha sample average} + \text{forbes kg/ha sample average}$$

4. Calculate the sample average utilization class:

$$\text{Equation: } \frac{\sum(\text{midpoint of class } x)}{\text{number of subplots with data}}$$

Where: x is the class as defined in the manual

For example:

$$(\text{mid point of class 1} + \text{mid point of class 1} + \text{midpoint of class 4})/3$$

## Sample Data Compilation Process

Note: For 1995, it should be divided by the number of subplots for which there are data to a maximum of 4. For 1996 and beyond there is only 1 bag for collection, but the data should still be divided by 4. For column 98 of card type RS, blank = zero in this case and only this case.

### Percent shrub cover

The steps for determining the percent shrub cover are:

1. Calculate the sample average percent cover by species for layer B1 and layer B2.

$$\text{Equation: } \frac{(\sum a \text{ species along } T1 + \sum \text{same species along } T2)}{\text{observed line length}} \bullet 100$$

Note: there may be 2 or more records per sample and B1 may not have any values.

3. Calculate the sample average percent cover in metres for all shrubs in each layer.

$$\text{Equation: } \frac{\sum \text{sample avg \% cover by species}}{\text{observed line length}} \bullet 100$$

4. Calculate the sum of layer B1 and B2 by species.

Procedure:

- Sum the sample average percent cover values obtained for individual species for layers B1 and B2.

5. Calculate the sample total percent cover of all shrubs combined for both layers.

Procedure:

- Sum the values from Step 3.
- Sum the sample average for B1 and the sample average for B2.

6. Calculate the average phenological class for all shrubs and deciduous trees in both layers.

Procedure:

- Sum of all shrubs in T1 for layer B1 and layer B2 plus sum of all shrubs in T2 for layer B1 and layer B2.
- Calculate the number of non-blank observations (i.e., if there is an observation, 0 or a value, then increment a counter).

$$\text{Equation: } \frac{\sum \text{all shrubs in } T1 \text{ and } T2 \text{ for layer } B1 \text{ and } B2}{\text{number of non blank observations}}$$

7. Calculate the average phenological class for conifer trees in both layers (see Step 5).

Where T1 = Transect 1,

T2 = Transect 2.

## **5.2 Range summary data from the vegetation plot**

The range summarized files include information which is copied from the Min. of Forests, Research Branch. BC Plant Species and selected attributes, current version): This information includes:

- Latin and common names,
- if the plant is poisonous, and to what lifeforms, and
- if it is a weed species.

## **5.2 Ecological Summary data:**

The ocular estimate data from Cards ET and EH undergo a very basic summarization as well as relevant data is extracted from the Min. of Forests species list, as described above.

## Glossary

B1 Layer	Shrubs 2-10 m in height (no trees).
B2 Layer	Shrubs and trees less than 2 m in height.
Bark Thickness	The average of at least two readings of bark thickness measured with a bark gauge or calipers.
Basal Area	The cross-sectional area of a tree at 4.5 feet above ground level.
Basal Area Factor (BAF)	Factor used to convert sample information to basal area per unit area.
Bole	Stem.
Boring Height	Height at which the radial core of rings is extracted to determine age.
Breast Height	1.3 metres above the point of germination.
Breast Height Age	Age measured from a core taken at breast height.
Call Grade	The classification of timber, lumber or logs according to quality or end use.
Cluster	Sample plot.
Coarse Woody Debris (CWD)	Downed or suspended (not self-supported) woody material greater than 7.5 cm in diameter.
Damage Agents	A set of codes completed on card TL and looks at mortality conditions for all agents, bark beetles, defoliators, needle rust and blights, terminal weevils, stem rusts, root rots, Dwarf mistletoes, stem swelling for coastal mistletoe, mammals birds, etc, and defoliators (i.e., codes collected about the tree to indicate what if anything has damaged it).
Diameter at Breast Height (dbh)	The diameter measured at 1.3 metres above the point of germination.
Diameter Inside Bark (dib)	The diameter of a tree or log excluding bark thickness.
Forbes	Any broad-leaved herbaceous plants except Gramineae (or Poaceae), Cyperaceae and Juncaceae families; and for forage measurement purposes, includes ferns and fern allies, club mosses and horsetails.

Forest Inventory Zone (FIZ)	Inventory unit of similar forest types.
Graminoids	Grass or grass-like plants (sedges and rushes) such as Poa, Carex, and Juncus species.
Ground Sampling	The measurement of tree and other vegetation attributes from a sample of the polygons to provide overall totals and averages for timber and non-timber vegetation resources in an inventory unit, and to provide the basis for statistical adjustment of the photo interpreted estimates.
Gross Total Volume	The volume of the main stem of a tree including stump and top, or the volume of the stand including all trees.
Increment Core	The part of the cross section of a tree extracted by an increment borer. Used to determine tree age and growth pattern.
Key Range Plants	Forage species that must, because of their high degree of use, be considered in the management program.
Lorey Height	Average stand height weighted by tree basal area.
Mean Annual Increment (MAI)	The average annual increase in volume of individual trees or stands up to a specified point in time.
Net Volume	Volume of the main stem excluding stump and top as well as the defective and decayed wood of trees or stands.
Per Hectare Factor (PHF)	A number used to convert sample plot information to per hectare information.
Potential Natural Community	The biotic community that would become established if all succession sequences were completed without interference's by man under the present environmental conditions.
Quadratic Mean Diameter (QMD)	The dbh of the tree of average basal area within a group.
Relascope	An angle gauge for measuring small horizontal angles, with automatic compensation for inclined sight lines.
Sample Plot	A carefully measured area laid out for measurement.
Shrub Cover (foliar coverage)	The percentage of ground covered by vertical projection of the aerial portion of plants. Small openings in the canopy and intraspecific overlap are excluded. Foliar cover is always less than canopy cover, either may exceed 100%.

## Sample Data Compilation Process

Site Height	The average height of the selected site trees in the sample. Heights are collected for site trees and one randomly selected tree.
Site Index	A measure of site quality expressed as the site height in metres at a breast height age of 50 years.
Site Trees	First and second leading species trees. Identified as 'L' (leading species in the sample) and 'S' (second species in the sample).
Slash	The residue left on the ground after felling, including unused logs, uprooted stumps, broken tops, etc.
Sampling	The selection of sample units from a population and the measurement and recording of information on these units to obtain estimates of population characteristics.
Stems per Hectare (SPH)	The total estimated number of trees per hectare.
Strata	Groups of forest types with the same or similar species composition, age and height class.
Stump	Less than 1.3 m in height.
Taper	The decrease in stem diameter with increasing height up the stem.
Timber Value	Calculated for a species and log grade and expressed as dollars per hectare.
Total Age	Derived value.
Transect Line	A cross-section of an area used as a sample unit for recording mapping or studying the vegetation and its use. May be a series of plots, a belt or strip, or merely a line, depending on the purpose.
Tree Volume	The volume or weight of the commercially marketable portion of a tree.
Utilization Standards	The utilization limits (stump height and top diameter inside bark) which define commercially saleable trees, thus the trees to be harvested.
VBAR	The ratio of volume/basal area calculated for individual trees or stands.

Weed Species

Plants that interfere with management objectives for a given area of land at a particular time. BC Noxious weeds are defined and listed in the Weed Control Act and are designated by the Weed Control Regulation. Noxious weeds are typically difficult to control, have significant impacts on forage for livestock and wildlife, and threaten the biodiversity of native plant communities and forest regeneration.

