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# **Net Volume Adjustment Factor Sampling Standards and Procedures**

Prepared by  
Ministry of Forests, Lands and Natural Resource Operations  
Forest Analysis and Inventory Branch

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# 1. Introduction

## 1.1 Background

The Forest Resources Commission recommended a review of the provincial resource inventory process in its report *The Future of our Forests*. The Resources Inventory Committee (RIC) was established with the objective of achieving common standards and procedures and it, in turn, established several task forces. One of these task forces, the Terrestrial Ecosystems Task Force, set up the Vegetation Inventory Working Group and charged its members with:

.....making recommendations pertaining to the vegetation inventory...(and)...designing and recommending standards and procedures for an accurate, flexible .... inventory process.

The Vegetation Inventory Working Group recommended a photo-based, two-phased vegetation inventory program:

- Phase I: Photo Interpretation
- Phase II: Ground Sampling

The Ministry of Forests, Lands and Natural Resource Operations is implementing the recommendations in the Vegetation Resources Inventory (VRI).

## 1.2 Purpose of the Manual

The purpose of this manual is to provide inventory samplers with instructions regarding sample selection, data collection and quality assurance required to collect unbiased NVAF tree data.

## 1.3 The Vegetation Resources Inventory Process

The 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. Phase I (Photo Interpretation) involves estimating vegetation polygon characteristics, from existing information, aerial photography, or other sources. No unbiased ground sampling is done in Phase I. Phase II (Ground Sampling) provides the information necessary to determine how much of a given characteristic is within the inventory area. Ground samples alone cannot be collected in sufficient numbers to provide the specific locations of the land cover characteristics being inventoried.

The ground measurements are used to estimate the proper total for the population. The relationship between the polygon estimates and the ground samples is calculated and used as to assess the state of the inventory in relation to what is indicated on the ground.

## 1.4 The NVAF Process

The Net Volume Adjustment Factor (NVAF) is an integral part of the VRI. It corrects for bias in the volumes of trees produced by the taper equations and the cruiser's net factoring estimates of decay.

The NVAF adjustment is needed for the following reasons:

1. The cruiser estimated net volumes are obtained when a cruiser applies standard rules to determine the percentage of sound wood in a tree after detecting physical indicators of decay on a tree. The process of applying the decay estimation rules is known as *net factoring*. If no decay indicators are detected, a tree is considered to be 100% sound. However, a tree may have decay even if there are no visible indicators, or a cruiser may miss the indicators. Therefore, net volume may be over-estimated.
2. The rules used to associate decay indicators with amount of decay are based on expert knowledge, and past experience. As would be expected, the rules may over-estimate or under-estimate the amount of decay on the average for a ground sample project. For more information on how the rules are applied, please refer to the *Vegetation Resources Inventory Ground Sampling Procedures* manual (available on the website <http://www.for.gov.bc.ca/hts/vri/standards/index.html#vri>).
3. The BEC-based tree taper equations may over-estimate or under-estimate close utilization volume when applied to local areas.

## 1.5 Principles of the NVAF process

The principles of the VRI sample data collection require that the results be unbiased. For this reason, it is required that the following principles be followed during NVAF data collection:

1. No bias:
  - The sampling selection processes (ground samples and trees) are without bias.
  - Rounding and vague definitions are avoided.
2. The ground and destructive sampling must be done correctly and carefully. Errors in the samples are translated directly into error in the inventory. Accuracy is the watchword.
3. The sample trees are preselected and their replacement must only be done if:
  - Sample tree or ground conditions represent an undue safety risk.
  - Replacement trees are selected without bias using procedures cited in this document.
4. Measurements are made to a known level of precision. Estimates made at the sample are acceptable where measurements cannot be taken.
5. All measurements are to be completed and recorded in the field.
6. NVAF sample data will be pooled using sampling probability weights to allow for the calculation of provincial NVAF strata based on biogeoclimatic (BEC) strata, tree species and age group.

## 1.6 Overview of NVAF Data Collection Step

The NVAF data collection occurs in two sequential steps, with each step requiring a separate visit to the field. These data collection steps are:

### *Step One*

The first step of NVAF data collection involves selection of sample trees from a large number of trees tallied in phase II ground samples. It consists of 5 stages:

1. Selection of polygons.
2. Selection of points within the sample polygons where a VRI phase II five-plot cluster will be established.
3. Tallying of trees in the auxiliary plots which will be eligible for consideration in the creation of a tree list from which to select NVAF sample trees.
4. Collection of preliminary measurements, which include tree species, dbh, height, call grades and net factoring to facilitate the estimation of tree net volume.
5. Selection of NVAF trees to be felled from the tree list by stratum or subpopulation. The number of sample polygons and sample trees is normally documented as part of a VRI sample plan.

The final stage of Step one is described in detail in section 2 of this manual.

### *Step Two*

The second step of NVAF data collection involves accurate measurement of actual net decay and merchantable volumes on the ground through destructive sampling and stem analysis. The sample trees selected in Step 1 are felled and sectioned to measure actual net volume.

Step two is described in detail in section 3.

This two-step NVAF data collection process limits the timing of the NVAF results. The NVAF subset of the VRI phase II ground samples must be completed prior to the selection of the NVAF sample trees.

Quality assurance is conducted on 10% of the sample trees and this stage is described in section 4.

## 1.7 Components of the Manual

This manual consists of 5 sections. A brief description of the contents of each section is provided here for quick reference.

Section 1: Provides the broad highlights of the manual.

Section 2. Describes the procedure for the replacement of sample trees.

Section 3. Describes the stem analysis process.

Section 4. The complexity of the NVAF data collection requires that rigorous quality assurance be implemented. This section provides the quality assurance procedures and standards.

Section 5. Defines key terms to ensure that the user has a quick reference in case they encounter terms or acronyms with which they are not familiar.

## **1.8 Roles and Responsibilities**

Generally, this manual is written for NVAF samplers to allow them to capture the NVAF measurements and replace NVAF sample trees according to the accepted standard. Sample selection, data processing and analysis are the domain of the Forest Analysis and Inventory Branch (FAIB).

## 2 Sample Tree Replacement Procedures

### 2.1 Background

Sample trees are selected using a selection matrix usually composed of:

- Tree species or species group
- Age group: immature vs mature where 120 years is the dividing age in most cases
- Biogeoclimatic unit in some cases

Each matrix cell will have a specific target sample size and trees within the cell will be selected systematically (with a random start) across the range of diameters (dbh).

**Once a decision has been made to replace a sample tree, the tree must be replaced with one from the same sample selection matrix cell and be of a similar dbh.**

### 2.2 Sample Tree Replacement

All selected trees should be used in the computation of the NVAF. However, there are a number of situations where one or more selected NVAF trees may need to be replaced. These situations include:

- A selected tree is unsafe to fall.
- A selected tree is situated in such a way that if felled, it would be impossible to measure, i.e. the tree is above a bluff or a waterway.
- A selected tree is found to be an active wildlife tree or has other characteristics that would outweigh its importance to the NVAF sample.
- The tree conditions no longer match the matrix cell used to classify the tree for the selection process or the dbh is substantially different from the one used in the selection. For example, the tree could have died or have been heavily damaged by fire or other causes.

If this occurs, then select a replacement tree from the same selection matrix cell and with a similar dbh. It is essential to select the replacement trees without bias. Replacement selection methods vary on circumstance as per:

#### **Individual tree found to be unsuitable for sampling:**

1. Select the replacement tree from one of the tallied trees in any of the auxiliary plots of the ground sample. This is the most efficient from a sampling perspective and is used when the felling or sampling restriction applies to an individual tree rather than an entire sample, or
2. If there are no suitable trees amongst the tallied trees, a replacement tree can be selected from elsewhere in the polygon through the use of a random bearing from the center of the auxiliary plot. The replacement tree should be given a non sequential tree number, such as #99 and fully enhanced prior to felling and sectioning.

#### **Ground sample found to be unsuitable for sampling:**

1. Replacement trees are selected from the list of trees tallied in the auxiliary plots of the remaining NVAF ground samples, which may mean a return visit to a sample already completed. The replacement selection must be done by FAIB.

2. If there are an insufficient number of trees for the replacement selection or their distribution is limited as can occur with uncommon species, then additional ground samples are selected for NVAF. FAIB will identify the subset of ground samples that contain tallied trees of the same selection matrix cell and make a random selection of enough ground samples to satisfy the number of replacement trees. Usually this will amount to 1 to 3 additional ground samples.

### **2.3 Sample Tree Replacement**

Replacement trees must be enhanced prior to felling if not already done. The following attributes are required, captured using the VRI Ground Sampling procedures::

- Tree species
- Dbh
- Height
- Call Grades and net factors of each log
- Loss indicators
- Live/dead status of the tree
- Forest Health (optional)

**Enhancements must be done by a certified VRI ground sampler.**





## 3 Stem Analysis Data Collection

### 3.1 Introduction

This section outlines the tasks required to collect stem analysis data on selected trees. The standards and procedures for the NVAF stem analysis sampling adhere to those for volume and decay sampling.

#### 3.1.1 Data Collection Software

**NVAF data must be captured in the field using the DVHand and Host data collection software.**

#### 3.1.2 Principles

NVAF sampling entails the collection of data that will allow for the calculation of actual net and merchantable tree volume. Log sections are kept short at a 2 m length to minimize errors around the formula, Smalians, used to calculate log volume. The cross sectional area of decay and other losses to sound wood in each section are precisely determined and exclude any contiguous areas of sound wood.

#### 3.1.3 Timing of Sampling

NVAF sampling should only be conducted when the wood is not frozen. This is due to the difficulty in determining decay in frozen wood.

## 3.2 Supplies and Materials

**Table 1 - Materials required for stem analysis.**

---

• map and photo holder	• compass
• field notes for sample	• clinometer
• NVAF Standards and Procedures manual	• 30 or 50 m (Eslon style) tape
• user guide for data collection software (DVHand)	• diameter tape
• handheld computer	• thin pointed knife $\geq$ 10 cm blade
• spare batteries for the handheld computer	• axe $\geq$ 2.5 lb
• regional biogeoclimatic ecological classification (BEC) book	• indelible felt markers or log crayons
• VHF radio or satellite phone	• 15 cm scale ruler starting at 0 cm
• first aid/survival gear	• metric carpenter's tape
• field book with blank field sheets	• spray paint

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- pencil
  - calculator
  - altimeter or topo map
  - GPS
  - flagging tape
  - high powered hand lens
  - site index age correction tables
- 

### 3.3 General Procedures

The general procedures for the stem analysis are outlined sequentially. The detailed procedures follow further in the section.

#### 1. Describe Field Orientation and Navigation

- Access the sample.
- Identify the sample.
- Identify the plot.
- Identify the tree.

#### 2. Record Sample and Plot Attributes

- Record sample attributes.
- Record plot attributes.

#### 3. Assess Standing Tree for Path Indicators

- Identify each indicator
- Estimate location on tree

#### 4. Mark and Measure Standing Tree

- Limb branches and remove obstructions.
- Relocate and mark the high side of the tree.
- Mark the butt taper heights.
- Measure the butt taper diameter outside bark (DOB).
- Cut bark windows and measure double bark thickness (DBT).

#### 5. Fall, Buck, and Measure Age of Tree

- Fall and limb the tree.
- Buck out the 1.3 m cookie.
- Buck out the 0.3 cookie.
- Count age.

#### 6. Mark and Measure Felled Tree

- Reconstruct the tree if broken during falling.
- Run measuring tape along stem of tree.
- Locate crown height.
- Identify primary and secondary leader(s).
- Locate heights of primary and secondary leaders.

- Locate the upper utilization diameter inside bark heights (Utop) of primary and secondary leaders.
- Locate, mark, and measure broken top(s), fork(s), and crook(s).
- Identify and measure path indicators.
- Mark significant taper changes.
- Mark off sections above 1.3 m and between the Utop.
- Assign leader number(s) to secondary leaders.
- Buck sections.
- Buck “cookies”.
- Measure DIB of each section.
- Identify decay characteristics and shape.
- Identify decay by section.
- Measure decay.
- Measure voids.
- Measure nonmerchantable.
- Determine length of decay by section (intermediate bucking as required).
- Check path indicators for hidden decay.
- Cut blaze on tree stump and identify sample tree.

## **7. Data Edits and Processing**

- Deletion of unwanted trees.
- Ensure consistency of broken top attributes.
- Ensure all decay length information is entered.
- Ensure decay attributes are entered.

## **3.4 Detailed Procedures**

### **3.4.1 Describe Field Orientation and Navigation**

#### **3.4.1.1 Access the Sample**

Use the existing sample field documentation to determine the location of the sample and determine the nearest access point. The UTM coordinates of the IPC are crucial. Note that the original access point may be inadequate due to changes to the road systems in the area and to different safety considerations that come from the felling of trees. The NVAF measurement crews may want to consider alternate forms of access to the sample, such as flying in and finding a helispot close to the sample to avoid a long hike.

#### **3.4.1.2 Identify the Sample**

The sample identity consists of region, compartment, and VRI ground sample number. The region and compartment information can be obtained from the inventory database, forest cover maps or from FAIB.

### 3.4.1.3 Identify the Plot

The plot is identified by its cardinal direction from the IPC. The following numbers differentiate the plots:

- 1 = north plot
- 2 = east plot
- 3 = south plot
- 4 = west plot

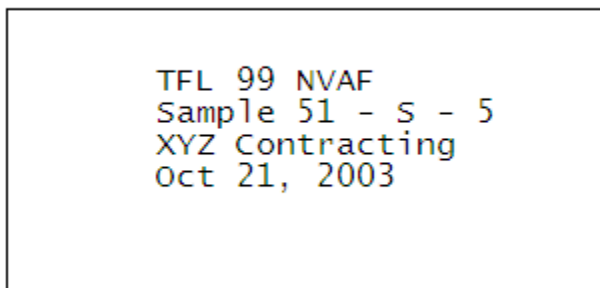
The VRI ground sampling process contains replacement plots. Identify the NVAF plot as the plot number that has been replaced. For example, if the North plot has been replaced during the VRI ground sampling with replacement location 12, then still label the NVAF plot as “1” but note in the comments that the plot is located at replacement location 12.

### Identify the Tree

The tree is identified with the same tree number given in the VRI ground sampling phase. Clearly identify the sample tree by blazing the stump and recording:

- project code
- sample ID
- plot ID
- date
- initials of crew members

For example, if the sample tree is #5 on the south plot of sample 51 of the TFL 55 VRI, then record the following: **TFL 99 Sample 51 tree S-5 sampling crew initials, date**, (see figure 1).



**Figure 1 - Sample Tree Label**

To mark the tree, use an indelible felt marker, a log crayon, or a nailed/stapled metal tag on the blaze.

## 3.4.2 Record Sample and Plot Attributes

### 3.4.2.1 Record Sample Attributes

The sample attributes are biogeoclimatic zone, subzone, and variant. Determine the BEC zonation of the site using the regional guide book. This is a field assessment and the BEC map should only be used as a guide.

### 3.4.2.2 Record Plot Attributes

The plot descriptors — elevation, slope position, percent slope, aspect, and site series — are determined for each plot.

### 3.4.3 Assess Tree(s) for Pathological (Path) Indicators

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**Note:** The assessment of path indicators **must** be made for all trees in the sample plot **before felling neighbouring trees.**

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Assess for the standard FLNR volume and decay/appraisal cruise pathological (path) indicators. These are: conks, blind conks, frost cracks, scars, forks, crooks, large rotten branches, dead tops, root rot, and broken tops and their definitions adhere to the traditional ones of the British Columbia Loss Factor System. The objective is to maintain a system that is compatible with current and past inventories, but will also meet future needs. Path indicators and VRI loss indicators are identical, the exception being that the consideration of the time elapsed since the path indicator was created. The VRI loss indicator system does not recognize time. The general guideline for pathological indicators that describe stem damage, such as scars, forks, crooks, and dead and broken tops, is that at least 5 years must have passed since the damage was created. This guideline conforms to existing operational timber cruising, inventory audit, and volume and decay sampling rules for path indicators.

**For each indicator on the standing tree, identify, estimate, and record the start and end (bottom and top) height. For scars, also record the average width.**

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**Note:** A complete reassessment of path is made for the felled tree, which may include much of the standing path but will also include indicators hidden in the crown or in the stem.

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Do not confuse broken tops with forks or crooks, as this will affect tree height and the compiled taper equation volume.

Assess measurable secondary leaders for path indicators.

Candelabras are also recorded but are not considered to be path indicators.

#### General Procedures

1. Record path indicators for all sample trees.

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**Note:** Record path indicators for dead trees also.

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2. Enter the appropriate code for the path indicator. See Table A.1 for the appropriate code.
3. Enter a minus sign (–) if below high side ground level.
4. Estimate the position of each path indicator on the stem of each sample tree to the nearest 0.1 m.
5. Record path indicators for all measurable leaders from the tree base to the top of the leader.
6. If the path indicator is too numerous, i.e. 20+ conks over a 10 m length, to separate as individual items, record as one item. Make a note if this situation occurs.
7. For closed scars, record 0.1 cm width. For open scars, record average width of opening.

**Table 2 - Stem Analysis Path Indicator Codes**

Code	Description
CONK	Stem or root decay conk
BC	Blind Conk
FC	Frost Crack
SCAR	Scar
FK	Fork
CK	Crook
RB	Rotten Branch
DT	Dead Top
BT	Broken Top
CD	Candelabra

***Conk Stem Decay Observed on Bole***

Conks refer to the fruiting bodies (sporophores) of stem decay fungi and are definite and reliable indicators of decay. Typically conks are thick, hard, woody-like perennial structures. Only specific root, butt, and heart-rot conks are considered to be path indicators. Slash conks that occur on dead branches and wounds of living or dead trees are not considered path indicators. Fruiting bodies can occur anywhere on the main stem and/or branches, but they appear most frequently around knots and on the underside of dead branch stubs and live branches. Record position on trunk.

***Conk Root or Butt Rot Observed on Roots or Ground***

Root rot refers to fruiting bodies that located on the roots and associated with stem decay and include decays such as *Phaeolus schweinitzii*. Typically, fruiting bodies are short-lived, soft, and fragile. Often you may be able to see an indication of root rot decay directly on the roots. Record “0” (ground level) as the length for any single or multiple root rot indicator.

***Blind Conk***

Blind conks are pronounced swellings or depressions around knots, usually caused by *Phellinus pini* (DDP) on conifers, and *Phellinus tremulae* (DDT) on aspen. Blind conks are definite indicators that decay is extensive in the tree stem. Find evidence of **conks** in the surrounding stand before recording blind conk as an indicator. Look for stem swellings and stem depressions thought to be where the tree attempts to heal over decay emerging through a knot or branch stub. Bright yellow to buff-coloured material can be observed by chopping into basal branch stubs. This form is most often found in the interior of the province. The project supervisor will direct crews regarding procedures for chopping into trees.

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**Note:** Verifying the existence of blind conks is the only situation where we allow crews to chop into live trees on the plot.

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### ***Frost Crack***

Frost cracks result from deep radial splitting of the trunk, caused by uneven expansion of moisture in the tree after a sudden and pronounced drop in temperature. The cracks usually originate at the base of the trunk and may extend many meters, following the longitudinal grain of the tree. The wound will often spiral up the tree following the movement of moisture. Frost cracks are often reopened and extended by wind stresses or refreezing. Repeated healing of the cambium produces pronounced callous tissue, giving a ribbed appearance to the wound.

### ***Scar***

A scar is an injury caused by external forces that damage the cambium or heartwood of the tree, exposing the tree to wood-decay fungi. A scar can occur anywhere on the main stem or root collar of the tree. Scars on branches or candelabras are not recorded.

A scar may be “open” meaning the wood is exposed, or “closed” meaning that the bark has grown over the injury. Old healed-over fire scars are recorded.

### ***Fork***

A fork is caused by significant damage to any measurable leader of a tree that results in more than one branch (leaders) competing for apical dominance. The damage to the leader from external forces, physiological factors, animals, or insects (weevil) exposes the stem to potential wood or decay fungi. The following conditions are **not considered forks**:

- natural branching in deciduous trees
- small sharply angled branches or spikes, unless associated with a noticeable offset or diameter change at the location
- flattening of the tree tops caused by wind or physiological conditions where no terminal leaders are evident
- candelabra branches

### ***Crook***

A crook is caused by significant damage (mechanical, physiological, animal, or insect attack) to the leader of a tree. Crooks potentially expose the wood to decay fungi. Crooks may still have the stub of the old leader and differ from forks by the absence of two or more leaders. To be recorded as a crook, it must meet the following conditions:

- the diameter of the main stem changes noticeably from the normal taper, and indicates that an injury has occurred
- the stem must be offset severely enough to indicate that damage has occurred to the main stem

### ***Large Rotten Branch***

Large rotten branches are defined as those with a diameter inside the bark greater than 10 cm at the base. They have obvious signs of heart rot and typically appear as short, rotten branches on overmature trees. They should not be confused with branches that have died through normal causes.

### ***Dead Top***

Any number of external injuries, physiological stresses, insects, or diseases can cause a dead top. The top should be obviously dead with no green needles or leaves present. Record the length to the base of the dead top (top of live crown).

### ***Broken Top***

A broken top is produced when an external force or condition causes the top of the tree to break away from the main bole. Wind breakage, snow damage, and mechanical damage from other falling trees commonly cause broken tops. Record the length to the break (estimate by folding back any jagged parts of the stem to form a complete stem).

### ***Candelabra***

A candelabra is a leader that was **not** created from direct damage to the original leader, but developed from abnormal branching.

## **3.4.4 Mark and Measure Standing Trees**

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**Note:** Complete the standing measures for all sample trees in the plot, before the falling begins. It is vital that the path indicators are assessed prior to any fellings so to match the stand condition found by the VRI ground sampler.

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### **3.4.4.1 Limb Branches and Remove Obstructions from Tree Base**

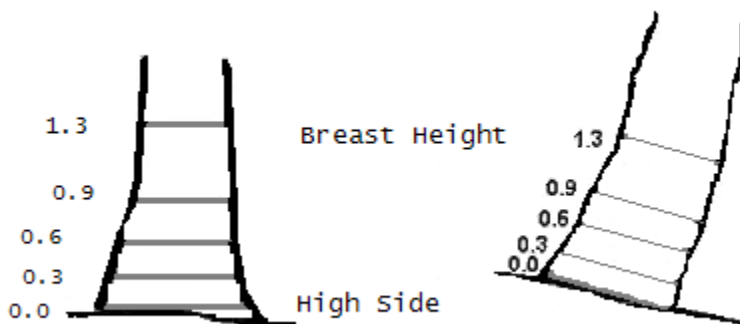
Prepare sample tree by limbing lower branches. If possible, remove obstructions round the base of the tree.

### **3.4.4.2 Relocate and Mark the High Side of the Tree**

High side is defined as the highest point of mineral soil around the base of the tree. If the tree has a pronounced sweep, logs, rocks, or boulders at the base, the point of germination will be high side.

### **3.4.4.3 Mark the Butt Taper Heights**

Mark the butt taper (0.3, 0.6, 0.9, 1.3 m) heights above high side and around the bole with paint. Measure the butt taper height measurements parallel to the trunk (Figure 2).



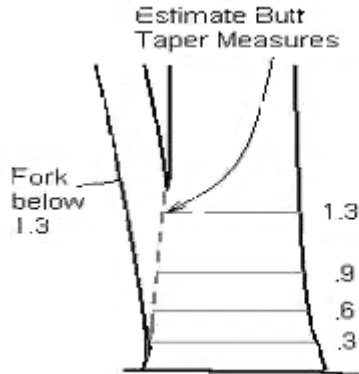
**Figure 2 - Butt Taper Marks in Meters Above High Side**



**Note:** The data collection software allows for an optional DOB and DBT measures at a user defined height anywhere between 0 and 0.3 m. This optional height is not a NVAF standard.

**3.4.4.4 Measure the Butt Taper Diameter Outside Bark (DOB)**

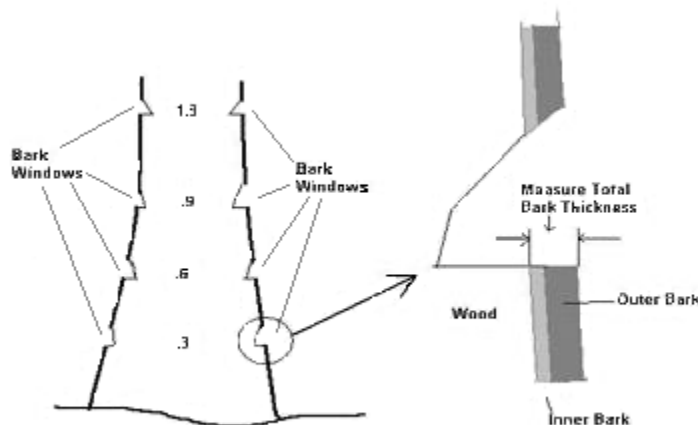
For each of the butt taper heights measure the DOB with a diameter tape. Use two people to ensure the D tape is at right angles to the trunk. If there are obstructions, swellings or forks below 1.3 m, estimate the butt taper DOBs, (Figure 3).



**Figure 3 - Estimation of Butt Taper DOBs in Case of Forks**

**3.4.4.5 Cut Bark Windows and Measure Double Bark Thickness (DBT)**

With a chain saw or an axe cut bark windows at opposite sides of the tree stem at each butt taper point. When locating the sites to cut bark windows, attempt to avoid atypically thin or thick bark. For trees on steep slopes, it is acceptable to cut the bark windows on either side of the contour due to difficulty in reaching the upper butt taper heights on the bottom side of the tree. Measure both of the bark thicknesses at each taper point at a representative thickness and add them together to produce the double bark thickness (DBT), (Figure 4).



**Figure 4 - Bark Windows**

The bark on all but very young trees varies considerably over small distances due to small troughs and projections. The objective is to convert the DOB measure to a diameter inside bark (DIB) value by subtracting the DBT. Therefore, select a typical bark projection and measure from the cambium to the outer edge of the projection (Figure 5). Calculate a prorated bark thickness if bark is missing from a significant portion of the stem. For example, if bark is missing from 25% of the trunk circumference, then cut bark windows from the portion with bark and then reduce the double bark thickness by 25%.

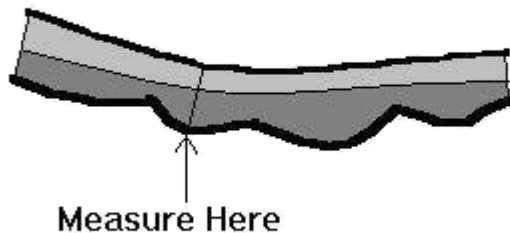


Figure 5 - Selection of Site to Measure Bark Thickness

### 3.4.5 Fall, Buck, and Measure Age of Trees

#### 3.4.5.1 Fall and Limb the Tree

Ensure the crew moves to a safe distance when the sample tree is felled. On a hillside, the most favourable landing of the tree is across the hill, rather than up or down hill. Where possible, avoid falling trees across a stream or creek. The falling process is at the faller's discretion. Limb the sides and top of the tree stem.

#### 3.4.5.2 Buck Below 1.3 m (Butt Taper Sections)

Buck the 0.3 m section and the 1.3 m sections of all sample trees. A 'cookie' is bucked at each of these heights. See section 3.4.6.11 for the cookie definition and instructions of cutting.

#### 3.4.5.3 Measure Age

Buck a cookie (see section 3.4.6.11 for the cookie description) **from the top of the 1.3 m section**, instead of from the bottom of the 2.3 m section.

**Count the age using the growth rings, marking 20-year increments with an indelible marker.** This is an important measure and care must be taken to clean off a radius for an accurate ring count using a high powered hand lens. Estimate the number of years required for the tree to grow to breast height, and record as the age correction. A site index table is suitable for use.

If decay precludes an accurate ring count, then count the rings that are observable and measure the radial extents of both the counted and uncountable wood (Figure 6).

Measure the sound wood at a point that reflects the growth rate for the missing section.

The handheld software will calculate the rings per centimetre of the counted wood and apply this factor to the uncountable wood to determine the stump age of the tree.

If the uncountable portion is localized at and around 1.3 m such that accurate age counts can be made adjacent to breast height between and including the 0.3 and 2.3 m sections, then count the age at the more accurate location.

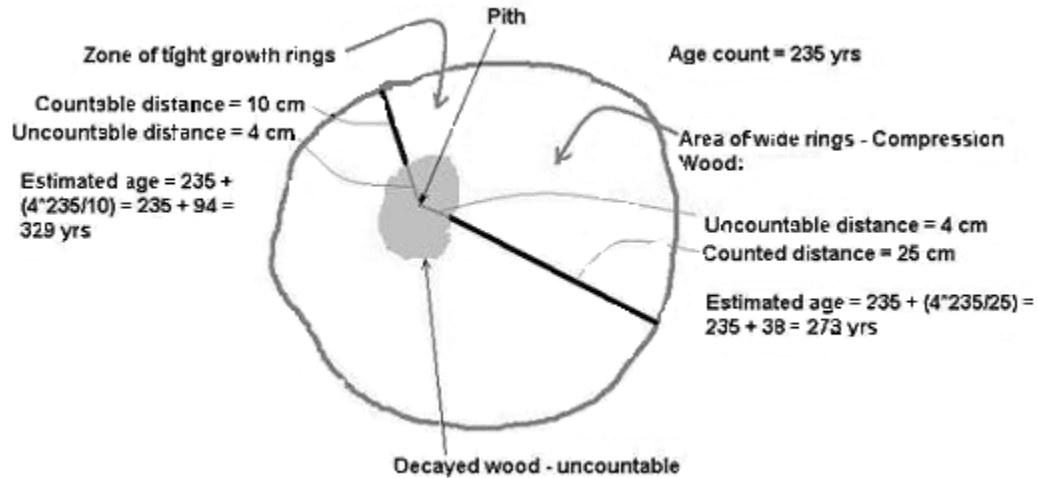


Figure 6 - Determining Age in Rotten Trees

### 3.4.6 Mark and Measure Felled Trees

#### 3.4.6.1 Reconstruct the Tree if Broken During Falling

Before limbing the upper portion of the tree, look for the tree top and forks. The top of the tree can readily break off during the felling process and be difficult to locate. Consequently, it's easier to identify the top before the cut limbs obscure the ground.

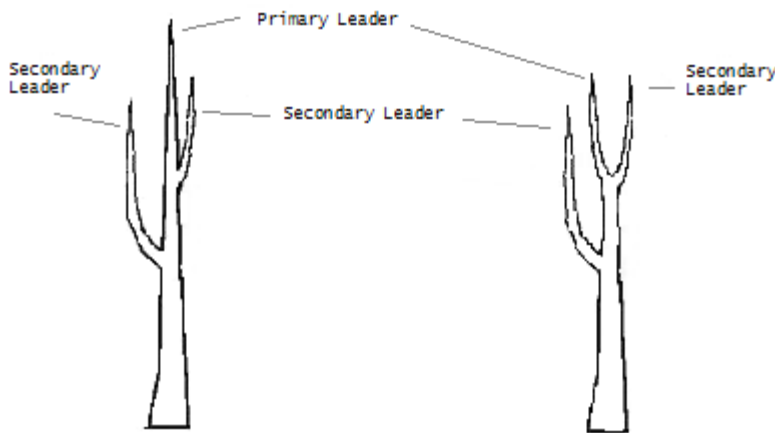
#### 3.4.6.2 Run Measuring Tape along Stem of Tree

Attach the metric tape to the butt of the felled tree at 1.3 m and run it up the tree stem to mark sections and defects. To avoid measurement error, ensure the 1.3 m mark on the tape is lined up exactly with the trunk's breast height.

#### 3.4.6.3 Identify Primary and Secondary Leader(s)

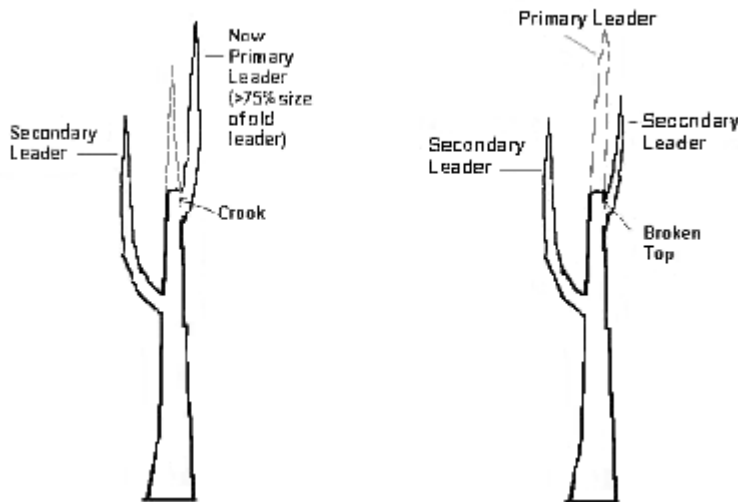
##### *Identify the Primary Leader*

The primary leader is determined by leader length and will be the longest leader, all other leaders are potential secondary leaders, (Figure 7).



**Figure 7 - Primary Leader Identification**

The one exception to the rule of the primary leader being the tallest leader is in the case of a broken top. If a tree has produced new leaders as a result of a broken top, the determination of the primary leader is based on projecting the old broken off top and comparing its size to the new leaders. As a guideline, if a new leader's height and DIB (diameter inside bark) at its base is greater than 75% of the projected broken top then it is a primary leader candidate, (Figure 8).



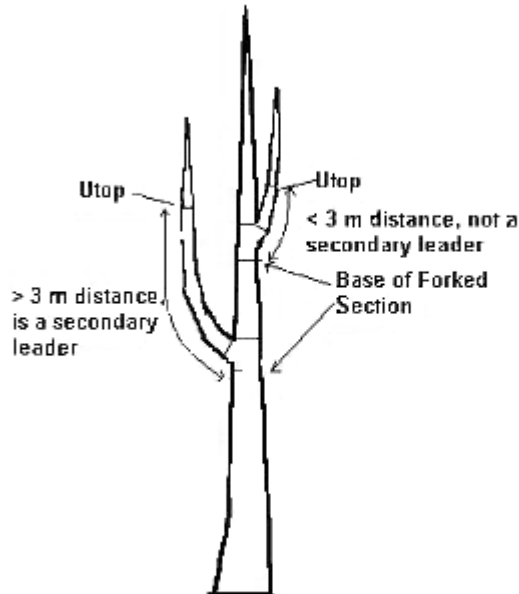
**Figure 8 - Identifying the Primary Leader if a Broken Top**

***Identify Secondary Leader(s)***

The secondary leader is greater than 3 m in length from its base to its upper utilization point (Utop) of 10 or 15 cm (depending on tree age and location) diameter inside bark (DIB). The base of the leader is the bottom point of the forked section of the primary leader. Secondary leaders are measured if the following applies, (Figure 9):

- originates from the primary leader,
- originates above breast height,
- is alive,

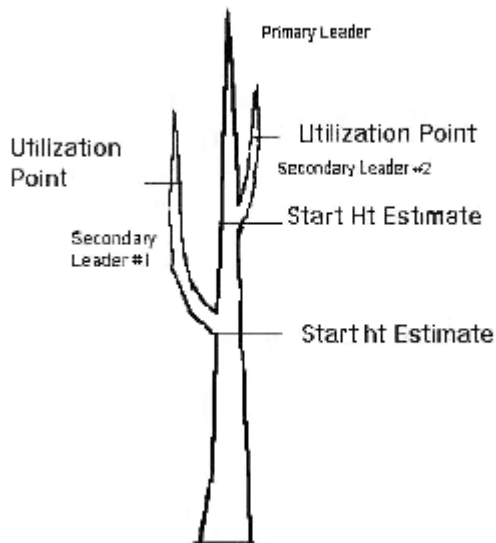
- meets the length criteria.



**Figure 9 - Secondary Leader Merchantability**

Assign a leader number to a secondary leader before marking the individual sections. Estimate the approximate height of the leader's start height (point of origin on the primary leader). In the case of multiple secondary leaders, the identity of the leader is determined by its approximate start height (Figure 10).

**SECONDARY LEADER IDENTIFICATION**



**Figure 10 - Secondary Leader Identification**

#### 3.4.6.4 Locate Heights of Primary and Secondary Leaders

Heights are measured to the nearest 0.01 m.

##### *Primary Leader*

###### Crown height

Measure the base height of the live crown on the primary leader. When determining the base of the lowest contiguous live crown, do not consider forks or epicormic branches. The height is normally the location on the stem where live branches occupy about 75% of the stem circumference. If the crown is asymmetrical, select a height equivalent to the average crown. Dead trees will not have a live crown and should be given a live crown height .01 m below the tree or broken top height.

###### Utop height

Determine the location of the Utop on the primary and secondary leaders by:

- estimating the approximate location
- chopping a bark window
- measuring the bark thickness
- calculate the double bark thickness
- adding the DBT to the Utop DIB

This process provides the Utop diameter outside bark (DOB). Then, locate the Utop DOB on the leader by selecting the upper most point on the stem that will give the correct Utop inside bark diameter. Ensure the bark window is less than 30 cm from the final utop position. Because of abrupt changes in leader taper due to branch swellings, forks, or crooks, there may not be an actual Utop DIB. If this is the case, provide a best estimate of the Utop.

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**Note:** Utop DIB is either 10 or 15 cm and depends on location and tree total age. Coastal trees > 120 years of age have a 15 cm Utop DIB and all other trees have a 10 cm Utop DIB.

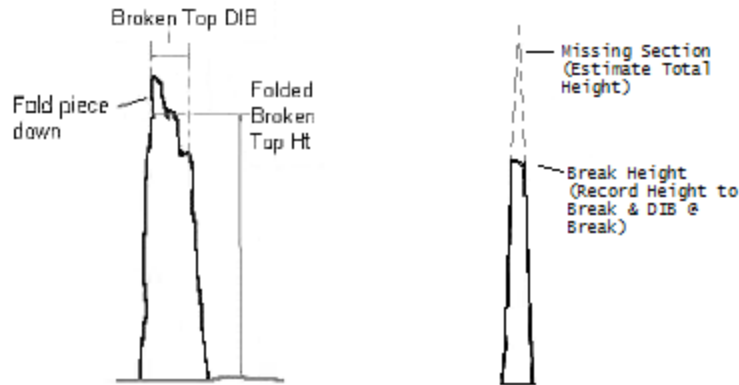
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###### Broken Top Height

If the primary leader has a broken top, fold the top down to produce an even height as per the VRI ground sample process and measure the height to the break point. Then, estimate the length of the missing section and add it to the break height to produce the total height. The estimate can come from a measurement of the broken top if located or by assessing intact trees in the vicinity, (Figures 8 and 11).

Broken tops can be differentiated from forks or crooks by comparing the size of old broken off leader to the new leaders that have formed as a result of the break. If the new leader's height and DIB at its base are less than 75% of the original leader's projected height and DIB at the break, a broken top is called; if the new leader is greater than 75%, then a fork or crook is called.

Trees with broken tops require an estimate of projected height beyond the break. In contrast, the height of a forked or crooked tree is that of the tallest leader's terminal bud. Hence, using a projected height versus an actual height will profoundly affect the volume estimated by the taper equations.



**Figure 11 - Broken Top Height and DIB Measurement**

Broken Top Diameter

- Measure the diameter inside bark of the break.

Total height

- Measure the total lengths of the primary and secondary leaders.
- In the case of trees with flat tops that are not broken as in the case of suppressed or very old trees, measure the top at a point where the top starts to level off.
- Mark the leader tops with ribbon or a dot of paint.
- In the case of a top that cannot be located and the missing portion likely amounts to a very short length of < 1m with a DIB < 1 cm, then estimate the length of the missing section and add it to the measured length and record this sum as the total height. In many cases, the missing portion amounts to part of one year's leader growth and ranges from 20 to 50 cm of length. The sampler should be confident about their estimate.
- In the case of a top that cannot be located and the missing portion likely amounts to a long length of > 1m and a DIB > 1cm, then measure the actual length and record as a broken top. Estimate the missing portion and add it to the measured length and record the sum as the total height. Do not record a broken top path call.

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**Note:** Differentiating between a broken top and a fork or crook is vital in determining tree height and the subsequent estimation of gross tree volume through the taper equation.

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***Secondary Leader***

Utop height

Apply the same procedure as for primary leader.

Total height

Top height for the secondary leader is taken from high side to the tip of the top of the secondary leader.

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**Note:** Secondary leaders do not require a projected height.

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**3.4.6.5 Locate, Mark, and Measure Fork(s), and Crook(s)**

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**Note:** Forks, and crooks must be properly identified at this stage in the NVAF sample.

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See section 3 for the definition of the crook and fork path indicators.

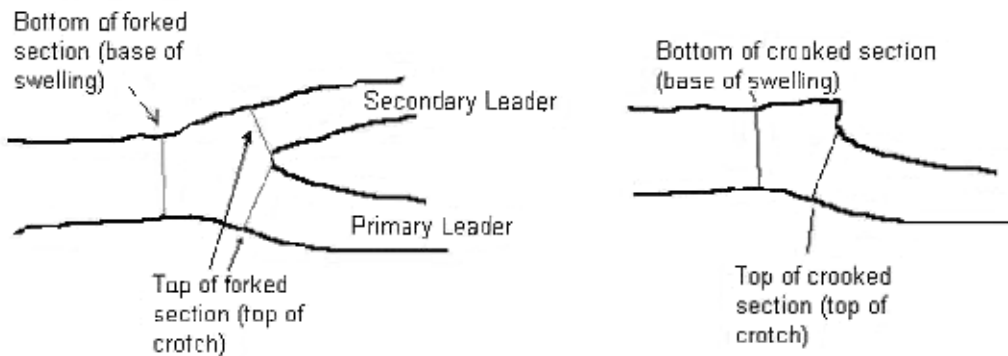
The principle of sectioning out forks and crooks is to:

- Ensure the volumes for the preceding and subsequent sections of the tree are relatively accurate in terms of an even change in taper for their sections.
- To readily capture decay arising from the old broken top origin of the fork or crook.

Always mark the bottom and top of a crook or forked section regardless of the length of the secondary leader. The bottom mark is made where the swelling of the trunk begins. Mark the top immediately above the crotch of the fork or crook. If the other leaders of a fork meet the secondary leader requirements, then place the top section marks of the leaders at the same height as the primary leader section (Figure 12).

Forks and crooks are also sectioned on secondary leaders.

Forks and crooks are not sectioned below 1.3 m.



**Figure 12 - Marking the Bottom and Top of a Forked or Crooked Section**

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**Note:** If a sample tree has a secondary leader in the butt section (below 1.3 m), measure only the leader that is identified as the sample tree. If the secondary leader belongs to the same tree, then record the secondary leader as a path indicator.

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#### 3.4.6.6 Identify and Measure Path Indicators

Scrutinize all the tree sections for path indicators using the list of standing path indicators as a guide. See section 3.0 for definitions.

Locate **all** path indicators. Identify each indicator, measure and record the lower and upper heights of all indicators. Record the average widths of scars. If numerous indicators such as conks or scars occur every few centimetres along the stem, record the height range and make a comment. In determining the height of the primary leader, differentiate between a fork or crook and a broken top.

Path indicators that were called incorrectly as standing path are corrected for the felled path. For instance, a standing frost crack found to be a scar once the tree is felled is to be identified as a scar.

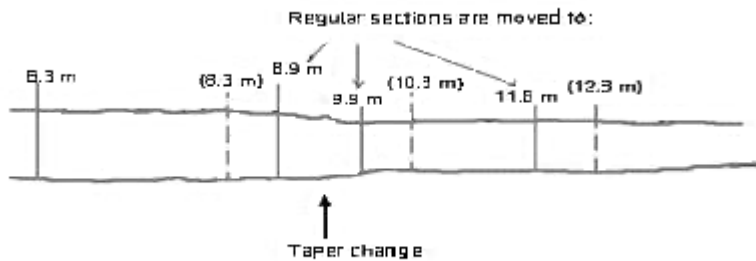
Identify the decay organism associated with a conk only if certain, otherwise identify it as unknown. If a conk associated with heart rot is identified in a branch, record the height of the base of the branch as the height of the conk. Common conks associated with heart rot are *Echinodontium tinctorium*, *Phellinus pini*, *Fomitopsis pinicola*, and *Phaeolus schweinitzii*



(the last usually occurs on the ground near the base of the tree). For *Phaeolus schweinitzii* occurring on the ground, record the height as 0 m.

**3.4.6.7 Mark Significant Taper Changes**

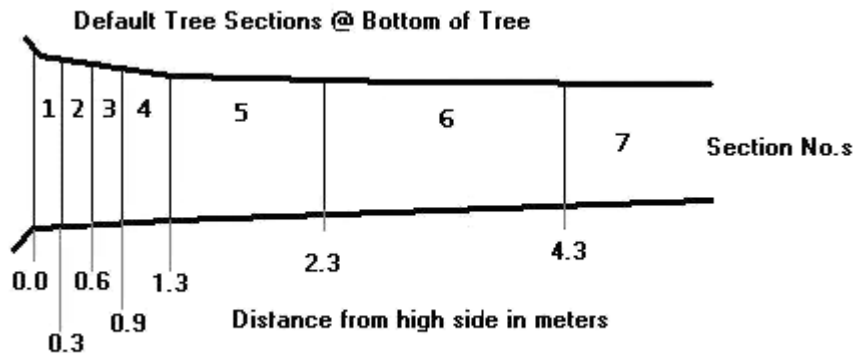
If the diameter taper of a section is not even from one end to the other end and the taper change is not due to a fork or crook, then adjust the section length to better capture the section volume. Alter the sectioning to allow for a section to encompass the area of significant taper change. This is done to capture the change in volume due to the decreased or increased section diameter (Figure 13).



**Figure 13 - Sectioning of Taper Changes**

**3.4.6.8 Mark Off Sections Above 1.3 m**

With paint, mark off sections. The standard section length is 2.0 m. The first section above breast height is section number 5, and the top of this section will be at 2.3 m (2.0 m above the 0.3 mark) (Figure 14).



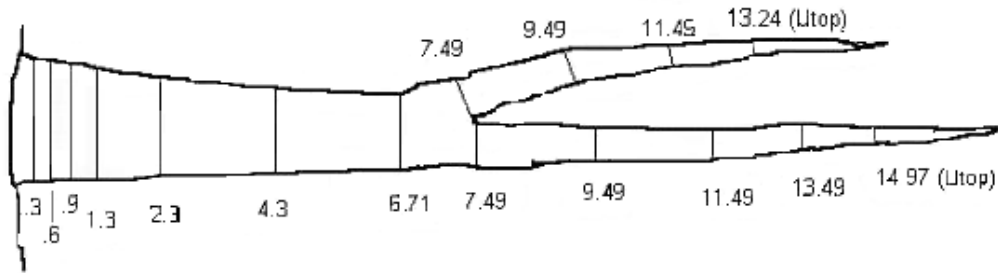
**Figure 14 - Sectioning of the Bottom of the Tree**

Section lengths can be extended for up to half of the default length (i.e., 1.0 m). Sections are extended to meet the bottom section of a fork, crook, top, or broken top. The default section length of 2.0 m is resumed above forks and crooks. Mark section cumulative lengths and leader number at the top of each section. **Do not section above the leader Utop height.**

*Secondary Leader*

Divide the secondary leader into sections using the same process as the primary leader. The top of the first section of the secondary leader will always be the same height as top of the forked section on the primary leader.

Mark and section all crooks and forks on the secondary leader, but **do not section secondary leaders off secondary leaders**, (Figure 15).



**Figure 15 - Marking of the Sections**

**3.4.6.9 Assign Leader Number(s) to Secondary Leaders**

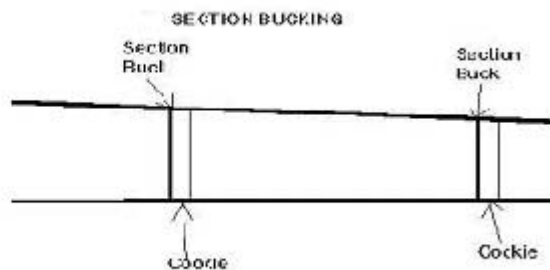
Using the leader start height as a guide, assign the appropriate secondary leader number to the forked primary leader section.

**3.4.6.10 Buck Sections**

After the tree is marked and the path indicators have all been located, buck out all of the tree sections including the Utop section, with the exception of the .6 and .9 sections.

**3.4.6.11 Buck “Cookies”**

Cut a 5 cm thick cross-section (a “cookie”) off the bottom of every section. Identify each cookie by marking the cumulative length and the tree and leader number on the face of each cookie (Figure 16).



**Figure 16 - Bucking of the Sections and Cookie Cutting**

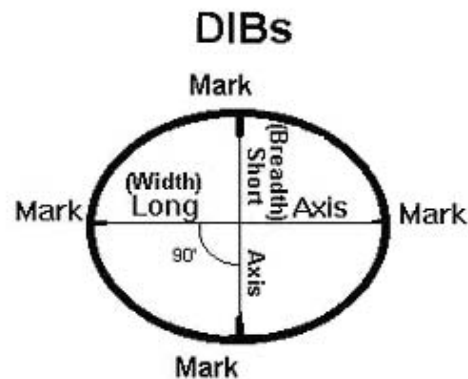
**3.4.6.12 Measure DIB (Diameter Inside Bark) of Each Section**

*Regular Shape*

Start measuring the bottom-most section of the tree (starting at sections above 1.3 m) and work towards the top. Measure the lower face of the cookie cut from the bottom of the next section.

Determine the longest axis and mark the two end points with an indelible felt pen. Then at right angles (90°) to the long (width) axis mark the short (breadth) axis, (Figure 20). Having long and short axes will create an elliptical shape. Using a carpenter's tape, measure to the nearest 0.1 cm.

If the cookie has fallen apart due to excessive decay or bucking/falling damage, it is acceptable to measure the DIBs off of the bottom end of the next section.



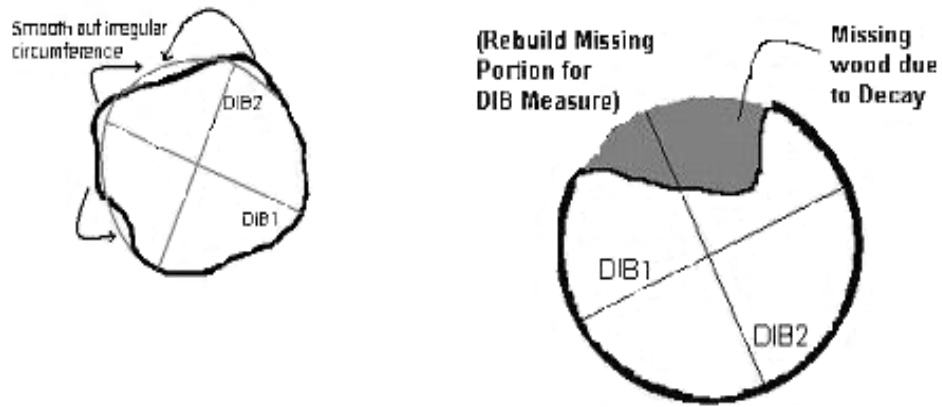
**Figure 17 - Measuring the Cross-Section DIB, Short and Long Axis**

***Irregular Shape***

If the shape of the cross-section is severely distorted then determine if decay has caused the irregular shape

- **Decay:** If the cause **is decay**, “rebuild” the decayed portion and measure the DIB to the edge of the “rebuild” portion (Figure 18).
- **Void/Irregular Shape:** If the distortion is **not due to decay** but to other causes such as large knots, irregular cambial growth, extensive weathering, or scar voids, then smooth out the irregularity into a more regular elliptical shape (Figure 18). The sampler should assess the overall section taper when making their decision about the final shape of the section.

## NVAF Sampling Standards and Procedures



**Figure 18 - Measuring the DIB of an Irregular Section**

### 3.4.6.13 Identify Decay Characteristics

#### *Stains*

Stains and discolourations may be caused by incipient decay, by chemical reactions, and by stain-producing fungi.

Stains caused by non-woodrotting fungi are usually confined to the sapwood of the tree, whereas those caused by incipient decay are usually associated with the heartwood. Although stains do not affect the strength of wood, the unsightly discolourations are sometimes commercially unattractive, which may be reflected in a lower grade. Decay and stain are often found together because they develop under the same conditions.

#### **Recognizing Decay**

Wood-rotting fungi cause decay of wood. Hyphae, which constitute the vegetative stage in the life cycle of the fungus, penetrate the cell walls of wood and dissolve various constituents, which then nourish the fungus. These physical and chemical changes cause the wood to disintegrate in a process called decay.

#### *Stages of Decay*

The three stages of decay are incipient, advanced, and final (Figure 19).

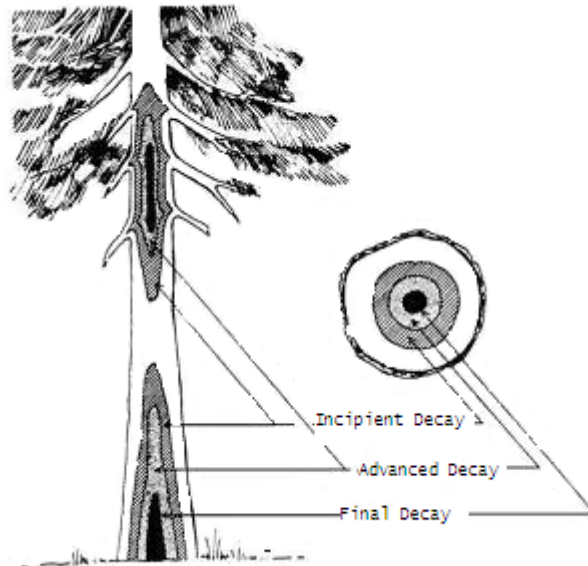
1. In the *incipient* (initial or early) stage, affected wood *may appear* quite sound and hard. The only visible evidence of attack, if any, is a slight or pronounced change in colour. The degree of discolouration varies with the species of fungus involved and, sometimes, with the species of tree affected. Incipient decay often appears as a light to dark reddish-brown, olive, or purple streaking (or banding) of the heartwood. In some decays, the delignifying action of the fungus bleaches the wood. In recent infections, incipient decay may occur alone, time having been insufficient for advanced stages to develop. **For the purposes of NVAF sampling, incipient decay is defined as wood that is likely attacked by wood rotting fungi but no loss of fibre strength can be detected.**
2. At the *advanced* stage (large or typical) of decay, the strength of the wood has been so seriously affected that it is easily broken and can often be crumbled between the fingers. When tested with a knife, wood affected by advanced decay is soft and has a punky or brash texture. To test for these symptoms, use the point of a knife or an axe.
3. In the *final* stage of decay, destruction of the heartwood may be complete, leaving only a shell of sound sapwood.

#### **Measurements are taken of the advanced and final stages of decay.**

Advancement of decay varies with the individual tree and with the species of fungus. In older infections, incipient decay appears at the advancing margins of visible decay, separating the advanced decay from sound wood. This advancement occurs radially and from the advanced decay to the sound wood. Longitudinally, the incipient decay can extend a few centimetres or several meters from advanced decay; radially, it extends usually 2 or 3 cm.

Decay may be classified by the type of wood attacked (heart rot or sap rot) or by its location within the tree (root rots, butt rots, trunk rots, or top rots).

Multiple infections often occur in the same tree: butt rot caused by one fungus gaining access through roots, trunk rot in the second log caused by another fungus gaining entrance through a scar, and top rot caused by a fungus entering through a broken top.



**Figure 19 - Various Stages of Decay in an Infected Tree**

### ***Entrance***

Determine the entry point of the decay organism. Examples are scars, broken branches, conks, forks, crooks, broken tops, or roots. If the entry point is not obvious, record it as unknown.

### ***Descriptors***

Decay descriptors identify the pathological characteristics of the decay. Examples are pits, flecks, strength, colour, and shape. NVAF sampling does not normally require a pathological description of the decay and instead relies on an average (or compound) description to be selected from a list of common compound descriptors.

Examine the most advanced portion of the decay in the tree and select the most appropriate descriptor.

Decays are classified into two broad groups according to their effect on wood: white and brown rots. Both types of decay may appear in the same tree, with brown rots usually following the white rots. This classification is used for the possible recovery of pulp from the cellulose of white rots. No cellulose can be recovered from brown rots.

### ***White Rots***

White rots refer to a group of fungi that decompose lignin. The wood is generally reduced to a white, spongy mass, to white pockets or to a white stringy or friable condition varying in colour and form. Certain white rot fungi produce decays of colours varying from light to dark brown that can resemble brown rots in appearance.

### ***Brown Rots***

Brown rots result from fungi that primarily decompose the cellulose and its associated pentosans, leaving the lignin more or less unaffected. Their colour, always brown, is formed by the residual oily-brown or black derivatives of the lignin. The wood is reduced to a brown carbonaceous mass, often breaking into cubes, from which the term “brown cubical rot” is derived.

The classification of “brown-coloured” will help overcome the difficulty of differentiating decays in the field that are neither white nor brown cubical.

### ***Brown-Coloured Rots***

Brown-coloured rot refers to all brown rots that are not cubical in appearance. They may be yellowish, tan, or light brown and stringy or fibrous.

If possible, determine the species of the decay organism. If the species is not associated with a known conk, record it as unknown.

#### **3.4.6.14 Identify Decay by Section**

Starting with the bottom-most section, examine the surface of the cookie for discoloured or decayed wood. Outline areas of possible decay, then crack open every section cookie radially with an axe and scrutinize for decay. Crack the cookie into quarters and pick at the fibre with a knife to determine fibre length and strength with a particular focus on the areas initially outlined.

Measure decay in each section with the exception of the .6 and .9 sections where interpolation can be used.

#### ***Identify Decay Area With the “Pick Test”***

Use the “pick test” to determine the cross-sectional extent of decay. A sharp pointed knife is used to obliquely pick at the wood fibre on the radial edge to determine the length and strength of wood fibre, where weak and short fibres are candidates for decay. This is a subjective test and it is recommended that the sampler start off in areas of obvious sound wood in an effort to calibrate themselves as to what would constitute sound wood. In areas of advanced decay, the pick test will readily determine short and weak fibres. However, great care must be taken for incipient decay and its boundary between advanced decay.

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**Note:** Measure only final decay and advanced decay indicated by the presence of short, weak fibres. **Do not measure incipient decay.**

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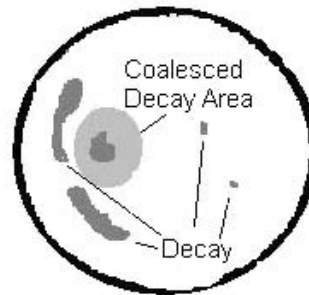
Some decays are characterized by pitting such as *Phellinus pini* (white pits) or to a lesser extent *Echinodontium tinctorium* (orange brown pits). For these two decays only, the boundary between decayed and undecayed wood is not determined by wood strength but by the presence or absence of the white pits (Figure 20). If pitting is intermittent, measure using the approach used in cases of extreme intermingling of decay and sound wood described below.



**Figure 20 - Phellinus pini Pitted Decay**

*Coalesce the Decay Area*

If the decay is not obvious or has an irregular cross-section, use a marker to delineate the cross-sectional boundary of the decay. Take care to identify areas of sound wood within the decayed area. Coalesce the decay into a more regular elliptical shape for measuring with long and short axes (Figure 21).



**Figure 21 - Coalescing an Irregular Decay Shape**

**3.4.6.15 Measure Decay**

At this stage, look over the sample tree and decide on the most efficient strategy to describe, measure, and record the decay(s) in terms of shape and mix.

**Note:** Only one attribute can be set for each decay characteristic.

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**It cannot be changed part way up the tree.** If the wrong attribute is chosen, the sample may fail or cause the sampler to take extra effort and time.

---

If decay is present, record it for every section in which it occurs throughout the tree, from high side to the tip of the leader. If the decay ends in a section, then occurs elsewhere in the tree, it will need a separate identity. For example, if the same decay occurs in the primary and the secondary leaders, give the decay in the secondary leader a separate identity and description.



**Shape**

Decay shape can be either solid or ring-shaped and is always measured as an elliptical form. Decay shape often changes form throughout its length and this change can make measuring difficult if the most appropriate shape is not determined from the start. Once the shape has been decided it cannot be changed. To determine the easiest shape to measure, take a look at the behaviour of the decay in the sections further up the tree.

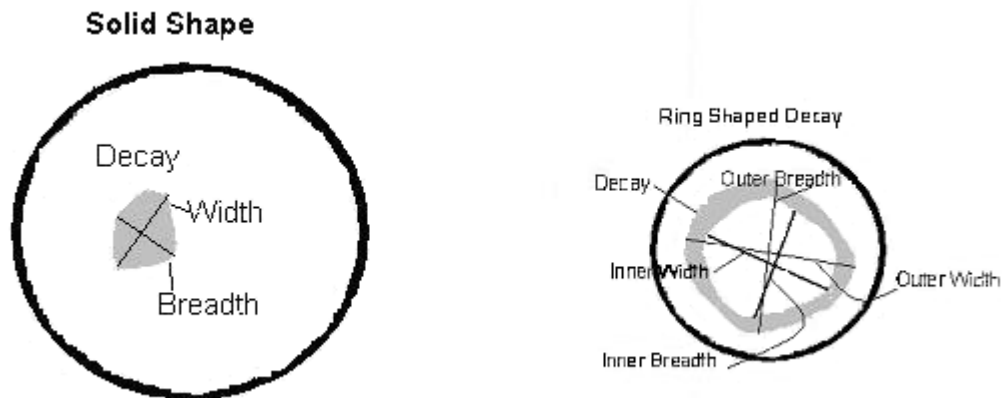
If the decay is a **solid shape**, measure the diameter of the decay in the same way as the section DIB for the sections with long and short axes.

If the decay is a **ring shape**, measure the diameter of the decay in the same way as the solid shape. However, for each axis record both the inner and outer measures (Figure 22).

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**Note:** A ring-shaped decay can be converted to a solid by measuring the inner diameters as minimal lengths of 1 mm by 1 mm.

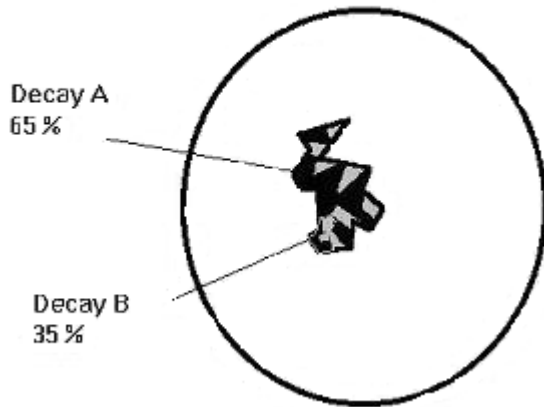
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**Figure 22 - Measuring Diameters for Ring and Solid Shaped Decays**

**Mixed Decay**

Decays are considered to be mixed if two or more decays are so intermingled that they are impossible to separate. Frequently, decays can be separate in one section and mixed in another. A decay that has been set as a separate decay can be difficult to measure if intermingled with other decays. Therefore, it is important to identify from the onset the appropriate strategy in recording mixed decay. It is recommended to create a mixed decay due to the sampling efficiencies that can be gained. Estimate the percentage of the cross-sectional area occupied by the mixed decay to the nearest 5%. The mixed percentage is section-specific. If one decay ends before the other(s) in the mix, set the percentage to 1% for the duration of the mix (Figure 26). **Do not mix voids and decays together.**



**Figure 23 - Estimating the Proportion of Mixed Decays**

***Measurement if Extreme Intermingling of Decay and Sound Wood***

In some extreme cases, the decay will be intimately intermingled with sound wood which would otherwise require extensive cookie cracking and picking. Not only can the determination of decay be time consuming, but it can also be inaccurate due to the difficulty in piecing together the cookie from the numerous breaks. A quicker more accurate method would be crack the cookie into quarters, pick the wood and estimate a percentage of decay within the area of intermingled decay and sound wood. Measure the diameters of the overall area of intermingled decay and sound wood and reduce one axis by multiplying it by the decay percentage estimates. For example, if the overall area of intermingled decay and sound wood is 32 by 25 and the percentage of decay within this area is 75% then multiply 32 by .75 and record the measurements 25 by 24. Leave an audit trail by writing the percent estimate of decay on the cookie (Figure 24).



**Figure 24 - Decay Estimation for Intermingled Decays and Sound Wood**

### 3.4.6.16 Measure Voids

Voids are described as losses to sound wood that is not due to decay. They are subdivided into voids in the interior or exterior of a tree. **At present, flute voids are not measured operationally.**

#### *Interior Voids*

These consist of ingrown bark, insect damage (holes or cavities bored in sound wood by insects) and pitch pockets. Interior voids can be anywhere in the tree, from the high side to the Utop. They are measured the same as decay is, by coalescing into an elliptical shape and measuring long and short axes. To determine the length of the internal void, follow the process for intermediate bucking in Section 3.4.6.18. (Figure 25).



**Figure 25 - Measuring Bark Seams**

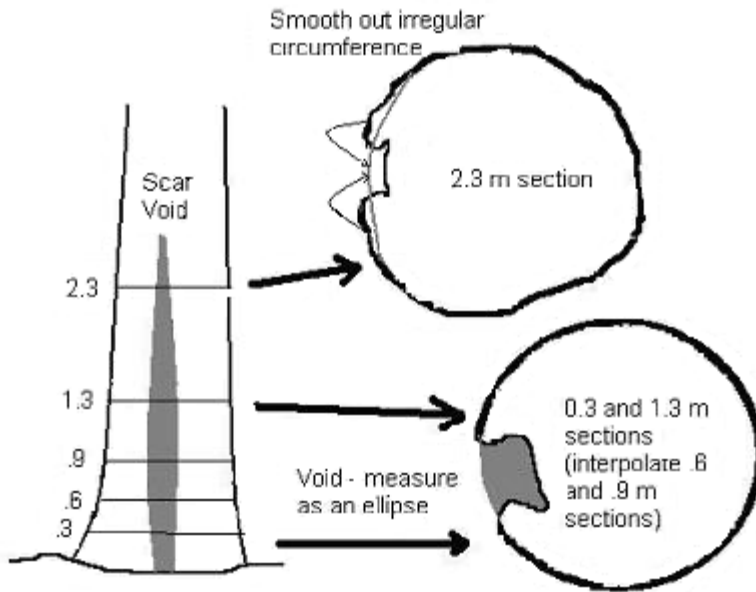
#### *Exterior Voids*

These result from scars or fluting at the base of a tree. **Measurements are generally only done for butt taper sections (high side to 1.3 m).**

This is because irregularities in the circumference of sections above 1.3 are smoothed out through the DIB measurement process, (see Figure 18) whereas the DOB measures in the butt taper include these irregularities. In some cases, scar voids may be measured above 1.3 m if they occur in the middle of a section length (see hidden decay measure, Figure 28) or where the scar void has such a substantial affect on section volume that would not be picked up through the normal DIB measure process.

The area of the void is coalesced into an ellipse, the same as for decay, (Figure 23). The length is measured directly from the tree, using the length of the start and end of the void.

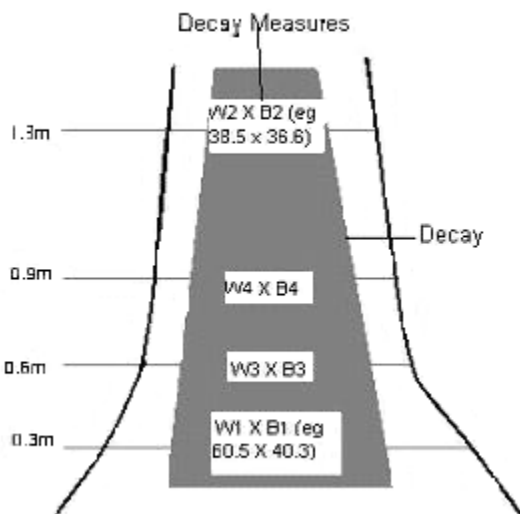
**Flutes do not need to be measured for NVAF purposes.**



**Figure 26 - Measuring Exterior Voids**

*Decay Interpolation Between 0.3 and 1.3 Heights*

When decay is found at the 0.3m and 1.3m sections of a tree, the width and breadth of the decay must also be recorded for the 0.6m and 0.9m sections. The 0.6 and 0.9m sections do not have to be bucked to determine the width and breadth of the decay, this can be determined by pro-rating the measurements taken from the 0.3m and 1.3m sections, (Figure 27).



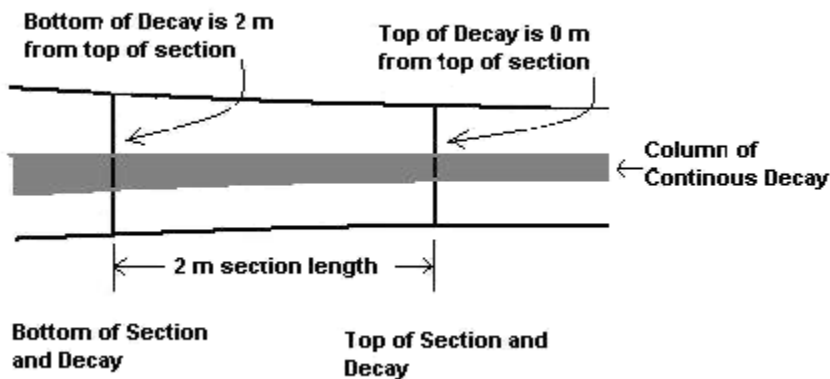
**Figure 27 - Interpolation of Decay in Butt**

1. To determine the rot width at 0.6m, take the two largest measurements from the 0.3 and 1.3m sections, and use the following formula:  $W3 = W1 - ((W1 - W2) * .3)$

2. Using the diagram above, the following numbers would be used  $60.5 - ((60.5 - 38.5) * .3) = 53.9\text{cm}$ , where 53.9cm is the rot width for the 0.6m section.
3. To determine the breadth for the **0.6m** section, take the smaller two measurements from the 0.3m and 1.3m sections and use the same formula with these measurements:  $B3 = B1 - ((B1 - B2) * .3)$
4. Using the measurements from the diagram, the formula would read:  $40.3 - ((40.3 - 36.6) * .3) = 39.2\text{cm}$
5. To determine the rot measurements for the **0.9m** section, the formula would read:  $W4 = W1 - ((W1 - W2) * .6)$  and  $B4 = B1 - ((B1 - B2) * .6)$ , or using the measurements from the diagram,  $60.5 - ((60.5 - 38.5) * .6) = 47.3\text{cm}$  and  $40.3 - ((40.3 - 36.6) * .6) = 38.1\text{cm}$

### 3.4.6.17 Determine the Length of Decay by Section

Decay length is measured relative to the top of each section by measuring the distance from the bottom and top of the decay to the top of the section, (Figure 28).



**Figure 28 - Measuring the Decay Length Within a Section**

#### *Intermediate Bucking*

If the decay is not evident at both ends of the section, determine the length of the decay within the section by making a regular series of intermediate bucks, as follows:

Make the first buck halfway along the section. If the decay is still evident, make the next buck halfway along the remaining section, and so on. The maximum unbucked length should be approximately 25 cm. The preferred method of making the intermediate bucks is to cut a wedge shaped piece out of the section without cutting through the section (Figure 29).

Standard buck points for a 2m long section and the corresponding top or bottom heights are cited in Table 4.



**Figure 29 - Measuring Decay Length for Decay Ending in a Section**

**Table 3 - List of Buck Points and Decay Top or Bottom Heights for a Standard 2 m section**

Intermediate Buck Point – Distance from the Top of the Section (m)	Top or Bottom Height (m)
0.25	0.12
0.50	0.38
0.75	0.68
1.0	0.83
1.25	1.13
1.5	1.38
1.75	1.68
(2.0)	1.88

**3.4.6.18 Measure the Non-merchantable Wood and Associated Defect**

The measurement of non-merchantable wood and associated defect includes decay, checks, shake and portions of sound wood that are adjacent to the defect (trim allowance) or are considered too small in area to be economic for milling (grade reduction). Regardless of the cause of the non-merchantable wood, capture the combined area as a single ellipse.

***Trim Allowance***

Trim allowance is a 2 cm wide border of sound wood adjacent to the defects that is lost to lumber recovery. It is measured around all sides of shake, bark seams, decay or holes. Exceptions are made for the inner points of checks, sap rot and shallow scars.

***Grade Reduction***

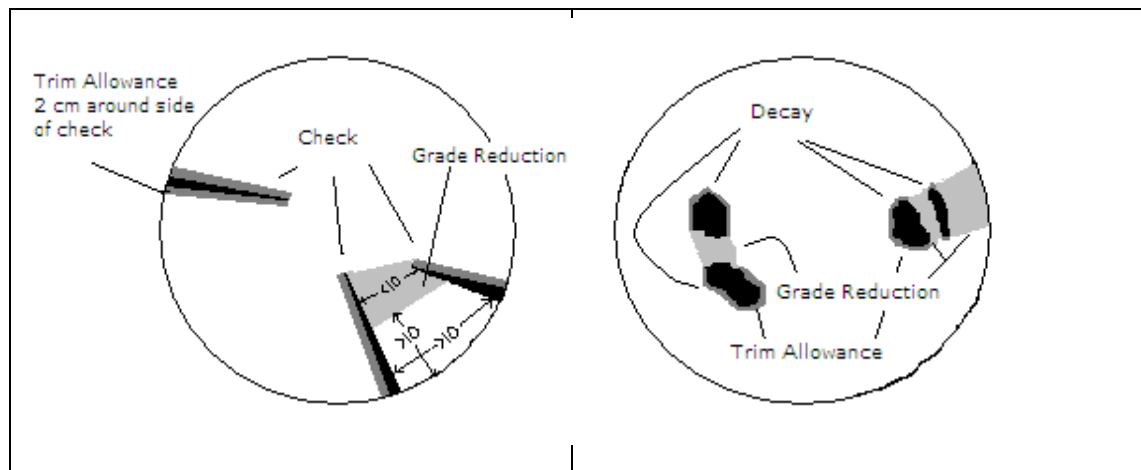
Grade reduction is an area of sound wood that is too small to mill and includes:

- A 10 cm spacing between defects measured from defect to defect (and not trim allowance to trim allowance).
- Where all or portions of the soundwood collar are less than 10 cm thick .

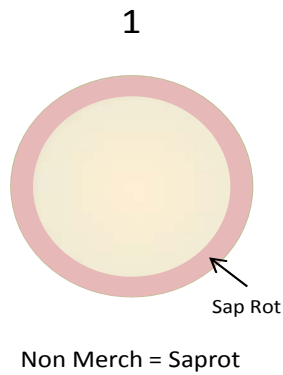
- Grade reduction is projected straight out to the outside of the section from the trim allowance of cracks or shake or straight out from the decay.
- Non-merchantable wood also applies to any crack caused by checks or shake. The crack should be a failure in the wood and be open to a knife blade. Once the crack has been confirmed, the outer extents are estimated visually.
- The entire area of an intermingled decay is considered non-merchantable, (see figure 30).
- Trim allowance is added to the sides of scars and bark voids if defect depth is  $> 2$  cm as per check specifications.
- The bottom of the secondary leader where it joins the primary is considered non merchantable.
- Do not measure nonmerch above utop

### *Checks*

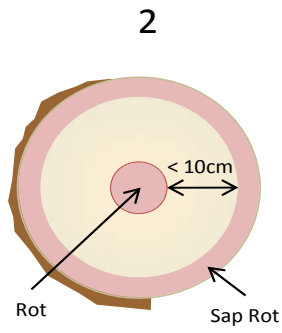
Checks are defined as radial splits from the outside of the bole that are  $\geq 2$  cm deep.



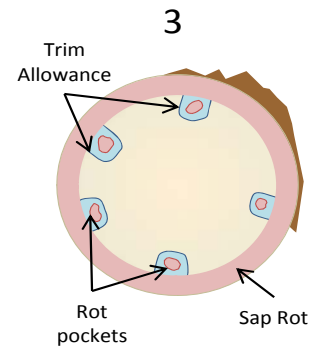
NVAF Sampling Standards and Procedures



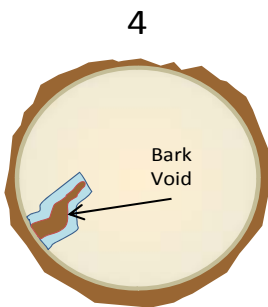
Non Merch = Saprot



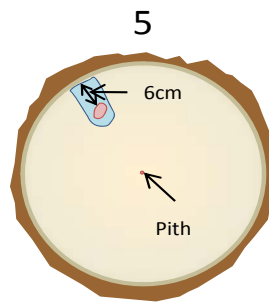
Non Merch = Entire cookie area



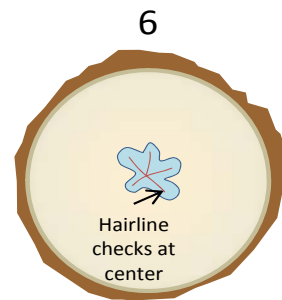
Non Merch = Saprot + decay + Trim allowance.  
Rot and Trim "pushed out" to include in the saprot ring



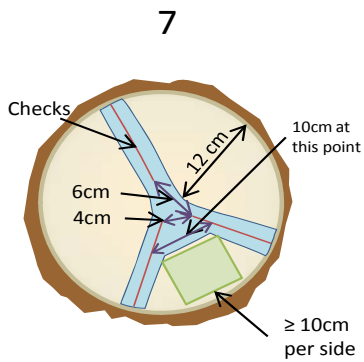
Non Merch = Bark Void + Trim Allowance



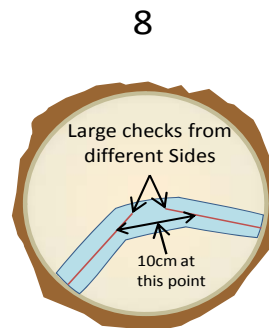
Non Merch = Saprot + decay + Trim allowance



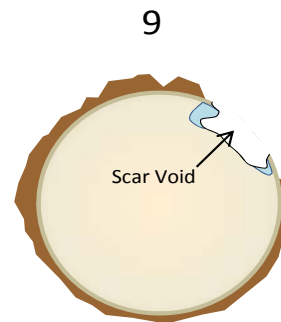
Non Merch = Saprot + decay + Trim allowance



Non Merch = Trim Allowance + Grade Reduction

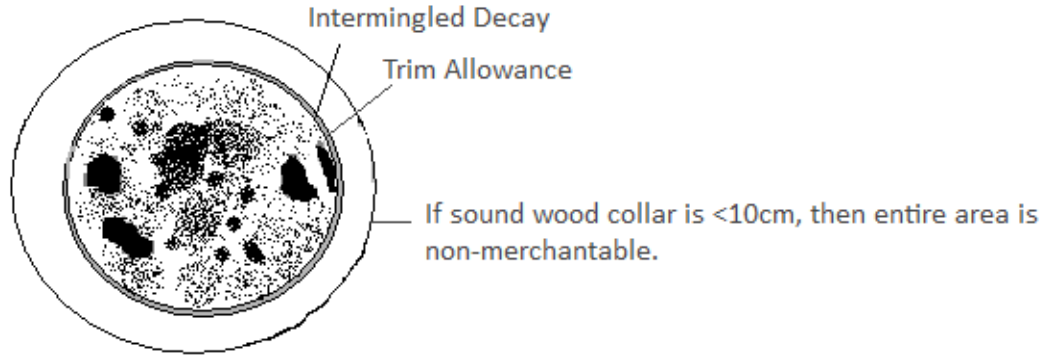


Non Merch = Trim Allowance + Grade Reduction



Non Merch = Scar Void + Trim Allowance



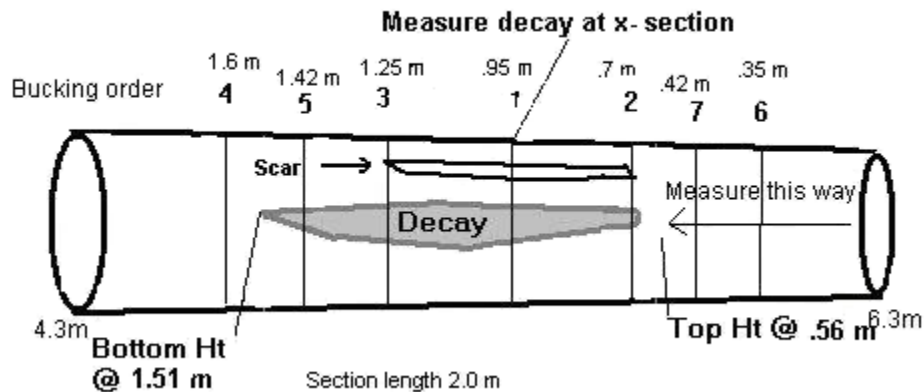


**Figure 30 – Measuring Non-merchantable Wood in a Section**

**3.4.6.19 Check Path Indicators for Hidden Decay**

All path indicators below Utop must be cut into and checked for hidden decay unless if decay is already evident. A typical situation is a scar on a section that otherwise does not exhibit decay. A pocket of hidden decay could be present beneath the scar.

Buck through the section, halfway along the path indicator. If decay is present, then measure the decay diameters at this buck. Make a buck at each end of the path indicator, then follow the regular intermediate bucking rules to determine the length of the decay in the section (Figure 31).



**Figure 31 - Bucking and Measuring Hidden Decay**

**3.5 Data Edits and Processing**

FLNR requires the submission of clean data using the volume and decay data collection software. The data is relatively error free, but may contain some small nonfatal errors that must be fixed prior to submission to FLNR. Most errors can be identified through a review of the decay reports produced by DVHost portion of the volume and decay data collection software.

### **3.5.1 Deletion of Unwanted Trees**

Due to data entry errors or a failure to initially section the tree correctly, some trees are re-entered as new version of the same tree. The convention is to renumber the tree by adding 100 to the tree number. Previous versions of the same tree should be deleted prior to data processing and the DVHost software does allow for the selective uploading on individual trees from the handheld.

### **3.5.2 Consistency of broken top attributes**

Broken top information is entered in separately for tree height, felled path and as a section. All three sources must be made consistent in terms of path identity, height and broken top diameter. Since there is a strict definition for the broken top path indicator, it is possible to have a broken top height and as a section but not as a path indicator.

### **3.5.3 Decay length information**

The handheld software provides an incorrect default bottom height for decay of 0.0 m for the 0.3 m section and for the lowest section of a secondary leader.

### **3.5.4 Decay attributes**

The handheld software occasionally deletes the essential decay attributes of compound decay description and decay shape.

### **3.5.5 Dead tree attributes**

Since the handheld software was created prior to the advent of the sampling of dead trees, all trees are assumed to be alive and there are no attributes or codes to specifically identify dead trees. Dead trees must be identified by:

- standing and felled path: using the code DT with a start height of 0.0 m and an end height equal to the top of the tree or the broken top height.

Crown height is 0.01 m below the top of the tree or the broken top height.

## 4 Quality Assurance and Data Collection Standards

### 4.1 Introduction

This section outlines the quality assurance procedures and the data collection standards for NVAF sampling. The intent of quality assurance (QA) is to determine the overall quality of the NVAF sample. The QA information is used for contractual payment purposes and to identify errors if remedial action is required. Due to the destructive nature of the NVAF sample, it is impossible to consider the QA as an independent sample.

A minimum of 10% of the sample trees must be inspected in order to determine the overall quality of a batch of sample trees. The batch is passed if 90% of the inspected sample trees meet the sampling standards. Use a guideline of one ground samples to be selected for every twenty NVAF sample trees. Therefore a NVAF sample of approximately 60 trees will require a minimum of 6 trees inspected from a minimum of 3 separate VRI ground samples. The standard is to select randomly select ground samples and sample trees for the field inspection. Since NVAF sample trees range in sampling difficulty, stratification by decay or difficulty class and a proportional selection from each class will ensure that range of trees are selected for quality assurance.

The standards for NVAF inventory cruising adhere to the ones set for the VRI ground sample. Refer to the VRI ground sampling standards and procedures document.

Due to the rapid weathering of NVAF sample trees, QA should be done within a few weeks of the sampling.

### 4.2 General Procedures

1. **Determine the sample sizes for audit**
  - Stratify the sample trees by difficulty class
  - Identify the ground samples with difficult trees
  - Calculate the sample size for ground samples and sample trees by difficulty class
2. **Select the sample locations and trees.**
  - Select ground samples
  - Select sample trees
  - Select replacement samples and trees
3. **Conduct field audit.**
4. **Summarize the results and determine overall quality**
  - Calculate the differences between audit and sampler measurements
  - Calculate the penalty points
  - Summarize and report results
  - Determine overall quality
5. **Recommend specific remedial action if necessary.**

## **4.3 Detailed Procedures:**

### **4.3.1 Determine the Sample size For Audit**

#### **4.3.1.1 Stratify the Sample trees into Difficulty Classes**

If the sample trees are grouped into classes that reflect the complexity of NVAF sampling, then 10% of the trees from each class are selected for inspection. Immature trees lacking decay or aberrant form can be considered to be the least difficult; over mature trees with decay and aberrant form would be the most difficult to sample. Usually only two difficulty classes are created for QA purposes. The intent is to ensure that all types of trees are inspected in order to properly assess the overall quality of the sampling.

#### **4.3.1.2 Identify the Ground Samples that Contain Difficult Trees**

The ground samples are stratified based on the presence or absence of difficult trees. Use the decay tree reports to identify decayed or difficult trees.

#### **4.3.1.3 Calculate the Sample Size for Ground Samples and Sample Trees**

The sample size for inspected trees is based on the target of an inspection of a minimum 10% of the trees in the batch. The sample size for ground samples is determined by using a guideline of one ground sample for every 30 sample trees. For example, if the batch consists of 40 trees, then select 2 ground samples and 4 sample trees.

If the sample trees are stratified into two difficulty classes then select 10% of the sample trees from each class. Increase the stratum sample size in order to ensure that the combined selection amounts to at least 10% of the overall batch. To ensure that difficult trees are selected, select a ground sample from the batch of samples that contain difficult trees.

### **4.3.2 Select Sample Locations and Trees**

#### **4.3.2.1 Select Ground Samples**

Assign a random number to each ground sample, sort by random number and select from the top of the list.

#### **4.3.2.2 Select Sample Trees**

Assign a random number to each sample tree, sort by random number and select from the top of the list.

#### **4.3.2.3 Select Replacement Samples and Trees**

Logistical problems may prevent an inspection of the selected sample and mechanical problems, such as the selected tree may be irretrievably buried under other sample trees that may prevent the inspection of the selected tree, consequently replacement samples and trees should be selected in advance.

If a sample tree cannot be inspected, select the next tree from the sorted list.

If a ground sample cannot be inspected, select the next sample from the sorted list and the first tree from the sorted list of trees within the sample.

### 4.3.3 Conduct the Field Audit

There are two processes to inspect: the sample tree measurements and the procedures used to measure the tree. Since this is not an independent measure, the auditor's role is to determine the adequacy of the samplers measurement and their application of due diligence. The auditor must carry a copy of the sampler's measurements on site and refer to them at each measurement. In order to produce an actual net merchantable volume for the sample tree, the allowable errors around each measure are relatively tight. However, the destructive nature of the sampling or the often incipient nature of decay can create situations where it is impossible for the auditor to measure precisely. Therefore the auditor must make a decision in the field about the quality of the measure and the sampler's adherence to due diligence. The 'benefit of the doubt' rule must be used. Since auditors are not required to use a chain saw, they can only work with the existing condition of the tree and cannot cut new sections or cookies. The auditor should double check all measurements that appear to deviate from the standard. Section DIBs that may have changed due to excessive shrinkage or swelling should be confirmed by measuring the top of the section.

All tree attributes are audited.

### 4.3.4 Summarize Results and Determine Overall Quality

#### 4.3.4.1 Calculate the Differences Between Auditor and Sampler Measurements

Calculate the differences between the two sets of measurements in absolute terms and percentages. Use an elliptical formula to calculate the cross sectional area of a section or a decay.

When an absolute standard and a percentage standard are both cited, then the standard that allows the greater tolerance is used. For example, if the dbh is found to be 34.8 cm and the contractor measure is 34.6, the absolute difference is 0.2 cm and the percentage difference is 0.57%. In this case, the absolute difference is used and the measure conforms to standard.

#### 4.3.4.2 Calculate Penalty Points

Penalty points are assigned when a measure fails to comply to the standards. The type and magnitude of the error determines the number of penalty points.

**A tree fails to meet the standard if the number of penalty point equals or exceeds 10.**

Section decay diameters in the interpolated butt section are based on the 0.3 and 1.3 meter sections and should not be penalized if the basis for the decay interpolation is in error.

If decay has been missed in a section or has been measured where it does not exist, assess penalty points on the basis of decay area, not on decay length. If the intermediate bucking in a section is done incorrectly, then assign the double amount of penalty points for this error.

The penalty for missing or miscalling path indicators is based on allowing 1 poor call for every 5 instances of the specific path indicator. For instance if 6 scars were recorded for the tree and only 5 were found, there would not be a penalty. However, if only 4 were found, then there would be a penalty.

Points are assigned when the measure fails to comply to the standards (Table 9). The magnitude of the error determines the number of points. For instance, if a contractor has recorded 95 years for a 100 year old tree, two points are assigned. If the contractor had recorded 91 years, then 4 points are assigned.

**Table 4 - Standards and Penalty Points for NVAF Sampling**

Sampling attribute	Sampling standards for individual measure	Audit points if beyond standard	
		< 2 X	≥ 2 X
Sample tree not sampled	No error permitted if capable of being sampled	10	
Sample tree not correctly identified	No error permitted	10	
Sample tree cookies not cut and properly identified	No error permitted	10	
Sample tree not correctly identified	No error permitted	10	
Butt taper heights per measure	± 5 cm	2	4
Butt taper diameters outside bark @ 0.3, 0.6, 0.9, and 1.3 m heights per measure	± 0.2 cm or 0.5%	2	4
Butt taper double bark thickness per measure	± 0.3 cm or 6%	1	2
Age, countable portion	± 2 yr or 4%	2	4
Age, countable and uncountable portion lengths	± 1 cm per measure	1	2
Age, counted height	± 10 cm	1	2
Age correction	± 3 yrs	1	2
Species	No error permitted	10	
Total tree length, if intact	± 10 cm	4	8
Total tree length, if broken by felling	± 25 cm	4	8
Estimated length of section above a broken top	± 2 m	4	8
Primary upper utilization point height	± 10 cm	4	4

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Secondary leader length, if intact	± 20 cm	2	4
Secondary leader length, if broken by felling	± 40 cm	2	4
Secondary upper utilization point height	± 15 cm	2	4
Secondary leader starting heights, upper and lower locations	± 10 cm per measure	2	4
Section upper and lower locations	± 10 cm	1	2
Section length	± 5 cm	2	4
Section cross-sectional area, if has a regular circumference.	± 8 cm <sup>2</sup> or 2%	2	4
Section cross-sectional area, if collapsed or has a very irregular circumference	± 20 cm <sup>2</sup> or 4%	2	4
Loss indicators standing or felled, number by type *	± 80%	4	
Loss indicator lower and upper locations	± 10 cm per measure	1	2
Loss indicator scar width	± 2 cm or 20%	0.5	1
Section decay length *	± 25 cm	1	2
Section decay cross sectional area, if intact	± 10 cm <sup>2</sup> or 5%	2	4
Section non-merchantable cross sectional area.	± 20 cm <sup>2</sup> or 10%	2	4
Section decay cross sectional area, if collapsed *	± 20 cm <sup>2</sup> or 10%	2	4
Hidden decay investigation per path indicator	no error permitted	5	
Decay type	± 1 class	0.5	1
Section decay percentage for mixed decays	± 10%	0.5	1
Crown height	± 1 m	0.5	1
Biogeoclimatic zonation	no error	5	
Site series	± 1 series	1	2
Slope position	± 1 position	1	2
Slope percent	± 10%	1	2

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Aspect	± 20°	1	2
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\* Denotes a more detailed explanation in ‘Calculate Penalty Points’ section that precedes the Standards Table.

### 4.3.4.3 Summarize and Report Results

Summarize the results of the inspection in terms of:

- The type, magnitude and penalty points of each error for each sample tree.
- Total penalty points for each tree.
- The ratio of the number of trees that pass the inspection over the total number of trees inspected.

### 4.3.4.4 Determine Overall Quality

Report the end result of the inspection in terms of pass or failure.

An example of an inspection report is contained in Figure 32 below.



<b>2002 Bobs Lk NVAF Sample QA Summary</b>							
Auditor: Will Smith		Audit Dates: Sept 16,17; Oct 2,3 2002					
Overall Result of QA				Pass			
<b>Audit Results:</b>							
Number of Trees Audited:				9			
Number of Trees Meeting the Standard				9			
Percentage of Trees Meeting the Standard				100%			
<b>Audit Summary per Tree</b>							
Sample	Tree#	Penalty Pts	Pass/Fail				
57	N-2	0	Pass				
171	N-2	4	Pass				
171	W-1	6	Pass				
171	W-3	0	Pass				
174	E-2	6	Pass				
174	N-5	4	Pass				
194	N-5	2	Pass				
195	E-2	4	Pass				
195	E-5	0	Pass				
<b>Summary of Errors</b>							
Sample	Tree #	Attribute	Measure		Difference		Penalty Points
			Auditor	Sampler	Absolute	Percentage	
171	N-2	0.3 section decay area	6	9	-2.4	-37.5%	0
171	N-2	no. of conks	0	1	-1	100.0%	4
171	W-1	2.3 section area	191	170	21	11.0%	4
171	W-1	counted age	165	154	11	6.7%	2
174	E-2	counted age	160	145	15	9.4%	4
174	E-2	10.3 section area	242	252	-10	-4.1%	2
174	E-2	14.3 section area	155	159	-4	-2.6%	0
174	N-5	counted age	225	234	-9	-4.0%	0
174	N-5	no. of scars	1	0	1	100.0%	4
194	N-5	6.3 section area	305	299	6	2.0%	0
194	N-5	12.3 section area	190	181	9	4.7%	2
195	E-2	no. of frost cracks	0	3	-3	100.0%	4
195	E-5	no. of scars	9	8	1	11.1%	0
195	E-5	2.3 section area	635	629	6	0.9%	0

Figure 32 - Example of a Quality Assurance Report

**4.3.5 Recommend specific remedial action if necessary**

If the inspection has found the work to fail to meet the standard, then some sort of remedial action will be required in order to use the data for its intended purpose. If at all possible, the inspector should identify specific types of errors that require correction in order to provide a focus to the remedial action.

**4.3.6 Send a Copy of the Audit Report to FAIB**

Send a copy of the field inspection to the NVAF project leader at FAIB.



## 5 Definitions

The following acronyms and terms may be encountered in this manual. Their meaning is provided here to facilitate easy reference, and make it easier to follow the description of the procedures.

**NVAF:** Net volume adjustment factor is a factor used to adjust net tree volumes estimated from net factoring and taper equations. The NVAF adjustment accounts for errors in loss estimation (decay and waste) and possible taper equation bias.

**VRI:** Vegetation Resources Inventory is a toolbox of inventory procedures for assessing the quantity and quality of BC's vegetation resources that includes: BC Landcover Classification Scheme (BCLCS), Phase I, Phase II, NVAF Sampling, Within Polygon Variation sampling (WPV) sampling, and Change Monitoring Inventory (CMI).

**FLNR:** Ministry of Forests, Lands and Natural Resource Operations

**FAIB:** Forest Analysis and Inventory Branch

**Net Factoring:** The process of estimating a "net factor", which is an estimate of the % sound wood (less decay) in each log of the tree.

**Stem Analysis:** The felling, sectioning and measuring of tree sections to estimate volume or study other tree characteristics, otherwise known as destructive sampling for volume and decay.

**Cruiser Estimated Net Volume:** Net close utilization tree volume obtained by adjusting the gross volume from taper equations to account for decay and waste loss determined by the net factoring process

**Actual Net Volume:** Close utilization tree volume obtained by summing the sound wood volumes (less decay and waste) of sections of a stem analysed tree.

**Population:** The entire collection of the elements of interest. In the NVAF, the population is typically all trees with a dbh equal to or greater than 12.5cm in an inventory unit, such as a TFL or TSA.

**Stratum:** A sub-division of the population or sub-population (e.g., by leading tree species).

**Nonmerchantable:** Nonmerchantable wood in the context of NVAF is the total of sound and decayed wood estimated to unavailable to be sawn into boards.

**Decay:** Decayed wood that fails the pick test or is pitted.