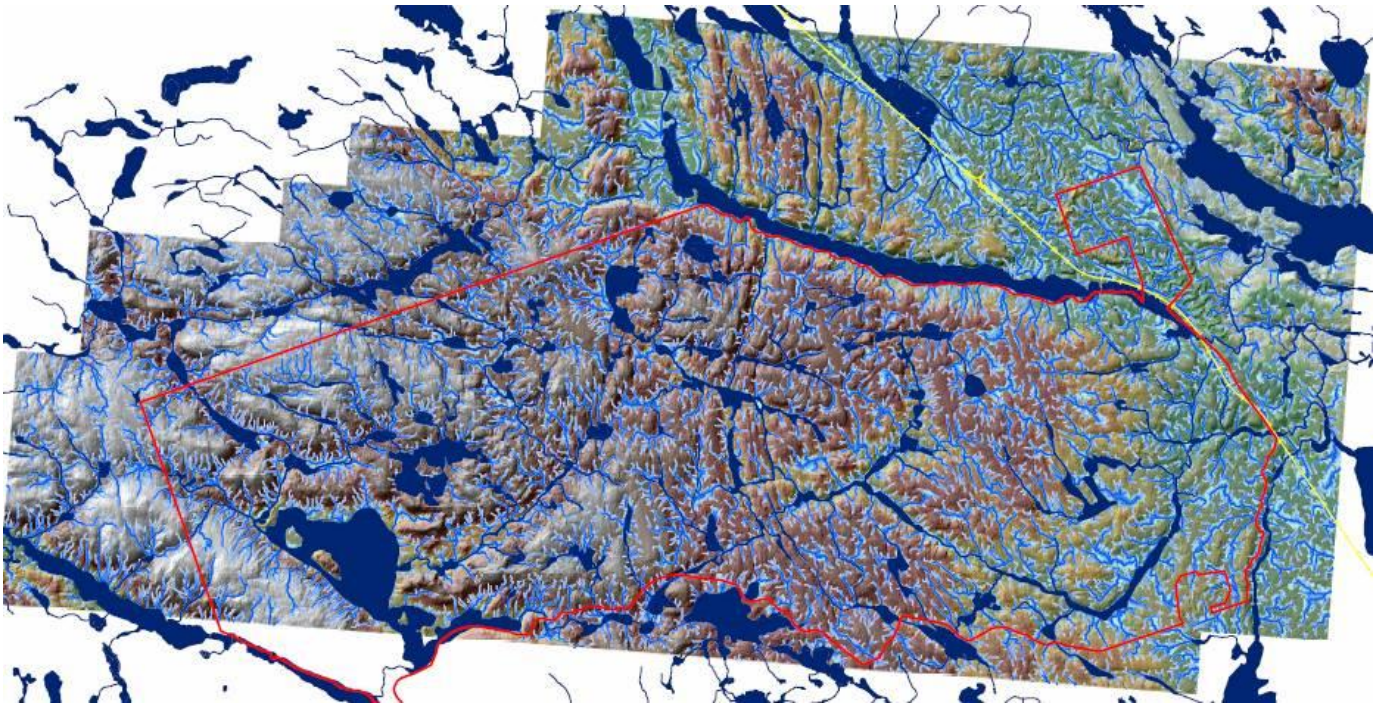
Field Procedures Manual for Plot Establishment in Support of LiDAR Derived Inventory for the Petawawa Research Forest

Modified June 9 2014 for 2014 Field Season



Murray Woods & Doug Pitt with enhancements by Margaret Penner , Peter Arbour, Leighton Winter & Len Lanteigne

June 9, 2014

Table of Contents

1 Objectives

The overall objectives of this project are:

- To establish and measure a series of geo-referenced temporary sample plots (tsp) within defined forest conditions (strata) for the purpose of model construction and validation.
- To, based on paired tsp and LiDAR data, develop forest-condition specific models that predict inventory parameters (e.g., stand height, average tree diameter, merchantable stem volume, stem density etc.) from airborne LiDAR data for the Petawawa Research Forest (PRF).
- To validate predictions in based on independent sample plot data.

This manual pertains specifically to the first objective above. Stratification for sampling was based on input/knowledge from local forest management staff at the Petawawa Research Forest and is structured to define meaningful forest types that we expect will require unique LiDAR prediction equations.

2 Stratification

Forest type (FT) strata were identified and prioritized by Petawawa Research Forest (PRF) management staff working with the project team. A total of 15 strata were identified. It is paramount that the full range of strata conditions be sampled to permit comprehensive model development. To accomplish this, ranges of height and stocking (from here on called Development Stage (DS) are included in the stratification matrix (Table 1).

3 Plot Location

3.1 Candidate Sampling Areas and Plot Identification

In an ideal world, the FT development stage combinations outlined in Table 1 would be mapped across the PRF and our model building and validation exercise would be accomplished by simply drawing samples at random from within each of the resulting strata. However, the absence of mapped strata and the need to minimize costs force us to use an approach that involves more *subjective* than *random* plot location. Through this process, however, **we must still end up with a series of plots that represent, in an unbiased fashion, the forest types outlined in Table 1, across the full range of conditions encompassed by the forests of PRF.** Given this goal, our modified approach will consist of 1) identifying candidate *sampling areas*, 2) field verifying the sampling areas, and then 3) locating sample plots within the sampling areas.

Table 1 - Plot stratification for the Petawawa Research Forest

	Forest Strata	Species	Priority (precision)	2-5m			6-15m			16-30			31+			Total
	we			Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	
	Stocking (Density or Ba)															
Plantations	PjPlant	Pj	Medium	2	2	2	3	3	3	3	3	3	3	3	3	33
	PrPlant	Pr	High	2	2	2	2	3	3	4	4	4	4	4	4	38
	SwPlant	Sw												3	3	33
	LaPlant	La														6
	PwPlant	Pw	Low	2	2	2	2	2	2	2	2	2	2	2	2	24
Natural Stands	TolHwdMix	Mh/Be/Bd/By	Medium	3	3	3	3	3	3	3	3	3	3	3	3	36
	Or	Or>=4	Medium	3	3	3	3	3	3	3	3	3	3	3	3	36
	Intolhwd	Po>=7 /Bw>=7 OR Po+Bw >=7 Get at least one Bw and one Pt in each cell	Medium	3	3	3	3	3	3	3	3	3	3	3	3	36
	LowlandHwd	Ab	Very Low	1	1	1	1	1	1	1	1	1				9
	LowlandCon	Sb/Ce	Very Low	1	1	1	1	1	1	1	1	1				9
	Pine	Pr>=7 or Pw >=7 or Pr+Pw>=7	High	3	3	3	3	3	3	4	4	4	4	4	4	42
	PineMix	Pw/Pr/Pj/Sw/Ms/Bw/Or	High	3	3	3	3	3	3	4	4	4	4	4	4	42
	Jack Pine	PJ >=7	Medium				2	2	2	2	2	2	2	2	2	18
	SpruceMix	Sw Leading /Pt/Bf/etc	Medium	3	3	3	3	3	3	3	3	3	3	3	3	36
	Mixwood	Conifer/Intol/Hwd Mix	Medium	3	3	3	3	3	3	3	3	3	3	3	3	36

This matrix was the original 2013 framework that plots were selected by. For 2013 through 2014 a PCA Matrix was used to locate plot locaitons vs us trying to find these conditions.

Unsure if these exist

Suggested	Low	Med	High
Density Ranges sph	500-1400	1500-2500	2600+
Basal Area Ranges m2	5-19m2	20-35m2	36+

434

A candidate sampling area will typically be a stand at least 5-ha in size that contains the particular FT/DS condition being sought. Such areas may be identified through the following sources:

- Local knowledge
- Digital imagery in conjunction with the LiDAR Canopy Height Model
- Derived LiDAR Vertical Complexity Indices
- Recent cruise information
- Historic Forest Resource Inventory

Sampling areas must cover the full range of forest conditions present on the PRF, however, cost minimization must be considered by, whenever possible, adhering to the following criteria:

- Accessible from drivable roads
- Accessible by walking <200m from access point

These preferences are in place to try and maximize crew efficiency in meeting and exceeding the plot count target. If necessary, these preferences can be waved in situations where certain strata require tougher or more remote access situations. However, sample sites requiring the use of boats or ATV's should be a last resort and only deemed appropriate when a needed condition can only be reached through these methods.

Candidate sampling areas must be field verified as containing the FT/DS conditions being sought. Typically, such verification will be done by visual inspection and not involve the taking of measurements. If the conditions being sought are not present, the **actual conditions present** should be recorded on a map and the sampling area discarded unless it offers an alternative set of conditions yet to be sampled (such information, if mapped properly, could be useful in inventory validation).

3.2 Plot Centre Location

If, upon field verification, a candidate sampling area meets the sought FT and DS conditions, a plot centre must be established within a representative portion of the stand. True *random* location will be difficult to achieve in practice and so care must be taken to insure that the **625-m^2 circular plot (14.1-m radius**) falls **at least 50 m within the desired condition** (including roads) and is not biased for ease of establishment in any way (e.g., positioned near gaps).

We will typically place only one plot in any given FT/DS condition within a sampling area. However, occasionally a large sampling area (> 10 ha) may offer the opportunity to sample more than one FT/DS condition. In this case, a second plot may be installed, provided it is **at least 100 m from the first**. No more than **2 plots** should be located in a given sampling area. Exceptions to these rules may be made for FT/DS conditions of very low representation on the forest.

4 Responsibilities of Plot Locator

4.1 Assigning Plot Number

The person(s) tasked with locating the plots has the following responsibilities:

- Meet the location criteria specified in section 2.

- Establish a plot centre location by pounding in a wooded 2”X2”” post into the ground. If the site is rocky/shallow – please brace the plot post with rocks as best as possible.

- With a permanent black marker – assign the plot a number that follows the following format:

e.g.

Forest: PRF
Number: 001

The above example plot number would be recorded as **PRF001**

- Spray paint the plot number on the nearest large tree.

- Hang flagging tape on the tree chosen for painting the plot number to ensure plot location will be visible to the field establishment crew. **Note: do not place flagging tape around stem as it may restrict diameter growth, especially with winter weight flagging tape**

4.2 GPS Protocol

GPS the plot centre with a SX Blue II GPS system capable of providing sub-metre readings.

- data must be collected in UTM NAD83 Zn18
  (Load a UTM NAD83 Zn 18 Shapefile)
- start unit at truck and wait until lights indicate maximum satellite locations, proceed into the plot center and set up unit on stake and leave until 300+ points are identified
- Set to average 300 points,
- PDOP < 4.5

- Flag a line from the plot centre to the tie-in access point (i.e., roadside parking spot, culvert, large tree, etc.) and flag a roadside tie-in point. If permitted, spray paint the plot number on the roadside object (trees are best).

- Draw a sketch map that includes the GPS coordinates. Each plot will have a sketch map created that provides tie-ins to physical features such as road intersections,

bridges, culverts, etc. This map is to be part of the developed plot package that is handed to the field crew for plot establishment.

Record the located plot number on a master plot tracking form.

4.3 Assigning Forest Type Code

Each plot is to be assigned a plot Forest Type (table 2) code based on the plot locator's best professional guess as to what forest type is being sampled. This is to be entered on the tally forms.

- Based on known stand history
- Based on field sampling
- Based on professional ocular assessment of what will be measured within the plot.

Table 2 – Valid plot abbreviations for Forest Type

Forest Type	Code
Jack Pine Plantation	PJP
Red Pine Plantation	PRP
White Spruce Plantation	SWP
Larch Plantation	LAP
White Pine Plantation	PWP
Tolerant Hardwood Mix	THN
Red Oak	ORN
Intolerant Hardwood	IHN
Lowland Hardwood	LHN
Lowland Conifer	LCN
Pine	PIN
Pine Mix	PMN
Jack Pine	PJN
Spruce Mix	SMN
Mixedwood	MWN

4.4 Management System Codes

The plot locator is also required to indicate any past management activities that may have occurred in the portion of the stand that the plot is being located and established within.

Acceptable Management System codes are:

Description	Management System Code
No Management	NM
Uniform Shelterwood	US
Single Tree Selection	SS
Seed Tree	ST
Thinning	TH
Other - please write on tally form	OT

5 Responsibilities of Plot Establishment Crew

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

5.1 Plot Size & Shape

Fixed area circular plots are to be established for this project. Plot radius measurements are to be verified with a calibrated Vertex at the centre of the trees.

Shape	Area	Dimensions
Circular	625m^2	14.1m radius

5.2 Photographs

Each plot will have a total of six (6) photographs taken in the following order:
Photo #1 – Picture of plot number (Use number on post or tree)
Photo #2 – From Plot centre a picture in the North direction
Photo #3 – From Plot centre a picture in the East direction
Photo #4 – From Plot centre a picture in the South direction
Photo #5 – From Plot centre a picture in the West direction
Photo #6 – From Plot centre a picture vertical to show crowns

Indicate a check mark on the tally form for each picture taken

6 Small Tree Assessment (<9.1cm DBH and ≥1m tall)

All commercial tree species (<9.1 cm DBH with height ≥1m)) will be assessed on each plot. Different protocols will be followed for assessing commercial tree species (section 6.1).

Trees ≥ 9.1 cm DBH will have additional attributes assessed (referred to as Large Trees – refer to section 7.0).

6.1 Small Tree Sampling (DBH <9.1cm and ≥ 1m tall and >2.5cm) Commercial Species

The field assessor is to look at the height layers (≥ 1m) present on the plot of small diameter trees (DBH<9.1cm but >2.5cm), by species, and determine if the heights for a given species is found within one height layer (+/- 2m) or if more than one height layer is present (figure 1).

For each species and height layer, record:

- average height (+/- 0.5m)
- density count
- average DBH

Height Class	Bottom of Class	Top of Class
2	1	3.0
4	3.1	5.0
6	5.1	7.0
8	7.1	9.0
10	9.1	11.0
12	11.1	13.0
etc		

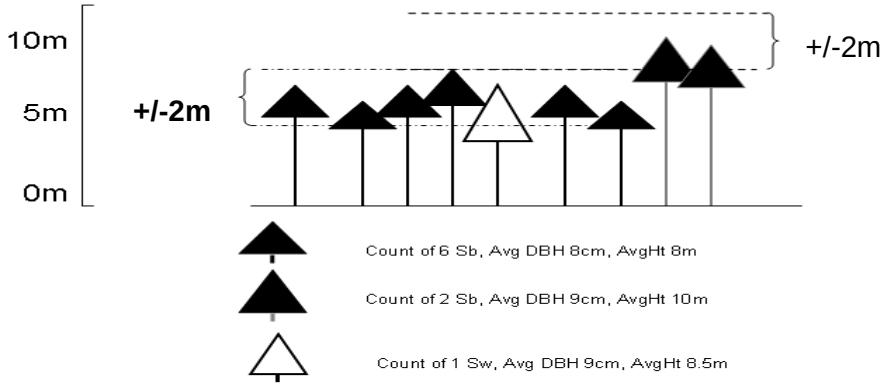


Figure 1 Example of Small Tree assessment for commercial tree species

7 Large Tree Assessment (≥ 9.1cm)

7.1 Tree attributes Collected on Each Plot

Trees are assessed as "in the plot" if their pith at their base is within the 14.1m radius. However, there are some exceptions to this rule as it relates to leaning stems.

A Suunto, sighting vertically from the plot boundary, must be used to assess whether the centroid (tallest part of crown) is in or out of the plot area

Considerations for Leaning Trees	Criteria
A Leaning-In (LI) Tree – tallied as part of plot if :	pith at base is outside 14.1 m radius but their centroid (tallest part of crown) is within the plot – **measure** and identify as "LI" – leaning in under the comments section. Measure tree as part of plot.
A Leaning-Out (LO) Tree – Tallied as part of plot if:	pith at base is inside 14.1 m radius but their centroid (tallest part of crown) is out of plot – **measure** and identify as "LO" – leaning out under the comments section. Measure tree as part of the plot.

Each plot will have the following attributes measured for all trees **≥ 9.1cm (see Section 8 for definitions)**:

- Status (live, dead, live veteran)
- Species
- DBH
- Origin (Natural or Planted)
- Crown Class (OS, I, C, D, E)
- Decay Class (1,2,3,4,5)

8 Plot Measurement Protocols

8.1 Tree Numbering

Assign a temporary tree number (using flagging tape with permanent marker, tube paint or spray paint to each tree **≥ 9.1** cm measured. The intention is for tree numbers to last 2-3 years.

Trees should be numbered starting from the North position in the plot and moving clockwise, east-south-west and back to north.

8.2 Tree Species Codes

The following MNR Growth and Yield Program **numeric** species codes will be used for tree species.

Name	MNR Code	MNR Species
American elm	50	EW
American beech	44	BE
Balsam fir	20	BF
Balsam poplar	73	PB
Basswood	51	BD
Black cherry	58	CB
Largetooth aspen	70	PG
Black ash	45	AB
Black spruce	11	SB
Eastern hemlock	19	HE
Ironwood	56	IW
Eastern red cedar	23	CR
Jack pine	3	PJ
Northern white cedar	22	CE
Pin cherry	139	CP
Trembling Aspen	74	PT
Red (soft) maple	32	MR
Red oak	41	OR
Red pine	2	PR
Sugar Maple	30	MH
Tamarack	25	TA
White ash	46	AW
White Oak	40	OW
White pine	1	PW
White birch	38	BW
White spruce	12	SW
Willow	1086	WI
Yellow birch	37	BY
Norway Spruce	15	SN
Unknown Species	99	

8.3 Tree Status

Record the status of the tree.

The following codes are used:

L - Live	**D** - Dead	**V -** Live veteran

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.**

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 Tree Data Form.

Veteran (V)
A tree is considered a veteran when it is significantly older (based on visual inspection) than trees in the main canopy (> 20 yrs) and possesses one or more of the following characteristics:

- Evidence of surviving one or more disturbance events (e.g. fire scars, harvesting damage)
- Exhibits branching and form defects characterized of an open grown or poor quality tree (e.g. wolf tree)
- Scattered remnants. (e.g. constitute $\leq$ 10 % of the crown closure of the stand)
- Extends well above the main canopy (e.g. emergent crown class)

Note that this class would apply to scattered residuals following harvest.

8.4 Tree Origin

Record the origin of the tree. The following codes are used:

N - Natural (e.g. single stem from seed or root sprouting)	**L** - Layering	**C** - Coppice (multiple stems growing from a single stump e.g. white birch)
P - Planted		

Tree origin is a designation that describes how a tree was established.

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).

8.5 Diameter at Breast Height (DBH)

Record the DBH of all numbered trees using metric calipers (to the nearest 0.1 cm).

DBH is measured at 1.30 m from the base of the tree.

Use the following guidelines when measuring DBH:

- Gently remove excessive bark flakes and needles from the bole of the tree.
- Ensure that the calipers are held perpendicular to the stem at both the front and back of the tree.
- Ensure that the calipers are closed snugly to the bole of the tree.
- When the tree is of an irregular shape – take two measurements – one from each side of the tree – and average the measurements.
- 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 operator 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.*

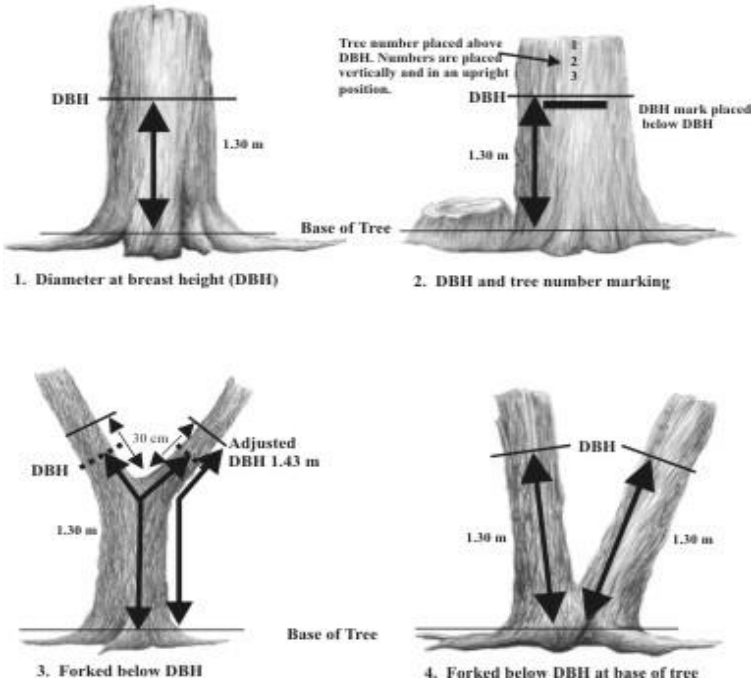
Guidelines for determining the height to DBH are:

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 2.1 and 2.2). 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 one tree is an error made on 16 trees!



Figures 2.1- 2.4. Diameter Measurements

Use the following descriptions and Figure 2 when measuring DBH on trees that are:

Forked below DBH

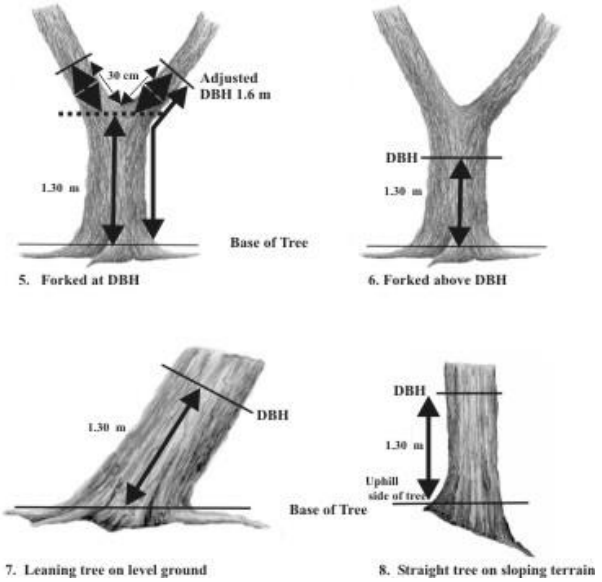
Treat each forked stem with a DBH greater than or equal to 2.5 cm as an individual tree. Diameter should be taken at a point 30 cm above the crotch of the fork (Figure 2.3 & 2.4). If the new diameter position results in a stem that is less than 2.5 cm in diameter, tag the tree and record the new diameter.

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 2.5). If the new diameter position results in a stem diameter that is less than 2.5 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



Figures 2.5 - 2.8 Diameter Measurements (continued)

measurement point ***below*** the swelling but as close to DBH as possible (Figure 2.6).

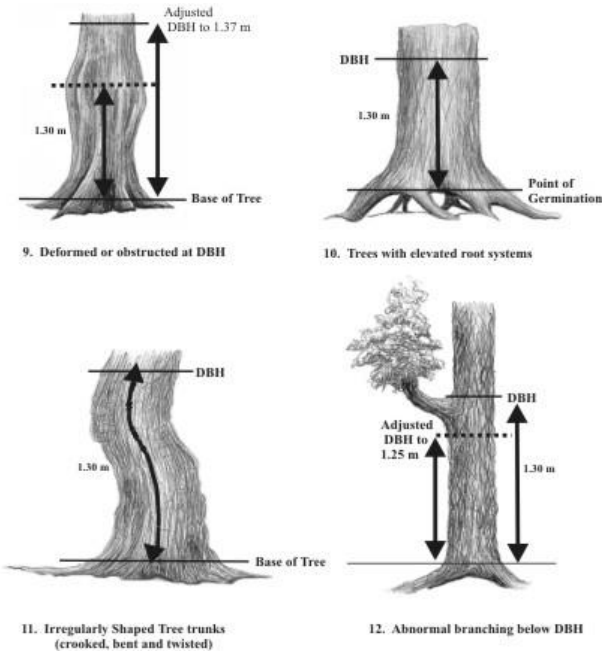
Leaning tree on level ground

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 2.7).

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 2.8).

Deformed or obstructed at DBH



Figures 2.8 - 2.12 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 2.9).

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 2.10. The height to DBH is measured from the point of germination as opposed to the base of the tree.

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.

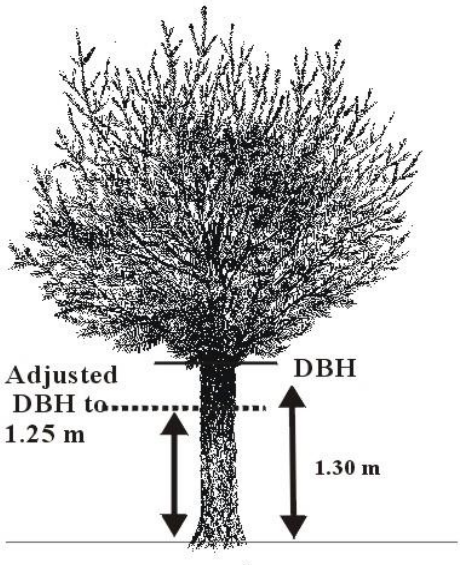


Figure 2.13. Diameter Measurements (continued)

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 2.11).

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 2.12 and 2.13). 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

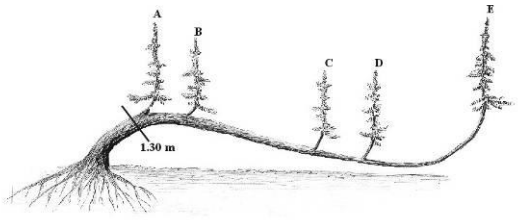
In Figure 2.14, a severely leaning tree has lateral branches above DBH that are exhibiting tree form. In this case A, B, C and D are all lateral branches of tree E are not tagged nor counted as trees.

Two Rooting Systems with Forks above DBH

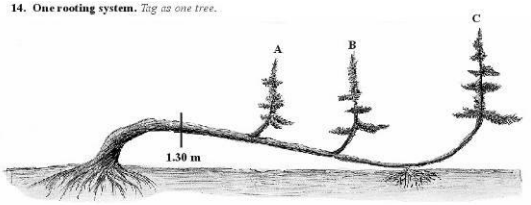
In Figure 2.15, a severely leaning tree has lateral branches above DBH that are exhibiting tree form. The top portion of the stem of the tree has made contact with the ground and has developed its own rooting system. A is a branch above DBH of tree B. Tree B is tagged. Tree C is tagged as a tree as it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

Two Rooting Systems with Forks below DBH

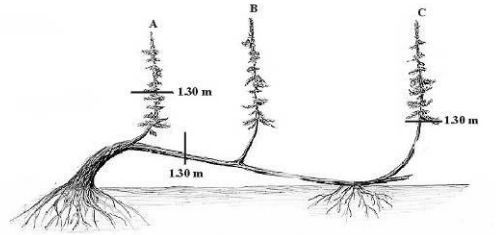
In Figure 2.16, a severely leaning tree has lateral branches below and above DBH that are exhibiting tree form. The top portion of the stem of the tree has made contact with the ground and has developed its own root system. Tree B is tagged and coded as a fork below DBH. Tree A is forked below DBH with 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 2.14 - 2.16 Diameter Measurements (continued)

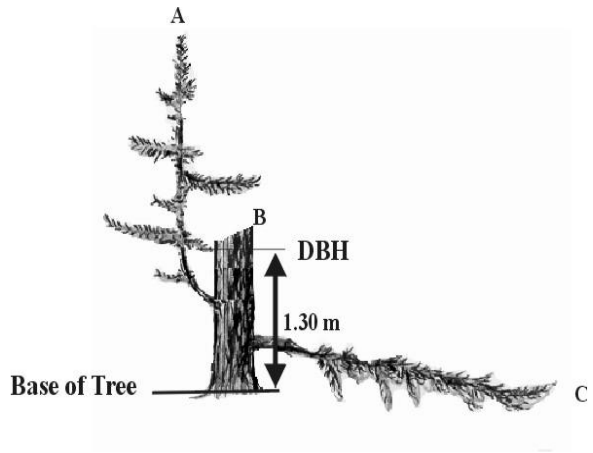


Figure 2.17. Diameter Measurements

Broken Bole/Live Laterals

In Figure 2.17 the bole of tree B has been broken off at or above 1.30 m by wind or ice damage. Tree A and B are tagged as trees. C is branch of tree B.

8.6 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.).

8.7 Decay Class

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	**4** - Decay class 4
2 - Decay class 2	**5** - Decay class 5
3 - Decay class 3	

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 3 and the diagrams in Figure 3 to assign the snag to the most appropriate class. Use this classification for both coniferous and hardwood species.

Table 3 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.

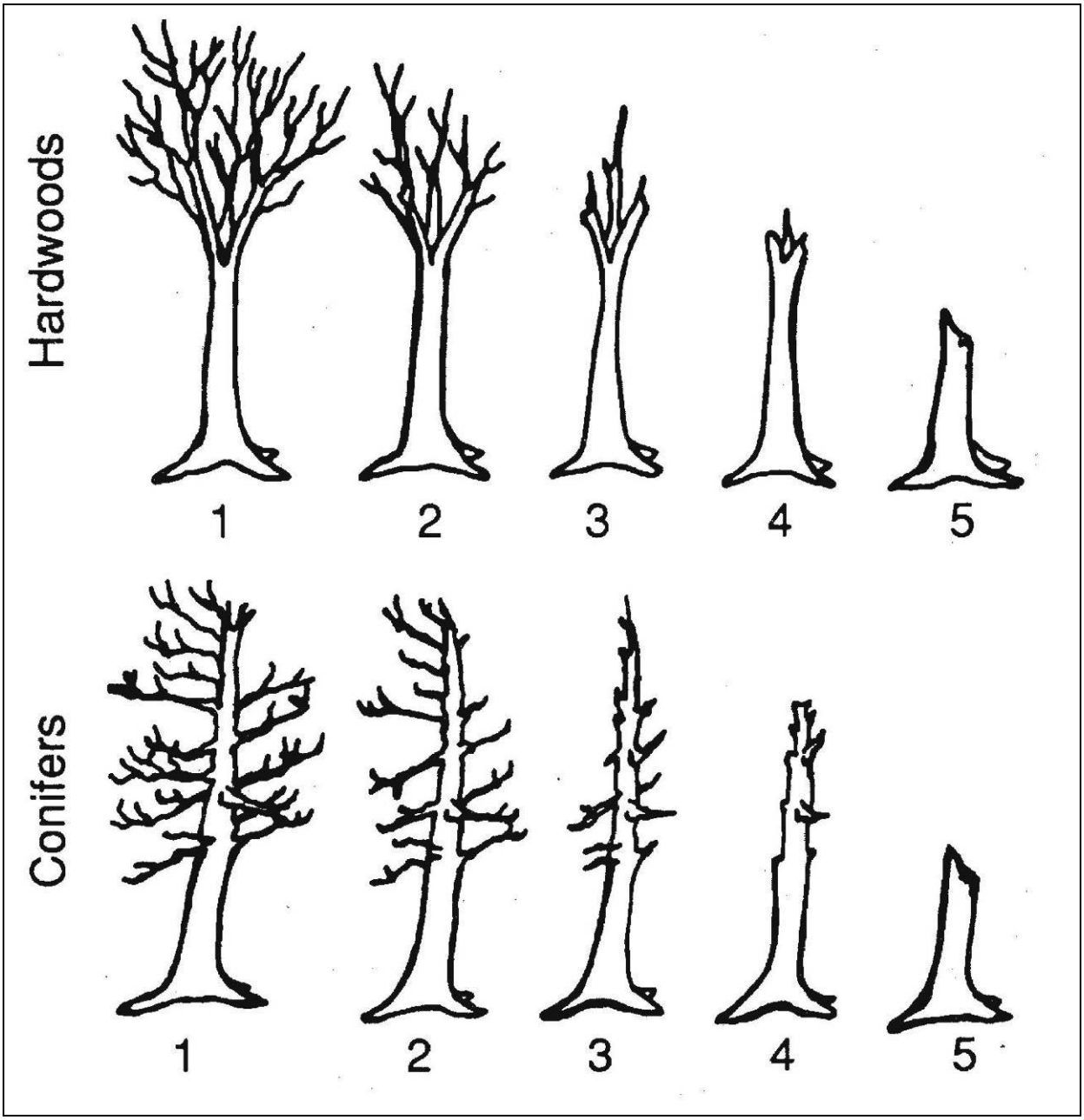


Figure 3. Decay Class Descriptions

9 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.

A height sample for trees ≥ 9.1cm is to be selected to represent the heights, by species and diameter class. The procedure for selecting which trees to sample for heights is presented below.

A sample of heights will be selected, by diameter class and species: **Main** and **Secondary**, Trees with broken tops, are dying, leaning > 20 degrees, or expressing some other characteristic that makes them unrepresentative of the plot norm, should not be selected for height measurements. Trees where the measurement point for DBH has been raised by 10cm up the stem are also ineligible for height measurement.

Species dominance is to be assessed based on a crew's visual assessment of proportion of basal area by species. The crew is also to use the species position in the canopy to assist the determination of primary, secondary or tertiary.

The Height Sample Diameter Class Form is to be used to record the tree numbers by species group and diameter class that are selected for height measurement. Select a candidate height tree from the range of DBH's present within the diameter class (i.e., small-medium-large) whenever possible.

9.1 Main Species

The main species of the plot will be sampled for height (to the nearest 0.1 m) by **5-cm diameter classes**. Within each 5-cm diameter class, **3[1] trees** will be selected and measured. In addition for the main species, the **4 largest diameter trees** (free from any visible top damage) will also be selected for height measurement. These trees can form

[1] Modified from 2 trees to 3 trees June 9, 2014

part of the 2 trees selected for the largest size class. In addition to total height, a height measurement of base of live foliage will also be recorded:

- For Primary species
- plantation scenarios.

The diameter class breakdown is as follows:

5-cm Diameter Class

15cm Class – 9.1 - 14.9cm
20cm Class – 15.0 - 19.9cm
25cm Class – 20.0 - 24.9cm
30cm Class – 25.0 - 29.9cm
35cm Class – 30.0 - 34.9cm
40cm Class – 35.0 - 39.9cm
45cm Class – 40-0 - 44.9cm
50cm Class – 45.0 - 49.9cm
>50cm Class – >50cm

9.2 Secondary Species

The secondary species of the plot will be sampled for height by **5-cm diameter classes**. Within each 5-cm diameter class **2 trees** will be selected and measured. In addition to total height, a measurement of base of live crown will also be recorded in plantation scenarios.

If unclear if one or two different species should be treated as Secondary – treat them both as Secondary and sample them appropriately.

10 Height to Live Foliage – PRIMARY Species and PLANTATION SITUATIONS ONLY

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

10.1 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 3.

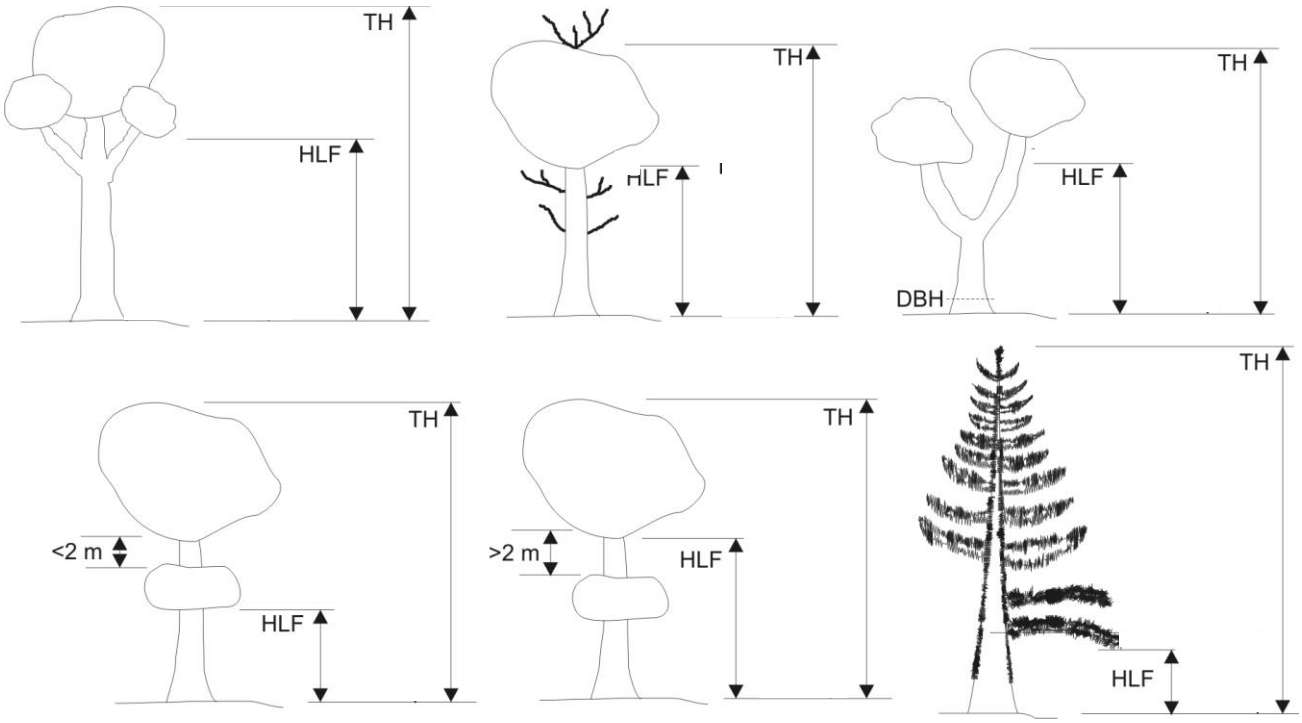


Figure 3 Measurement examples for Total Height and Base of Live Foliage. TH = Total Height. HLF= Height to Live Foliage.

11 Appendix A - Tally Forms

AFRIT PRF PLOT INFORMATION & LOCATION MAP

Plot Number -	**PRF**	**Declination Used -**	
Forest Type Identifier:		**Azimuth to Plot Centre -**	
Management System:		**Distance to PGP Centre -**	
Plot Locator:		**Plot Radius-**	**14.1 m**
Date:		**PlotArea (m^2) -**	**625 m2**

Easting									
Northing									

Map is not drawn to scale

Plot Photos **North** ☐ **South** ☐ **East** ☐ **West** ☐ **Vertical over above plot Centre**

AFRIT PRF 2012 LARGE TREE DBH TALLY FORM (>9.0cm)

Plot Number - PRF　　　　**Crew -**

Measurement Date -　　　　**Crew -**

625m^2 = 14.1m radius plot

Tree #	Tree Spec	Tree Status	Tree Origin	DBH (cm)	LI	LO	Crown Class	Qual Class	Decay Class	Comment	Tree #	Tree Spec	Tree Status	Tree Origin	DBH (cm)	LI	LO	Crown Class	Qual Class	Decay Class	Comment

Notes

Number and measure all Live and Dead trees $\geq$ 9.1cm

AFRIT PRF 2012 HT/DBH FORM - PRIMARY SPECIES

Plot Number - PRF

Crew Members -

Measurement Date -

Primary Species:

Select **3** trees per dclass for height sampling (can include 4 largest Dbh trees

Diameter Class (cm)

10.0 - 14.9		
Tree #	Total Ht	HLF

15.0 - 19.9		
Tree #	Total Ht	HLF

20.0 - 24.9		
Tree #	Total Ht	HLF

25.0 - 29.9		
Tree #	Total Ht	HLF

30.0 - 34.9		
Tree #	Total Ht	HLF

35.0 - 39.9		
Tree #	Total Ht	HLF

40.0 - 44.9		
Tree #	Total Ht	HLF

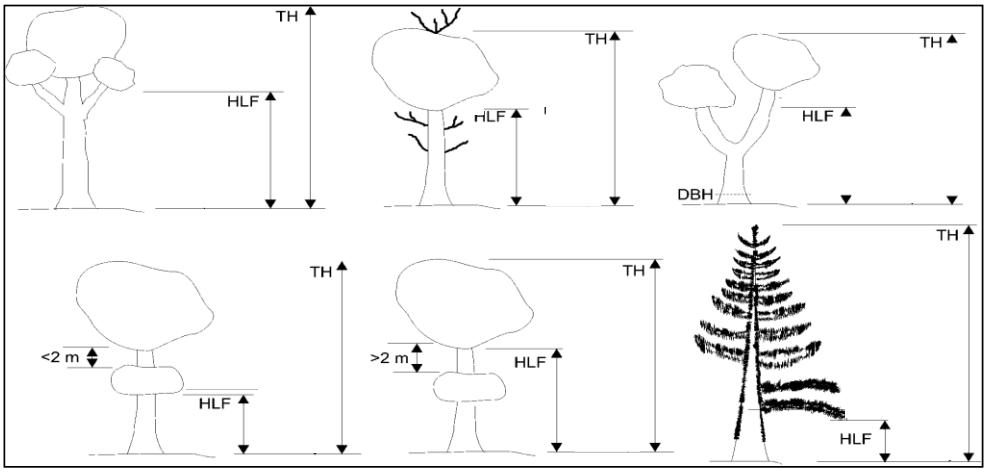
45.0 - 49.9		
Tree #	Total Ht	HLF

50.0 - 54.9		
Tree #	Total Ht	HLF

55.0 - 59.9		
Tree #	Total Ht	HLF

Trees >60cm		
Tree #	Total Ht	HLF

Notes:



AFRIT PRF 2012 HT/DBH FORM - SECONDARY SPECIES

Plot Number - PRF

Crew Members -

Measurement Date -

Secondary Species:

Select **2** trees per diameter class for height sampling

Diameter Class (cm)

10.0 - 14.9		
Tree #	Total Ht	HLF

15.0 - 19.9		
Tree #	Total Ht	HLF

20.0 - 24.9		
Tree #	Total Ht	HLF

25.0 - 29.9		
Tree #	Total Ht	HLF

30.0 - 34.9		
Tree #	Total Ht	HLF

35.0 - 39.9		
Tree #	Total Ht	HLF

40.0 - 44.9		
Tree #	Total Ht	HLF

45.0 - 49.9		
Tree #	Total Ht	HLF

50.0 - 54.9		
Tree #	Total Ht	HLF

55.0 - 59.9		
Tree #	Total Ht	HLF

Trees >60cm		
Tree #	Total Ht	HLF

Notes:

Secondary Species:

If an additional secondary species is identified

10.0 - 14.9		
Tree #	Total Ht	HLF

15.0 - 19.9		
Tree #	Total Ht	HLF

20.0 - 24.9		
Tree #	Total Ht	HLF

25.0 - 29.9		
Tree #	Total Ht	HLF

30.0 - 34.9		
Tree #	Total Ht	HLF

35.0 - 39.9		
Tree #	Total Ht	HLF

40.0 - 44.9		
Tree #	Total Ht	HLF

45.0 - 49.9		
Tree #	Total Ht	HLF

50.0 - 54.9		
Tree #	Total Ht	HLF

55.0 - 59.9		
Tree #	Total Ht	HLF

Trees >60cm		
Tree #	Total Ht	HLF

Notes:

AFRIT- PRF 2012 - SMALL TREE DATA DOT TALLY FORM

Plot Number -	PRF	Crew -	
Date -		Crew -	
Strata -		$625m^2$ = 14.1m radius plot	

Species	Ht Class							
	2	4	6	8	10	12	14	
Avg Dbh								
Dot Tally								

Species	Ht Class							
	2	4	6	8	10	12	14	
Avg Dbh								
Dot Tally								

Species	Ht Class							
	2	4	6	8	10	12	14	
Avg Dbh								
Dot Tally								

Species	Ht Class							
	2	4	6	8	10	12	14	
Avg Dbh								
Dot Tally								

Species	Ht Class							
	2	4	6	8	10	12	14	
Avg Dbh								
Dot Tally								

Species	Ht Class							
	2	4	6	8	10	12	14	
Avg Dbh								
Dot Tally								

Species	Ht Class							
	2	4	6	8	10	12	14	
Avg Dbh								
Dot Tally								