Provincial Monitoring British Columbia

Ground Sampling Procedures

Prepared by

Ministry of Forests
Forest Analysis and Inventory Branch

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Digital Copies are available on the Internet at:

https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-inventory/ground-sample-inventories/provincial-monitoring/standards

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The Government of British Columbia provides funding for the Resources Information Standards Committee which supports the effective, timely, and integrated use of land and resource information for planning and decision making by developing and delivering focused, cost-effective, common provincial standards and procedures for information collection, management, and analysis. Representatives to the Committee and its Task Forces are drawn from the ministries and agencies of the Canadian and the British Columbia governments, including academic, industry, and First Nations involvement.

The Resources Information Standards Committee evolved from the Resources Inventory Committee which received funding from the Canada-British Columbia Partnership Agreement of Forest Resource Development (FRDA II), the Corporate Resource Inventory Initiative (CRII), and by Forest Renewal BC (FRBC), and addressed concerns of the 1991 Forest Resources Commission.

For further information about the Resources Information Standards Committee, please access the RISC website at:

https://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/laws-policies-standards-guidance/inventory-standards

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Major Amendments for 2024

1. Reference Points and Tie Points are no longer required for CMI and YSM samples.
2. PSP Tie Point now referred to as Access Point in line with CMI and YSM samples.
3. Re-instated the requirement for nails on 3 stem map trees near IPC.
4. Allow stem mapping from an offset location.
5. Updated the tree species code list.
6. White pine blister rust added to YSM rust requirements.
7. Foliar scorch burn severity code is only required in same year as the fire.
8. Small tree plot partial reason code no longer required.
9. Small tree plot, for PSP, change in third tally class from 4.0cm to 2.0cm upper limit.
10. Broken Top (BTP) no longer a loss indicator code.
11. Removed the 25/ha qualifier from the definition of a residual tree.
12. Not suitable for age – added ROT and CRC as not suitable.
13. Previously selected sample trees with codes of WHO, CRC, NOC, and OUT need to be redrilled for age.
14. Updated the "Remeasuring Samples" section.
15. Added Precise Point Positioning (PPP) to GPS Type Code.

Table of Contents

1. Introduction

The procedures developed for the Ministry of Forests Vegetation Resources Inventory (VRI) form the basis for the various Provincial Monitoring sample types. As the multitude of inventory monitoring sample designs currently used in BC are different from (though related to) VRI, it has been necessary to modify some of the VRI procedures to suit the various sample designs.

The core structure of this document is focused on the CMI (Change Monitoring Inventory) sample type, although it is intended to cover all the following fixed-radius sample types as well, with differences indicated throughout the manual:

- Change Monitoring Inventory (CMI; Type-M)
- Young Stand Monitoring (YSM; Type-Y)
- CMI Light (Type-L)
- Early YSM (Type-A)
- Permanent Sample Plot (PSP; Type-PSP)

Additionally, there is significant overlap between the Provincial CMI sample type and the National Forest Inventory (NFI) sample type, which includes both timber and ecology sampling. The Canadian Forest Service (CFS) oversees the NFI program, including the nationally standardized NFI ground sampling procedures. However, each province has its own version of a modified NFI sample that suits each province's specific needs. In BC, a CMI sample with some modifications to the timber collection protocols is used, and then complete the ecology sampling largely following the national NFI standard. To this end, this manual is also intended to cover the timber sampling aspects of the NFI:

- National Forest Inventory (NFI; Type-F)

For reference, the full nationally standardized NFI ground sampling procedures are available in a stand-alone document on the CFS website (nfi.nfis.org/en/ground_plot).

Background

The ability to report on the status of the forest resource in British Columbia and to monitor change over time has become a primary focus for the Forest Analysis and Inventory Branch. The CMI and the other fixed-radius sample types are designed to meet that need. The permanent plot design of the CMI allows for the repeated measuring of forest attributes at defined locations.

The program can provide status and trend data—at the provincial and, ultimately, national levels—on 25 attributes of sustainability. Prior to the CMI, reporting on the current state of the forest resource in British Columbia relied on an annual summary of the information contained in all the province's VRI spatial inventories. The permanent, re-measurable design of the CMI puts in place a statistically based system of monitoring and reporting, which can be completed in conjunction with the NFI program.

The data requirements for the CMI closely parallel the attributes collected in the BC VRI ground sampling program, which was also developed in the mid-1990s. The foundations for the procedures in this document are derived from the VRI program.

Principles of the Inventory Ground Sampling Process

1. All data are attached to the Integrated Plot Centre.

2. The ground sampling must be done correctly and carefully. Errors in the ground samples are translated directly into errors in the inventory or models.
3. Measurements are made to a known level of precision. Estimates made at the sample are acceptable in cases where measurements cannot be taken.
4. All measurements are to be completed and recorded in the field.

Principles of the CMI Ground Sampling Process

1. Sample plots will be selected randomly from a provincial grid.
2. Moving plots is never acceptable. Sample plots must be established where they fall. Special replacement procedures will be used, or samples dropped, when this constitutes a temporary or permanent safety hazard. Consult with the Ministry when a safety hazard is encountered.
3. The concept of minimal known bias and small sampling error are integral to the monitoring process. It is achieved by ensuring the following:
    - Minimal bias
        - The sampling processes are statistically valid.
        - Rounding and vague definitions are avoided.
    - Small sampling error
        - The sample selection method may be combined with traditional stratification to ensure variance stabilizes more quickly than a random sample and that ensures controlled sample sizes in all land types.

Principles of the PSP Ground Sampling Process

1. PSP locations are determined in a biased manner to allow a specific “matrix” cell to be filled, allowing models to be developed for various stand types across the province.
2. PSPs are established in a non-random fashion (purposive) so they are not suitable for monitoring model output.
3. The primary objective of the Ministry’s Growth Natural PSP program has always been focused on developing a database covering the full range of conditions needed for calibration of growth models. Thus, PSPs are not representative of average conditions on the landbase and should not be used to develop statistics based on sampling theory.

A Note on PSP Samples

Currently the Ministry is not establishing new PSPs in the province, but the remeasurement program is active. Whereas most of the data collection closely resembles a CMI sample, there are some significant differences for PSPs. These differences are explained in detail in Section 6.6. Some of the significant differences are:

- Diameter at Breast Height (DBH) tagging limits are different.
- PSP large tree plot sizes and the subplot sizes are variable.
- Plot shapes can be circular, square, or rectangular.
- Loss indicator locations are recorded differently.
- Small tree tally class difference.

How to Use This Document

This document deals with the ground sampling component of the Provincial Monitoring program. It describes procedures for the location, establishment, and remeasurement of sample plots, and the collection of data related primarily to timber attributes.

The Inventory Sample Management Consolidation (ISMC) handheld data entry program is available for recording field information. The procedures for entering data in the electronic field recorder (EFR) are not discussed in detail in this document.

A brief background is provided in Section 1 to explain the rationale behind the procedures. The remainder of the document describes the procedures or methods required for ground sampling.

- Section 2 describes the procedures required to locate a sample plot.
- Section 3 details how to establish the various nested plots all centre on the Integrated Plot Centre (IPC).
- Section 4 explains the measurement and recording of tree information (including forest health factors) at the IPC.
- Section 5 describes the net factoring criteria, guidelines, and rules.
- Section 6 provides information specific to remeasurement of samples (as opposed to sample establishment).

2. Field Orientation and Navigation

Introduction

This section outlines the steps needed to traverse from an Access Point to the Integrated Plot Centre (IPC) for sample establishments. The field crew is responsible for selecting suitable access points, navigating to the IPC, and recording the navigation information. The route must be suitably marked to locate the plot centre and to aid relocation in the near future (5-10 years).

Objectives

1. To provide directions to the sample location for future field crews.
2. To locate the IPC at the given UTM coordinates for the sample.
3. To mark and document the IPC location and navigation points to allow for short and long-term sample relocation.

General Procedures

Office Preparation

1. Prepare and become familiar with area characteristics and access prior to field visitation.
    - Identify the location of the IPC on available imagery.
2. Determine potential access routes.

Field Location

1. Create access notes to allow other field crews to arrive at the sample location.
2. Locate and confirm an access point in the field. Mark the point appropriately and record the GPS coordinates.
3. Navigate to the intended IPC UTM coordinates using GPS.
4. Ensure you are in the correct ground position as indicated on the imagery and by the UTM coordinates.
5. Use a GPS unit to provide a final location for the IPC. The most common method is once you are near the intended location, take an average waypoint to determine how far away you are from the intended IPC location. Then navigate to the intended location.
6. Drive a metal stake into the ground, leaving only ~10-15 cm exposed if possible.
7. Select a nearby tree to use as a reference tree. Paint and ribbon the tree and nail the plot centre plaque.

Detailed Procedures

Standard procedures of location, marking, and recording must be followed so that sample plots are easy to relocate for quality control and re-measurement purposes. The following procedures are designed to be used with a GPS unit as the primary means of navigation and plot location.

It is important to remember there can still be errors in GPS readings, especially in dense timber and on steep slopes. The crew will still need to confirm that the sample is in the correct location.

GPS data will be recorded at the Access Point and the Integrated Plot Centre.

2.1 Recording Access Notes:

Access notes are created to allow for quick and easy relocation of the sample. The notes should include a narration of the route traveled from a known location to the Access Point, in enough detail to aid relocation by a different crew for re-measurement in approximately 5-10 years.

Procedures

1. **If travelling by vehicle:**
   - Decide on a suitable starting point. It should be easily locatable by anyone reading the access notes (e.g., the junction of a highway and a secondary road on one end of town, or midspan of a major bridge on a highway between two cities, etc.). Record an accurate description of the starting point, and the direction of travel from there.
   - Include enough subsequent access notes to keep the reader on the correct route. There are two typical types of access note entries:
     - During a long mostly obvious stretch of access, include major navigational features to keep the reader's confidence that they are on the correct route (e.g., part way through a 50 km stretch between the starting point and the first turn, include an entry for a major bridge/river crossing). At the same time, don't record every side road along this stretch.
     - Typically, as you get further off highway, roads/turns become more frequent, smaller, and less discernable. Include enough detail to ensure someone doesn't miss a turn or take a wrong turn. At the same time, don't needlessly clutter the access notes with every possible turn if the correct action at a particular location is reasonably obvious.
   - End with an entry for the Access Point. Provide a thorough physical description.
   - Finally, note the approximate bearing(s) and distance(s) (or other navigation notes that are appropriate) from the Access Point to the IPC.
2. **If travelling by helicopter or boat:**
   - Record the location of departure (e.g., helibase or dock in a particular town). Recording the service provider could aid future crews.
   - Include an entry that describes the general route taken, and the time and/or distance travelled.
   - End with an entry for the Access Point, which will be the location you leave the helicopter or boat. Provide a thorough location description, and a description of the Access Point feature (marked as described below).
   - Finally, note the approximate bearing(s) and distance(s) (or other navigation notes that are appropriate) from the Access Point to the IPC.

2.2 Locating and Marking the Access Point

An Access Point is typically the location where the crew starts walking cross country to access the IPC. Usually this is where the crew parks their truck or lands in a helicopter. The Access Point may be in another location if for instance it is still a long walk or on a deactivated road to a more suitable access point location. Some ribbon and paint should be placed on a nearby tree. Collect, and record, GPS data (recreation grade acceptable) for the Access Point.

2.3 Navigating to the Integrated Plot Centre

From the Access Point navigate to the IPC location.

Procedures

1. Locate the IPC using a GPS unit, flagging the access line adequately to enable an auditor or field remeasurement crew to re-locate the IPC.
2. Evaluate the location. When you find that the imagery and ground location agree, proceed with establishing the IPC. If you arrive at the intended IPC location and find that the imagery and ground location do not agree, evaluate the potential reasons why and find the correct sample location. Note that imagery registration can occasionally be inaccurate, or GPS coordinates may be in error. The objective is to find the **correct ground location** as per the given UTM coordinates of the sample point. You will not be "moving" the plot location if there is a conflict, you will be "finding" it. The map, GPS, and other tools are aids in finding the correct location.

2.4 Establishing the Integrated Plot Centre

From the Access Point, measure to the Integrated Plot Centre.

Procedures

1. Navigate using GPS from the Access Point to the pre-determined IPC coordinates.
2. Stop at the approximate coordinates for the IPC and use a GPS unit to record an averaged waypoint (collect between 100 and 150 averaged points).
3. Compare the averaged waypoint coordinates to the intended IPC coordinates and adjust the required X (easting) and Y (northing) distances with a tape to get to the intended coordinates. The following table provides an example of this exercise.

	Easting	Northing
Intended IPC coordinates:	689283	5616623
Averaged waypoint coordinates (from GPS unit):	689287	5616621
Required adjustment to get from waypoint to IPC:	Go 4 m West…	and 2 m North

4. This point becomes the IPC regardless of the site or conditions. The plot centre may be in an open forest, a rocky area, a road, a creek, or inside a standing tree.
5. Drive the pin into the ground at the IPC, leaving only ~10-15 cm exposed if possible. If site conditions make it impossible or inappropriate to imbed the aluminum pin at the IPC, place it as close as possible to the plot centre, and record the offset distance and bearing from the pin to the plot centre.

6. Scribe the necessary details onto a plot centre plaque and nail it to a tree near IPC above breast height so that it is conspicuous. Use four nails, one in each corner, and leave the nail heads and plaque extended out from the tree to allow for growth. Paint and ribbon the tree to make it conspicuous.
7. Collect GPS data at the IPC with a GPS unit capable of collecting files for post-processing. When GPS data cannot be collected at the plot centre, move to an area where data can be collected (such as an opening). Measure the distance and bearing from the point where data was collected back to the IPC and record as the GPS Offset. The final post-processed coordinate recorded must include any adjustments for offsets. If GPS data cannot be collected for the IPC at any site, try collecting an averaged waypoint with a recreational grade GPS unit. If that too is unsuccessful, the intended coordinates must be recorded using “Intended” as the GPS Type.

Note: It is critical that IPC coordinates are as accurate as possible to ensure samples can be used in a variety of analyses where knowing the precise location of the IPC is crucial. This is also important as the IPC is the only location requiring post-processed coordinates.

2.5 When the IPC Location is Non-Representative

CMI sampling is based on a 20 km by 20 km grid. There is no target population or sampling ages, and polygon boundaries of the mapped forest inventory, or on the ground, do not impact sample location or sampling procedures in any way. **There is no circumstance (aside from safety issues) where a CMI sample is to be dropped. The IPC is never moved, and the sample will measure whatever is there (or not there).**

However, clarity is needed around what to do when a YSM IPC falls in non-standard situations (e.g., a hole in an otherwise stocked stand, a residual tree patch, or when the IPC is inside the target polygon according to the inventory linework, but outside the target population on the ground because it is at the edge of the polygon).

YSM sampling is based on a defined population (15-50 years *total* age) and selection of samples is based on the current mapped inventory. The actual age on the ground might differ from the mapped inventory age, putting the sample outside the target population, yet the sampling must still occur based on the mapped inventory. There are several circumstances where a decision to establish the sample or not needs to be made or what procedures need to be followed:

- The YSM IPC lands in an unmapped portion of the target polygon (e.g., secondary road, rock outcrop, mature wildlife patch) that is younger or older than the target population age (i.e., <15 or >50 years).
    - In this instance, the sample should be measured. The IPC location and the plot are simply capturing within-polygon variation that is inherently part of the target population and must be sampled if encountered.
    - Since there are no mapped inventory polygon lines involved, the Walkthrough Methodology (Appendix D) does <u>not</u> apply.
- The YSM IPC lands within but near the edge of the target polygon, and a portion of the plot extends into the neighbouring mapped inventory polygon that is either younger or older than the target population age (i.e., <15 or >50 years).

  - In this instance, the sample should be measured.
  - If the mapped inventory polygon line is closer than 22.56 m to the IPC, the Walkthrough Methodology (Appendix D) must be employed.

- The YSM IPC lands in the middle of an inventory polygon away from all edges, but the average age of the target polygon on the ground turns out to be clearly significantly older than the target population age (i.e., >100 years BH age). (*Note that samples younger than the target population will always be sampled as intended in this scenario*).
  - If, in this instance, the sample is a required CMI sample as well (i.e., it's on the 20 km grid; a CMI-YSM sample), it will be measured regardless of the age of the stand
  - If, however, the sample is not also a required CMI sample, the sample should be dropped. This sample will not be used in the data analysis as it is clearly outside the target population.

2.6 When the Sample is Inaccessible

In some instances, the complete sample or some part will not be accessible because of factors such as dangerous slopes, denied access, or physical safety concerns. It may be readily apparent from the access point or earlier that the area is inaccessible, or only as the sample location is approached. In some cases, small unmapped local features such as beaver ponds and water bodies may be encountered. The field crew is not expected to sample beyond what is considered reasonable and safe. For example, if the water level is above the "boot tops," then estimate the attributes if possible or drop the plot if reasonable estimates cannot be made.

The safety of the field crew is the priority.

Collect as much information as possible to the point where field work was terminated. However, if more than ¼ of the plot is inaccessible, or unsafe, then the plot should be dropped in its entirety.

When a sample is dropped, inform the Ministry representative as soon as possible. Specify why the sample cannot be established, for example:

- access to plot is too dangerous
- plot would be located in an unsafe area
- plot would be located in a river or lake
- permission denied to access private land

Provide detailed comments as required.

3. Plot Establishment

Procedures

Depending on the sequence of measurements, perform the functions described below.

3.1 Establishing the Plots at the Integrated Plot Centre

*Note that plot radii for the Tree Details plots for individual PSP samples vary in size, and are not standardized at 5.64 m and 11.28 m.

TREE DETAIL PLOT (5.64M AND 11.28M FIXED RADIUS)

1. Establish a 5.64m fixed-radius plot (Figure 3.1), for trees ≥ 4.0 cm DBH
2. Establish an 11.28m fixed-radius plot (Figure 3.1) for trees ≥ 9.0 cm DBH
3. Establish 8 pie-shaped, 0.005 ha (45 degrees) tagging sectors
4. Number the trees sequentially clockwise in sectors from the north.
5. Make detailed measurements on the selected “in” trees for species, diameter, length, loss indicators, damage agents, and other details.

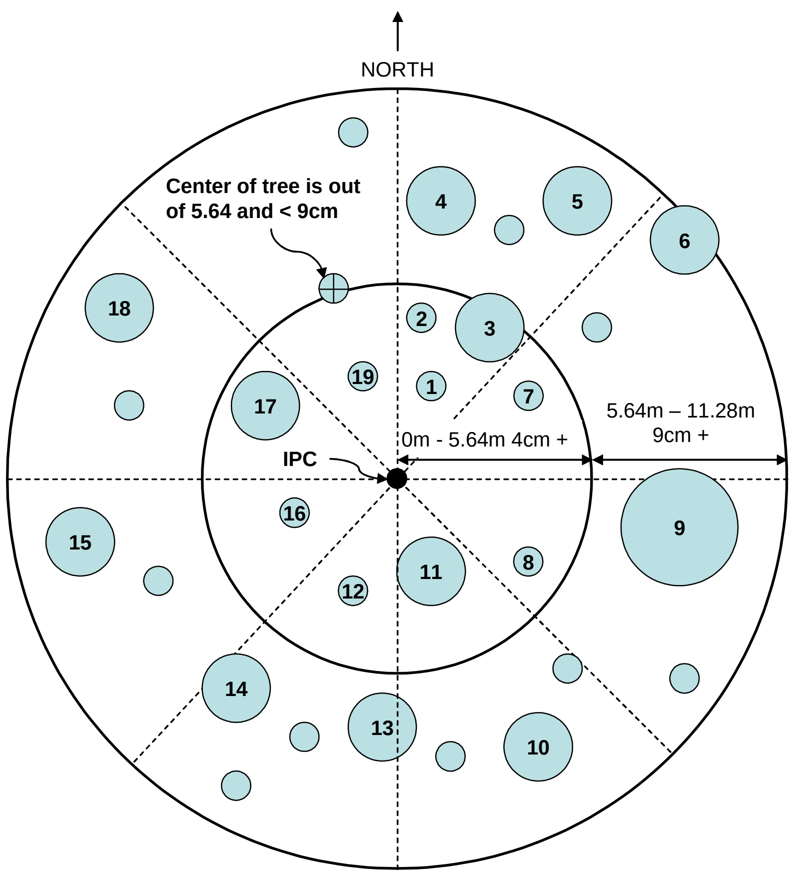


Figure 3.1 - 5.64m and 11.28m fixed-radius plot layout.

SMALL TREE PLOT (2.52 M, 3.99M, OR 5.64M FIXED-RADIUS)

1. Establish a 2.52 m, 3.99 m or 5.64 m fixed-radius plot (as determined by the project specifications), centred on the Integrated Plot Centre.
2. Count live trees less than 4.0 cm DBH and more than 10 cm in length. Record in three predetermined classes.

SAMPLE TREE PLOTS (5.64 M FIXED-RADIUS PLOT AND QUADRANTS OF THE 11.28 M FIXED-RADIUS PLOT)

1. Establish a 5.64 m fixed-radius plot, at the Integrated Plot Centre (Figure 3.2).
2. Measure a top-height tree, if a suitable tree is available within this plot.
3. Determine the species composition (by basal area) for the sample.
4. Measure a sample tree of the leading and second species by basal area, if a suitable tree is available within each quadrant.
5. Measure a sample tree of each next species in order of basal area (for species >20% basal area only), if a suitable tree is available within each quadrant.

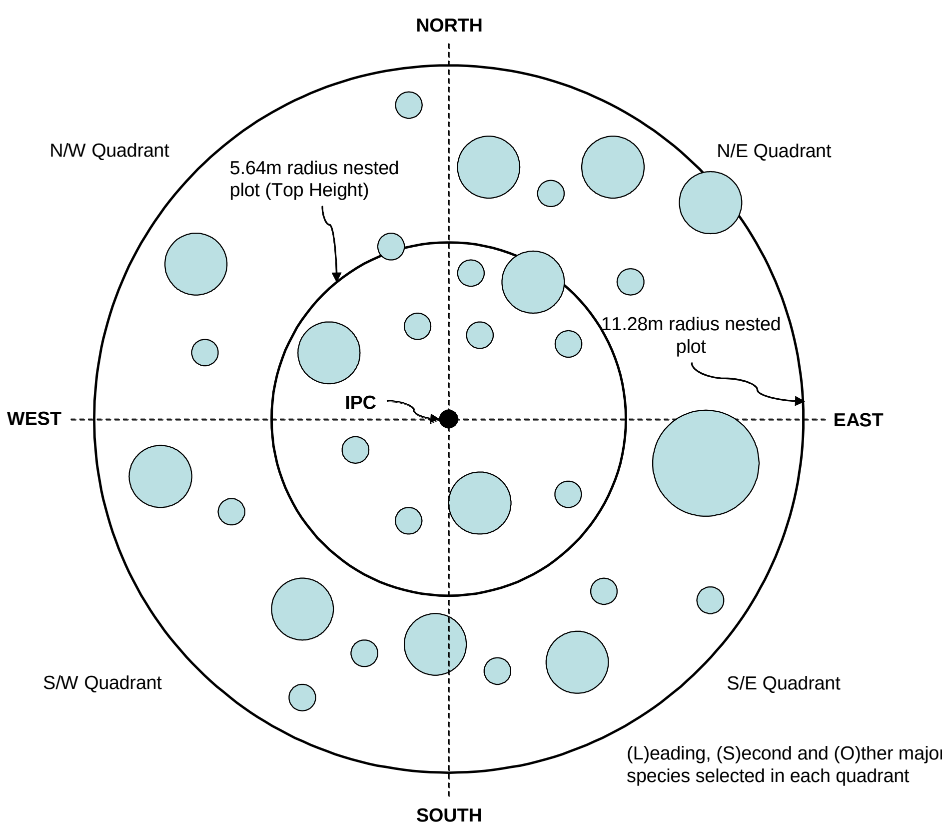


Figure 3.2 - Top-height tree 5.64 m fixed-radius plot.

3.2 Taking Ground Photographs

A series of ground photos will be taken at each IPC using a quality digital camera with flash.

OBJECTIVES

The photos will be available as digital data for:

- initial assessment by potential users who may want to sub-sample on these locations for other values; and
- capturing information that is not directly measured, which may be helpful when analyzing the data to explain anomalous measurements or trends.

PROCEDURE

Ground photos are required for all samples of all sample types. If a sample is not completed for some reason, but the IPC pin has been established, ground photos are still useful and should still be collected if safe to do so.

One of two different sets of photos is required (Table 1, Table 2), depending on whether Coarse Woody Debris (CWD) is required for the sample type.

Table 1. Ground photos required for samples that include CWD measurements.

Code Value	Code Description	Details
PP	Plot Pin	Ground shot of the plot pin and surrounding area
T1S	Transect 1 Start	From IPC looking out, along Transect 1
T2S	Transect 2 Start	From IPC looking out, along Transect 2
T1M	Transect 1 Mirrored	From IPC looking out, 180 deg. from Transect 1 bearing
T2M	Transect 2 Mirrored	From IPC looking out, 180 deg. from Transect 2 bearing
T1E	Transect 1 End	From end of Transect 1, looking in towards IPC
T2E	Transect 2 End	From end of Transect 2, looking in towards IPC
REP	Representative	Could be from outside of plot looking in, or vice versa
CAN	Canopy	Vertical, above IPC
SOIL	Soil Profile	All excavated soil horizons (only if required)
OTH	Other	Path, damage, unknowns, etc. (optional)

Table 2. Ground photos required for samples that do not include CWD measurements.

Code Value	Code Description	Details
PP	Plot Pin	Ground shot of the plot pin and surrounding area
N	North	From IPC looking out, along North cardinal direction
E	East	From IPC looking out, along East cardinal direction
S	South	From IPC looking out, along South cardinal direction
W	West	From IPC looking out, along West cardinal direction
REP	Representative	Could be from outside of plot looking in, or vice versa
CAN	Canopy	Vertical, above IPC
OTH	Other	Path, damage, unknowns, etc. (optional)

1. Do not cut trees or vegetation to provide an unobstructed view.
2. Take the photo before taking measurements if the site may be damaged during sampling.

3. As a guideline, photos should be taken with a camera setting of 5 to 8 megapixels. This should result in a maximum target file size for individual pictures of approximately 6 MB.
4. The Plot Pin photo should be taken at a steep angle (about 60°) above the pin showing the pin and the ground for approximately one metre or more around the pin so the vegetation can be seen. Include the plot number in this photo.
5. Photograph the random-bearing transects from a position behind the plot centre pin.
   - Include the IPC Pin in the foreground, if possible.
   - Include something for relative scale determination.
   - Try to include the various crown levels with a “portrait” (vertical) format, if required.
6. For a representative photo, photograph a portion of the plot which the crew considers representative of the sample vegetation and structure . Include the IPC and an item for scale in the photo.
7. Photograph any other unusual features that you think would be of interest to users of this data. You may wish to illustrate issues about the sampling process, such as when rules do not seem clear or appropriate. Make notes about these photos so the points can be addressed later.
8. Try to include people in each photo for scale. Use a scale in any close-up photos.
9. Photos must be delivered in digital format, and named as follows:
   - Project ID_Sample ID_Plot Type Visit #_Code Value
   - For example: “2022-004_1458816_M2_PP.jpg”

3.3 Data Requirements for All Sample Types

The required data for each sample type is shown in Table 3.1 below. There is no ability to change the required data for a given sample type – these are the exact data requirements.

Table 3.3 – Data forms for Ground Sample Types

Type	Code	Header	Navigation	Cluster	Tree Data	Loss / Damage	Net Factor	Sample Trees	Small Tree Dot	Walkthrough	Access Notes
CMI	M	Y	Y	Y	Y	Y	Y	Y	Y	*S*	Y
YSM	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y
CMI Light	L	Y	P	Y	Y			Y			Y
Early YSM	A	Y	Y	Y	Y	Y		*S*	*S*		Y
PSP	PSP	Y	P	Y	Y	Y		Y	Y		Y
NFI	F	Y	Y	Y	Y	Y	Y	Y	Y	*S*	Y

Y = Mandatory

S = Sometimes (depends on if whether the A-type sample is “Planted” or “Forest Health”, and if the M-type and F-type sample are doubling as a Y-type sample)

3.4 Recording Header Information

The Header information must be completed for all samples. **Error! Bookmark not defined.**

PROCEDURE

1. Record the following Header information:

<table>
<tr><td>SURVEY DATE</td><td>The date the sample measurements were initiated.</td></tr>
<tr><td>END DATE</td><td>The date the sample measurements were completed (often the same day, but not always).</td></tr>
<tr><td>CREW LEADERS</td><td>Record the crew leader first and last name.</td></tr>
<tr><td>HELPERS</td><td>Record the first and last names of any other crew members.</td></tr>
<tr><td>SITE ACCESS (TYPES)</td><td>Record all the access types that were used to access the IPC (truck, ATV, helicopter, boat, airplane, bicycle, hike > 1 km, other).</td></tr>
<tr><td>SITE ACCESS (ISSUES)</td><td>Record any access issues that exist for the sample (in park, across or on private, across or on reserve, across or on federal, gates, other).</td></tr>
<tr><td>STAND DISTURBANCE</td><td>• This refers to recent disturbances that contribute to the current state of the stand. Examples would be recent logging, fire, stand regenerating after mountain pine beetle attack, windthrow, etc.
• If there is more than one cause in a plot, choose the most significant cause. If there are two successive causes then record the most recent one (an area burnt and then salvage logged would be recorded as logging)
Stand Disturbance codes are:
N - Non-biological / abiotic injuries
NB - Fire
NW - Windthrow
DD - Heartrots
DF - Foliage diseases
DR - Root diseases
D - Unknown disease
I - Unknown insects
IB - Bark beetles
ID - Insect defoliators
A - Animal
L - Logging, thinning, clearing, brushing and weeding
X - Other known (add details in comments)
U - Other unknown
O - No significant damage</td></tr>
<tr><td>COMMENTS</td><td>Enter any comments relevant to the sample measurements.</td></tr>
</table>

3.5 Recording Navigation Data

The Navigation data provides an additional means of relocating samples in the short and long term (20 years or more). **Error! Bookmark not defined.**

PROCEDURE

1. Record the following information:

ACCESS POINT GPS	Record a GPS location for the Access Point. A recreational grade GPS unit can be used for the Access Point.
AP TO IPC	The azimuth and distance from the AP to the IPC is automatically calculated using ISMC when the GPS coordinates are entered for both features.
DECLINATION USED	Record the declination used for the sample measurement.
OFFSET GPS LOCATION	If the IPC GPS location is not collected right at IPC, measure and record the distance (maximum of 25m) and bearing from where the GPS point was collected to the IPC.
GPS TYPE	Choose the appropriate type of GPS coordinate recorded: - DGPS = Differentially corrected GPS coordinate. - PPP = Precise Point Positioning corrected GPS coordinate - RGPS = Recreation grade GPS coordinate (e.g., averaged waypoint with a Garmin unit). - Intended = No actual GPS point/file was obtained in the field – coordinates entered are simply the intended coordinates.
GPS IDENTIFIER	Record the name given to the IPC digital GPS file.
VISIT IPC GPS COORDINATES	Record the IPC coordinates according to the GPS Type: - For DGPS: enter the differentially corrected IPC coordinates - For PPP: enter the corrected coordinates - For RGPS: enter the averaged waypoint coordinate for the IPC - For Intended: enter the intended IPC coordinates
COMMENTS	Record anything of importance regarding the procedures and data related to the navigation. Note anything that would make it easier to relocate the sample in the future.

3.6 Recording Plot Cluster Data

The plot cluster data refers to information on the features around the Integrated Plot Centre and the features associated with the sample.

PROCEDURE

1. Record the following plot cluster information:

PLOT RADIUS	Contains data on plot size
WALKTHROUGH PLOT	Record as walkthrough if the sample is a Y-type (or an F or M that fits the criteria of a Y) and the conditions for invoking walkthrough methodology are met.
SLOPE %	Measure and record the average slope of the sample, using an approximate 25 m radius area to estimate it.
ASPECT	Measure and record the average aspect of the sample, using an approximate 25 m radius area to estimate it.
STATUS	Record Nil Tally if the large tree plot does not contain any taggable trees. Otherwise record as Collected.
PIN OFFSET	If the IPC pin is not able to be secured into the ground at the exact location where it needs to be, place it somewhere else (as near to the intended location as possible) and measure and record the azimuth and distance from the physical pin to the true intended IPC location. The true location should be marked on the ground with paint or rock cairn if possible.
SUBPLOT RADIUS	Displays the sub-plot radius for the sample
COMMENTS	Record anything of importance regarding the procedures and data related to the plot cluster attributes.

4. Inventory Cruising

Introduction

This section deals with the identification and collection of detailed tree information. Trees are sampled using a combination of fixed-radius plots. **Error! Bookmark not defined.**

Objectives

- To collect attributes for the calculation of tree and stand volumes.
- To collect site index information.
- To assess and collect tree attributes for:
    - growth and yield assessment,
    - decay research
    - forest health information.

General Procedures

The steps for establishing and measuring a sample are discussed in the following order:

1. Establish plot layout and identify (tag) trees to measure.
2. Identify and record tree attributes.
3. Record damage agent and severity codes.
4. Identify and record tree loss indicators.
5. Establish fixed-radius plot for small tree data.
6. Classify and tally small trees by species.
7. Establish a fixed-radius plot for top height and quadrants for sample tree measurements.
8. Determine leading species composition (by basal area) for the sample.
9. Select and record top height, leading species, second species, and other major species tree data.

Detailed Procedures

4.1 Establishing Plot Layout

Sampling Method

The sampling design specifies the use of a series of fixed-radius plots for the sample.

Measuring Borderline Trees “In” and “Out”

It is important to accurately determine if the trees are ‘in” or “out” of the appropriate fixed radius plot. The horizontal distance from the centre of the tree at "point of germination" to the IPC will be used to check this borderline distance.

Marking the Plot Circumference

1. Measure and mark the 5.64 metre and 11.28 metre plot radius around the IPC.
2. Carefully check the horizontal distance for trees close to the edge of the plot circumference. These trees are called borderline trees. Include borderline trees in the plot when at least half their base at the "point of germination" is inside the plot.

Boundary Plots – Walkthrough Method (YSM Samples only)

Determine if there is a boundary within 22.56m of plot centre. A boundary, for this purpose, is defined as being a polygon which is outside the 15–50-year-old YSM population definition. If a boundary is identified, then the Walkthrough Methodology (Appendix D) must be followed. The Ministry representative will have identified potential samples for boundary plots during the project planning stage. However, there may be instances where a boundary has been created that the Ministry representative did not know about. An example is a new cutblock that is not on available imagery or entered in RESULTS yet.

Dividing the Plot into Sectors

Divide the plot into 8 pie-shaped, 0.005 ha (45 degrees) tagging sectors. These tagging sectors are later combined into pairs to have 0.01 ha quadrants for the selection of sample trees.

Sector 1 is always the first sector clockwise from due north. The additional sectors are numbered clockwise from sector 1.

Tagging sectors are as follows:

Tagging Sector	Azimuth Range
1	0-44
2	45-89
3	90-134
4	135-179
5	180-224
6	225-269
7	270-314
8	315-359

Tagging Trees

Tag all living (standing and fallen) and dead (standing only) trees that have a DBH of 4.0 cm and greater within the 5.64 metre radius sub-plot, and trees with a DBH of 9.0 cm and greater between the 5.64 metre and 11.28 metre area. Do not duplicate tag numbers in a plot.

Tagging by Sectors

1. Start with sector 1. In this sector, affix the tags so that they **face the plot centre**.
2. Tag the trees near the plot centre first; then continue tagging outward by moving side-to-side across the pie-shaped sector. (see Figure 3.1)

3. As you reach the circumference of sector 1, make the last sideways pass in the direction of sector 2 so that the last tree tagged in sector 1 is as near as possible to the first tree tagged in sector 2.
4. In sector 2, affix the tags so that they **face the circumference** of the plot, away from plot centre.
5. Tag the trees near the circumference first, then continue tagging inward by moving side-to-side across the pie-shaped sector.
6. Make sure the last tree you tag in this sector is the one closest to the plot centre.
7. Repeat the procedures used in sectors 1 and 2 for the remaining sectors. Remember that tags in odd-numbered sectors face the plot centre while those in even-numbered sectors face the circumference (away from plot centre).

Attaching Tags to Trees

Determine the point at the base of the tree that is equal to the high side location. High side is defined as the highest point of mineral soil or a humus layer around the base of the tree, no lower than the point of germination. Nail the tag at 1.3m above high side (Exception: NFI samples have the tags placed at high side base):

- use 6 cm aluminum nails;
- drive the nail slightly upward so the tag hangs away from the tree;
- drive the nail into the trunk just enough to hold the tag securely and yet allow for radial growth.

Nail & DBH Location

The placement of the nail is directly tied to the DBH of the tree, as the correct procedure for measuring DBH is to place the diameter tape directly above (and touching) the nail. This ensures repeated measurements of DBH over time are taken at the very same location.

The ideal height of the nail is at exactly 1.30 m above high side (breast height). However, there is some allowance for moving the nail from this ideal location in order to achieve a better measure of DBH. If 1.30 m would result in a DBH measurement skewed by a branch whorl, stem swelling, or other abnormality causing a non-representative diameter, the nail should be moved either up or down by a maximum of 10 cm in order to avoid the anomaly (the direction chosen should be the one that achieves the best compromise of shortest distance moved and most representative diameter. If the nail can be placed between 1.20 m and 1.40 m and result in a representative diameter when the diameter tape is placed directly above the nail, then that is all that needs to be done (Figure). No comment is needed about the nail moving up to 10 cm away from breast height, and no adjustment needs to be made when measuring the tree height (i.e., still just accept the vertex default of adding 1.3 m in the height calculation).

If moving the nail by a maximum of 10 cm does not provide for a good DBH measurement, then it needs to be determined if moving the nail further would improve the DBH measurement enough to warrant that move (Figure). In this case, a comment should be made, and the nail height needs to be considered with the tree height.

Another option for recording the DBH is taking an average of the diameter above and below breast height and recording that as an estimate (Figure). However, a repeatable directly measured diameter is preferred to an averaged or estimated diameter.

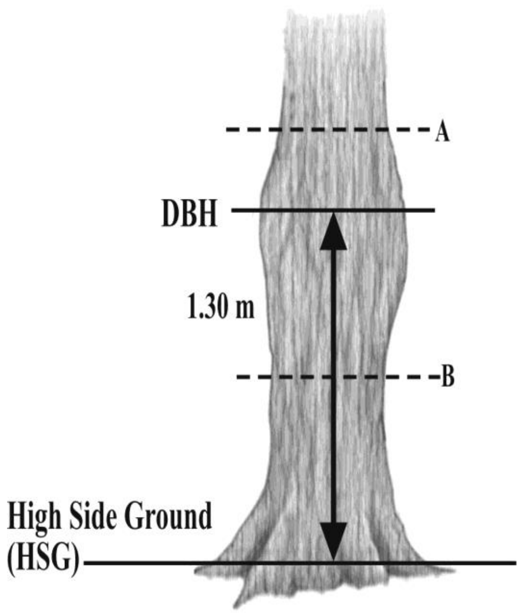


Figure 4.1. Stem swelling requiring nail and DBH measurement to be moved to location A.

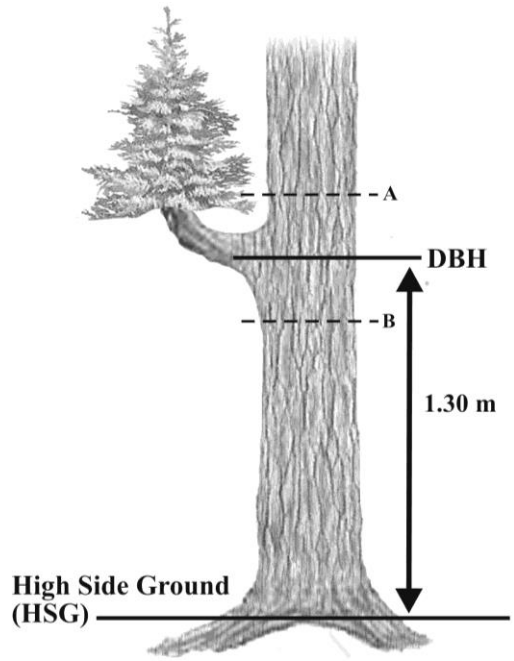


Figure 4.2. Branch whorl requiring nail and DBH measurement to be moved to location A or B, or averaged from A and B.

One exception to the description above is for samples at NFI locations. These samples have the nail and tag placed at high side base (i.e., 0.0 m) rather than at breast height. When remeasuring these samples, the nails should never be moved to 1.3 m unless directed by the Ministry representative. All the same principles apply (e.g., changing the height at which DBH is measured or taking an averaged DBH from above and below), with the difference being that there won't be a nail to mark exactly where DBH was measured.

Tagging Forked Trees

Special rules are required for tagging forked trees:

1. Tag the stem as a single tree if:
   - the fork occurs above 1.3 m or
   - the fork occurs below 1.3 m, and only one of the stems meets the minimum tagging limits.
2. Tag each stem separately if:
   - the fork occurs below 1.3 m, and
   - both stems above the fork meet the minimum tagging limits.
   - On NFI plots, locate the tag at high side ground level directly below the fork so it is evident which tag belongs to each stem.

4.2 Identifying and Recording Tree Attributes

The attributes to be recorded for each tree are listed and described below.

For the purposes of this inventory, a **tree** is defined as:

- a species identified as a tree as per the current version of the modified inventory ground sampling tree list as per Appendix C;
- longer than 1.3 m
- greater than or equal to 4.0 cm at DBH (2.0 cm DBH for PSP).

TREE NUMBER

All trees will be marked with numbered tags to identify them in the field and in the database. The plots will be re-measured in the future, and tagging the trees in a consistent sequence will enhance the chances of a successful remeasurement program.

TAGGING SECTOR

All trees will have the sector number recorded to assist relocation at the time of re-measurement. The tagging sector is also used for identification of sample trees.

TREE SPECIES

Assign a species code to all trees. The tree species recognized in the inventory is a subset of the current version of the BC Tree Code List and is included in Appendix C.

Note: Most notably, it has been decided not to measure any maple besides Bigleaf Maple or any of the willow "tree species" on the large tree or small tree plots.

Procedure

1. Record a species code (up to 3-characters) for the tree being measured.
2. Code all species as accurately as possible. If the species cannot be identified with confidence, record the genus, if known. If the genus is not known, record the appropriate code for unknown species (such as Xc for an unknown conifer).

TREE STATUS

Assigning tree status allows for reporting trees in categories and reflects some potential for future growth.

Procedure

1. Record for each tree whether it is live or dead, standing or fallen.
2. Use the codes described in Table 4.1.

Note:

Live Fallen (LF) trees are NOT recorded in L-type samples.

Dead Fallen trees are NOT recorded on establishment samples. They are only recorded on remeasurement samples.

Table 4.1 – Tree Status Codes.

Code		Description
Live/Dead	**L**	**Live** trees have live foliage (live cambium is present) and are rooted into the ground. Lack of foliage for some species, of course, is no indication of death during some seasons.
	D	**Dead** trees are obviously dead, or roots are separated from the ground.
Standing/ Fallen	**S**	**Standing** trees are self-supporting (that is, the tree would remain standing if all supporting materials were removed).
	F	**Fallen** trees are not self-supporting.

DIAMETER BREAST HEIGHT (DBH)

Measure and record the DBH of all live (standing and fallen) and dead (standing), trees that meet the minimum tagging limits. Refer to the "Nail & DBH Location" section above for further discussion.

<u>Procedure</u>

1. Determine high side ground level at the base of the tree (this is the height where the tag is placed for NFI samples). High side is defined as the highest point of mineral soil or a humus layer around the base of the tree, no lower than the point of germination. Breast height is 1.3 m above high side measured parallel to the tree bole. Figure 4.1 shows the location of high side and DBH locations for various tree forms.
2. On curved stems measure along the curve parallel to the centre of the tree. (For NFI samples, crews should place the base of their DBH stick on the tree tag nail when determining the location to measure DBH).
3. Nail a tag at the 1.3m location on the appropriate side of the tree, depending on the tagging sector.
4. Record the DBH with a tight diameter tape at the nail location, making no allowance for missing bark.
5. If there is abnormal swelling or obstructions at DBH, see the "Nail and DBH Location" section above.
6. Record whether the DBH was measured (M) or estimated (E).

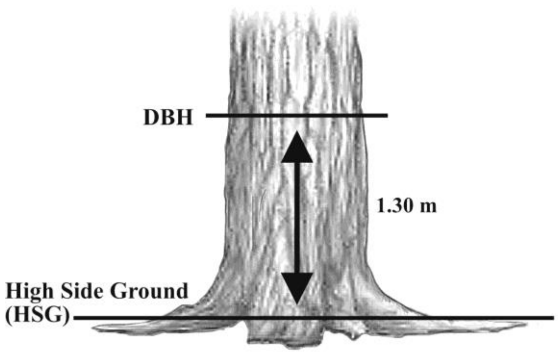
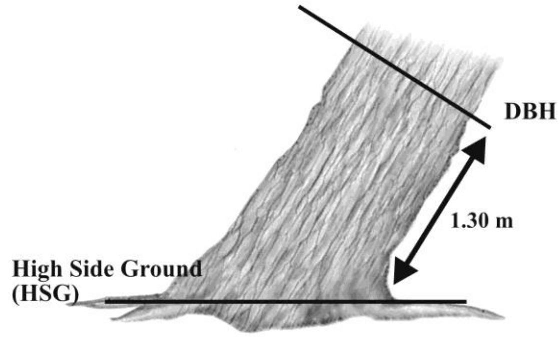
	

Figure 4.3.1	Figure 4.3.2

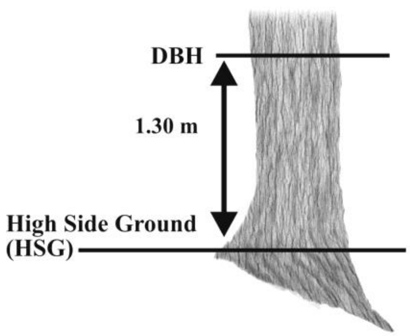
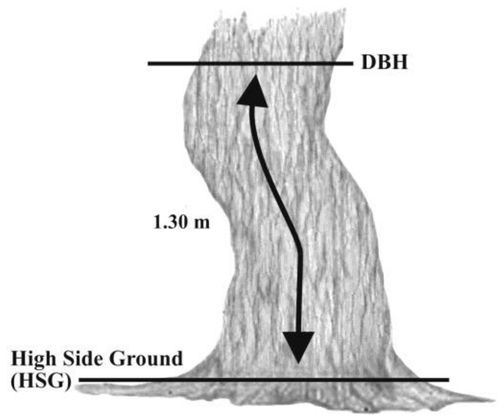

	

Figure 4.3.3	Figure 4.3.4

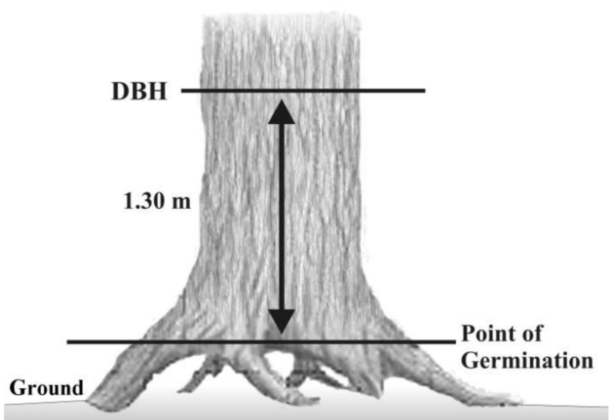
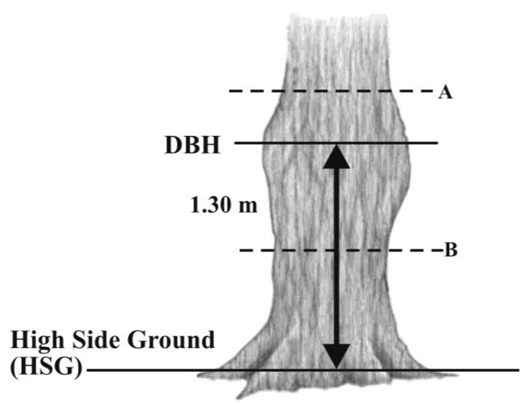

	

Figure 4.3.5	Figure 4.3.6

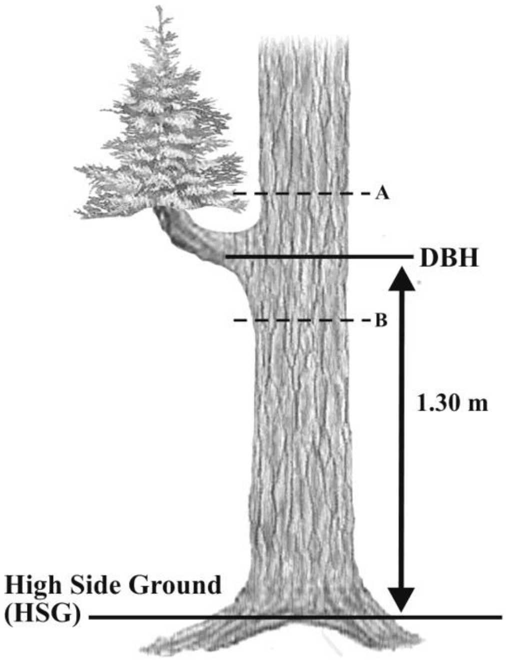


Figure 4.3.7

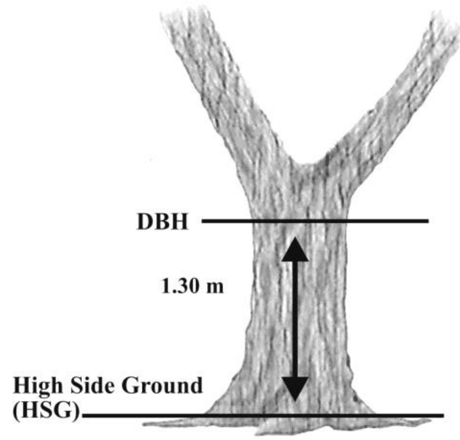


Figure 4.3.8

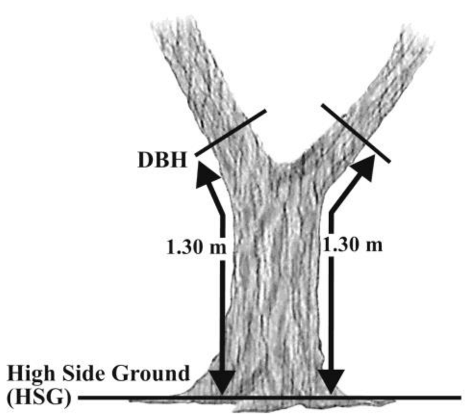


Figure 4.3.9

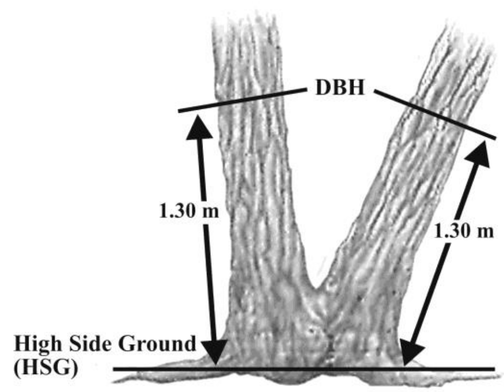


Figure 4.3.10

Figure 4.3 - DBH in Relation to High Side Ground and Point of Germination (diagrams courtesy of Canadian Forest Service)

TREE LENGTH

Measure the length for each tagged tree in the plot.

Measure all trees except where the measurement is physically obstructed, it is unsafe to make the measurement, or when an accurate measurement is impossible. In such cases estimate the tree length.

For trees with broken tops, see discussion of Broken Tops below. For odd-shaped trees see Figure 4.4.

Procedure

1. Measure the length of the tree from the ground level on the high side along the stem to the top of the stem. Record length to the nearest 0.1 m.
   - For species that typically have an apical droop (e.g., cedar and hemlock), the measurement of the length should be made while standing perpendicular to the droop and measured to the apex of the droop. No additional estimated length should be added to account for the remainder of the tree length that extends beyond the apex of the droop. This should be recorded as a measured length, not an estimated one.
   - For broken stems, measure the length after visually folding in shattered or broken wood to make a whole diameter. This does not require that a hollow tree be "filled" but rather that the remaining circumference of wood be retained. See figure 4.5 for an example.
   - For fallen, broken trees, record the length of the stem to the break. Measure the portion of the tree from the root collar to the top of the last connected portion (the pieces must be physically attached so that if one part is moved the next part will move).
2. Record whether the length was measured (M) or estimated (E).
   - ‘Estimated’ should be recorded in several different circumstances:
     - The tree length is truly a visual estimate (e.g., the top third of an intermediate tree is fully buried in the thick crown of a dominant tree).
     - The entire tree has a severe lean and sweep/bend such that a straight-line measurement is unlikely to be reliable.
     - Using Pythagoras’ theorem on a severely leaning tree.
     - For a non-apical drooping species, adding an estimated length to a measured portion of the overall tree length to account for a bent top.
   - ‘Measured’ should be recorded in most other circumstances.

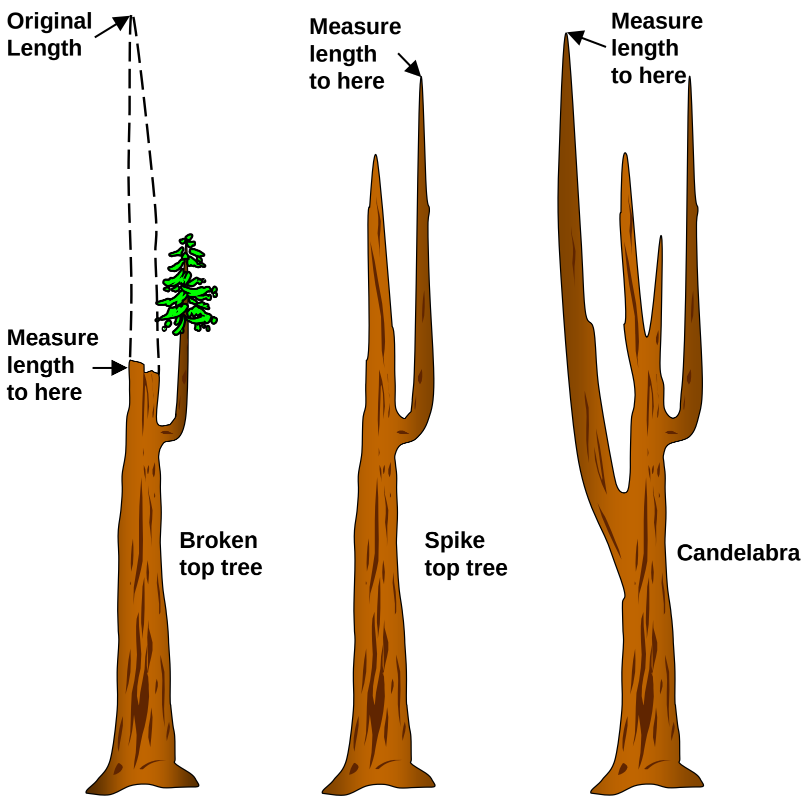


Figure 4.4 - Measurement of odd-shaped trees.

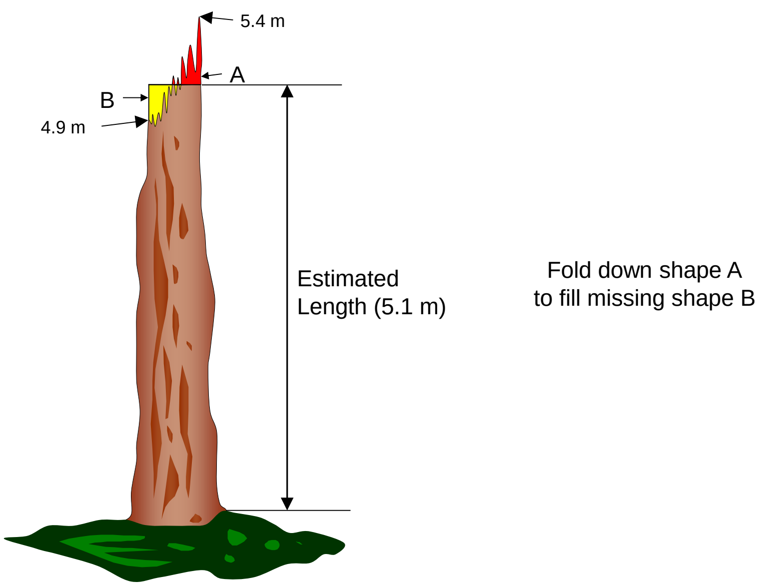


Figure 4.5 - Measuring height of broken trees.

CROWN CLASS

Crown class is a ranking by crown position of a tree in relation to other trees in the immediate area. The crown class is critical to the identification of sample trees. Only trees that are dominant or codominant can be selected as sample trees.

Procedure

1. Assign a crown class code to all **live standing** trees using the descriptions in Table 4.2.
2. Dead trees and fallen live trees will **not** have a crown class assigned.
3. On trees with a broken or dead top, assess the remaining live portion of the crown as to its present location in the canopy. For example, a tree was formerly in a dominant crown position, but the top of the crown has died back and only the lower limbs are alive. This crown would most likely be ranked in the intermediate or suppressed position based on its position in the canopy.

Table 4.2 - Crown class codes.

Code	Description
D	**Dominant** Trees with crowns that extend above the general level of the crown canopy (may include trees, shrubs or other obstructions) immediately around the measured trees. They are somewhat taller than the codominant trees, and have well-developed crowns, which may be somewhat crowded on the sides, receiving full light from above and partly from the side.
C	**Codominant** Trees with crowns forming the general level of the crown canopy (may include trees, shrubs or other obstructions) immediately around the measured trees. The crown is generally smaller than those of the dominant trees and is usually more crowded on the sides, receiving full light from above and little from the sides.
I	**Intermediate** Trees with crowns below, but extending into, the general level of the crown canopy (may include trees, shrubs or other obstructions) immediately around the measured trees. The crowns are usually small and quite crowded on the sides, receiving little direct light from above but none from the sides.
S	**Suppressed** Trees with crowns entirely below the general level of the crown canopy (may include trees, shrubs or other obstructions) around the measured trees, receiving no direct light either from above or from the sides.

Note: Portions of the plot may fall within *unmapped* areas of within-polygon variation (i.e., areas where the trees, ecology, microsite, etc. are significantly different from the average conditions of the majority of the plot and polygon). Although crown class in these situations can be highly subjective, with enough physical separation, trees that are significantly shorter than the polygon/plot average can still be deemed to be codominant. This issue has implications for which trees are available for sample tree selection (refer to section 4.6).

HEIGHT TO LIVE CROWNERROR! BOOKMARK NOT DEFINED.

Measure the height to the live crown on all live standing trees (live fallen trees do not require a height to live crown). The height to live crown is the distance along the bole from the high side ground level to the crown base. The crown base is normally the location on the stem where live branches occupy about three-quarters of the stem circumference. The primary objective is to estimate the "effective" extent of live crown for growth projections.

Procedure

1. Determine the crown base. If the definition of crown base is obviously not effective for the tree, then use your judgment as to the effective crown length. An example may be a tree that has no branches on one side.
2. Record the height to live crown for all live trees to the nearest metre

BROKEN TOPS

Record a Yes/No as appropriate to denote whether the tree has a broken top.

Note: In situations where an older broken top tree has a new leader that is taking over, a decision must be made whether the old broken top should now be considered a fork instead of a broken top. The basis for this decision should be on what length best represents the volume of the tree. If it is called a broken top, the length will be taken to the break, if it is determined to be a fork, then the length will be taken to the top of the new leader. In no instance should there be a double call of broken top and fork.

CLASSIFICATION OF RESIDUAL TREES

Classify all tagged trees as to whether it is a residual from a former stand. In making this assessment, refer to the general area around the plot. Trees are classed as residual if they are present in even aged stands, are living remnants of a former stand, and occur as the occasional large stem of an older age class than the stand as a whole. Typically, these trees have larger diameters, a higher incidence or indications of decay, thicker bark, larger branching and "ragged" or flat tops. These trees must be clearly residual. Uneven-aged stands do not generally have residual trees.

Procedure

1. Determine if the tree is a residual as per the given definition.
2. Record an "R" if the tree is a residual.

Note: The one exception to the definition of a residual tree can be encountered in YSM samples where the plot extends across a boundary into older timber and the walkthrough method is employed. In this case, there is no requirement for residuals to occur only as occasional stems, but rather all the stems of the significantly older neighbouring stand can be classified as residual. This ensures that sample trees are chosen from the target population. This exception does not apply to multi-age stands, stands with advanced regen that are similar in stature (i.e., diameter and height) to the target population, or very gradual polygon transitions.

Note: Advance regen can be a grey area between residual and non-residual status. Some guiding principles regarding advance regen are as follows. If advanced regen are 1) relatively abundant in the stand and distributed throughout, and/or 2) of a similar diameter and height to the rest of the trees in the stand, then they should not be considered to be residuals. They are simply a component of a mixed-age stand and will likely be managed as part of the same cohort as the younger trees. As non-residuals, they will be available for sample tree selection, and if one is selected it will not be suitable for site index due to suppression in the core.

WALKTHROUGH

If the conditions are met for a YSM sample to be a Walkthrough plot, then each tree requires a walkthrough code.

Procedure

1. Set each tree to the appropriate walkthrough code:
   - "O" – The tree is in the described "out" zone, as delineated by the walkthrough pins.
   - "W" – The tree is in the described "walkthrough" zone, as delineated by the walkthrough pins.
   - "-" – The tree is in the regular portion of the plot.

PLANTED

This attribute is only used in the Type-A (Early YSM) samples, where very recently planted blocks will have a sample established, and all planted seedlings will be identified and tagged. In all other sample types, this attribute is not recorded by the field crew.

Procedure

1. For each identified planted seedling, set the Planted code to "Y".

STEM MAPPING AZIMUTH AND DISTANCE

All tagged trees will be stem mapped.

Procedure

1. Measure and record the azimuth (nearest degree) from the Plot Centre Pin to the centreline of the tree at its point of germination.
2. Measure and record the distance (nearest 0.01 m) from the Plot Centre Pin to the centre of the tree (point of germination).

In case of a stand changing event such as harvest or severe windfall, three (3) plot trees need to be identified to aid relocation of the IPC pin. in case of a.

Procedure

1. Select three suitable trees at various aspects around the plot centre.
2. Insert an aluminum nail at the base of the tree low enough that it can be found on a remaining stump. The nail should be placed at the centre of the tree on the side of the tree (nail is placed at a 90° angle to the line from the tree to the plot pin).
3. Record the three stem mapped tree numbers in the Header comments section.

Note: In some locations there may be no tagged trees within the plot. In this case the plot status will be "Nil Tally" and no trees can be recorded in the tree data fields. However, some stem map information must be recorded to aid in the relocation of the Plot Centre Pin. If trees are present that are less than the minimum diameter for tagging, three of the largest stems can be used and measurements would be taken from these stems. If only stumps are available, use some stumps and take measurements from these stumps or a combination of small trees and stumps as required. Nails would be placed on the sides of these small trees or stumps. In some instances, with no trees or stumps available, rocks or other features may be used to facilitate relocating the IPC. Record species data, size, description of non-tree object, azimuth and distance in the Plot Cluster Comments.

Note: Offset Stem Mapping:

In some situations, it may be difficult to stem map from the IPC pin location. Examples include the IPC being in a clump of alder, in the centre of a tree, or at a wasp nest, etc. A new tool has been added to the data collection software to allow for stem mapping from an offset location near the IPC.

MODE

The Mode codes (**Error! Reference source not found.**) are a way to flag anomalous situations that have m ore significance for the overall data and their subsequent compilation and analysis than for individual trees. As such, care should be taken not to miss entering these codes when required.

Note that the D, H, M, and N codes only apply to remeasurement samples. The Z code can apply to establishment and remeasurement samples. The F and P codes only apply to Type-A (Early YSM) samples. See Section 4.6 for a full discussion on non-tally sample (Z) trees.

Procedure

1. Evaluate each tagged tree to determine if it requires a Mode code, according to the following table.

Table 4.3 – Mode codes

Code	Description	Required Attributes
D	Dropped – A previously measured tree that is to be dropped because it is outside of the plot	Sector, species, DBH, and stem map azimuth and distance (remove the tag and nail)
F	Forest Health – A tree in an Early YSM Forest Health sample that is below the standard YSM tagging limits	All attributes (may or may not have a DBH, depending on length)
H	Harvested/Cut – A previously measured tree that cannot be found and has obviously been cut or harvested	Sector, species
M	Missed – A tree that was obviously missed at the previous measurement	All attributes (tag the tree with an unused number)
N	Not Found – A previously measured tree that cannot be found	Sector, species
P	Planted, Too Small – A planted seedling identified and tagged in an Early YSM Planted sample	All attributes except DBH, CC, and HTLC
Z	Non-Tally Sample Tree – A tree that is not tallied yet is selected as a sample tree	Requires all attributes except Loss, Damage and Net Factor

4.3 Assessing Damage Agents and Severity

Note: The assessment of damage agents and loss indicators share some common elements, but they are separate and distinct processes. Tree loss indicators are discussed in Section 4.4. **Error! Bookmark not defined.**

Damage agents and severity is collected on individual trees to provide an assessment of forest health. The sample will identify the agent or agents that cause the damage and quantify severity of the damage. Damage agent types include abiotic, disease, insects, treatment injuries, animal damage, and problem vegetation.

Procedure

1. Assess damage agent(s) or conditions, and damage severity(ies) on all tagged trees. Every tree **must** have at least one damage agent code. This includes using damage agent code "O" when there is no detectable damage.
   - See Appendix A for damage agent codes, and Appendix B for damage severity and mortality condition codes and standards.
2. Record the damage agents for each tree.
   - Use a 1-, 2-, or 3-letter code, depending on your confidence in the identification (in most situations, a 3-letter code should be attainable). The damage agent codes are hierarchical and enable coding from very general (type or category) to specific (species). The first letter indicates the type of damage agent: abiotic (N), disease (D), insect (I), treatment (T), animal damage (A), and problem vegetation (V). The second and third letters indicate the specific agent, if it can be determined.
   - For example, Armillaria root disease is coded DRA (D = disease, R = root rot, A = Armillaria). If unable to identify the specific disease, only that it is a root disease, record DR. If you cannot determine that it is a root disease, but you are certain it is a disease (not an insect or other damage agent), record D for disease.
   - Crews should strive to get the full three letter code for common damage agents. If damage agent cannot be identified, photos should be taken of the damage (Code OTH) and sent to the Ministry representative for further identification.
3. Up to five damage agents can be recorded per tree. If there are more than 5 damage agents on the tree then the 5 most damaging/significant damage agents should be recorded. Priority ranking is determined by the potential for mortality and soundwood loss (refer to the Damage Ranking table in the Field Guide and Appendix A.
4. Record the damage severity using the codes listed in Appendix B.
5. Record "O" (alpha character O) if no damage agent is observed.
6. Record "U" if the damage agent is not known. In many instances damage may be evident but the damage agent is not known. Use this code as sparingly as possible, as it causes problems of ambiguity in the data analysis. (Note the "UF" and "UCR" are perfectly acceptable and can be quite common).

DETAILED RUST & CANKER MEASUREMENTS (YSM SAMPLES ONLY)

In addition to the standard procedures for damage agents and severity, the following additional forest health data must be collected for YSM samples.

For comandra blister rust (DSC), stalactiform blister rust (DSS), western gall rust (DSG), white pine blister rust (DSB)and atropellis canker (DSA) encountered on YSM samples, a different severity code is used. The severity code will be a combination of infection height to the nearest metre and percent encirclement to the nearest decile as follows:

Table 4.4 – Severity Codes for Rust and Canker Measurements (YSM only)

Infection Height (1st digit)		% Encirclement (2nd digit)		'Branch' Indicator (3rd digit)**	
Severity Code	Ht. Range (m)	Severity Code	(% Encirclement)	Severity Code	Location
0	0.0 – 0.5	0	1 - 5	B	On a branch
1	0.6 – 1.5	1	6 - 15	<null>	On main stem
2	1.6 – 2.5	2	16 - 25		
3	2.6 – 3.5	3	26 - 35		
4	3.6 – 4.5	4	36 - 45		
5	4.6 – 5.5	5*	46 - 55		
6	5.6 – 6.5	6	56 - 65		
7	6.6 – 7.5	7	66 - 75		
8	7.6 – 8.5	8	76 - 85		
9	8.6 +	9	86 - 100		

*There is a significant break-point for modelling the rusts/cankers at the 50% mark – particular attention should be paid when an infection is close to this % encirclement to ensure the correct decile is recorded.

**The third digit should only be used on Type-A forest health samples, where there is a desire to record branch cankers if present.

The following rust and canker type damage agents are listed in general order of most to least significant:

Comandra blister rust (DSC)

1) Stalactiform blister rust (DSS)
2) Western gall rust (DSG)
3) Dwarf mistletoe (DM_) (Hawksworth severity)
4) Elytroderma needle cast (DFE) (expressed as branch and foliar infection) (Hawksworth severity)
5) Atropellis canker (DSA)
6) Broom rust (DB_) (Hawksworth severity)

The only difference regarding rusts and cankers for YSM vs. CMI is the severity code used. For YSM samples for DSC, DSS, DSG, DSB, and DSA, the severity to be used is the 2-digit code for infection height and % encirclement, as outlined in the table above. For other rusts and cankers in YSM samples or for all rusts and cankers in other samples, the severity is SC (stem canker) or TK (top kill) or the Hawksworth scale. Note that branch cankers are never recorded except on Type-A (Early YSM) samples.

PLOT-LEVEL FOREST HEALTH COMMENT

There is one standardized comment required (for YSM establishment samples only) in the Comments field of the Header Section related to forest health. The procedure to determine the comment is as follows:

- Attempt to identify the leading cause (i.e., damage agent) of fallen trees within the plot. This should consider only trees that are recently fallen and/or are not incorporated into the forest floor (e.g., most of these trees would have an identifiable root collar). Look beyond the plot boundary (but within the target polygon) if needed to help identify the leading damage agent. Be as specific as possible (i.e., 3-letter codes are more desirable than 2-letter codes, especially for root disease).
- Using the exact prescribed format below, record (on its own line) in the Header Comments field (replacing the 'X' and '#' symbols with assessed data) the damage agent code, number of fallen trees attributed to that damage agent, and average age (at time of death) of those fallen trees:
    - "Leading damage agent for fallen trees: XXX, ## fallen trees, ### yrs at death"
- If there are no downed trees, then record the comment as follows:
    - "Leading damage agent for fallen trees: n/a"

If root rot is confirmed in general within the plot, attempt to identify specific root rot infection in individual tagged trees, and record the damage agent code and severity per tree as usual.

4.4 Assessing Tree Loss Indicators

Specific loss indicators signify the potential presence of decayed wood. The loss indicators to be measured are: conks, blind conks, frost cracks, scars, forks, crooks, large rotten branches, dead tops, root rot, soundings, direct observation, and broken tops. The specific indicator, its extent, and frequency are recorded for each tagged tree.

The inventory design for measurement and description of loss indicators attempts to adopt the traditional definitions and procedures of British Columbia and the Pacific Northwest wherever possible. The objective is to maintain a system that is compatible with current and past inventories but will also meet future needs.

<u>Procedure</u>

1. Record loss indicators for all live trees (standing and fallen) in the plot. It is not required to collect loss indicators on dead trees, but it may be beneficial to collect them to assist with net factoring.
2. Enter the appropriate code for the loss indicator (see Table 4.5 for codes and description).
3. Measure the position of each loss indicator on the stem of each numbered tree from ground level on the high side of the tree, to the nearest 0.1 m. Record the lower and upper extents as "From" – "To". Record a "-" before the number in the "From" column if the location of the loss indicator is below high side ground level.
4. If an indicator is a point feature, such as a singular conk, record the location once under the "From" column with a frequency of "1".
5. If the indicator occurs more than once and is best described as a series, record the frequency as the number of times the loss indicator occurred in a particular interval. The maximum number of occurrences to record is 9. If there are more than 9 occurrences, still enter 9.

6. Up to five loss indicators can be recorded per tree. If there are more than five loss indicators for a tree, then the most significant ones must be recorded.
7. Record multiple occurrences of loss indicators which do not have common causes as separate occurrences. The intent is to localize the loss indicator (for example a tree with basal scars from logging and a scar in the upper crown from a rubbing tree stem would be entered as separate occurrences).

Note: Loss indicators are only recorded for the main stem on trees forked above DBH.

Table 4.5 - Loss indicator codes.

Code	Description
DD __	Unknown stem decay (conk) DDE is a known stem decay (*Echinodontium tinctorium*)
DR __	Unknown root decay DRA is a known root decay (*Armillaria ostoyae*)
BNK	Blind Conk
NGC	Frost Crack
SCA	Scar
FRK	Fork
CRO	Crook
LRB	Large Rotten Branch
DTP	Dead Top
SNG	Sounding
OTH	Other (cause is known, but no appropriate code)
DIR	Direct observation (decay or missing wood seen without cause observed)

Note: Broken Top (BTP) is no longer considered a Loss Indicator in CMI sampling. The Broken Top Yes/No field takes care of the presence of the broken top for the tree and requiring the loss indicator as well was deemed to be redundant.

LOSS INDICATOR – STEM DECAY (DD _) AND ROOT DISEASE (DR _)

Only specific root, butt, and heart-rot conks are loss indicators. Sap rot conks that occur on dead branches and wounds of living or dead trees are not considered as loss indicators. (Refer to Appendix A: for stem decay and root disease conk codes.)

Stem Decays (Conks) Observed on Bole (DD _)

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. 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 the following:

1. The code for the species of conk
    - The loss indicator codes for conks are hierarchical. They are taken from the Forest Damage Agent and Condition Codes. The code identifies stem decay damage agents as DD_. The species of conk is then identified by the third letter. The codes for specific stem decays are shown in Appendix A.
2. Length to any single or isolated conk.
    - The frequency is 1.
3. If multiple conks occur in one section of the stem, record:
    - species of conk (should only be one species in each multiple occurrence)
    - length to the lowest in the series; length to the highest
    - frequency as to the number of conks in the series
    - if conk series are widely separated record as two series

Stem Decays (Root Rot) Observed on Roots or Ground (DR _)

Root Rot refers to fruiting bodies which are located on the roots and are associated with stem decay.

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.

Schweinitzii butt rot (*Phaeolus schweinitzii*, DRS) is considered a root rot species, but the fruiting body may occasionally be observed on the main stem some distance above the ground (see Section 5.3 #2 for how to address this specific occurrence).

Record the following:

1. The code for the species of root rot
    - The loss indicator codes for root rots are hierarchical and are taken from the Forest Damage Agent and Condition Codes. The code identifies stem decay damage agents as DR_. The species of conk is then identified by the third letter. The codes for specific root rots are shown in Appendix A.
2. Length for any single or isolated root rot indicator is recorded as “0.0” (ground level).
    - The frequency is 1.
3. If multiple root rot indicators are observed, record:
    - species of root rot (should only be one species in each multiple occurrence)
    - length from “0.0” to “0.0”
    - frequency of indicators in the series

LOSS INDICATOR – BLIND CONK (BNK)

Blind conks are pronounced swellings or depressions around knots, usually caused by *P. pini* (DDP) on conifers, and *P. tremulae* (DDT) on aspen. Blind conks are definite indicators that decay is extensive in the tree stem.

Evidence of **conks** should be found in the surrounding stand before recording blind conk as an indicator.

Blind conks are identified as follows:

- 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 found by chopping into basal branch stubs. This form is most often found in the interior of the province and crews will be directed by the project supervisor regarding procedures for chopping into trees.

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

Record the following:

1. The loss indicator code BNK
2. For a single occurrence record:
   - the length to blind conk
   - the frequency as “1”
3. For multiple blind conks in one area of the stem, record:
   - length to the lowest; length to the highest
   - the frequency as the number in the series, including the lowest and highest

LOSS INDICATOR – FROST CRACK (NGC)ERROR! BOOKMARK NOT DEFINED.

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 several metres up the tree, 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.

Record the following:

1. The loss indicator code NGC
2. For a single frost crack, record:
   - lowest extent (may be a negative value if it extends below ground on high-side)
   - the highest extent.
   - the frequency as “1”
3. For multiple frost cracks on one section of the stem, record:
   - lowest extent of the lowest frost crack in the series and highest extent of the highest frost crack in the series
   - frequency as to the number of frost cracks in the series

LOSS INDICATOR – SCAR (SCA)

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.

Record the following:

1. The loss indicator code SCA
2. For an individual scar record:
   - lower extent of the scar (may be a negative number if it extends below ground on high side)
   - upper extent of the scar
   - the frequency as "1"
3. For multiple scars along one section of the stem, record:
   - lowest extent of the lowest scar in the series; highest extent of the highest scar
   - frequency of scars in the series

LOSS INDICATOR – FORK (FRK)

A fork is caused by damage to the 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

If the secondary leader is visible, record the following:

1. Loss indicator code FRK (no minimum size limit)
2. Location of fork (the divergence of the stems); frequency as "1"
3. Distinct forks (record as separate occurrences)
4. Multiple forks within a reasonable range and a probable common cause (record upper and lower occurrence and number observed)

LOSS INDICATOR – CROOK (CRO)ERROR! BOOKMARK NOT DEFINED.

A crook is caused by damage (mechanical, physiological, animal or insect attack) to the leader of a tree. Crooks potentially expose the wood to decay fungi.

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.

Record the following:

1. Loss indicator code CRO
2. For a single occurrence, record
   - height of each individual crook
   - frequency as “1”
3. For multiple crooks in a section of the stem, record:
   - length to the lowest crook; length to the highest
   - frequency as the number of crooks

LOSS INDICATOR – LARGE ROTTEN BRANCH (LRB)

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.

Record the following:

1. The loss indicator code LRB
2. For a singular occurrence, record:
   - the height to the central point of the branch
   - frequency as “1”
3. For multiple occurrences record:
   - the length to the central point of the lowest branch in the series
   - the length to the central point of the highest branch
   - the frequency as the number in the series (including the highest and lowest)

LOSS INDICATOR – DEAD TOP (DTP)

A dead top can be caused by any number of external injuries, physiological stresses, insects, or diseases. The top should be obviously dead with no green needles or leaves present.

Record the following:

1. The loss indicator code DTP
2. Length to the base of the dead top (top of live crown), length to the top of the tree; frequency as “1”

Loss Indicator – Sounding (SNG) Error! Bookmark not defined.

Every tree on every plot is sounded. Sounding the tree involves striking the bole near the base of the tree with a blunt instrument. A hollow sound indicates a large amount of potential rot. If the tree sounds hollow it must be bored to confirm the presence or absence of decay, and the length of the solid core is used in the net factor calculation.

Record the following:

1. The loss indicator code "SNG" whenever the tree "sounds" hollow. If subsequent boring indicates no decay or decay is present, the "SNG" loss indicator code is left on the field card. Record in the comments section that no decay was found.
2. Frequency and length are not recorded

Loss Indicator – Other (OTH)

Sometimes rot or missing wood can be observed directly, and the cause is **known**. However, there is no appropriate loss indicator code.

Examples of "Other" may be hollow trees, butt rot, or sap rot on a live tree. In all these examples the cause is **known**.

Record the following:

1. Loss indicator code OTH
   - In the Comments, state the reason for the loss
2. Location and frequency, if appropriate

Note: If this type of loss occurs frequently an appropriate code will be assigned in the future.

Loss Indicator – Direct Observation (DIR)

Sometimes rot or missing wood can be observed directly, but the cause is **not** known.

An example of "Direct Observation" may be hollow trees where the cause is **unknown**.

Record the following:

1. Loss indicator code DIR
   - Make a comment in the Comments section if you think it is appropriate to do so.
2. Location and frequency, if appropriate

Note: If this type of loss occurs frequently an appropriate code will be assigned in the future.

4.5 Measuring Small Trees

SMALL TREE DOT TALLY

A fixed-radius small-tree plot will be established at some Integrated Plot locations. The purpose of this plot is to determine relative numbers of small diameter live trees that are not sampled in the main tree plot.

Procedure

1. At the Integrated Plot Centre establish a fixed-radius plot that is either 2.52m, 3.99m or 5.64m in radius, as determined in the project plan. The edge of this plot may be marked temporarily to ensure accurate measurements.
2. Record the following general information about the small tree plot:
   - Status: Record the status as Collected, Not Collected or Nil Tally
   - Plot Size: Record as Full, Half or Quarter plot
3. Count the live trees, less than 4.0 cm DBH and taller than 10 cm. Small trees must have their point of germination within the fixed plot radii to be measured as "in" trees. Record the total number by species and by length class. The length classes are as follows:
   - 10 cm to 29 cm
   - 30 cm to 1.3m
   - >1.3 m and < 4.0cm DBH (PSP limit >1.3m and < 2.0cm DBH)
4. If there are no small trees in the plot, record status as “Nil Tally,

Example of small tree dot tally			
Species	**Length**		
	10 to 29 cm	**30 cm to 1.3 m**	**> 1.3 m but < 4.0 cm @ DBH**
Cw	4	2	1
Hw	9	6	—
Fd	—	1	3

PLOTS WITH CLUMPS OF TREES OR SUCKER GROWTH FROM STUMPS

In some instances, particularly with deciduous species, clumps of stems originating from a common root system or stump that is vegetatively alive are encountered. Some or all these stems could potentially grow into trees at some time in the future. The sampling intent is to identify the stems which express apical dominance to the best *judgment* of the field crew.

Procedure

1. Count the number of stems that appear to express apical dominance. The intent is not to examine each stem in detail but to arrive at a reasonable assessment of numbers within each class.

SPLITTING SMALL TREE DOT TALLY PLOTS FOR EXCESSIVE TREE COUNTS

In some instances, tree regen can be extremely abundant. To avoid error due to excessive counting, there are procedures to allow for splitting the dot tally plot if the estimated tree tally is >50.

Procedure

1. Visually **estimate** the number of small trees in the dot tally plot. If <50, complete the full plot. If >50, then split the plot in half according to the table below.
2. Visually **estimate** the number of small trees in the selected half plot. If the estimate is still >50, split the plot in half again (resulting in a quarter plot) according to the table below.

Sample #	Selected Half	Selected Quarter
Even	East ½	Northeast ¼
Odd	West ½	Southwest ¼

4.6 Recording Sample Tree Data

Objective

Sample trees are measured to determine age for the major species by basal area in the sample and can also be used to estimate site index and projected rate of growth.

General Procedures

In each Integrated Plot a top height tree, up to four leading species trees, up to four second species trees, up to four each of other major species, and one residual, if present, will be bored to determine age. The following types of sample trees are measured for age:

Sample tree types:

- Top height (Type = T) In the 0.01 ha plot measured within a 5.64 m radius of the plot centre; of the trees that are live and dominant/codominant, (regardless of species or residual status); the largest DBH tree
- Leading species (Type = L) In each 0.01 ha quadrant of the 11.28 m plot; of the trees that are of the leading species by basal area, live, dominant/codominant, and non-residual; the largest DBH tree
- Second species (Type = S) In each 0.01 ha quadrant of the 11.28 m plot; of the trees that are of the second species having more than 20% of the basal area in the plot, live, dominant/codominant, and non-residual; the largest DBH tree
- Other major species (Type = O) In each 0.01 ha quadrant of the 11.28 m plot; of the trees that are of all species (other than the leading or second leading species) having more than 20% of the basal area in the plot, live, dominant/codominant, and non-residual; the largest DBH tree

- Residual tree (Type = V) In the 11.28 m plot; of the live residual trees; one "representative" tree (if present)

Note: Species with < 20% of the basal area in the plot may still be collected as O trees (if present) at the discretion of the cruiser. These potential O trees are optional, whereas O trees are required for species with > 20% of the basal area.

Table 4.6 - Guide for selection of sample trees

	Population Selection Criteria							Tree Selection Criterion
Type	*Plot*	*Species*	*Basal Area*	*L/D*	*C.C.*	*Age Suit.*	*Ht Suit.*	*Only 1 Consideration:*
T	5.64 m Plot			Live	D/C			Largest DBH
L	11.28 m Quad	Leading		Live	D/C	Non-Residual		Largest DBH
S	11.28 m Quad	Second	>20%	Live	D/C	Non-Residual		Largest DBH
O	11.28 m Quad	Other	>20%	Live	D/C	Non-Residual		Largest DBH
V	11.28 m Plot			Live		Residual		Representative
X								Representative

The leading species, second species and other major species are determined from the basal area of the **live** tagged trees (excluding residuals) in the IPC. The tree species with the greatest basal area is the leading species; similarly the species with the second largest basal area is the second leading species.

Non-standard selection type X:

- Extra tree (Type = X) An alternate tree outside 0.01 ha plot

Additional X trees may also be selected in a non-standard manner at the discretion of the field crew. This flexibility is provided for instances where the field crew feels that adequate information cannot be provided following the standard procedure alone. For example, the sample is located in a patch of recently killed trees or a tree is unsafe to measure. For this to be of any practical use, comments must be supplied to explain why the tree was selected.

Non-Tally Sample Trees

In younger stands with smaller diameter trees close to the 4 cm or 9 cm tagging limit, there is a requirement to check for non-tagged trees within the bounds of each quadrant that might be a sample tree. The largest tree of a particular species in a quadrant may be below the tagging limit and not be tagged, however it is still a valid sample tree. The largest diameter live codominant tree of that species in that quadrant will be a sample tree.

This type of sample tree is referred to as a “non-tally sample tree”. These trees do not factor into the leading species calculation (i.e., basal area calculation), and they do not contribute to the compiled data (i.e., their volume is not included in the total plot volume, etc.).

The procedure for these trees, if present, is as follows:

- Apply a tree tag with a number that is not being used elsewhere in the sample
- Record a "Z" in the Mode field (this is important, as this is the flag that prevents the tree from being "tallied" and contributing to the leading species calculation, plot volume, etc.)
- Record all the standard tree attributes except damage agents, loss indicators, and net factoring)
- Record the sample tree data

Suitability of Height and Age

All sample trees must be assessed for suitability in two ways:

1) Height and age suitability (comparing the sample tree to other similar trees in the plot in terms of height and age) (note that residuals are always not suitable for age).
2) Site index suitability (determining if the sample tree will provide a reliable site index based on the SIBEC standard)

First assessment: height and age suitability

The intent of this assessment is to provide an indication of whether the sample tree *generally* reflects the height and age of the average plot tree in its cohort (i.e., other trees in the plot of the same species, crown class, diameter class, and age cohort).

Examples of reasons for a tree not being suitable for height:

- significant broken top
- significant dead top
- fork or crook that significantly affects height growth
- abnormally high amount of scarring or other damage that may have affected height growth [for example - significant mistletoe infection, such as a Hawksworth severity rating of 4, 5, or 6]

Note: *Significant* refers to a reduction in the length of the tree compared to what it would be if undamaged. This is a subjective assessment without any defined percent height loss requirement. If the sample tree appears shorter than the majority of the other plot trees from the same cohort (species, crown class, diameter class, general age), then it should be called <u>not</u> height suitable.

There are several reasons for a tree being not suitable for age:

- being a residual tree
- having a measurement code of ROT
- having a measurement code of CRC (could not reach centre)

Second assessment: site index suitability

The intent of this assessment is to indicate if the sample tree will provide a reliable site index, using the SIBEC standard as the assessment tool. The requirements for the SIBEC "tree selection" standard must be met for the sample tree to be called "suitable for site index" (the SIBEC "plot selection" standard is not considered).

To meet the SIBEC tree selection standard (in addition to the requirements meet to be the sample tree [live, dominant/codominant, largest DBH, etc.]), the sample tree must be:

- free of suppression;
- not wolf, open-grown, or residual;
- straight-stemmed, free of disease, rot, insect damage, and other significant damage including forks, scars, and breakage (minor damage is allowed but should not occur over more than 5% of total tree height);
    - temporary exemption: Lodgepole pine and ponderosa pine trees that are in the green- or red-phase of Mountain Pine Beetle (MPB) attack are suitable site trees. However, these trees must be in recently attacked stands (green- or red-phase) and still meet all the other requirements of a site tree; and
- vigourous with a full crown.

Suppression will be exhibited in the increment core as a number of tight growth rings (at least 2-3) immediately around pith followed by better diameter growth "release" rings.

Assessing for a maximum total height loss of 5% can be subjective, but can be somewhat objectively assessed by comparing the sample tree to other trees in its cohort, and by looking for shorter than expected internodes above visible damage (when compared to "undamaged" internodal distances further above and below the damage). This becomes harder to accurately assess in older sample trees, as past damage and/or visible height loss can become "overgrown" and hidden.

General Procedure for Measurement and Recording of Sample Trees

1. Verify the selected sample tree and bore it for age. In some instances, boring is not recommended, or necessary; see the section below for further details.
2. Code the tree with the appropriate type label (T, L, S, O, V, or X). Note that a sample tree can be the T tree and also another type, but all other types are mutually exclusive.
3. Enter the bored diameter and bored height. Typically this will be the DBH and 1.3 m, but a tree could need to be cored at a different height for a variety of reasons (e.g., branch whorl, excessive damage, etc.).
4. Determine the suitability for height, age, and site index (Yes or No). If a particular suitability is "No", consider entering a comment for the tree to provide details as to why.
5. Record the appropriate measure code (see below for description of all options).
6. Measure and record prorate length, if required.
7. Count the visible rings and record field age.
8. Estimate and record missed years to pith, if required.

Specific Procedures for Measurement and Recording of Sample Trees

There are several methods of acquiring a field age for a sample tree, and each one requires different procedures, measure codes, and complementary attributes (e.g., prorate length).

Procedure for Measuring Age on Bored Trees

The most common method of obtaining a field age is to bore the sample tree at breast height. Bore sample trees with the increment borer facing plot centre, if possible. Determine the age by a ring count from an increment borer core and enter the data in the field age. The count will be the number of full rings. Several situations are possible, listed here by the applicable measure code:

- PTH (pith) – Where a complete core is collected, and it contains pith, simply record the ring count in field age. The count will be the number of full rings.
- NOP (no pith) – Where a complete core is collected, but it does not contain pith, record the ring count in field age, and estimate the number of missing rings in “missed years to pith” (see next section for full details on this).
- CRC (cannot reach centre) – Where the sample tree is too large for the borer to reach the centre, record the ring count of the obtained portion of the core in field age, and record the length of the core in centimeters (excluding the bark) in prorate length.
- ROT (rotten core) – Where the sample tree is rotten or has missing wood in the centre, record the ring count of the sound/present portion of the core in field age, and record the length of the core in centimeters (excluding the bark) in prorate length.

Procedure for Determining Age on Small Trees

If boring the sample tree would risk severe damage or death due to its small size, there are two alternatives to obtain a field age, listed here by the applicable measure code:

- WHO (whorl count) –
  - For trees >1.3m in length: Count the whorls above breast height, and record that in field age. Bored Height will be 1.3m.
  - For trees <1.4m in length: Count the total whorls from the base of the tree and record that in the field age. Bored Height will be 0.0m.
- OUT (out-of-plot tree) – Locate a tree outside the plot of the same species and similar apparent age to the sample tree, bore it or cut it down at breast height, and record that tree’s ring count in the field age for the sample tree selected inside the plot.

Note: It is difficult to estimate whorls for indeterminate species such as cedar, hemlock or deciduous species. In those cases, make an attempt at estimating an age or use the OUT measure code and cut down a similar size tree outside the plot.

PROCEDURE FOR SPECIAL SITUATIONS

Lastly, there are two special situations with their own measure code and procedures:

- PRE (previously aged) – This is for remeasurement samples only. Where the sample tree was also a sample tree in a previous measurement, do not bore the tree but simply record the PRE measure code and leave Bored Diameter, Bored Height, and Field Age blank; the new current age will be calculated during data compilation.
- NOC (not collected) – Where no core is collected and no field age is estimated through a means described above, record the NOC measure code and do not record a field age. This should be a very rare occurrence, if ever.

Note that all field ages in all instances are collected at breast height (or at the tagged nail height if it has been shifted from breast height, for example, to avoid a whorl or damage), never at ground level, and never for a "total age". Years to breast height will be calculated during data compilation.

Missed Years to Pith

Pith should be included in sample tree cores as often as possible to ensure accuracy of the age of the tree, particularly in stands less than 80 years old. However, obtaining pith on every core is not always possible. In this case, the measure code for the sample tree is NOP, and missed years to pith is required. Note that this is a different circumstance than CRC or ROT, in which case prorate length would be recorded rather than missed years to pith.

If a solid intact core is long enough to pass the location of pith, yet does not contain pith, and you can confidently estimate that the core is within a few years of the pith (relative to the tree age), then the procedure is a follows:

- Record "NOP" for the measure code
- Count the visible rings on the core and record that in field age
- Estimate how many rings are missing between the last visible ring on the core and the missing pith, and record that in missed years to pith. Be sure to enter just the missing ring count here, not the combined total of visible rings plus missed rings.

Note: It is expected that the missed years will be 5 years or less. If the estimate is more than 5 years, then the tree needs to be redrilled.

Collected Cores & Office Age

All sample tree cores will be processed and measured by a third-party laboratory to determine the final office age. Due to the specialized equipment used for these processes, extra care should be taken to collect and provide intact cores that include pith in as many cases as possible, which may mean that some sample trees will need to be cored several times. In general, the older the tree, the more attempts can be made to acquire an intact core that includes pith without adversely impacting the tree. However, it is more important to have accurate ages for younger trees since the impact of one missing year on the calculated site index (the main use for collecting ages) increases as tree age decreases.

All sample tree cores will be counted in the field, with the field age recorded. If required, missed years to pith or prorate length will also be measured and recorded.

Each sample tree core will be placed in its own clear/translucent straw. A provided core label (ideally printed on waterproof paper) will be completed in pencil and stapled to one end of the straw. Do not write directly on the core as the ink can cause issues for the lab's core analysis. To prevent mold growth, straws must be stapled on both ends, rather than being sealed with heat or tape. If possible, cores should be kept refrigerated while awaiting delivery to the lab to preserve moisture content and overall core integrity. Freezing the cores is not recommended as it can rupture the cells and cause issues for the lab's core analysis.

At the end of each batch (or at a very minimum, once per month), the cores will be securely packaged (bundled by sample using flagging tape, not masking tape) and sent to the Ministry representative.

The Contractor must maintain a digital sample tree core log to list each core collected. A printout of the core log/report must be shipped with the cores to avoid any confusion as to the identity of the cores. The updated digital core log/report must also be emailed to the Ministry representative.

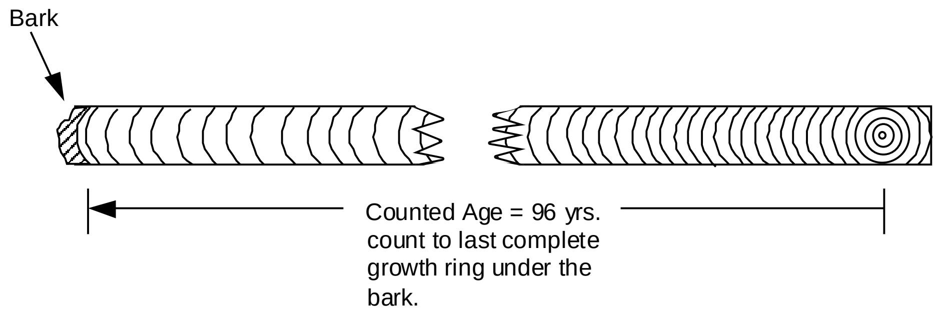
Recording Sample Tree Information

See Section 4.2, "Identifying and Recording Tree Attributes," for a complete description of codes.. The following details are recorded for sample trees:

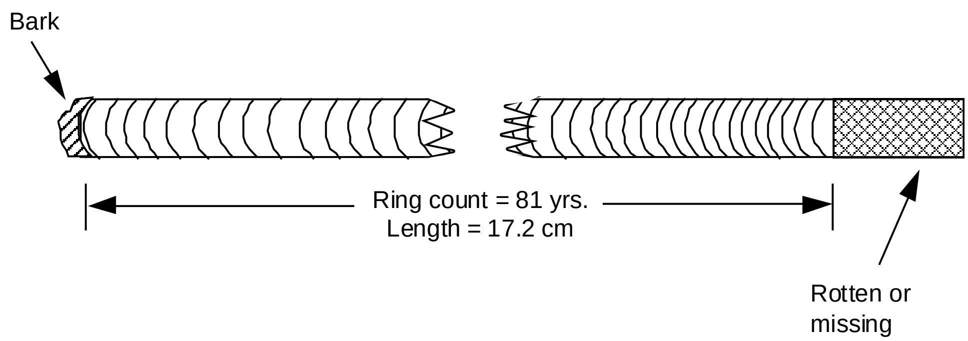
SAMPLE TREE TYPE	T = top height tree, L = leading species, S = second species, O = other major species tree, V = residual tree, X = additional tree.
BORED DIAMETER (CM)	Diameter outside bark at location of increment boring.
BORED HEIGHT (m)	Height (above high side ground level) where boring was made.
SUITABLE HEIGHT	Record a "Y" for "yes" if the tree height has not been significantly affected and *generally* reflects the height and age of the average plot tree in its cohort. Otherwise, record "N" for "no".
SUITABLE AGE	If a top height tree (T) is residual then record a "N" for not suitable, otherwise record a "Y". All L, S, and O trees must have a "Y" entered for suitable for age as they must be non-residual. A V-tree must have a suitable for age of "N". An X-tree must follow the convention of the sample tree type it is representing.
SUITABLE FOR SITE INDEX	Record a "Y" for "yes" if the tree meets all the conditions of a site index tree. Otherwise, record "N" for "no".
MEASURE CODE	PTH: Pith obtained in core.
	NOP: Complete core obtained but does not contain pith.
	CRC: Increment borer cannot reach centre (tree too large).
	ROT: Core of tree rotten or missing.
	WHO: Age determined from whorl count
	OUT: Age determined from a similar tree outside of the plot.
	PRE: Sample tree was aged in previous measurement.
	NOC: Core not collected (rarely used).
PRORATE LENGTH (CM)	When a full boring is not possible (CRC or ROT) record the length of the countable portion of the increment core (excluding bark)
FIELD AGE	Record the age (count of visible rings or whorls above breast height)
MISSED YEARS TO PITH	When a complete core is collected without pith (NOP), record the estimated number of missed years (i.e., rings) between the last visible growth ring and pith.

EXAMPLES OF RECORDING AGE INFORMATION

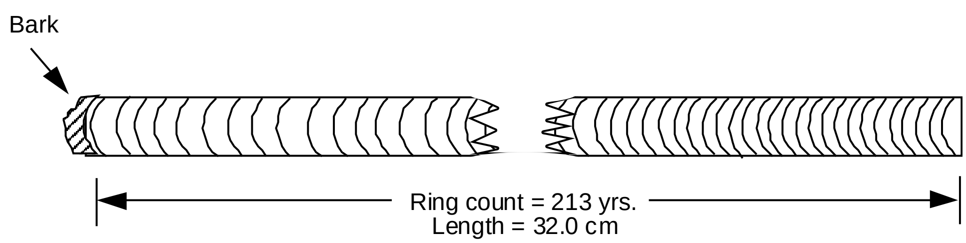
1. Normal tree where the increment borer can reach the tree pith (Measure Code = PTH)



2. Tree with rotten or missing core (Measure Code = ROT)



3. Tree where increment borer cannot reach centre of the tree (Measure Code = CRC)



5. Net Factoring

Introduction

This section outlines the steps needed to assess the net volume of trees on the IPC.

Net factoring is the process used to assess net tree volume. No attempt is made to predict volume loss without direct evidence. Log lengths and net factor are required for CMI samples (Types M and F). Trees are split into logs based on the net factoring required for a tree, using the main guiding principle of isolating rot/loss where it makes sense to do so. Form alone (such as forks and crooks) has no bearing on splitting a tree into multiple logs.

Objectives

To provide a rule-based estimate of net tree volume.

Definitions

Net Factoring involves estimating the net volume of sound wood (gross volume less decay) of variable log lengths. These net volumes are based on: (1) direct measurements (includes visual estimates and physical measurements); or (2) standard, rule-based deductions associated with loss indicators.

Pencil bucking is the imaginary sectioning of trees into potential logs.

General Procedures

- The net factoring process is based on only making allowances for decay on consistently measurable or detectable features. Some trees will contain decay but will not have any visible symptoms.
- Standard rule-based deductions will be used to determine the extent of the defect and the calculation of the net factor (% sound wood).
- Pencil bucking is used to identify log breaks in a tree and to localize where the net factor is applied.
- Net factoring is for sound wood loss only (decay or missing wood). No additional deductions are made for anticipated breakage, manufacturing loss, or splits and fractures.
- When calculating log volumes the diameter of the log will be the DBH, when dealing with the bottom log, or will be estimated at the midpoint of the log when dealing with upper sections of the tree.

Detailed Procedures

5.1 Net Factoring Procedures

All trees in the Integrated Plot will have net factors calculated for each log.

1. Complete the tree loss indicators information prior to the net factor process.
2. Determine the applicable log lengths for each tree.
3. Using measurements and rule-based deductions, calculate the net factor for each log section.

4. Where loss indicators are located on the tree below high side ground or extend below high side ground, consider the application as if the indicator was in the first log length. For example, a frost crack that extends from minus 0.5 m to plus 1.5 m is calculated as a 2 m frost crack with losses applied to the first log. Similarly a root rot conk present on the ground is applied to the first log length.
5. Measure all net factor calculations from high side ground.
6. Since net factoring is a priority when major defects exist it is desirable that the defect be isolated as a log. If this process creates an unrealistic description of the tree, incorporate the defect into a longer log.
7. Assign a net factor to each log. If the log has no major defects, and you detect no measurable sound wood loss, the net factor is 100%.
8. The last log in the tree must always have a "99" for length. This indicates to the compiler to use the length of the tree to determine the actual log length.

Net factors will only be recorded where:

- a conk, frost crack, or blind conk is present.
- decayed or missing wood is visible (note – broken tops, dead tops, forks and other loss indicators cannot have net factor deductions applied unless rot is visible).
- sounding of the stem indicates decay, and subsequent boring provides a relative decay ratio.
- root rot is observed.

5.2 Calculating Volume

In assessing the percent deduction of a log, you will need to calculate volumes. Logs are considered cylindrical, and depending on the type of defect, the decayed portion is considered to be rectangular (such as scars), cylindrical (such as conks), or conical (such as butt rot). The following conventions and formulas shown in Table 5.1 will be used in the calculations.

Diameter: length of a straight line passing through the centre of a circle.

Radius: line extending from the centre of a circle to the circumference (½ diameter).

L = length; W = width; D = depth; R = radius; π = 3.14 (to 2 decimal places).

Table 5.1 - Formula for calculating volume.

Shape	**Formula**
Rectangular solid	Volume = L * W * D
Cylinder	Volume = $\pi R^2 * L$
Cone	Volume = $(1/3) \pi R^2 * L$
Units must be consistent (all cm or all m).	

5.3 Applying Deduction Rules

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Table 5.2 - Summary of procedures for determining net factor for loss indicators.

Defect	Form	Method	Deduction area	% Sound of Deduction Area
1. Heart Rot Conk (DD_)	Cylindrical	Rule	4 m above conk 6 m below conk	50%
2. Root rot (DR_)	Conical	Rule	3 m	81%
3. Blind Conk (BNK)	Cylindrical	Rule	4 m above conk 6 m below conk	50%
4. Frost crack (NGC)	Other	Rule	extent of frost crack	calculated
5. Scar (SCA)	Rectangular	Calculate	extent of scar	calculated
6. Cat face (SCA)	Conical	Calculate	extent of scar	calculated
7. Fork (FRK)	Other	Rule	if decay present: 1 m below	50%
8. Crook (CRO)	Other	Rule	if decay present: 1 m below	50%
9. Rotten branch (LRB)	Cylindrical	Rule	1 m above 1 m below	50%
10. Dead top (DTP)	Other	Calculate	live crown to top of tree	calculated
11. Broken top (BTP)	Other	Rule	broken off portion remaining stem 1.0 m of decay below break, only if rot is visible at the break	00 00
12. Sounding (SNG)	Other	Calculate	various	calculated
13. Direct Observation (DIR)	Other	Rules	various	calculated
14. Other (OTH)	Other	Rules	various	calculated

1. Heart Rot Conk (DD _)

Inventory conventions assume that conk rot extends 4 m above the conk and 6 m below it. This is normally a 10 m log with a net factor of 50%.

For example, a tree with a conk at 12 m would be 6-100/10-50/99-100.

The rule for heart rot conk is as follows:

Table 5.3 - Deduction rule for Heart Rot Conk.

Form	Cylindrical
Method	Rule
Deduction area	4 m above conk; 6 m below
% Sound of deduction area (net factor)	50%

For multiple conks, where the lengths between conks are less than the 10 m minimum, decay is assumed to extend 4 m above the top conk and 6 m below the lowest conk. The length is given a net factor of 50%.

If you can measure more severe decay, pencil buck the affected portion and assign a greater net factor. This is done in at least 1 m increments.

Note: Other major defects, such as frost cracks associated with conk, can be assumed to be cylindrical in nature as well, with the same net factor.

2. Root Rot (DR_)

All root rots are assumed to be conical in nature. Unless otherwise observed, the inventory convention is that the cone of rot extends 3 m from the ground and that the ratio of the diameter of the rot to the diameter of the butt is 75% (¾).

The deduction (for the 3 m section) is a constant, with the net factor always equal to 81% for that section.

The rule for root rot is as follows:

Table 5.4 - Deduction rule for Root Rot.

Form	Conical
Method	Rule
Deduction area	0 — 3 m
% Sound of deduction area (net factor)	81%

Note that if a Schweinitzii butt rot (*Phaeolus schweinitzii*, DRS) fruiting body is observed above the ground on the main stem, then the rule is modified slightly: the first log should extend from the ground to 3 m above the highest DRS fruiting body, the standard net factor of 81% still applies.

Formula

$$\text{Net Factor \%} = \left(\frac{\text{volume of log} - \text{volume of decay}}{\text{volume of log}}\right) * 100\ \%$$

Shortcut Formula

Since the relative size of the defect is constant, the decayed percentage for the first 3 m is a constant of 19%. The simple form of the equation is:

$$\text{Net Factor \%} = 100\% - \left(19\% * \left[\frac{\text{length of decay}}{\text{log length}}\right]\right)$$

EXAMPLE
Log length: 3 m; Rot extends: 3 m Since the relative size of the defect is constant, the decayed percentage for the first 3 m is always 19%. Net Factor = 100%-19% = 81%

Figure 5.1 - Example of net factor calculation for Root Rot.

Note: An alternate net factor calculation to the one described above is to apply a standard 0.6 m length deduction [based on: (3.0 m rot section – 0.6 m length deduction) / 3.0 m log = 80%].

3. Blind Conk (BNK)

Interior and transition zones: typically bright orange rot is visible when knots are cut open.

Coastal zone: typically excessive swelling of the bole or a collapsed bole.

The rule for blind conk is as follows:

Table 5.5 - Deduction rule for Blind Conk

Form	Cylindrical
Method	**Rule same as conk**
Deduction area	4 m above conk; 6 m below
% Sound of deduction area (net factor)	50%

4. Frost Crack (NGC) Error! Bookmark not defined.

The rule for frost crack is as follows:

Table 5.6 - Deduction rule for Frost Crack.

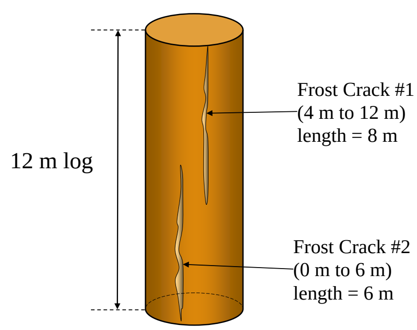
Form	Other
Method	Rule
Deduction area	Pencil buck at top and bottom of the series of frost cracks.
% Sound of deduction area (net factor)	Sum of frost crack length(s)/log length * 10%. Maximum deduction 40% (Net factor would be 60% sound).

EXAMPLE

log length: 12 m;

Two frost cracks are located as follows: 6 m long (from 0 m to 6 m)
8 m long (from 4 m to 12 m)

$$\text{Deduction} = \left(\frac{\Sigma \text{ crack lengths}}{\text{log length}}\right) * 10\%$$



Calculation of Net Loss Factor

$$\text{Net Loss} = \left(\frac{\Sigma \text{ crack lengths}}{\text{log length}}\right) * 10\%$$

$$= \left(\frac{8+6}{12}\right) * 10\%$$

= 12% volume loss

Net Factor = 88%

Figure 5.2 - Example of net factor calculation for Frost Cracks.

5. SCAR (SCA)

The rule for scar is as follows:

Table 5.7– Deduction rule for Scar.

Form	Rectangular
Method	Calculate
Deduction area	Extent of scar
% Sound of deduction area (net factor)	Calculated

Indicator is **present** and rot or missing wood is **evident**.

Calculate the net factor using one of the following two methods, depending on whether or not the depth of rot can be measured.

Method 1: When depth of rot can be measured (for example, butt scars)

Assume the scar is rectangular:

Volume of Decay = length * width * depth

Assume the log is cylindrical (diameter DBH for butt logs, midpoint for other logs):

Log volume = π * radius^2 * length

Formula

$$\text{Net Factor \%} = \left(\frac{\text{volume of log} - \text{volume of decay}}{\text{volume of log}}\right) * 100\ \%$$

Note: To have a net factor less than 90% is rare for a scar.

EXAMPLE	
log length: 10 m; diameter: 100 cm	
scar: length 10 m, width 20 cm, depth 10 cm	
1. Volume of Decay	= L * W * D (volume of rectangle)
	= 10 m * 0.2 m * 0.1 m
	= 0.2 m^3
2. Volume of Log	= $\pi R^2 L$ (volume of cylinder)
	= $\pi * (0.5\ m)^2 * 10\ m$
	= $3.14 * 0.25\ m^2 * 10\ m$
	= 7.8 m^3
3. Net Factor	= $\left(\frac{7.8 - 0.2}{7.8}\right) * 100\%$
	= $\left(\frac{7.6}{7.8}\right) * 100\%$
	= 97%

Figure 5.3 - Example of net factor calculation for Scar with known depth.

Method 2: When depth of rot cannot be measured

1. Estimate width and measure length of scar on log
2. Calculate circumference of log at the scar (π * D)
3. Calculate "decay length" deduction = $\frac{1}{2}\left(\frac{\text{width of scar}}{\text{circumference of log}}\right) * \text{scar length}$
4. Net Factor = $\left(\frac{\text{length of log} - \text{decay length}}{\text{length of log}}\right) * 100\%$

EXAMPLE

log length: 10 m; diameter: 60 cm; scar 6 m in length, 20 cm wide

Decay Length $= \frac{1}{2}\left(\frac{\text{width of scar}}{\text{circumference of log}}\right) * \text{scar length}$

$= \frac{1}{2}\left(\frac{20\text{cm}}{3.14 * 60\text{cm}}\right) * 6\text{m}$

= 0.32 m

Net Factor $= \left(\frac{\text{length of log} - \text{decay length}}{\text{length of log}}\right) * 100\%$

$= \left(\frac{10\text{m} - 0.32\text{m}}{10\text{m}}\right) * 100\%$

= 97%

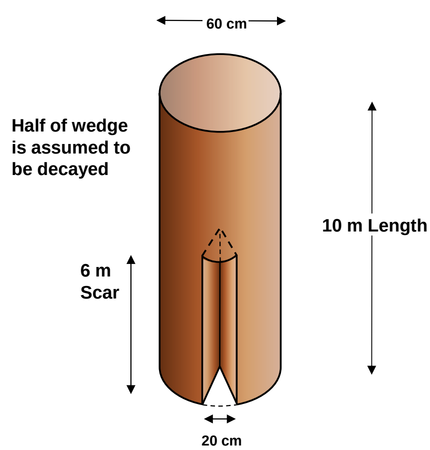


Figure 5.4 - Example of net factor calculation for Scar with unknown depth.

6. CAT FACE (SCA)ERROR! BOOKMARK NOT DEFINED.

The rule for cat face is as follows:

Table 5.8– Deduction rule for Cat Face.

Form	Cylindrical/Conical
Method	Calculate
Deduction area	Extent of Scar
% Sound of deduction area (net factor)	Calculated

Cat face is a scar (SCA) or missing section of wood that allows measurement of decayed or missing wood.

There are two methods of dealing with this form of internal decay, depending on whether the associated heart rot is cylindrical or conical in nature, and that decision must be made by the cruiser on-site.

Method 1: Formula for Cylindrical Defect

$$\text{Net Factor \%} = \left(\frac{\text{volume of log} - \text{volume of decay}}{\text{volume of log}}\right) * 100\ \%$$

Shortcut Cylindrical Formula

$$\text{Net Factor \%} = \left[1 - \left(\frac{(\text{radius of decay})^2 * \left(\frac{\text{length of decay}}{\text{log length}}\right)}{(\text{radius of log})^2}\right)\right] * 100\%$$

EXAMPLE
Cylindrical Defect

Log length: 10 m; Cylindrical cat face for 6.0 m

Sound wood = 20 cm (solid outer ring of wood)

Diameter = 200 cm (radius = 100 cm [1.0 m])

$$\text{Net Factor} = \left[1 - \left(\frac{(0.80\text{m})^2 * \left(\frac{6\text{m}}{10\text{m}}\right)}{(1.0\text{m})^2}\right)\right] * 100\%$$

$$= [1 - (0.384)] * 100\%$$

$$= 62\%$$

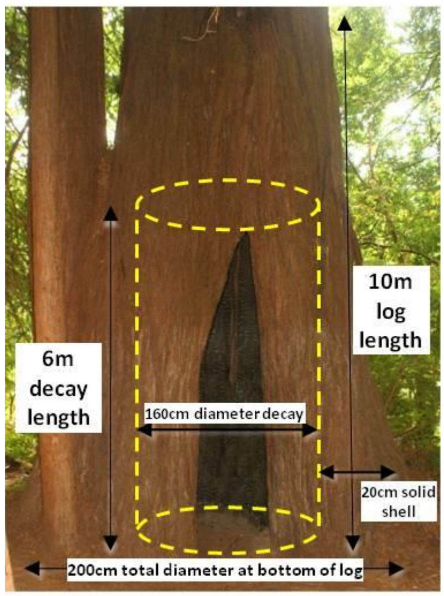


Figure 5.5 - Example of net factor calculation for Cat Face (cylindrical defect).

Method 2: Formula for Conical Defect

$$\text{Net Factor \%} = \left(\frac{\text{volume of log} - \text{volume of decay}}{\text{volume of log}}\right) * 100\ \%$$

Shortcut Conical Formula

$$\text{Net Factor \%} = \left[1 - \left(\frac{\left(\frac{1}{3}\right) * (\text{radius of decay})^2 * \left(\frac{\text{length of decay}}{\text{log length}}\right)}{(\text{radius of log})^2}\right)\right] * 100\%$$

EXAMPLE (Conical)
defect length not equal to log length

Conical cat face for **5.0** m of **8.0** m log

Sound wood 20 cm (solid outside radius, therefore 80 cm defective core)

Diameter = 200 cm (radius = 1.0 m)

$$\text{Net Factor} = \left[1 - \left(\frac{\left(\frac{1}{3}\right) * (0.8\text{m})^2 * \left(\frac{5\text{m}}{8\text{m}}\right)}{(1\text{m})^2}\right)\right] * 100\%$$

$$= \left[1 - \left(\frac{0.33 * 0.64 * 0.63}{1}\right)\right] * 100\%$$

= [1 – (0.13)] * 100%

= 87%

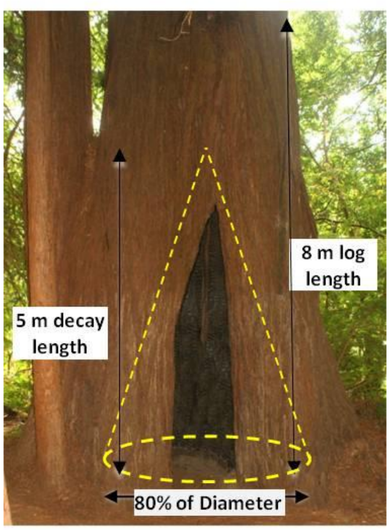


Figure 5.6 - Example of net factor calculation for Cat Face (conical depth).

Method 3: Uses table 5.9, butt rot guide for length deductions

1. Find the ratio $\left(\frac{\text{diameter of decay}}{\text{DBH}}\right)$
2. Use Butt Rot table for ratio of butt rot.

Note: to develop consistency in the net factoring process individuals should not interpret between the butt rot ratios. Determine the nearest ratio and apply the selected value.

3. Express length deduction as percentage of log length.

Another option of conical defect associated with butt rot is to use the butt rot guide for length deductions.

The Butt Rot Guide (Table 5.9) gives the conical butt rot ratios by log length. Deductions are based on rot/DBH ratio. Calculate the ratio to the nearest ¼ diameter, determine the deduction from the table below, and reduce the log volume by the deduction.

Table 5.9 - Butt Rot guide for length deductions.

Ratio	Length	Deduction
¼ diameter	2.0 m	0.2 m
½ diameter	4.0 m	0.4 m
¾ diameter	6.0 m	1.2 m
4/4 diameter	7.0 m	2.4 m

EXAMPLE

The butt rot length is not visible, therefore we need a process to determine deduction length.

Rot diameter = 55 cm; DBH = 102 cm; log length = 10 m

Ratio = $\frac{\text{diameter of decay}}{\text{DBH}} = \frac{55}{102} = \text{approximately } \frac{1}{2}$

Using the table, butt rot extends 4.0 m, and the deduction is 0.4 m length.

Net Factor = $\left(\frac{10 - 0.4}{10}\right) * 100\ \%$

= 96%

Figure 5.7 - Example of net factor calculation for Cat Face (using butt rot table).

7. Fork (FRK)

If decay is visible the rules for fork are as follows:

Table 5.10 - Deduction rule for Fork.

Form	Other
Method	Rule
Deduction area	1 m below
% Sound of deduction area (net factor)	50%

8. Crook (CRO)

If decay is visible the rules for crook are as follows:

Table 5.11 - Deduction rule for Crook.

Form	Other
Method	Rule
Deduction area	1 m below
% Sound of deduction area (net factor)	50%

9. Rotten Branch (LRB)

Larger rotten branches/knots ($\geq$ 10 cm inside bark) are a significant indicator of cylindrical rot.

The rule for rotten branches is as follows:

Table 5.12 - Deduction rule for Rotten Branch.

Form	Cylindrical
Method	Rule
Deduction area	1 m above the rotten branch; 1 m below
% Sound of deduction area (net factor)	50%

Note: For multiple, overlapping rotten branches/knots (less than 2 m apart), deduction extends 1 m above and below the series.

10. Dead Tops (DTP)

(Broken tops are handled separately.)

Dead tops are usually associated with sap rot, but rot must be visible before a net factor can be applied.

The rule for dead tops is as follows:

Table 5.13 - Deduction rule for Dead Tops.

Form	Other
Method	Calculate
Deduction area	From top of live crown to tree length
% Sound of deduction area (net factor)	Calculated

Note: Dry checked wood will not affect the sound wood content (net factor).

Sap rot depth is to be estimated at the midpoint of the dead top.

Formula

$$\text{Net Factor \%} = \left(\frac{\text{volume of sound cone}}{\text{volume of cone}}\right) * 100\ \%$$

Shortcut Formula

$$\text{Net Factor \%} = \left(\frac{\text{radius of sound wood}}{\text{radius of log}}\right)^2 * 100\ \%$$

EXAMPLE
Midpoint diameter 20 cm (10 cm radius) 2 cm depth of sap rot (giving 8 cm radius of sound wood) $\text{Net Factor \%} = \left(\frac{8\text{cm}}{10\text{cm}}\right)^2 * 100\ \% = 64\%$

Figure 5.8 - Example of net factor calculation for Dead Tops.

11. Broken (Missing) Tops (BTP)

The tree is net factored normally to the broken top (pencil buck at the break). No net factor (or log) is required for the missing portion of the tree.

Broken tops, particularly on hemlock and balsam, are usually associated with rot, but rot must be observed on the stem before a net factor can be applied.

Rot associated with logs below the broken top is assumed to run 1 m below the break.

Table 5.14 - Deduction rule for Rot Associated with Broken Tops.

Form	Other
Method	Rule
Deduction area	1 m below the break
% Sound of deduction area (net factor)	00

<u>Formula</u>

$$\text{Net Factor \%} = \left(\frac{\text{last log length} - 1.0\text{m}}{\text{last log length}}\right) * 100\ \%$$

EXAMPLE
Last log length is 10 m up to a broken top $\text{Net Factor \%} = \left(\frac{10\text{m} - 1.0\text{m}}{10\text{m}}\right) * 100\ \% = 90\%$

Figure 5.9 - Example of net factor calculation for Broken Tops.

12. Sounding for Decayed or Missing Wood (SNG)

“Sound” all measured trees in the Integrated Plot. Only if the tree gives a hollow sound, bore the tree with an increment borer on the side facing the plot centre and record the loss indicator “SNG.” Even if the boring does not reveal any decay, the “SNG” code is still left as recorded.

Decay discovered by boring will not be used for net factoring except in the case of sounded trees. For instance, discovering decay by boring a sample tree, which did not sound hollow, would not result in a deduction.

Measure the length of sound wood of the core bored from the sounded tree.

Determine the ratio of decay to tree DBH. If there are no other indicators, assume that the rot is conical in nature and apply the deduction in Table 5.9 Butt Rot Guide for Length Deductions.

13. Direct Observation (DIR)

Sometimes rot or missing wood can be observed directly without, but the cause is **not** known.

Use one of the methods described for the deduction rules above that best fits the decayed or missing wood observed.

14. Other (OTH)

Sometimes rot or missing wood can be observed directly, and the cause is **known**. However, there is no appropriate loss indicator code. ***Error! Bookmark not defined.***

Use one of the methods described for the deduction rules above that best fits the decayed or missing wood observed.

15. Multiple Defects

In general, the assignment of net factors to trees with multiple defects is left to the professional judgment of the cruiser, based on the net factoring procedures discussed here.

However, several concepts should be noted:

- Net factors less than 50% will only occur with severe:
  - cylindrical butt rot
  - sap rot
  - missing wood
- Severe frost cracks/scars associated with conk on the lower bole can be assumed to be connected and will result in a net factor of <50% (since the conk results in a 50% reduction for heart rot, and the frost crack results in a reduction in sound sap wood).
- Sound sections 3 m or longer between defects can be treated as separate logs. Sound sections less than 3 m are incorporated with the log section above or below.

EXAMPLE
of isolated section between defects

Conk at 12 m and 24 m. This creates a 2 m section between the defect areas, so we can combine all three sections into one log.

Deduction length = $2 \times (6 + 4) = 20$ m

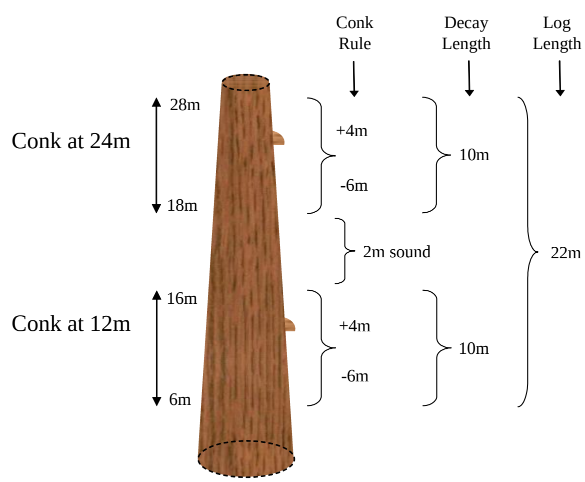
Log Length (from 6 m — 28 m) = 22 m

Conk Deduction 50% (of 20 m) = 10 m

Net Factor $= \left(\frac{\text{length of log} - \text{length of deduction}}{\text{length of log}} \right) * 100\ \%$

Net Factor $= \left(\frac{22\text{m} - 10\text{m}}{22\text{m}} \right) * 100\ \%$

= 54.5% Record as 55%



Note: If the upper conk were at 25 m, it would create a 3 m log between the two defects.. This would create three separate logs, each with its net factor (a more detailed description of the tree).

Figure 5.10 - Example of isolated sections between defects.

6. Remeasuring Samples

Introduction

This section is intended to highlight the differences in field procedures and circumstances when returning to and remeasuring a previously established ground sample. Much of the principles and general data remain the same between establishment and remeasurement, but the circumstances are more complicated for remeasurements, and thus the following clarifications need to be taken into account when remeasuring a sample.

Objectives

- To highlight the differences in ground sampling procedures for the remeasurement of samples (versus establishment, as covered in the preceding sections of this manual).
- To provide the field sampler with the logic and rationale necessary to make informed decisions about the data being collected in the inevitable cases of ambiguity.

6.1 Previous Sample Information

All information from the previous measurement will be provided in the digital sample file.

Some navigation information will be pre-populated for the current measurement from the data for the previous measure:

- Access Point GPS: Collect new coordinates if the Access Point has changed.
- AP -> IPC: This is derived and should not be adjusted.

6.2 Field Orientation and Navigation

Existing access notes and GPS coordinates should be used to navigate to the sample. Access notes need to be updated if there are any changes from the last visit.

Access Notes:

- Most previously established CMI and YSM samples will have access notes that appear with the distances as part of the text description, and with what should be single access note entries split between two or more consecutive entries. Example below:

ACCESS NOTES

Cum	Inter	Comments
0.0	0.0	START JUNCTION HIGHWAY 5 AND SHELL ROAD
0.0	0.0	IN BLUE RIVER, 0.0KM
0.0	0.0	HEAD NORTH FOR 59.3KM
0.0	0.0	TAKE RIGHT ON CLEMING CREEK
0.0	0.0	@ 2.7KM STAY RIGHT
0.0	0.0	@ 2.9KM STAY RIGHT

- The following actions are required for any access notes that appear this way in the ISMC remeasurement file:

- Enter the distance values into the appropriate “cumulative” column and delete the value from the text description. The “interval” column is a calculated value.
- Concatenate broken access note entries back into single entries
- Example of corrected notes below:

Cum	Int	Comments
0.0	0.0	Start Junction Highway 5 and Shell Road in Blue River. Head North for 59.3km
59.3	59.3	Turn Right on Cleming Creek
0.0	0.0	Reset to 0.0
2.7	2.7	Stay Right
2.9	0.2	Stay Right

- This is not an issue with PSP samples.

IPC Centre Pin:
- Locate the IPC pin and verify using stem map information that it is in the correct position.
- If the pin is missing, use the stem mapped trees and pictures (if available) to relocate the pin. The pin must be relocated to the original location as accurately as possible.
- Replace the pin if it has been damaged.
- Record notes about missing or damaged IPC pins.

Sample Disturbance:
- The sample may have been logged, burned, suffered significant blowdown, swept away by landslide, or some other catastrophic event.
- If the pin is not visible, look for nails on stumps that will indicate a stem mapped tree.
- A metal detector, previous pictures, and GPS coordinates will assist in relocation of the pin.
- Record notes as to how the pin was relocated.
- If there are no taggable trees present, yet there were trees at the last measurement, it is not a “Nil Tally” plot. The plot status will be “Collected”, and all the previous trees will need to have an appropriate Mode Code.

GPS Data:
- GPS data for the IPC must be collected.

6.3 Plot Re-Establishment

All plots are to be re-established as before, using the same radii and tagging limits:
- Tree Detail plots
    - Main fixed-radius plot for trees with the larger diameter tagging limit
    - Subplot fixed-radius plot for trees with the smaller diameter tagging limit
- Small Tree Dot Tally plot
    - Establish a 2.52 m, 3.99 m, or 5.64 m fixed-radius plot (as determined by the project specifications)

- Sample Tree plots
  - 5.64 m fixed-radius plot, at the IPC for the Top Height tree
  - 11.28 m fixed-radius plot quadrants for the other sample trees

6.4 Inventory Cruising

Tagging sectors should be re-established/verified. Ensure the magnetic declination is updated for the current year.

TAGGING TREES

All trees that met the minimum diameter criteria at the time of sample establishment will have had a tag attached at 1.3m above the base at high side. The tags will either face plot centre or face away from plot centre depending on the tagging sector they are in. Pull nails slightly to allow for future tree growth.

Standing tree with no tag:

- If it is obvious the tree met the diameter limit at the previous measurement, look to see if a tag is missing in the sequence. In most cases it will be obvious which tree it is. However, if more than one tag is missing, the DBH and species from the previous measurement data will be useful in determining the correct number. The standardized tagging sequence will also assist in identifying the correct tree number. The tree must be re-tagged with the same number it was in the previous measurement.
- If all trees are accounted for, it is either an ingrowth tree or was missed in the last measurement. If it is obvious the tree was missed at the previous measure, record a Mode of “M”, and collect the required attributes.
- All ingrowth tagged trees should be in sequence. The tag series to use for ingrowth will be supplied by the Ministry representative.
- If a tree is found very close to the edge of the plot without a tag and it seems obvious that it would have met the tagging limits at the last measurement, then it must be decided whether the previous crew missed the tree or if they determined the tree was out of the plot. First check for previous comments about borderline trees, and then accurately double-check the distance of the tree. If it is still not clear from the previous comments and distance measurements whether the tree was missed or measured as out, give the benefit of the doubt to the previous crew and call the tree out. This will have fewer negative impacts for the data.

Missing tags in sequence:

- If all standing trees have been accounted for and there are trees that have not been found, it means the tree is now fallen. Look for tags on dead fallen trees in the vicinity of where the tree would have been standing to verify.
- If the tree is found on the ground, mark it as dead fallen and collect all attributes.
- If the tree is not found, record a Mode of “N” and record the required attributes.
- In situations where there are significant numbers of trees on the ground, and it would take an unreasonable amount of time to identify and record attributes for all the downed trees, it is acceptable to not search for the missing trees and record them all as Mode “N”.

Ingrowth

- Ingrowth are defined as trees that have grown enough that they are now larger than the minimum tagging limits.
- All ingrowth are to be tagged in sequence with the tag series as specified by the Ministry representative.

TREE NUMBERS

Avoid renumbering trees (i.e., same physical tree with different tree numbers across time, or "one tree, two numbers"). This causes several down-stream issues in the database and for change monitoring. Best practices for various scenarios follow:

- If the original tag has gone missing or is unusable/unreadable, but you are *certain* of the tree number, attach a new tag of that same number. If you don't have that tag number available, use a buttersoft tag and inscribe that same number. If you don't have a buttersoft tag, write that same number on some flagging and make a comment that the tag is missing (accurate stem map information is very important here).
- If the previous tag has gone missing or is unusable/unreadable, but you are *not certain* of the tree number, then you must use the previous measured data (e.g., species, diameter, length, stem map, significant loss indicators, etc.) and problem solving skills to identify the tree number. If you still cannot reasonably attribute a previous tree number to the tree, then as a last resort use a tag from the series of ingrowth numbers provided and make a comment that it was previously measured but you could not determine the tree number. This should not be a common occurrence.

Avoid reusing tree numbers (i.e., same tree number applied to different physical trees across time, or "one number, two trees"). This also causes several down-stream issues in the database and for change monitoring. This happens after a major disturbance (e.g., fire, beetle attack, etc.) where some or all the previously tagged trees are gone, and a new cohort of trees grow into the tagging limit. This new cohort of trees *must* be tagged with *unique* numbers for this sample because they are unique trees, which is the reason we are now providing specified tag numbers to be used for ingrowth trees in all remeasurement samples.

TREE ATTRIBUTES

All tree attributes are to be collected as per the Procedures.

Accurate work is required when comparing new measurements with previous ones. Check growth measurements that appear to be out of the expected range, that is, measurements showing a very large increase or those showing little or no increase from the previous measurement to the new one. Record comments about measurements that appear to be out of the normal range.

Tagging Sectors:

- Only change sectors if there has been a significant error in assignment. Trees that are close to the boundary should be left as the original sector so as not to inadvertently influence sample tree selection.

Tree Species:

- Change species if the tree was incorrectly identified in the previous measurement.
- Enter a comment that the species was checked as an assurance the change is correct.

Status:

- If tree is "Live" and was incorrectly coded as "Dead" in the last measurement, change to "Live"

- If tree is "Standing" and was incorrectly recorded as "Fallen", change to "Standing"
- Enter a comment that the status was checked as an assurance the change is correct.

DBH:

- Always position the DBH tape just above the nail and perpendicular to the bole of the tree
- In the case where a DBH has decreased from the previous measurement:
  - previously Dead -> currently Dead: use previous DBH
  - previously Live -> currently Live: use current DBH
  - previously Dead -> currently Live: use current DBH
  - previously Live -> currently Dead: use current DBH if larger; else use previous
- Dead trees should never have a decrease in DBH from the last measurement

Broken Top:

- There will be instances where a tree with a previous broken top now has a leader that has taken over and the form of the tree is better represented by calling it a fork/crook.
- In this situation, record an "N" for broken top, take the length to the top of the new leader and record a fork or crook loss indicator.

Stem Map:

- Previous stem map information will be copied down to the current measurement.
- In 2022 the azimuth for the sector boundaries was changed. Due to this, there will be some instances for trees right on the sector line to have validation saying the tree is in the incorrect sector. In this case, change the stem map azimuth by a degree to keep it in the original sector.
- There is no need to redo the stem mapping for trees that have previously been stem mapped. However, all trees that are close to the 5.64 m and 11.28 m radius boundaries should be verified as to in/out status. These "boundary" trees will be the only previously stem mapped trees the Ministry will audit. Do not change stem map data for previously stem mapped trees unless it was significantly in error at the previous measure, as this can cause issues for data analysis.
- Similarly, do not call a previously tagged tree "out" if you check the stem map and find it to be out by a very small margin (e.g., a couple centimeters). Give the benefit of the doubt to the previous crew as the plot centre pin could have moved, etc. Significant/obvious stem map errors, could, of course, cause you to drop trees.
- All ingrowth trees must be stem mapped.

Mode Codes:

- Record any Mode code that applies to the trees.
- Mode codes mostly apply to remeasurement samples and are primarily used to account for missing or added trees.

Loss Indicators:

- Review original loss indicators to ensure they are still valid (do not blindly copy them)
- Record new, or missed, loss indicators as per the procedures.

Damage Agents:

- Review original damage agents to ensure they are still valid (do not blindly copy them). A damage agent from 5 or 10 years ago may no longer be present.
- Record new, or missed, damage agents as per the procedures.

Logs & Net Factor:

- All trees are to be net factored as per the procedures.
- Record a comment if there has been a significant change in the net factor compared to the previous measurement.

6.5 Sample Trees

- Sample trees are to be selected based on the current measurement data.
- Sample trees may change from the previous measurement.
- In most cases, if a sample tree was a sample tree in the previous measurement, the tree does not have to be redrilled for a new age. The measurement code will be PRE, no ages need to be recorded and the Bored Diameter and Bored Height should be left blank. The exceptions to this are if the previous measurement code for the tree was either WHO, CRC, NOC, or OUT.
    - WHO: drill the tree if it is now large enough to drill for age
    - CRC: In some cases, the CRC was applied because the crew did not have a bore long enough to reach the centre. The tree must be drilled again if the crew has an appropriate length bore.
    - NOC: drill the tree as it was not collected previously
    - OUT: drill the tree if large enough

6.6 PSP Specific Remeasurement Procedures

PSPs are very similar to CMI and YSM but do have several different requirements for plot setup and data collection as outlined below.

Small Dead Standing Trees

- PSPs do not require the remeasurement of trees <10cm DBH if they were dead at the previous measurement. These trees will be removed from the data download and will not be available for remeasurement. Tree tags may still be visible on these trees, but they can be ignored.

Tagging DBH Limits

- The main tree plot DBH limit is 4.0cm
- The subplot tagging limit is 2.0cm
- The small tree plot is the same as the CMI small tree subplot

Plot Shape

- Shape can either be circular (Type G) or square/rectangular (Type R). Plot size and tagging sectors are different for Type G vs Type R.

Plot Size

- Plot sizes are provided in the data and are not to be changed. In the rare case that a subplot size is not provided, the default size to use is 5.64m.
- Circular Plots (Type G)
    - Circular PSPs consist of a main circular plot and a nested circular subplot. The main plots can vary in size from 11.28m radius (0.04 ha) to 25.23m radius (0.2 ha). Subplots can vary in size from 1.78m radius (0.001 ha) to 17.98m radius (0.101 ha).
- Square/Rectangular Plots (Type R)
    - Plot sizes can range from 0.04 ha to 0.8 ha. There are varying combinations of length and width for the samples. Subplots also vary in size and can either be a fixed radius circular plot or be the same size as the main plot.

Tagging Sectors

- Tagging sectors are used to divide the plot into equal size portions. Tagging sectors aid with in-plot navigation as the sectors determine the direction the tags faced. Stem mapping of trees has replaced tagging sectors as an easier method to locate trees in the plot.
- Do not change tagging sectors on existing trees in the data.
- Tagging sectors are still required to be collected for ingrowth trees. Use the tagging sector number and tag direction of the nearest tree.
- Circular Plots (Type G)
    - Most plots were originally divided into 8 or12 pie-shaped tagging sectors, starting at either north or the tie line bearing. Odd numbered sectors have tags facing toward plot centre; even numbered sectors have tags facing away from plot centre.
- Square/Rectangular Plots (Type R)
    - The plots were originally divided into a variable number of strips (Figure 6.1). These strips (tagging sectors) aid with plot navigation as they determine the direction the tags face.

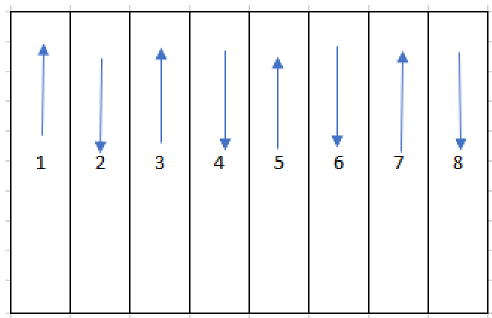


Figure 6.1 - Example of a rectangular plot with tagging sectors as strips.

Corner Posts

- Square and rectangular plots have posts/pins at the 4 corner positions. These corner posts must be relocated, flagged and stem mapped to the centre pin.

Loss Indicator Position

- Record the position for each loss indicator as occurring on the lower, middle, or upper third of the total height of the tree. The table below shows all the possible position combinations and the appropriate code to use.

Loss Indicator Position Codes	
Code	Position on Tree (tree is divided into thirds)
1	Lower third
2	Middle third
3	Upper third
4	Lower and middle third
5	Middle and upper third
6	Lower and upper third
7	All thirds

Small Tree Plot:

Third tally class has an upper limit of 2.0cm not 4.0cm.

Example of small tree dot tally			
Species	**Length**		
	10 to 29 cm	**30 cm to 1.3 m**	**> 1.3 m but < 2.0 cm @ DBH**
Cw	4	2	1
Hw	9	6	—
Fd	—	1	3

Sample Tree Selection

- Regardless of the plot size, or shape, the sample trees will only be selected from a virtual 11.28m radius plot centred on the plot centre stake. Trees that are outside the 11.28m radius will not be eligible to be selected as a sample tree.
- Stem mapping must be completed before the sample trees can be selected.

Provincial Monitoring British Columbia

Appendices to Ground Sampling Procedures

Appendix A: Damage Agent Codes

This section lists the damage agents which affect B.C. trees, with codes used in the VRI and monitoring (CMI, NFI & YSM) data gathering. This list of VRI Damage Agents is an updated list provided by the data custodian and is approved by the data custodian.

The first column denotes priority for being able to identify particular damage agents:

* = First/Highest priority
2 = Second priority
3 = Third/Lowest priority

Damage Agent Codes				
Field Codes			Description	
O	NO detectable abiotic or biotic damage			
U	UNKNOWN (Damage evident but causal agent unknown)			
*		UBT	Unknown Broken Top	
*		UCR	Unknown Crook	
*	UF		Unknown Fork Damage	
N	NON-BIOLOGICAL (ABIOTIC) INJURIES			
2		NAV	Avalanche or Snow Slide	
*	NB		Fire	
*		NBP	Post Burn Mortality	
*		NCA	Aspen (At) Decline	
*		NCB	Birch (E) Decline	
*		NCY	Yellow cedar (Yc) Decline	
2	ND		Drought	
2	NF		Flooding	
2	NG		Frost	
*		NGC	Frost Crack	
3		NGH	Frost Heaved	
2		NGK	Shoot/Bud Frost Kill	
2	NH		Hail	
3	NK		Fumekill	
2	NL		Lightning	
3	NN		Road Salt	
3	NR		Redbelt	
2	NS		Slide	
*	NW		Windthrow	
*		NWS	Windthrow - Soil Failure	
*		NWT	Windthrow - Treatment or Harvest-related	
*	NX		Wind scarring or rubbing	
2	NY		Snow or Ice (includes snow press)	
2		NYB	Snow or ice breakage	
2		NYP	Snow press	
2	NZ		Sunscald	
T	TREATMENT INJURIES			
2	TC		Chemical Injury	
*	TH		Harvested or Cut	
*	TL		Logging Wounds	
2	TM		Other Mechanical Damage (non-logging)	
3	TP		Planting (incorrectly planted)	

3		TPM	Planting (poor microsite)	
2	TR		Pruning Wound	
2	TT		Thinning or Spacing Wound	
V	PROBLEM VEGETATION			
3	VH		Herbaceous Competition	
3	VP		Vegetation Press	
2	VS		Shrub Competition	
*	VT		Tree Competition	
A	ANIMAL DAMAGE			
2	AB		Bear	
3	AC		Cattle	
2	AD		Deer	
2	AE		Elk	
2	AH		Hare or Rabbit	
*	AM		Moose	
3	AO		Pika	(*Ochotona* spp.)
2	AP		Porcupine	
*	AS		Squirrel	
3	AV		Vole	
2	AX		Birds	
2	AZ		Beaver	
D	DISEASES			
	DB		Broom Rusts	
2		DBF	Fir Broom Rust	*(Melampsorella caryophyllacearum)*
2		DBS	Spruce Broom Rust	*(Chrysomyxa arctostaphyli)*
	DD		Stem Decay	
3		DDA	White Mottled Rot	*(Ganoderma applanatum)*
*		DDB	Birch Trunk Rot	*(Fomes fomentarius)*
2		DDC	Brown Cubical Rot of Birch	*(Piptoporus betulinus)*
3		DDD	Sulfur Fungus	*(Laetiporus sulphureus)*
*		DDE	Rust Red Stringy Rot	*(Echindontium tinctorium)*
*		DDF	Brown Crumbly Rot	*(Fomitopsis pinicola)*
*		DDG	Sterile Conk Trunk Rot of Birch	*(Inonotus obliquus)*
*		DDH	Hardwood Trunk Rot	*(Phellinus ignarius)*
3		DDO	Cedar Brown Pocket Rot	*(Poria sericeomollis)*
*		DDP	Red Ring Rot	*(Phellinus pini)*
2		DDQ	Quinine Conk Rot	*(Fomitopsis officinalis)*
*		DDT	Aspen Trunk Rot	*(Phellinus tremulae)*
	DF		Foliage Diseases	
2		DFA	Western pine Aster Rust	*(Coleosporium asterum)*
2		DFB	Delphinella Tip Blight	(*Delphinella* spp.)
2		DFC	Large-spore Spruce-Labrador tea Rust	*(Chrysomyxa ledicola)*
2		DFD	Spruce Needle Cast	*(Lirula macrospora)*
*		DFE	Elytroderma Needle Cast	*(Elytroderma deformans)*
2		DFF	Marssonina Leaf Blights	(*Marssonina* spp.)
2		DFG	Cottonwood Leaf Rust	*(Melampsora occidentalis)*
2		DFH	Larch Needle Blight	*(Hypodermella laricis)*
2		DFI	Linospora Leaf Blotch	*(Linospora tetraspora)*
3		DFJ	Phaeoseptoria Needle Cast	*(Phaeoseptoria contortae)*
2		DFK	Septoria Leaf Spot	*(Septoria populicola)*
*		DFL	Pine Needle Cast	*(Lophodermella concolor)*
2		DFM	Larch Needle Cast	*(Meria laricis)*
3		DFN	Leptomelanconium Needle Blight	*(Leptomelanconium pinicola)*
3		DFO	Lophodermium Needle Cast	*(Lophodermium seditiosum)*

2		DFP	Fir Fireweed Rust	*(Pucciniastrum epilobi)*
2		DFQ	Alpine Fir Needle Cast	*(Isthmiella quadrispora)*
2		DFR	Douglas-fir needle cast	*(Rhabdocline pseudotsugae)*
*		DFS	Dothistroma Needle Blight	*(Dothistroma septosporum)*
3		DFT	Sirococcus Tip Blight	*(Sirococcus conigenus)*
2		DFU	Cedar Leaf Blight	*(Didymascella thujina)*
2		DFW	Swiss Needle Cast	*(Phaeocryptopus gaumanni)*
2		DFX	Brown Felt Blight	*(Herpotrichia* spp.)
3		DFY	Hendersonia Needle Cast	*(Hendersonia pinicola)*
3		DFZ	Rhizosphaera Needle Cast	*(Rhizosphaera kalkhoffii)*
	DL		Disease Caused Dieback	
3		DLD	Dermea Canker	*(Dermea pseudotsugae)*
3		DLF	Red Flag Disease	*(Potebniamyces balsamicola)*
3		DLK	Conifer Cytospora Canker	*(Leucostoma kunzei)*
3		DLP	Phomopsis Canker	*(Phomopsis lokoyae)*
3		DLS	Sydowia (Sclerophoma) Tip Dieback	*(Sclerophoma pithyophila)*
2		DLV	Aspen-Poplar Twig Blight	*(Venturia* spp.)
	DM		Dwarf Mistletoe	
2		DMF	Douglas-fir Dwarf Mistletoe	*(Arceuthobium douglasii)*
2		DMH	Hemlock Dwarf Mistletoe	*(Arceuthobium tsugense)*
2		DML	Larch Dwarf Mistletoe	*(Arceuthobium laricis)*
*		DMP	Lodgepole pine Dwarf Mistletoe	*(Arceuthobium americanum)*
	DR		Root Disease	
*		DRA	Armillaria Root Disease	*(Armillaria ostoyae)*
2		DRB	Black Stain Root Disease	*(Leptographium wageneri)*
3		DRC	Laminated Root Rot (cedar strain)	*(Phellinus weirii)*
*		DRL	Laminated Root Rot (Fd form)	*(Inonotus sulphurascens)*
2		DRN	Annosus Root Disease	*(Heterobasidion annosum)*
3		DRR	Rhizina Root Disease	*(Rhizina undulata)*
*		DRS	Schweinitzii Butt Rot	*(Phaeolus schweinitzii)*
*		DRT	Tomentosus Root Rot	*(Inonotus tomentosus)*
	DS		Stem Diseases (Cankers and Rusts)	
*		DSA	Atropellis Canker (Lodgepole pine)	*(Atropellis piniphila)*
1		DSB	White Pine Blister Rust	*(Cronartium ribicola)*
*		DSC	Comandra Blister Rust	*(Cronartium comandrae)*
2		DSE	Sooty Bark Canker	*(Encoelia pruinosa)*
*		DSG	Western Gall Rust	*(Endocronartium harknessii)*
2		DSH	Hypoxylon Canker	*(Entoleuca (Hypoxylon) mammatum)*
2		DSP	Cryptosphaeria Canker	*(Cryptosphaeria populina)*
2		DSR	Ceratocystis Canker	*(Ceratocystis fimbriata)*
*		DSS	Stalactiform Blister Rust	*(Cronartium coleosporioides)*
3		DST	Target Canker	*(Nectria galligena)*
2		DSY	Cytospora Canker	*(Cytospora chrysosperma)*
I	INSECTS			
	IA		Aphids	
2		IAB	Balsam Woolly Adelgid	*(Adelges piceae)*
3		IAC	Giant Conifer Aphid	*(Cinara* spp.)
2		IAG	Cooley Spruce Gall Adelgid	*(Adelges cooleyi)*
3		IAL	Larch (Lw) Cone Woolly Aphid	*(Adelges lariciatus)*
2		IAS	Green Spruce Aphid	*(Elatobium abietinum)*
	IB		Bark Beetles	
2		IBB	Western Balsam Bark Beetle	*(Dryocoetes confusus)*
2		IBD	Douglas-fir Beetle	*(Dendroctonus pseudotsugae)*
3		IBE	Silver Fir Beetle	*(Pseudohylesinus sericeus)*

2		IBF	Fir Engraver Beetle	*(Scolytus ventralis)*
2		IBH	Hylurgops Beetle	*(Hylurgops rugipennis)*
2		IBI	Engraver Beetles	*(Ips* spp.*)*
3		IBL	Lodgepole Pine Beetle	*(Dendroctonus murryanae)*
*		IBM	Mountain Pine Beetle	*(Dendroctonus ponderosae)*
2		IBP	Twig Beetles	*(Pityogenes, Pityophthorus* spp.*)*
3		IBR	Fir Root Bark Beetle	*(Pseudohylesinus granulatus)*
2		IBS	Spruce Beetle	*(Dendroctonus rufipennis)*
3		IBT	Red Turpentine Beetle	*(Dendroctonus valens)*
2		IBW	Western Pine Beetle	*(Dendroctonus brevicomis)*
	ID		Defoliators	
3		IDA	Black Army Cutworm	*(Actebia fennica)*
2		IDB	Two-year Budworm	*(Choristoneura biennis)*
3		IDC	Larch Casebearer	*(Coleophora laricella)*
3		IDD	Western Winter Moth	*(Erranis tiliaria vancouverensis)*
2		IDE	Eastern Spruce Budworm	*(Choristoneura fumiferana)*
*		IDF	Forest Tent Caterpillar	*(Malacosoma disstria)*
3		IDG	Greenstriped Forest Looper	*(Melanolophia imitata)*
3		IDH	Western Blackheaded Budworm	*(Acleris gloverana)*
2		IDI	Pine Needle Sheath Miner	*(Zellaria haimbachi)*
3		IDJ	Gray Forest Looper	*(Caripeta divista)*
*		IDK	Northern Tent Caterpillar	*(Malacosoma californicum)*
*		IDL	Western Hemlock Looper	*(Lambdina fiscellaria lugubrosa)*
3		IDM	Gypsy Moth	*(Lymantria dispar)*
2		IDN	Birch Leaf Miner	*(Fenusa pusilla)*
3		IDO	Filament Bearer	*(Nematocampa fiamentaria)*
2		IDP	Larch Sawfly	*(Pristophora erichsoni)*
3		IDQ	Hemlock Needle Miner	*(Epinotia tsugana)*
3		IDR	Alder Sawfly	*(Eriocampa ovata)*
3		IDS	Balsam Fir Sawfly	*(Neodiprion abietis)*
2		IDT	Douglas-fir Tussock Moth	*(Orgyia pseudotsugata)*
2		IDU	Satin Moth	*(Leucoma salicis)*
3		IDV	Variegated Cutworm	*(Peridroma saucia)*
*		IDW	Western Spruce Budworm	*(Choristoneura occidentalis)*
3		IDX	Large Aspen Tortrix	*(Choristoneura conflictana)*
3		IDY	Birch-Aspen Leafroller	*(Epinotia solandriana* (Linnaeus)*)*
3		IDZ	Western False Hemlock Looper	*(Nepytia freemani)*
3		ID1	Leaf Beetles	*(Chrysomela* spp.*)*
3		ID2	Bruce Spanworm	*(Operophtera bruceata)*
3		ID3	Winter Moth	*(Operophtera brumata)*
3		ID4	Cottonwood Sawfly	*(Nematus currani)*
3		ID5	Fall Webworm	*(Hyphantria cunea)*
*		ID6	Aspen Leaf Miner	*(Phyllocristis populiella)*
3		ID7	Woolly Alder Sawfly	*(Eriocampa ovata)*
3		ID8	Aspen Leaf Roller	*(Pseudexentera oregonana)*
3		ID9	Birch Leaf Skeletonizer	*(Buccalatrix* spp.*)*
2		IEA	Unidentified Aspen Defoliation	
3		IEB	Hemlock Sawfly	*(Neodiprion tsugae)*
3		IEC	Larch Budmoth	*(Zairaphera improbana)*
3		IED	Larch Looper	*(Semiothis sexmaculata)*
3		IEF	Cottonwood Leaf Skeletonizer	*(Phyllonorycytes apparella)*
3		IEG	Lodgepole pine Sawfly	*(Neodiprion burkei)*
3		IEH	Phantom Hemlock Looper	*(Nepytia phantasmaria)*
3		IEI	Saddleback Looper	*(Ectropis crepuscularia)*

3		IEJ	Willow Leafminer	*(Micrurapteryx salicifoliella)*
3		IEK	Rusty Tussock Moth	*(Orgyia antiqua)*
	IS		Shoot Insects	
2		ISA	Bronze Birch Borer	*(Agrilus anxius)*
3		ISB	Western Cedar Borer	*(Trachykele blondeli)*
*		ISC	Poplar Borer	*(Saperda calcarata)*
3		ISE	European Pine Shoot Moth	*(Rhyacionia buoliana)*
2		ISG	Gouty Pitch Midge	*(Cecidomyia piniinopsis)*
2		ISP	Pitch Nodule Moths	*(Petrova* spp.*)*
*		ISQ	Sequoia Pitch Moth	*(Vespamima sequoiae)*
3		ISS	Western Pine Shoot Borer	*(Eucosma sonomana)*
2		ISW	Poplar and Willow Borer	*(Cryptorhynchus lapathi)*
	IW		Weevils	
3		IWC	Conifer Seedling Weevil	*(Steremnius carinatus)*
3		IWM	Magdalis Species	*(Magdalis* spp.*)*
*		IWP	Lodgepole pine Terminal Weevil	*(Pissodes terminalis)*
*		IWS	White pine Weevil (on Spruce)	*(Pissodes strobi)*
2		IWW	Warren's Root Collar Weevil	*(Hylobius warreni)*
3		IWY	Cylindrocopturus Weevil	*(Cylindrocopturus* spp.*)*
2		IWZ	Yosemite Bark Weevil	*(Pissodes schwartzii)*

Appendix B: Damage Severity and Mortality Condition Codes and Standards

This section lists the damage severity and mortality condition standards for individual trees in the Vegetation Inventory Samples (also used on growth and yield permanent sample plots) with codes and description. **Error! Bookmark not defined.**

Damage Severity and Mortality Condition Codes and Standards		
Damage/condition or agent	**Severity code**	**Code Description**
Unknown Forks (UF) and Unknown Crooks (UCR)	M	Major fork or crook *(** see below for key info)*
	N	Minor fork or crook *(** see below for key info)*
Bark Beetles	FA	Failed Attack
	GR	Current (Green) Attack
	RA	Red Attack
	GY	Grey Attack
Elytroderma Needle Cast, Dwarf Mistletoes, Broom Rusts (see Figure below for details)	1, 2, 3, 4, 5, 6	Hawksworth's 6-class rating system
Terminal Weevils	Record:	
	C	Current attack only (no previous attack)
	O	Old attack (may also be current attack)
	and: below for 'O' only, if 'C' no further code allowed	
	M	Major crook
	N	Minor crook
	F	Forking
	S	Staghead
Stem rusts and cankers (see separate code table for YSM severities)	SC	Stem Canker(s)
	TK	Top-Kill
Root Rots	SC	Crown symptoms
	BR	Basal resinosis
	CS	Confirmatory symptoms (stain, decay, mycelia, rhizomorphs, or sporophores)

Damage Severity and Mortality Condition Codes and Standards		
Damage/condition or agent	**Severity code**	**Code Description**
Western Spruce Budworm	1-100	% current-year foliage defoliated, discoloured, or infected
Some Foliage Diseases (DFG, DFI, DFN, DFU, DFW)	1-100	% 2-yr-old foliage defoliated, discoloured, or infected
Western Pine Aster Rust	1-100	% 3-yr-old foliage defoliated, discoloured, or infected
All Other Foliage Diseases and Insect Defoliators	1-100	% all-years foliage defoliated, discoloured, or infected
Animals, Root Collar Weevils, Scarring, Sunscald, and some Treatment Injuries (TL, TM, TR, TT)	1-100	% circumference impacted
Drought, Hail, Fumekill, Road Salt, Redbelt, Aspen-Poplar Twig Blight	1-100	% live crown affected
Lightning	1-100	% bole length damaged
All other unlisted damage agents	[NULL]	No severity is allowed

Damage Agent: Rust and canker (DSB, DSC, DSS, DSG, DSA) in YSM samples only					
Infection Height (1st digit)		**% Encirclement (2nd digit)**		**'Branch' Indicator (3rd digit) Type-A samples only**	
Severity Code	**Ht. Range (m)**	**Severity Code**	**(% Encirclement)**	**Severity Code**	**Location**
0	0.0 – 0.5	0	1 - 5	B	on a branch
1	0.6 – 1.5	1	6 - 15	<null>	on main stem
2	1.6 – 2.5	2	16 – 25		
3	2.6 – 3.5	3	26 – 35		
4	3.6 – 4.5	4	36 – 45		
5	4.6 – 5.5	5*	46 – 55		
6	5.6 – 6.5	6	56 – 65		
7	6.6 – 7.5	7	66 – 75		
8	7.6 – 8.5	8	76 – 85		
9	8.6 +	9	86 – 100		

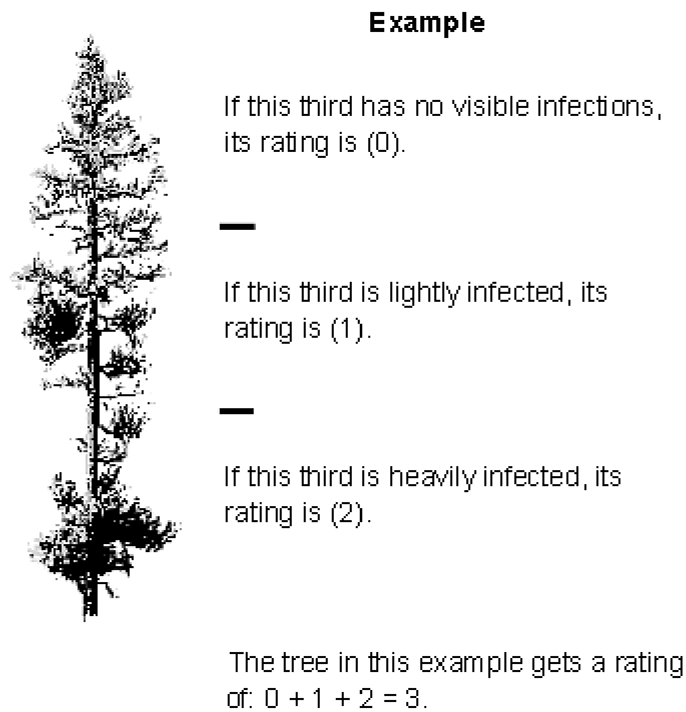
Damage Agent: Fire (NB, NBP)				
Wood Fibre Damage (1st column)			***% Scorch (2nd column)**	
Code	**Description**		**Code**	**Description**
O	No cambial or wood fibre damage		0	0% (no foliar scorch)
			1	1 - 15%
A	Cambial damage (i.e., more than scorched bark, but less than charred wood of a significant depth)		2	16 - 25%
			3	26 - 35%
			4	36 - 45%
B	Minor wood fibre damage (i.e., localized shallow charring)		5	46 - 55%
			6	56 - 65%
			7	66 - 75%
C	Major wood fibre damage (i.e., extensive shallow charring or localized or extensive deep charring)		8	76 - 85%
			9	86- 100%

***Foliar scorch only applies in the same year as the burn. Leave blank if visited more than a year after the fire.**

**** Severity Ratings for UF and UCR**
M (major): offset from the main stem is >= 50% N (minor): offset from the main stem is < 50%
NOTE: Any FRK or CRO that occurs in the portion of the main stem that is < 10 cm diameter is automatically an N (minor) severity NOTE: Select the severity that corresponds to the <u>most</u> severe occurrence of a UF and/or UCR
<u>Incidences to Ignore: (Do NOT call a FRK or CRO loss indicator for the following)</u> Potential FRK to be *ignored*: Spike branch with no to very little diameter loss or offset (~ < 10%) Potential CRO to be *ignored*: Very little diameter loss or offset (~ < 10%)

Hawksworth Scale for Elytroderma, Mistletoe Infection and Broom Rusts

Step 1:	Divide live crown into thirds according to stem length
Step 2:	Rate each third seperately. Give each third a rating of either as described below: (0) No visible infection (1) Light infection (1/2 or less of branches in the third infected) (2) Heavy infection (more than 1/2 of branches in third infected)
Step 3:	Add ratings of thirds to obtain a rating for the entire tree



All other damage agents require <u>NO</u> severity code.

Appendix C: Tree Species List

Conifers		
Species Code	**Common name**	**Scientific Name**
B	Fir (Balsam)	*Abies*
BA	Amabilis Fir	*Abies amabilis*
BG	Grand Fir	*Abies grandis*
BL	Subalpine Fir	*Abies lasiocarpa*
CW	Western Redcedar	*Thuja plicata*
FD	Douglas-Fir	*Pseudotsuga menziesii*
FDC	Coastal Douglas-Fir	*Pseudotsuga menziesii var. menziesii*
FDI	Interior Douglas-Fir	*Pseudotsuga menziesii var. glauca*
H	Hemlock	*Tsuga*
HM	Mountain Hemlock	*Tsuga mertensiana*
HW	Western Hemlock	*Tsuga heterophylla*
HXM	Mountain X Western Hemlock Hybrid	*Tsuga mertensiana x heterophylla*
JR	Rocky Mtn. Juniper	*Juniperus scopulorum*
L	Larch	*Larix*
LA	Alpine Larch	*Larix lyallii*
LT	Tamarack	*Larix laricina*
LW	Western Larch	*Larix occidentalis*
P	Pine	*Pinus*
PA	Whitebark Pine	*Pinus albicaulis*
PF	Limber Pine	*Pinus flexilis*
PJ	Jack Pine	*Pinus banksiana*
PL	Lodgepole Pine	*Pinus contorta*
PLC	Coastal Lodgepole Pine	*Pinus contorta var. contorta*
PLI	Interior Lodgepole Pine	*Pinus contorta var. latifolia*
PW	Western White Pine	*Pinus monticola*
PY	Ponderosa Pine	*Pinus ponderosa*
S	Spruce	*Picea*
SB	Black Spruce	*Picea mariana*
SE	Engelmann Spruce	*Picea engelmannii*
SS	Sitka Spruce	*Picea sitchensis*
SW	White Spruce	*Picea glauca*
SX	Spruce Hybrid	*Picea cross*
TW	Western Yew	*Taxus brevifolia*
YC	Yellow-Cedar	*Chamaecyparis nootkatensis*

Deciduous		
Species Code	**Common name**	**Scientific Name**
A	Aspen, Cottonwood Or Poplar	*Populus*
AC	Poplar	*Populus balsamifera*
ACB	Balsam Poplar	*Populus balsamifera ssp. Balsamifera*
ACT	Black Cottonwood	*Populus balsamifera ssp. Trichocarpa*
AT	Trembling Aspen	*Populus tremuloides*
AX	Hybrid Poplars	*Populus sp.x populus sp.*
DR	Red Alder	*Alnus rubra*
E	Birch	*Betula*
EA	Alaska Paper Birch	*Betula neoalaskana*
EP	Paper Birch	*Betula papyrifera*
EW	Water Birch	*Betula occidentalis*
GP	Pacific dogwood	*Cornus nuttallii*
KC	Cascara	*Rhamnus purshiana*
MB	Bigleaf Maple	*Acer macrophyllum*
QG	Gary Oak	*Quercus garryana*
RA	Arbutus [Aka Pacific Madrone]	*Arbutus menziesii*

Unknown	
X	Unknown
XC	Unknown Conifer
XH	Unknown Hardwood

Others	
Z	Other Tree Species
Zc	Other Conifer
ZH	Other Hardwood

The following species codes are no longer valid for 2024:

- Maples: M, MS, MV,
- Pacific Crab Apple: UP,
- Cherries: V, VB, VP, VV
- Spruce: SXW

Appendix D: Walkthrough Methodology – YSM Samples

Background

Young Stand Monitoring (YSM) monitors the performance of the 15–50-year-old population of stands to assess the accuracy of growth and yield predictions of key timber attributes in young stands.

When a YSM plot lands near a polygon boundary, the trees that are close to the polygon boundary do not have the same probability of selection as trees that are farther inside the polygon. There may also be trees within the plot that are outside the YSM polygon of interest. To deal with this issue the Ministry has chosen a modified "Walkthrough" method to reduce the bias associated with sampling near the edge of a polygon. All trees within the plot will be measured but the methodology will result in some trees being coded differently for compilation purposes.

General Procedures

1. Confirm plot is a Walkthrough sample.
2. Determine distance to boundary and bearing of boundary.
3. Enter data into the Walkthrough section on the handheld to determine walkthrough pin locations.
4. Place walkthrough pins in the ground at 11.28m from the plot pin at the calculated bearings.
5. Record trees in the affected area as either "W" for Walkthrough or "O" for Out of Polygon.

Detailed Procedures

1. Determine whether it is a Walkthrough Sample

A sample is considered a Walkthrough (WT) if the plot centre pin is within 22.56m of a polygon boundary **and** the other polygon is not a part of the 15–50-year-old target population. Examples would be if the adjacent polygon is mature, a new cutblock, or a mapped non-forest feature such as a lake. An unmapped road or unmapped mature patch within a large polygon would not require a WT.

The Ministry will make an initial assessment of whether the sample should be a WT and will include this information with the contract package. This assessment will be based on the intended sample location and the mapped boundary of the polygon in the database. The assessment will be either:

- Yes – it is a WT sample
- No – it is not a WT sample
- Possible – Distance to actual boundary needs to be verified on the ground

To assist determining the intended direction of a possible boundary, the provided digital pdf maps have the polygon lines and each polygon is labeled with its age.

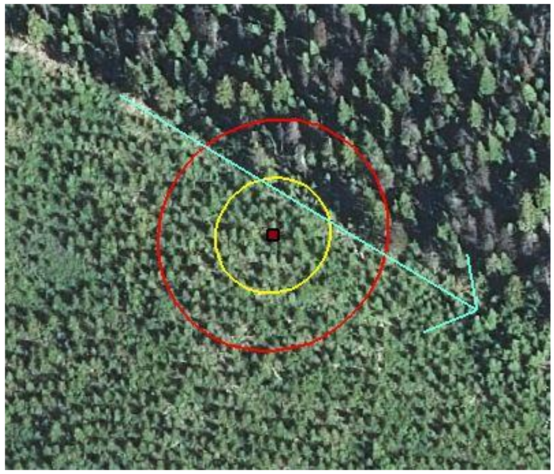
The final decision on whether it is a WT sample will always depend on the measured distance to the actual boundary as determined in the field. If it is determined to be a WT sample, then check the "Walkthrough Plot?" box on the Plot Cluster screen.

In the following example an 11.28m radius plot is shown in yellow and a 22.56m radius "affected" circle is shown in red. The sample will need to be established as a WT sample, as the plot centre is within 22.56m of the edge of the polygon. In this example, the 11.28m radius plot also crosses the polygon boundary.

2. Determine the distance to boundary and bearing of boundary

It is assumed that the polygon boundary is always a straight line. The cruiser must use their best judgement of where that boundary is. In cases where the boundary near the plot cannot be described by a single straight line, it may be a case where there are two or more boundaries and additional measurements are required and are listed in the section "Multiple Polygon Boundaries".

The bearing of the boundary is required for the data entry. The direction to take the bearing is based on looking to the right while standing facing away from the plot pin. In the example below, the blue arrow designates the direction to record the bearing of the boundary (126° for this example).



The field crew determines how close they are to the polygon boundary by measuring with a tape to the closest spot on the polygon boundary. Note that the angle between the polygon boundary and the plot centre MUST be 90 degrees when determining this distance.

In our example above, the distance from the IPC pin to the boundary is 7.59m and the bearing of the boundary is 126°.

3. Enter Data into Walkthrough Calculator

The Walkthrough screen requires the input of the distance to the boundary and the bearing of the boundary. The calculator will return either 2 or 4 bearings depending on the distance to the boundary.

If the boundary is closer than 11.28m there will be 4 bearings returned as shown in the example below.

		WalkthroughTree			
Bearing	Distance	Pin1	Pin2	Pin3	Pin4
126	7.59	106.3	325.7	83.7	348.3
0	0.00	0.0	0.0	0.0	0.0

If the distance to the boundary is greater than 11.28m there will be only 2 bearings returned as shown in the example below.

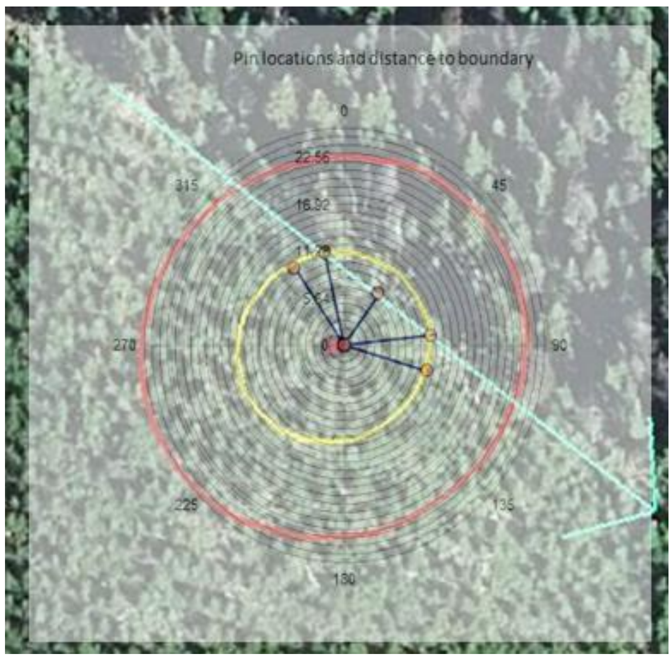
		WalkthroughTree			
Bearing	Distance	Pin1	Pin2	Pin3	Pin4
126	11.76	94.6	337.4	0.0	0.0
0	0.00	0.0	0.0	0.0	0.0

4. Place pins in the ground at 11.28m from the plot pin at the calculated bearings.

Pins are then located at these bearings at a distance of 11.28m from the plot centre.

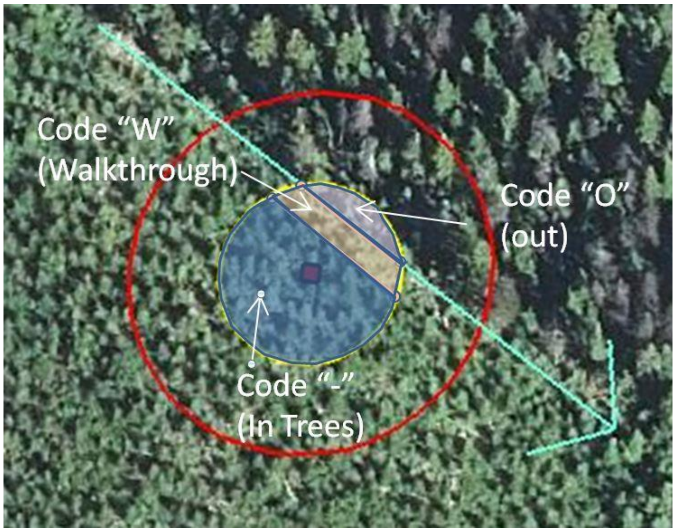
These samples will be remeasured many times and it is imperative that the boundary not fluctuate and include or exclude trees over time, simply because of minor differences of opinion on where the polygon boundary resides. These permanent pins are placed at the time of sample establishment and should not be adjusted.

The figure below shows the pin locations for the example with the boundary 7.59m from plot centre. (disregard the line at 90° to plot centre)



5. **Collect Walkthrough Data**

It is recommended that a field crew physically mark out the lines with a tape measure or string. In the 7.59m example two lines would be laid out, one between pins 1 and 2 and another between pins 3 and 4. The lines marked on the ground would look as follows.



In the Tree Data screen, the "Walk" field is used to record the walkthrough code for each tree. This field contains 3 separate codes:

- "-" – a tree that is not affected by the boundary
- "W" – a tree that falls within the "walkthrough" area
- "O" – a tree that falls outside of the target polygon

In the example above (with the distance to the boundary less than 11.28m), each tree in the area between the two lines will be assigned a code of "W". The trees within the plot radius beyond the second line will be assigned a code of "O". All other trees in the plot would have the default "-".

If the distance to the boundary is more than 11.28m, there will only be two pins established. The trees on the side of the line closest to the boundary would have "W" codes and all other trees would have "-" codes. There would be no "O" codes in this scenario.

If a pin cannot be placed due to an obstacle (IE large rock), place the pin in a close-by alternate location and record an offset bearing from where the pin is to the location where the pin "should be", but ensure the tape line is laid out in the field to the location of where the pin should be located.

Summary of Step-by-Step Instructions for Boundary Plots

1. Determine and record the distance to the polygon boundary at EXACTLY a right angle to the polygon boundary. If less than 22.56m, it's a Boundary plot, if greater than equal to 22.56m it's not.
2. If the sample is determined to be a walkthrough sample, check the "Walkthrough Plot?" box on the Plot Cluster screen.
3. Determine and record the polygon boundary bearing as per your back to the IPC, looking to the right (clockwise from the IPC)

4. Enter in the bearing and distance into the Walkthrough screen.
5. Establish pins at the edge of the 11.28m radius plot as per the bearings provided by the calculator. Record the bearing and offset distance required due to obstacles for pin location.
6. Mark the polygon and walkthrough areas using string or a tape measure by joining pins 1 and 2 and pins 3 and 4.
7. Record the appropriate walkthrough code on the Tree Data screen for each tree.

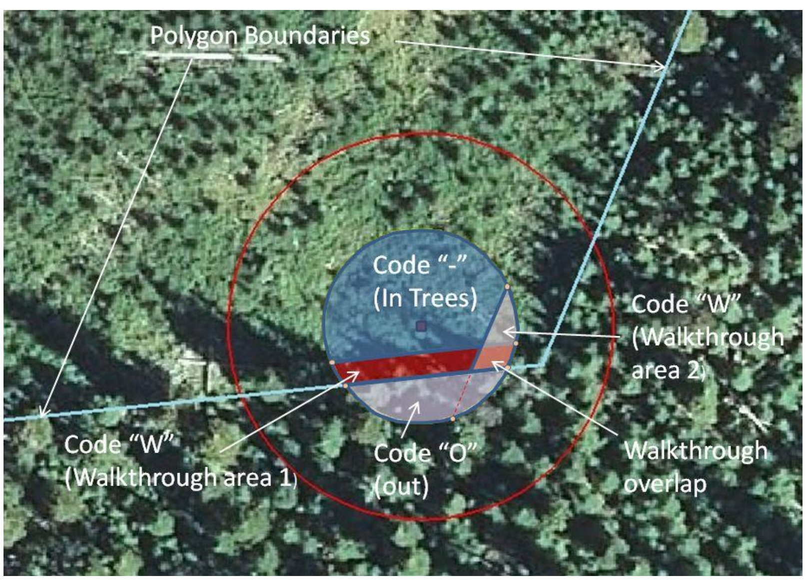
Multiple Boundaries

There are situations where there will be two or more boundaries that affect the sample. The same process is used, and each boundary is treated independently.

Dual Boundary Example:

Determine the boundaries and bearings separately as would be done with a plot that has a single boundary. Enter BOTH boundaries into the Walkthrough screen. Pins are placed at the edge of the 11.28m plot as identified in on the Walkthrough screen. Pin locations are shown as dots in the image below.

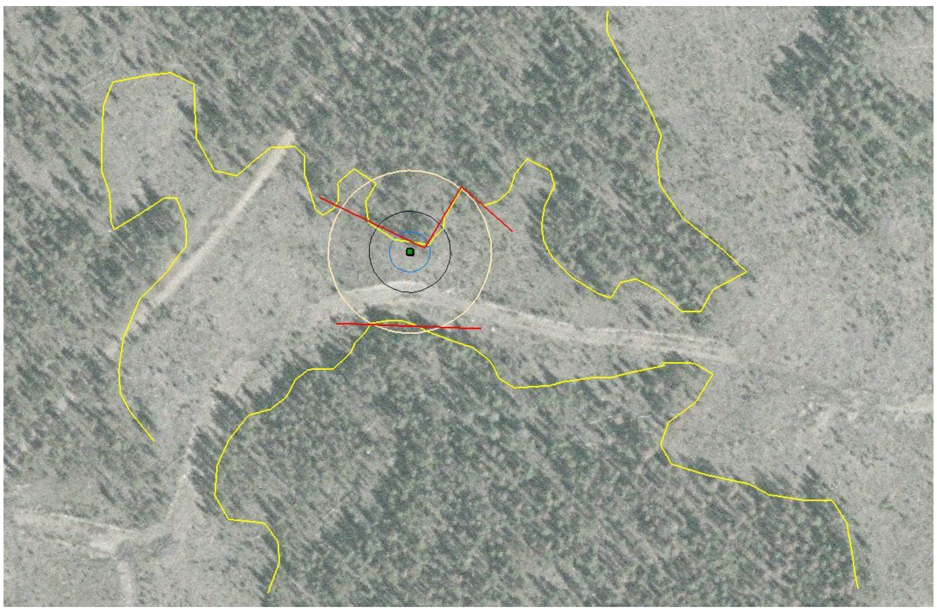
There are two separate walkthrough zones created in this example, one for each polygon boundary. There is an overlap area as well. Trees in this overlap are still only given a single "W" code and you do not have to enter the tree in more than once.



Complex Boundary Example:

Complex boundaries are established in the same way, each boundary is recorded separately in the handheld, and pins are still established to aid in tallying trees in future remeasurements. The example below is an actual sample location in the Williams Lake TSA. The 5.64m plot is shown in blue, the 11.28m plot in black and 22.56 m is shown in tan.

The first step in establishing a complex boundary walk through plot is to determine which boundaries are affecting the plot. As with a single boundary plot, we determine the straight line bearing and distance for each boundary. Below in red is an illustration of the straight line bearings that affect this plot.

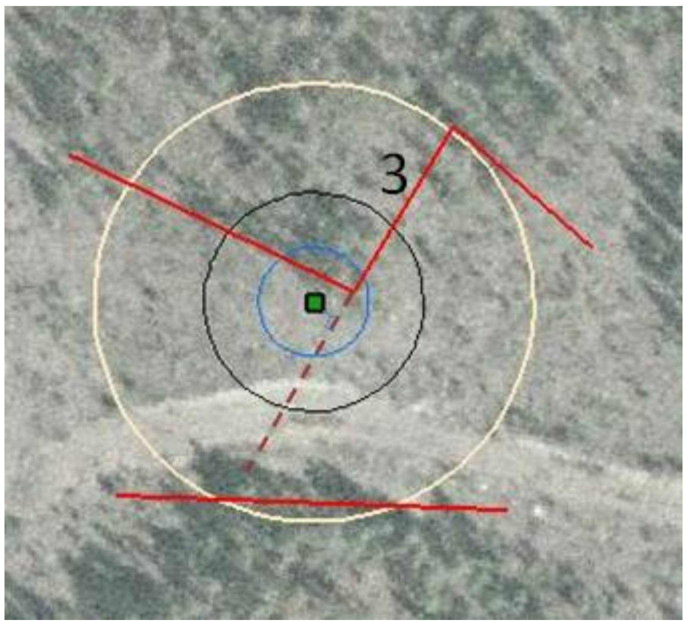


There are only three boundaries that affect this plot, the boundary on the North east side (4) is just outside of 22.56m.

Boundary number 1 is straightforward; the bearing is 280 degrees, and 18.8m at plot centre.

Boundary 2 was measured at 124 degrees, with a distance to the boundary of 0.54m. Note that even though this boundary does not extend all the way through the plot, we still record the boundary, and establish 4 pins (polygon boundary, and walkthrough) at the EDGES of the 11.28m radius plot. This will allow a future re-measurement crew to find the boundary pins easier, as they are at the edge of the 11.28m plot. The actual area that boundary measurements and walkthroughs are performed on does not extend through the whole plot, only up to where boundary 2 meets with boundary 3.

Boundary 3 bearing and distance is measured as an extension of the boundary to the south.



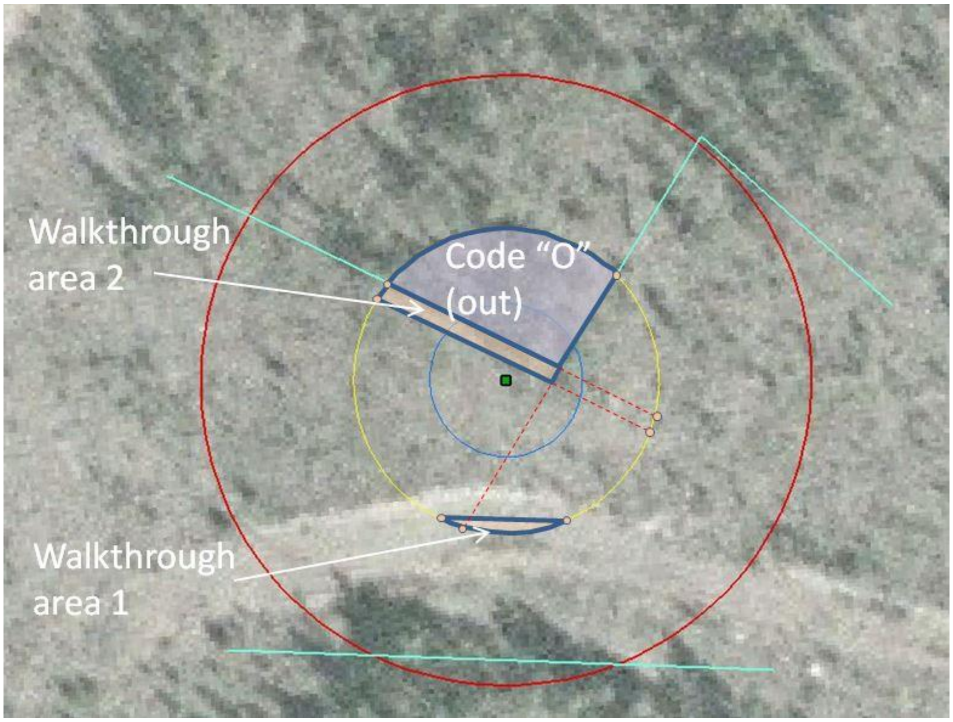
In the example above, extend boundary 3 to the south west and measure the right angle distance and bearing from the plot centre to the extended boundary (dashed line). Record this distance and bearing in the handheld. Note that a walkthrough boundary will be shown by the software, but that does not need to be staked for this boundary as the point in the boundary line that is perpendicular to the IPC is an imaginary line. We have EXTENDED the boundary for line three until it passes perpendicular to the IPC. Therefore will be no trees that have a “W” code that are associated with this particular boundary.

This boundary will be important for determining which trees are in and out however, as well as re-locating the boundary for future measurements.

The only points that need to be staked in the field for this boundary 3 is the actual boundary itself (noted as 11.28 in the software). Place the stakes at these bearings rather than the “actual” location of the boundary as we are recording the average straight line boundary.

The number of pins placed by boundary are:

- 2 pins for boundary 1 (walkthrough only),
- 4 pins for boundary 2 (walkthrough and polygon edge),
- and 2 pins for boundary 3 (boundary edge only). The walkthrough pins are areas are as shown below.



In complex boundary plots there may be the occasional boundary where a tree falls in the Walkthrough area, but it is NOT counted because when the distance from the IPC to the tree is doubled along the same bearing, the resultant point falls back IN the polygon. In this instance, we do NOT call the tree a walkthrough tree.

Appendix E: Modifications to Ground Sample Marking Procedures for "Hidden" Ground Samples

Introduction:

The CMI ground sampling procedures include extensive requirements for sample layout. These procedures may need to be modified in instances where samples or the access route fall within special management areas such as parks and recreation sites, private lands, or areas that are in high use by the public. The custodian of the lands in question (e.g. BC Parks, the private landowner, etc) should always be contacted to determine their specific requirements and to obtain permission to locate the sample. Consultation with the custodian will also help determine which of the modifications below need to be used. All samples located on private land or special areas of interest must:

a. have a signed agreement with the land owner on file

b. have a description of the agreed upon plot marking procedures signed and on file

The following document is intended to be used by Ministry representative, when planning sampling projects, as a guide on how to modify the sample marking procedures on such samples and how to go about relocating them for audits or other uses. In general, the modifications should not significantly affect the time it takes to establish a sample.

Modifications to marking procedures:

These modifications are intended to make the sample as “invisible” to a casual observer at the sample as possible. Some items such as soil pits are going to be somewhat visible regardless of procedure modifications.

1. Do not ribbon, spray paint, blaze or limb any tree on the sample, including the Access Point or reference tree. Crews may wish to temporarily hang a ribbon on trees in the sample cluster to aid in measurement and reduce confusion, but they must be removed prior to leaving the sample.
2. The route from Access Point tree to IPC location should not to be ribboned, and there must not be any ribbon at the IPC. Crews may place ribbon for use while at the plot (for example, to aid in estimating cover for ecological plots), but all ribbon must be removed prior to leaving the site.
3. The full length of all plot stakes is to be inserted into the ground, including the reference tree pin, and the IPC pin. The crews may wish to cut the pins in half to ensure that its entire length can be inserted into the ground or crews may want to carry a pipe cutter or hacksaw to custom cut the stakes to length on site. To assist relocation with a metal detector place a large iron nail inside the aluminum pipe (ensure the nail head is large enough to prevent the nail from sliding to the bottom of the stake). If appropriate a small cairn of rocks can be placed around the location of the stake.
4. CWD intersections are not to be painted or otherwise marked, but a stick or branch should be pushed into the ground at the end of each transect.
5. Additional effort to collect GPS positions in the field should be expended for the IPC and the Access Point.
6. If permitted, stem map nails should be placed.

7. Crews need to take a minimum of one picture (in addition to the regular VRI requirements) at the reference pin facing towards the IPC to aid in relocating the IPC. Any additional pictures that would aid in re-locating the IPC should be taken.
8. Tree tags should still be placed where allowed. If this is not possible, additional stem map information may need to be collected in the sample notes where it would be difficult for a re-measurement crew to determine which tree is a given number using normal tree numbering procedures (such as two trees side by side of the same diameter).
9. Record in the comments that the sample is a “hidden” sample, and briefly list the modifications to procedures. This will aid future crews to the sample in planning how to re-locate the IPC.

Suggested methods for re-locating the IPC for audit and re-measurement

Planning before leaving for the field will significantly reduce the time it takes to re-locate a hidden sample. The procedures listed below have been tested and the extra time to re-locate a hidden sample can be quite minimal given proper planning.

Samples where the Access Point is indistinct and/or the tie line is long may require the use of real-time corrected GPS. The crew re-visiting the sample should obtain the corrected co-ordinates for the sample before leaving for the field. Using the real-time GPS unit, the crew can navigate to the approximate location of the IPC pin, or offset as applicable. Real-time GPS is necessary on long tie lines as even a small change in bearing when re-chaining the line can result in the revisit crew being far enough away from the original IPC location that re-locating it could be impossible.

Once in the general area of the IPC, the re-visit crew should keep an eye out for tree tags if they have been placed (this should have been recorded in the original notes), soil pit, cairns, and plot centre pins (where allowed) which are the most visible signs of being near the IPC plot centre. If the reference tag is found, the crew should be able to find the reference pin using the reference tree details on the original Compass Card. If tree tags were placed originally, the direction of the tags will aid in the general location of the IPC, then check for stem map nails to accurately locate the IPC. Other clues to look for are the species in the area (such as, a lone spruce in the plot where the rest of the trees are pine), or an overly large tree in the plot. Using the sector these trees are in can help to locate the general area of the IPC. Increment borer holes on trees are another sign that you are in the vicinity of the IPC, and will be visible if the time between establishment and re-visit is not great enough to allow the scars to heal.

In situations where the plot centre stake has been buried, or if the placement of tags and nails was not permitted in the original establishment, re-location may require the use of a metal detector to determine the exact location of the plot centre. The metal detector can be used in a systematic way to cover the general area where the plot centre pin is located. Crews should ensure that they use a metal detector capable of identifying aluminum, as some are capable of identifying ferro-magnetic materials (iron) only. Most samples have been established with an iron or steel bolt inserted in the aluminum pin, but this may not always be the case. The user manual for a detector will tell what materials it can detect.

A metal detector “pin-pointer” is also useful to find tree nails and tags that may be buried in litter or overgrown by the tree. The pin-pointer can be quickly swept around the base of the tree to determine where to dig down and find the nail and tag.

Appendix F: Sampling and Enhancement of CMI Ground Samples for NVAF

The purpose of sampling and enhancement of the CMI ground samples is to tally a large set of trees for Net Volume Adjustment Factor (NVAF) sample tree selection purposes and to collect (enhancement) a set of tree attributes to allow for the estimation of net tree volume.

Sampling and enhancement for NVAF involves:

1. Enhancement of tallied trees in the auxiliary plots of VRI phase 2 sample clusters, or
2. Establishment of auxiliary plots from CMI samples and the enhancement of their tallied trees.

NVAF and the CMI Sample

For the CMI samples have been randomly selected for NVAF sampling, there are four departures from the regular CMI sampling procedures:

1. The establishment of two variable radius auxiliary plots from the CMI sample, where one plot is located exactly 100 m north and the other is preselected randomly to be 50 m either north, west or east of the first auxiliary plot.
2. The selection of a basal area factor using the standard VRI phase 2 procedure.
3. The tallying and enhancement of all standing trees with a DBH >= 12.5 cm. The standard suite of VRI tree attributes will be recorded for all tallied trees.
4. The collection of extra attributes describing tree conditions and general sample conditions to aid the stem analysis phase. These extra attributes are described below.

List of Extra Tree and Sample Attributes to Record

The non standard VRI attribute to collect is comments about individual trees on their extreme unsuitability as NVAF sample trees which would include the following:

- Major wildlife use, which includes eagle nests, bear dens and the like.
- Unsafe tree conditions that would imperil the faller.
- Site conditions that would prevent the tree once felled from being sampled, which include trees above bluffs and waterways.

Additional site and stand conditions, collected by the sampler, will facilitate the work of the destructive sampling crew. Useful information, in the form of comments, include descriptions of the general site conditions for the walk in and in and around the sample plots:

- Falling difficulty
- Sample access
- Terrain
- Brush
- Windfall and slash