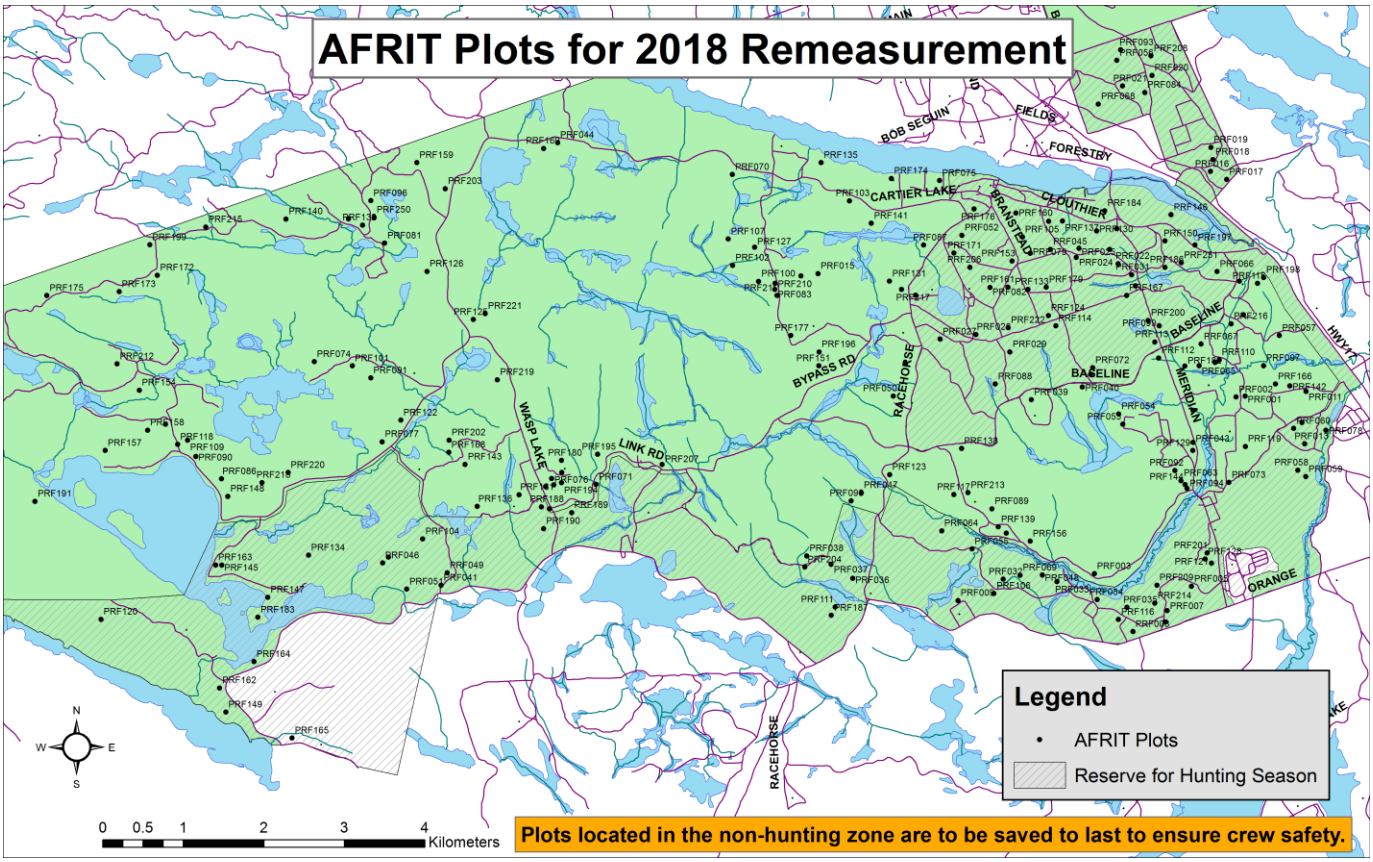
AFRIT SPL Field Plot Remeasurement Protocols for the Petawawa Research Forest - 2018



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1. Objectives

The overall objectives of this project are:

- To develop an area-based Single-Photon LiDAR (SPL) derived inventory for the Petawawa Forest that includes raster based predictions of stand attributes (measures of height, average tree size, volume/biomass, size-class distributions, etc.)
- To evaluate SPL LiDAR for individual tree crown segmentation and detection.
- To test the SPL derived digital terrain model product
- To validate the inventory predictions through the use of independent sampling

This manual pertains specifically to the first objective listed above. It will involve the remeasurement of a series of Temporary Sample Plots (TSP) originally established in 2013-2014 in support of an earlier LiDAR acquisition project. Additional new TSPs will be established to ensure complete coverage of the range of forest type conditions.
Responsibilities of Plot Locator

2. Plot Reconnaissance Responsibilities

The majority of these plots have not be revisited since they were established up to 5 years earlier. In some cases, their suitability for this project may have been compromised due to harvesting or natural events. As a result, an individual will have the responsibility of conducting a reconnaissance of the established TSPs and determining their status.

If the plots are determined to still be appropriate for this project their role will be to:

1. Update any map information to facilitate remeasurement crews clearly documented access route
2. If necessary, clear roads of fallen trees – or notify PRF operations manager of need to use equipment and skills of appropriate staff.
3. Replace flagging tape identifying route to plot centre
4. Carefully re-establish the plot centre post and freshen plot number on post and nearby tree.
5. Using the **TopCon™ GPS** unit – collect GPS centre post location (60 min static collection)
6. Collect **5** plot photos using the Ricoh Theta V 360 camera using the following protocol:
    a. Take a photo over the centre post (at a height of 2m above ground)
    b. At a position of **7m North** from the centre plot post – take a photo (at a height of 2m above ground)
    c. At a position of **7m East** from the centre plot post – take a photo (at a height of 2m above ground)

d. At a position of **7m South** from the centre plot post – take a photo (at a height of 2m above ground)
e. At a position of **7m West** from the centre plot post – take a photo (at a height of 2m above ground)
7. Establish the STP boundary by painting the forest floor at **3.99m** from plot centre.
8. Conduct small tree survey (See Section 4 – Small Tree Plot Assessment)

3. Plot Remeasurement Crew Responsibilities

The following section details the responsibilities and expectations of the plot remeasurement crews.

Plot Size & Shape

The project will use circular fixed-area plots of a nested design to facilitate efficient sampling (Figure 1):

- Large Tree Plot (LTP) with a radius of 14.1m (625m^2) that is used to measure trees **> 9.0cm**.
- Small Tree Plot (STP) with a radius of 3.99m (50m^2) that is used to measure trees **≤ 9.0 cm.**

For the establishment/confirmation of the LTP boundary a calibrated Haglof™ Vertex is to be used. For the establishment of the STP boundary a tape measure OR a calibrated Haglof™ Vertex is to be used.

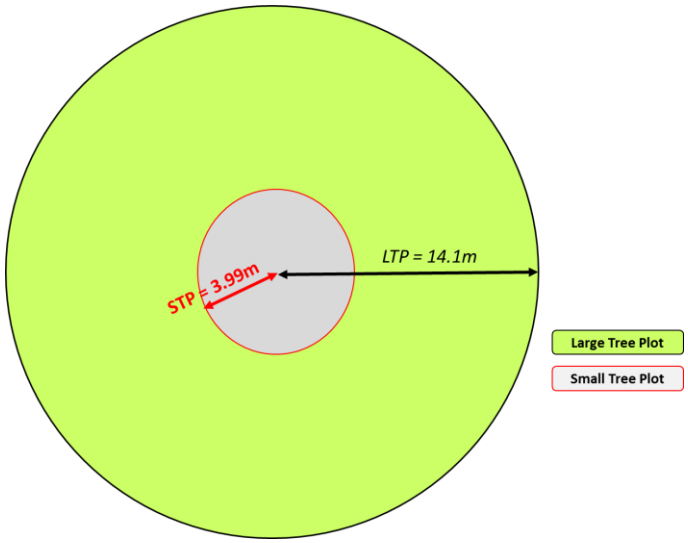


Figure 1 - Large Tree and Small Tree Plot Layout

4. Small Tree Plot Assessment (>= 2.5cm and < 9.0cm DBH)

All commercial tree species **>= 2.5cm and < 9.0cm DBH** will be assessed on the STP plot. Trees will not be numbered but will be tallied for species and DBH. Spray a dot of paint on each assessed stem. A random height sample will be conducted of a subset of the trees.

The trees will be recorded on the **Reconnaissance and STP Tally Form** (Appendix)

Random Height Sample of Small Tree Tally

Randomly select 5 trees from the small tree tally. You can use a random number table to assist the choice of trees or some alternative method to ensure no bias in tree selection.

5. Large Tree Plot Assessment (>9.0cm)

Live and Dead trees > 9.0 cm DBH will be measured for diameter and have additional attributes assessed. These include

- Status
- Species
- DBH
- Origin
- Crown Class
- Decay Class

Confirming Previously Measured Tree Attributes

Previously measured tree attributes are provided (Figure 2) to the field crew on the tally form to assist in locating numbered tree (in case paint has faded) and to confirm critical static attributes such as Species and Origin. If the field crew determines that an error was made previously in their assignment they are to cross off the attribute on the tally form and write in the correct description. ***Please only make this correction only when you and your crew member are confident in the change.***

AFRIT-SPL Large Tree Tally Form (DBH > 9.0 cm)

Plot:	PRF251		Meas. Date:	23-Jun-18		Crew:	John Smith
			Plot Size:	14.1m radius 625m^2			Todd Jones

Tree #	Spp	Status 2013	Origin	DBH 2013	Decay 2013	Ht 2013	Status 2018	DBH 2018	Crown 2018	Quality 2018	Decay 2018	Ht 2018	HLF 2018	Comment
1	1	L	N	43.4		31.8	L	44.5	C	AGS		33.0	21.0	
2	1	L	N	70.5		33.5	L	72.3	D	AGS		35	28	
3	2 1	L	N	50.8		32.6	L	52.1	C	AGS		35	23	

Figure 2 - Example of updating/completing information on the large tree tally form.

Remeasurement of Dynamic Tree Attributes

Dynamic tree attributes such as **Status** – **Origin** - **DBH** – **Crown Class** – **Decay Class** – **Height – Height of Live Crown** are to be remeasured and recorded on the LTP (Figure 2).

Tree Numbering

Tree numbers should be painted on the tree above breast height, facing the centre of the plot and numbered starting from the North position in the plot and moving clockwise, east-south-west and back to north.

Ingress

Measure all unnumbered trees (referred to as ingress) that may now have reached a diameter >9.0cm. Any tree that has reached a diameter > 9.0cm is to be added into the LTP. A number is to be assigned (based on the next available number referring to the previous measurement tree numbers. The tree is to be measured for all attributes: **Species – Status – Origin – DBH – Crown Class – Quality Class – Decay Class** (if Status is 'D'). A subset of these new trees may be later selected for height assessment (Height & Height of Live Crown)

Tree Species Codes

The following Ontario MNRF Growth & Yield Program **numeric** species codes will be used for tree species.

The tree species codes are presented in two ways: sorted by MNRF Code and sorted by Species Name Alphabetically

Sorted by MNRF Code

Tree Species Name	MNRF Code
White pine	1
Red pine	2
Jack pine	3

Sorted by Tree Species Name

Tree Species Name	MNRF Code
American beech	44
American elm	50
Balsam fir	20

Black spruce	13
White spruce	12
Norway Spruce	15
Eastern hemlock	19
Balsam fir	20
Northern white cedar	22
Larch	25
Sugar Maple	30
Red (soft) maple	32
Yellow birch	37
White birch	38
White Oak	40
Red oak	41
American beech	44
Black ash	45
White ash	46
American elm	50
Basswood	51
Ironwood	56
Black cherry	58
Largetooth aspen	70
Balsam poplar	73
Trembling Aspen	74
Unknown Species	**99**
Pin cherry	139
Willow	1086

Balsam poplar	73
Basswood	51
Black ash	45
Black cherry	58
Black spruce	11
Eastern hemlock	19
Ironwood	56
Jack pine	3
Larch	25
Largetooth aspen	70
Northern white cedar	22
Norway Spruce	15
Pin cherry	139
Red (soft) maple	32
Red oak	41
Red pine	2
Sugar Maple	30
Trembling Aspen	74
White ash	46
White birch	38
White Oak	40
White pine	1
White spruce	12
Willow	1086
Yellow birch	37
Unknown Species	99

Tree Status

Record the status of each tree < 9.0 Dbh. Tree status is used to evaluate the present condition of a numbered tree in the plot. **The determination of a tree's status always considers the tree from DBH and higher.**

The following codes are used:

L – Live D – Dead X – Fallen Down C – Cut/Harvested

A description of the codes are as follows:

Live (L)
A tree is considered live if it has one live needle/leaf or if the cambium is green at or above DBH.

Dead (D)
A dead standing/leaning tree is any dead tree that has a **DBH greater than or equal to 10.0 cm**, and is not lying on the ground at the time of plot establishment.

If a dead standing tree, whether fully connected at its base or not, and is leaning on or supported by another standing or leaning tree (alive or dead), consider it a standing dead tree.

Note: Dead trees that are lying on the ground within the plot boundary at plot establishment are not recorded on the LargeTree Tally Form.

Fallen (X) – Tree is coded as Fallen (X) if it has fallen to the ground and is not leaning on any other tree stems.

Cut/Harvested (C) – Tree is coded as cut/harvested (C) when a cut stump is located at the site of the tree. *During establishement of a plot (first time being measured) this code is not used.*

Tree Origin

Record the origin of the tree. Tree origin is a designation that describes how a tree was established. The following codes are used:

N – Natural **P – Planted** **C – Coppice** **L - Layering**

A description of the codes are as follows:

N - Natural
A tree of natural origin (e.g. single stem originating from seed or root suckering).

P - Planted
An artificially established forest seedling, transplant or cutting.

C - Coppice
Natural regeneration originating from the stump (usually clumped).

L - Layering
The rooting of an attached branch that is lying on or partially buried in the soil and is capable of independent growth after separation from the parent tree (most often used for black spruce and white cedar).

Diameter at Breast Height (DBH)

Record the DBH of all numbered trees using a diameter tape (to the nearest 0.1 cm).

DBH is measured at 1.30 m from the base of the tree at the point of highest ground height. Use a Dbh Stick (cut to 1.3m) to ensure consistent Dbh measurement height.

Use the following guidelines when measuring DBH:

- Gently remove excessive bark flakes and needles from the bole of the tree.
- Measure, using a DBH stick, 1.3 m from the point of highest ground contact.
- Measure diameter to the nearest mm.

Note individual tree diameters are important in this study; DBH should never be "guestimated".

Determining where to measure DBH

The base of the tree is defined as the point where the soil meets the air on the high side (uphill side) of the tree. When actually measuring the height to DBH, the field professional should firmly compress loose material at the base of the tree. *Neglecting to do this could alter the height to DBH measurement by as much as 10 cm.*

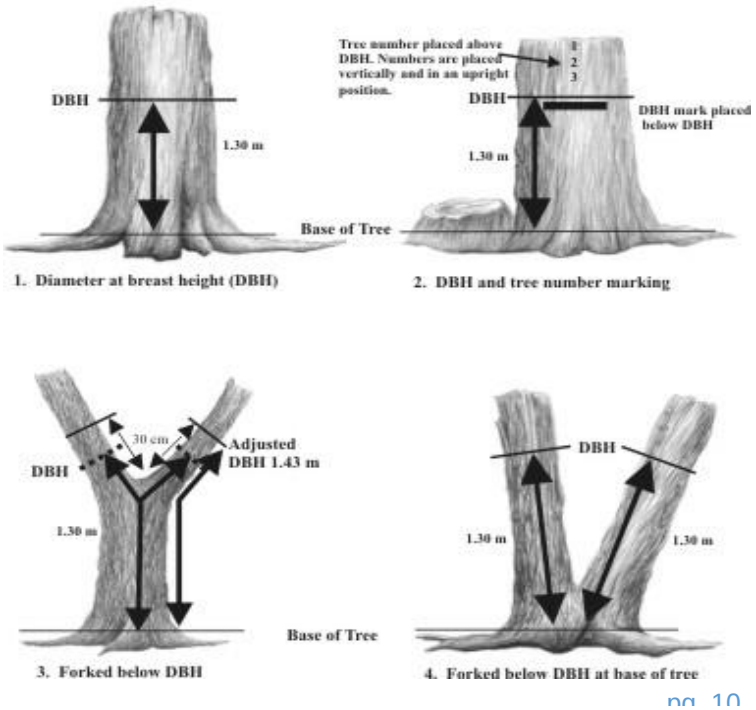
Guidelines for determining the height to DBH are:

If DBH occurs at a stem abnormality, adjust the height where the DBH is measured and record it on the tally form.

If the height to the DBH of any tree has to be changed by more than 20 cm, do not record the tree as a suitable tree for the height sample.

Where to Measure the Diameter on Trees with Abnormalities at DBH

The point on the tree where DBH is measured is important in ensuring that the basal area and volume that are calculated for any tree are in fact representative of the tree (Figure 3.1 and 3.2). Trees succumb to numerous wounds or abnormalities that can affect growth on all parts of the tree. If an abnormality occurs at 1.30 m or DBH, the resultant measurement will either underestimate or overestimate subsequent calculations of basal area and volume. It is also important to note that each tree measured in a 625 m^2 PSP represents 16 trees per hectare. An error in measurement on



Figures 3.1- 3.4. Diameter Measurements

one tree is an error made on 16 trees!

Use the following descriptions and Figure 3 when measuring DBH on trees that are:

Forked below DBH

Treat each forked stem with a DBH greater than or equal to 2.5 cm as an individual tree. Diameter should be taken at a point 30 cm above the crotch of the fork (Figure 3.3 & 3.4). If the new diameter position results in a stem that is less than 2.5 cm in diameter, tag the tree and record the new diameter.

Forked at DBH

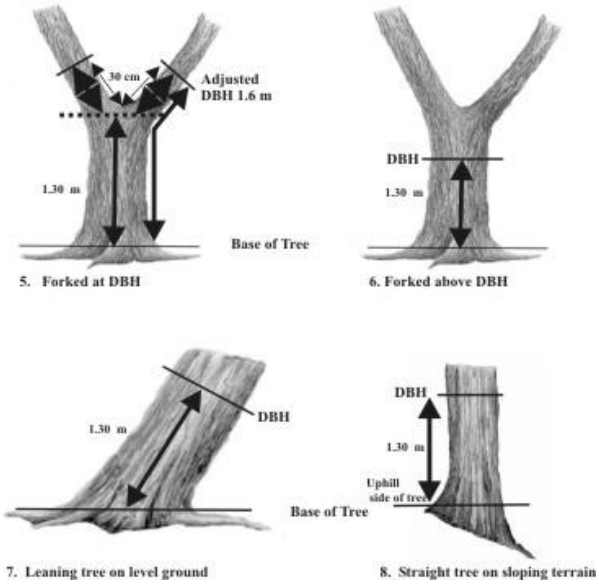
Move to a point above the fork where it no longer influences diameter growth (a minimum of 30 cm is suggested) and measure the diameter. Treat each forked stem with a diameter greater than or equal to 2.5 cm as an individual tree (Figure 3.5). If the new diameter position results in a stem diameter that is less than 3.5 cm, tag the tree and record the new diameter.

Forked above DBH

Treat as a single tree. If the fork has any influence on DBH at 1.30 m (perhaps due to fork swelling), move the diameter measurement point ***below*** the swelling but as close to DBH as possible (Figure 3.6).

Leaning tree on level ground

Measure to a point 1.30 m up from the base of the tree along the midline of the tree, relative to the ground (Figure 3.7).

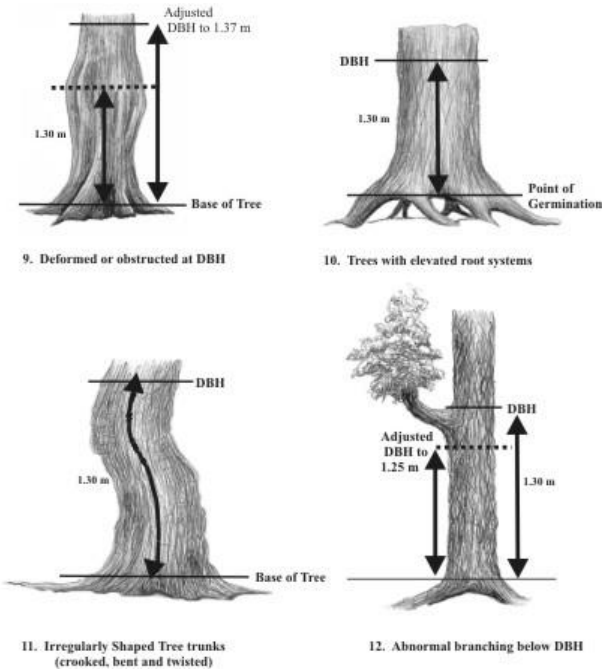


Figures 3.5 - 3.8 Diameter Measurements (continued)

Straight tree on sloping terrain

Measure at a point 1.30 m from the base of the tree on the uphill side of the tree (Figure 3.8).

Deformed or obstructed at DBH



Figures 3.8 - 3.12 Diameter Measurements

Deformities or obstructions at DBH include cankers, wounds, burls, fungus conks or whorls. Move to a point closest to 1.3 m (normally above the obstruction) to where it no longer influences the diameter. Measure the diameter at this location. Record the height at which the diameter was taken (Field D8). The obstruction should be identified by using the physical deformity type and cause codes. (Figure 3.9).

Trees with elevated root systems

The classic tree species that has an elevated root system is yellow birch. The situation arises when a seed germinates in a rotting tree stump. The result is shown in figure 3.10. The height to DBH is measured from the point of germination as opposed to the base of the tree.

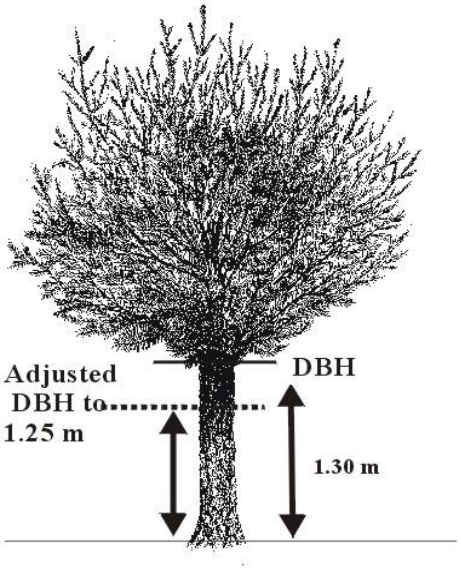


Figure 3.13. Diameter Measurements (continued)

Note: If a deformity is only expressed on one or two faces of a tree, use calipers and measure the DBH on the unaffected sides of the tree.

Note: Once a tree has been marked for DBH, the mark should be used at remeasurement unless the deformity has enlarged. If the deformity has grown (this would be identified by excessive diameter growth) move the DBH mark up to a point where there is no deformity. Describe the situation in the notes section.

Irregularly shaped tree trunks

Irregularly shaped tree trunks would normally be coded as “crooked, bent or twisted”. The height to DBH is measured from the base of the tree, along the midline of the tree, following the curvature of the tree (Figure 3.11).

Abnormal Branching below DBH (candelabra, stag or multiple leader)

Treat as a single tree with multiple branches. Move the diameter measurement point ***below*** the swelling caused by the defect but as close to DBH as possible (Figure 3.12 and 3.13). Record the height at which the diameter was taken.

Where to Measure Diameter on Abnormal Shaped or Broken Trees

In most cases, the following conditions will be observed on black spruce trees that have been bent by snow loading or ice damage. Growing portions of the tree are either close to or touching the ground and have the potential to develop roots. Because of the severe lean on the tree, lateral branches exhibit tree form. These branches are classified based on the following definitions:

One Rooting System

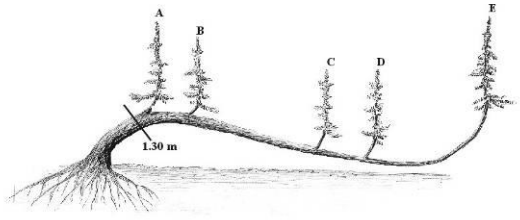
In Figure 3.14, a severely leaning tree has lateral branches above DBH that are exhibiting tree form. In this case A, B, C and D are all lateral branches of tree E are not tagged nor counted as trees.

Two Rooting Systems with Forks above DBH

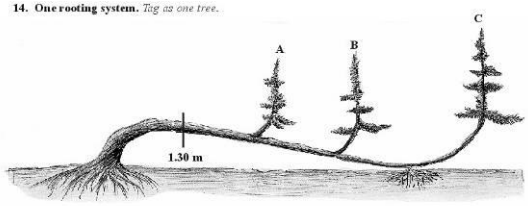
In Figure 2.15, a severely leaning tree has lateral branches above DBH that are exhibiting tree form. The top portion of the stem of the tree has made contact with the ground and has developed its own rooting system. A is a branch above DBH of tree B. Tree B is tagged. Tree C is tagged as a tree as it has its own rooting system.

Two Rooting Systems with Forks below DBH

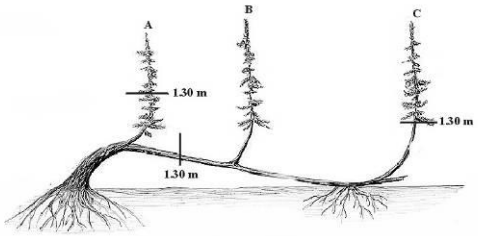
In Figure 3.16, a severely leaning tree has lateral branches below and above DBH that are exhibiting tree form. The top portion of the stem of the tree has made contact with the ground and has developed its own root system. Tree B is tagged and coded as a fork below DBH. Tree A is forked below DBH with tree B, and has a DBH greater than 2.5 cm. Tree A and is tagged as a tree. Tree C is tagged as it has its own rooting system and has a DBH greater than 2.5 cm.



14. **One rooting system.** *Tag as one tree.*



15. **Two rooting systems.** *Tag as two trees.*

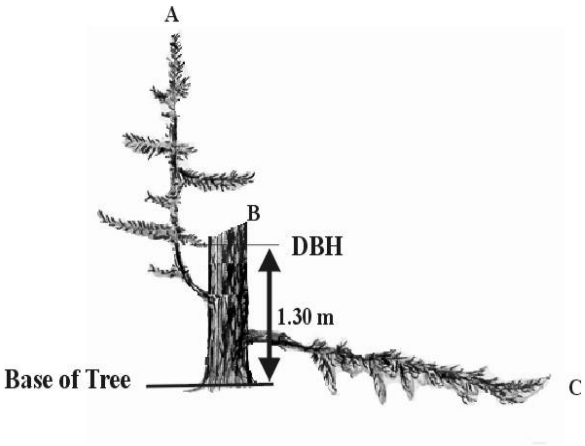


16. **Two rooting systems.** *Tag as three trees.*

Figures 3.14 - 3.16 Diameter Measurements (continued)

Broken Bole/Live Laterals

In Figure 3.17 the bole of tree B has been broken off at or above 1.30 m by wind or ice



17. **Broken bole with live laterals**

Figure 3.17. Diameter Measurements

damage. Tree A and B are tagged as trees. C is branch of tree B.

Crown Class

Record the crown class of live numbered trees. Crown class is a coding system defining individual tree crown characteristics (tree
position and vigour). Use the following descriptions to classify each tagged live tree in the plot.

The following codes are used:

C – Codominant D – Dominant E - Emergent I – Intermediate

OS - Overtopped/suppressed A – Anomaly

A Description of the codes follows:

Emergent (E)
Tree crown extends well above the general level of the crown layer and receives full light from above and from the sides. A tree in this class is much larger than the neighbouring trees and has a more fully developed crown. Emergent trees are usually older than the main canopy.

Dominant (D)
Tree crown extends above the general level of the crown layer and receives full light from above and partial light from the side.

Co-dominant (C)
Tree crown forms a part of the general level of the crown layer and receives full light from above but little light from the sides. Use this class when 2 or more trees of equal size are adjacent to one another.

Intermediate (I)
Tree that is shorter than its neighbours has a crown that extends into the neighbouring trees and receives direct light from above but not from the side.
Trees in this class usually have small crowded crowns on the side.

Overtopped/Suppressed (OS)
Tree crown is entirely below the general level of the crown layer and receives no direct light either from above or from the sides. Trees in this class normally display restricted height growth and may have elongated lateral branches, leaning terminal growth or flat topping.

Anomaly (A)
Trees that cannot be assigned a crown class due to anomalous situations (e.g. tree knocked over by skidder, windthrow etc.).

Decay Class

Use this code only when Status = D

Record the decay class of every standing dead tree that has been assigned a permanent tree number.

The following codes are used:

1 - Decay class 1
2 - Decay class 2
3 - Decay class 3
4 - Decay class 4
5 - Decay class 5

Decay class is a classification system designed to qualitatively categorize the degree of stem decay in dead standing trees Use the decay class descriptions in Table 1 and the diagrams in Figure 4 to assign the snag to the most appropriate class. Use this classification for both coniferous and hardwood species.

Table 1 Decay Class Description

DECAY CLASS DESCRIPTION

Decay class is a classification system designed to qualitatively categorize the degree of stem decay in dead standing trees Use this classification for both coniferous and hardwood species. All numbered dead trees will be assigned to one of the following classes:

Decay Class (1)

- recently dead, top is intact
- needles or leaves may still be attached
- bark is intact, fine branches present, heartwood is sound

Decay Class (2)

- top largely intact or has been lost as a result of physical damage due to wind and/or ice (i.e. not the result of decay)
- few fine branches
- greater than 50 % coarse branches remain
- bark may be loose, heartwood is sound

Decay Class (3)

- dead for a few years
- top is breaking up or has been lost as a result of physical damage due to wind and/or ice (i.e. not the result of decay)
- less than 50 % coarse branches and no fine branches
- bark may or may not have sloughed off
- incipient decay

Decay Class (4

- broken top
- few branch stubs, no coarse branches
- bark may or may not have sloughed off
- decay is present; spongy sections with a balance of softwood and hardwood

Decay Class (5)

- dead for several years
- top may have been repeatedly broken
- no branches, bark may or may not have sloughed off
- advanced decay; most of the remaining stem is soft or spongy with powdery sections
- height of remaining portion of tree (stub) is less than 6 m

Note: Decay Classes one through three will normally have a stem that is hard (sound). Decay Classes four and five will have a stem that is soft. If there is confusion when assessing dead trees use the branching and top characteristics as the deciding factors.

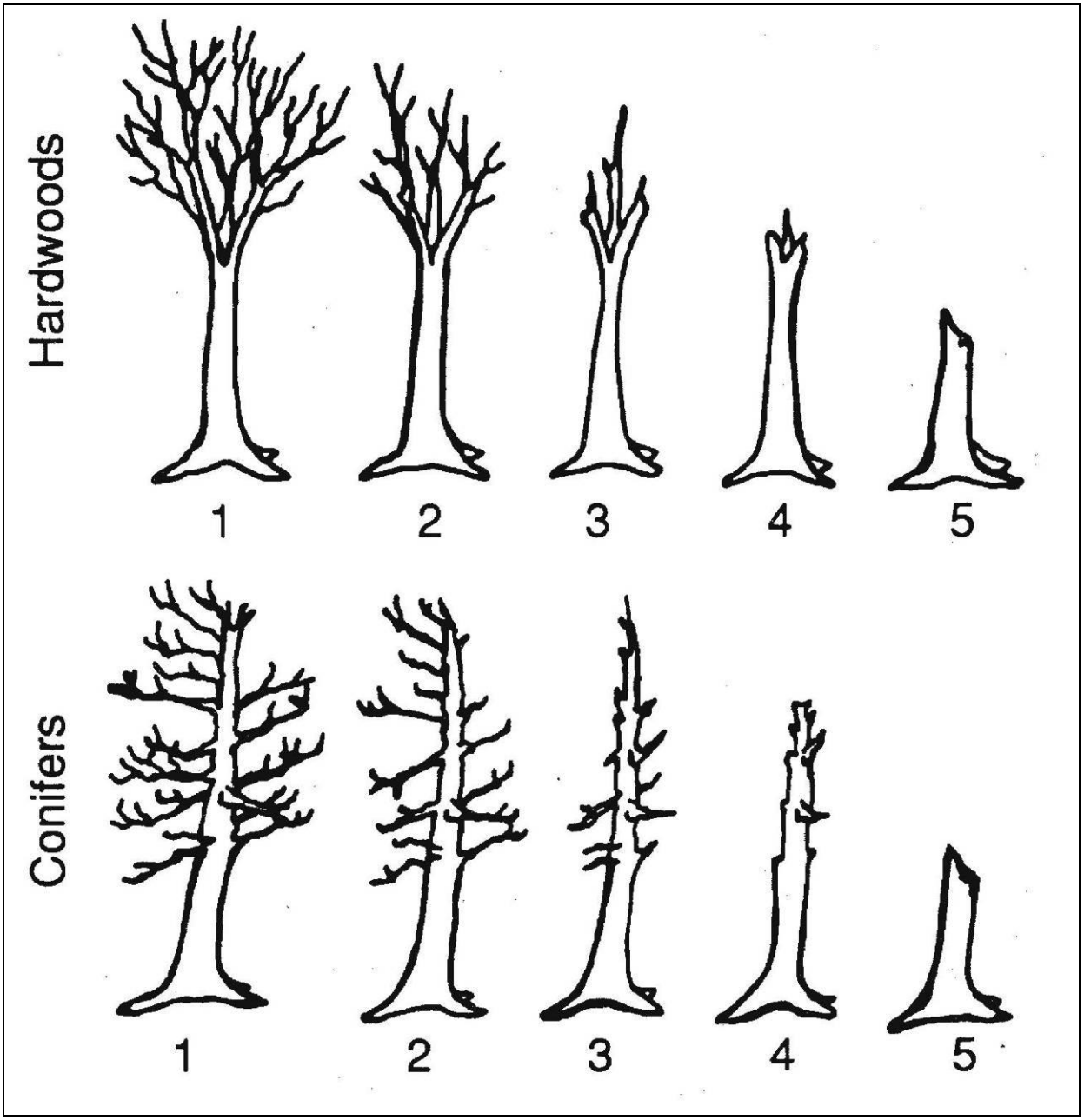


Figure 4 Decay Class Descriptions

6. Height Sample

Proper height measurement protocols using a VERTEX™ hypsometer are required and training methods must be employed by each crew member to ensure measurements are accurate.

Total Height measurements and Height to the base of live crown will be remeasured for all trees that were measured for height previously (refer to tally form). In some cases the term “add” has been added to the tally form in the previous height column to indicate that these trees should now be included for height assessment.

If a previously measured height sample tree has fallen (status= X), died (status = D) or has been harvested (status = C) a tree of the same species and diameter class will be selected for height. These trees should not exhibit a severe lean (>20 degrees), have a dead top, or expressing some other characteristic that makes them unrepresentative of the plot norm.

The **four largest trees** of the dominant plot species (determined ocular by the field crew and based on the assumed species basal area proportions) shall have height measurements taken. These trees should be eligible candidates (see conditions in paragraph above)

7. Height to Live Foliage

Each tree that was selected for height measurement requires a height to live foliage be measured and recorded.

What is the Height to the Live Foliage?

Height to live foliage is the vertical distance from the tree base to the lowest plane that continuous live crown exists. Scenarios and measurement protocols are provided in Figure 5.

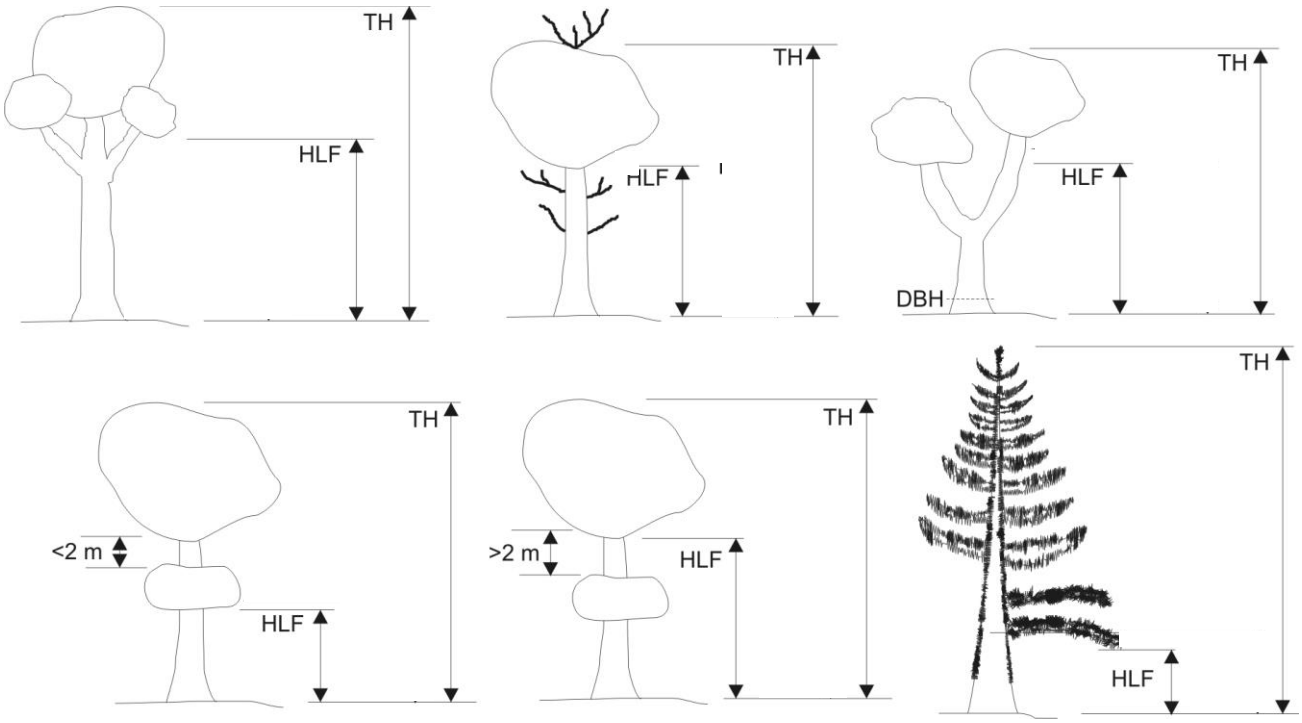


Figure 5 Measurement examples for Total Height and Base of Live Foliage. TH = Total Height. HLF= Height to Live Foliage.

8. Appendix - Tally Forms

AFRIT-SPL Reconnaisance and Photo Tally

Plot Number -	PRF	Date:	
Plot Radius -	14.1 m	Crew:	
Plot Area (m^2) -	625 m2		
Plot Status -	☐ Active	☐ Abandon due to disturbance	

Plot Photos

Take photos at a heigh of 2m above centre post and at a radius of 7m @ 2m high

Ricoh Theta V ☐ Vertical over above plot Centre ☐ North ☐ South ☐ East ☐ West

AFRIT-SPL Small Tree Plot Tally form (≥ 2.5cm - 9.0cm)

Plot Radius -	3.99 m	Notes -
Plot Area (m^2) -	50 m2	

Spp	Status	Origin	DBH	Height	Spp	Status	Origin	DBH	Height
	L					L			
	L					L			
	L					L			
	L					L			
	L					L			
	L					L			
	L					L			
	L					L			
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AFRIT-SPL Large Tree Tally Form (DBH > 9.0 cm)

Plot:	PRF207	Meas. Date:		Crew:	
		Plot Size:	14.1m radius 625m^2		

Tree #	Spp	Status 2013	Origin	DBH 2013	Decay 2013	Ht 2013	Status 2018	DBH 2018	Crown 2018	Quality 2018	Decay 2018	Ht 2018	HLF 2018	Comment
1	2	L	P	10.4		7.4								
2	2	L	P	10.6										
3	2	L	P	9.6		add								
4	2	L	P	14.8		11.2								
5	2	L	P	10.1										
6	2	L	P	9.6										
7	2	L	P	10.0										
8	2	L	P	11.1										
9	2	L	P	10.1										
10	2	L	P	13.0		add								
11	2	L	P	9.9										
12	2	L	P	11.5										
13	2	L	P	9.3										
14	2	L	P	9.1										
15	2	L	P	10.8										
16	2	L	P	17.8		11.8								
17	2	L	P	9.7										
18	2	L	P	9.9										
19	2	L	P	15.2										
20	2	L	P	11.8										
21	2	L	P	10.5										
22	2	L	P	11.7										
23	2	L	P	11.8										
24	2	L	P	16.9		12.4								
25	2	L	P	16.5		add								
26	2	L	P	13.5										
27	2	L	P	16.7		11.8								
28	2	L	P	9.2		add								
29	2	L	P	13.4										
30	2	L	P	11.2										
31	2	L	P	13.0										
32	2	L	P	11.0										
33	2	L	P	14.2										
34	2	L	P	17.2		11.9								
35	2	L	P	10.3										
36	2	L	P	16.0										
37	2	L	P	16.4		add								
38	2	L	P	15.0										
39	2	L	P	14.2										
40	2	L	P	12.6										
41	2	L	P	11.8										
42	2	L	P	12.3										
43	2	L	P	15.1										
44	2	L	P	14.3										
45	2	L	P	11.4										