Pilot Test of
A Growth & Yield Monitoring Program
for Weyerhaeuser's TFL 35: Sample Plan

Prepared for
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1. INTRODUCTION

1.1 BACKGROUND

Weyerhaeuser Company Ltd. has discussed the need to monitor the growth & yield (G&Y) of stands on Tree Farm License (TFL) 35 near Kamloops, BC for several years. Plans to develop a monitoring program for the TFL in the early 1990s were delayed as the Ministry of Forests (MOF) was in the process of developing a similar system. Weyerhaeuser did not want to risk developing a monitoring program for the TFL and have it superseded by a new MOF system. The MOF program is now sufficiently developed for operational testing. In late 1999, Weyerhaeuser arranged for funding from FRBC to design and test the new MOF protocol[1] for G&Y monitoring on TFL 35.

1.2 OVERVIEW

This sample plan describes the G&Y monitoring program designed for TFL 35. The plan was developed to meet Weyerhaeuser's business needs and to be compatible with the MOF's new preliminary monitoring protocol. The design and implementation of this G&Y monitoring program for Weyerhaeuser is also a pilot of the new MOF system.

This report contains four major sections that describe:

1) The process to define Weyerhaeuser's primary and secondary business needs.
2) The overall objectives of this monitoring program.
3) The sampling design to meet these needs and objectives.
4) A simulation of the sample system over the next 15 years.

1.3 TERMS OF REFERENCE

This report was completed for Don Brimacombe, *RPF* (Weyerhaeuser Company Ltd., Kamloops) by Eleanor McWilliams, *MScF, RPF* and Jim Thrower, *PhD, RPF* of J.S. Thrower & Associates Ltd.

[1] Ministry of Forests. 2000. Vegetation Resources Inventory Change Measurement: Preliminary Field Procedure. Version 1.0. Contract Report to the BC MOF Resources Inventory Branch. Victoria, BC 10 pp. March 31, 2000.

2. BUSINESS NEEDS

2.1 THE PROCESS

Business needs for monitoring on TFL 35 were identified and confirmed through several internal Weyerhaeuser meetings and discussions over a six-month period. These needs were discussed with MOF Regional and Branch staff during this time. Many needs for a monitoring program on the TFL were considered including monitoring all stands and all areas, only post-harvest regenerated (PHR) stands, and subsets of PHR stands (e.g., treated and non-treated). The need to monitor timber and non-timber forest attributes were also discussed. The many potential uses and needs for information that could come from a monitoring program were evaluated considering costs, benefits, uncertainty in management processes, and potential future changes. The agreed on business needs for current consideration (as presented below) were presented and discussed with MOF staff[2] at a meeting at the Kamloops Region office on May 3, 2000.

2.2 PRIMARY BUSINESS NEED

The primary business need identified for G&Y monitoring on TFL 35 was to periodically measure actual G&Y of PHR stands to check with projections used in timber supply analysis. The volume of many PHR stands on the TFL is projected to be higher than natural stands. This higher volume has a large impact on timber supply forecasts, and thus Weyerhaeuser wants to have an ongoing level-of-comfort that these forecasts are as accurate as possible. Furthermore, Weyerhaeuser wants to consider immediate corrective action if significant differences are observed in actual G&Y when compared to projected G&Y.

2.3 SECONDARY BUSINESS NEEDS

The most important secondary business need identified was to provide monitoring data and information to support market certification (e.g., for the Forest Stewardship Council (FSC)). The specific requirements for certification are unknown at this time, but will likely require monitoring the entire TFL landbase. This potential future need was considered in the program design.

Another possible future business need is to monitor the G&Y and stand dynamics in mature stands (primarily spruce (Sx) leading). The ability to meet this need in the future was also addressed in the proposed design.

[2] Attending this meeting were Bob MacDonald (MOF, Kamloops Region), Brian Russell (MOF, Kamloops District), Jon Vivian (MOF, Resources Inventory Branch – via phone from Victoria), Don Brimacombe (Weyerhaeuser, Kamloops), and Jim Thrower (JST, Kamloops).

3. MONITORING OBJECTIVE

Accordingly, the primary objective of the G&Y monitoring program on TFL 35 was defined as to:

> *Monitor the change in volume, species composition, top height, and site index in PHR stands on TFL 35.*

The secondary objective of the program is to:

> *Use a sample design that can be modified in the future to provide information to support market certification or other monitoring needs.*

The intent is that data from the monitoring program will be compared with predicted values of the same attributes used in timber supply analysis. This is to develop a level-of-confidence in the accuracy and precision of projections used in timber supply analysis. This program is not designed to provide data to develop yield curves or estimate the response of trees and stands to silviculture treatments.

In developing this program, we consider G&Y monitoring as *the process of comparing the actual G&Y of a forest or stand to the predicted or expected G&Y for that forest or stand.* This program is designed to check existing G&Y predictions for PHR stands – not to develop new G&Y predictions; however, these data may be used to develop other models and for other uses.

4. SAMPLE DESIGN

4.1 OVERVIEW

The key features of the sample design are:

1) Potential sample points are located on a 1-km grid across the TFL.
2) Samples are 400-m^2 circular plots centered at these grid points.
3) Measurements are taken for tree attributes only (as identified in the business needs).
4) Plots are installed only in PHR stands greater than 15 and initially less than 40 years of age.
5) All samples plots in the target population will be installed over more than one year.
6) Sample plots will be remeasured about every 5 years (funding permitting).

4.2 PURPOSE

The purpose of the proposed sample design is to provide tree-level data for a representative sample of PHR stands on the TFL. This design is intended to provide data to address the primary business need, be compatible with the MOF preliminary protocol for monitoring, and to provide this information in a cost-effective manner.

This design will give estimates of net change and allow the components of net change (survivor growth, mortality and ingrowth) to be calculated if required. However the primary focus is on obtaining accurate estimates of yield and net change and comparing this to predicted values.

This sample design will provide enough data to compare G&Y for all PHR stands in aggregate[3] and for Pl leading stands (the most prominent). The sample size is not large enough to separately check G&Y estimates stands with other leading species.

4.3 TARGET POPULATION

The target population is all PHR stands that are 15 years of age and older. The initial definition of the target population will also include a maximum age of 40 years. This maximum age was chosen to reflect the start of clearcutting on the TFL in the late 1950's. The target population will expand over time as more stands are harvested and subsequently regenerated.

4.4 SAMPLE PLOT LOCATIONS

The sample plots will be located on a 1-km square grid created using NAD 83 UTM coordinates. This results in approximately 59 sample points in the target population in the year 2000.

[3] Over the entire TFL are regenerated stands on average growing as expected.

4.5 SAMPLE PLOTS & MEASUREMENTS

The integrated plot center (i.e., the sample point) includes three circular overlapping plots (Figure 1). The *Main plot* –all trees 4.0 cm and greater in diameter at breast height (DBH) are measured and tagged. The *Small tree plot*– trees taller than 1.3 m and less than 4.0 cm in DBH are measured. The *Regen plot*– trees less than 1.3-m in height are tallied (Appendix I).

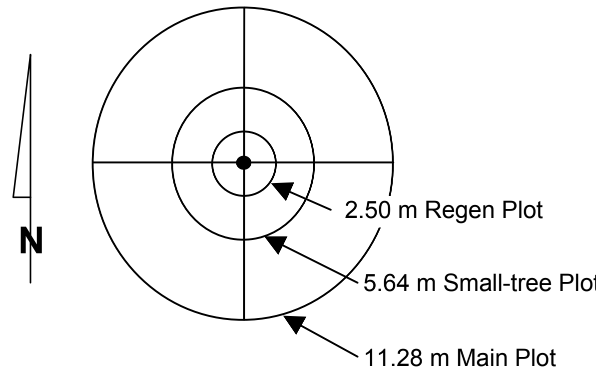

Figure 1. Monitoring sample plot.

Heights and ages are taken for the first and second species in each 100-m^2 quadrant of the 400-m^2 main plot to estimate site index. All measurements are recorded by quadrant and species. Plots locations are carefully documented for relocation. Trees in the main plot are tagged to facilitate relocation and to reduce the potential errors associated with missed trees in subsequent measurements.

4.6 DATA MANAGEMENT

An MS Access database will be developed to store the monitoring data in the next phase of this project. Each plot will be compiled to stand-level summaries expressed in units/ha. Summaries will include stand density, species composition, merchantable volume, diameter distribution, top height, and site index. The predicted values for each of the attributes at the sample point (i.e., polygon or aggregate values used in timber supply analysis) will be determined using the GIS.

4.7 ANALYSIS & INTERPRETATION

The analysis will focus on comparing measured and predicted G&Y for the target attributes (given above) at the sample points. The relatively small sample size allows analyses to be done for all plots in aggregate and the subset of Pl leading stands (we estimate that about 26 of the initial 59 plots will be in Pl leading stands). Other post-stratification of the data is possible, however, this is unlikely as there will not be a large enough sample to detect significant difference given the expected variation.

Graphical analysis will include plotting actual versus predicted and plotting differences (actual – predicted) versus stand age or other chosen variables to examine trends (Section 5). Statistical analyses will be similar to those used in inventory audit procedures. Average differences and their associated confidence intervals can be calculated.

The graphical and statistical analysis methods are intended as tools to examine the data for possible overall trends of over- or under-prediction – these analyses are not meant as definitive tests. If the analyses suggest over- or under-prediction, then possible sources of the differences should be identified. For example, when considering volume estimates, potential factors to consider as sources of mean error are the differences between the inventory inputs to the model and the actual stand attributes. Potential inventory attributes to examine include stocking, site index, treatment, species composition, stand structure, pest, and disease incidence.

4.8 FUTURE MODIFICATIONS

Future modifications to this sample design could include:

1) Increasing or decreasing the sample intensity.
2) Increasing or decreasing the frequency of plot re-measurements.
3) Changes to the definition of the target population.
4) Changes in the type of tree information measured in the sample plots.
5) Including non-timber attributes in the plot measurements.

Any of these changes should be accommodated by this sample design. The intensity of sampling can be increased or decreased by changing the grid size. For example, as the target population expands or when a higher level-of-comfort is developed in the G&Y projections, the sample size may be reduced to decrease the cost of maintaining the program. This could be done by selecting sample points from the 2-km grid or by randomly sub-sampling fewer points from the 1-km grid.

Additional tree and non-tree measurements can be added to the program at any time. The primary consideration is that change in new attributes cannot be estimated until a second measurement is taken for that attribute.

5. SIMULATION

5.1 OVERVIEW

The implementation of the G&Y monitoring program on TFL 35 was simulated using the GIS to identify the stands in which the 1-km sample grid points fall. Based on inventory stand ages the number of sample points in the target population now and in the future was simulated. In addition, based on inventory stand ages, leading species and site index and an assumed 20% coefficient of variation around the yield curves, plot volumes now and in the future were simulated. This example shows how the sample size increases over time and the various analyses that can be completed after different measurements.

5.2 SAMPLE SIZE

The number of grid points in the sample will increase over time as more area is harvested and regenerated (Table 1). The approximate rate of harvest is 400/ha/year on the TFL, thus about four plots/year are needed to sample the PHR area that was harvested 15 years previously and enters the sample population each year.

Table 1. Plots to establish and re-measure on the 1-km grid (assuming harvest of 400 ha/year)

MP	Year	Plots to		Plots with data to compare:			
					Growth for:		
		Estab-lish	Reme-asure	Yield	5-yrs	10-yrs	15-yrs
9	2000	59		59			
10	2005	19	59	78	59		
11	2010	18	78	96	78	59	
12	2015	25	96	121	96	78	59

The projection of stand age for the sample grid points shows that 59 plots are included in the sample now and another 19 are included on the grid in the next 10 years (Table 1). The number of plots in the sample will increase over time as more area is harvested and as stands age, however, the program should periodically be re-evaluated to consider reducing the sample size as more confidence is developed in G&Y predictions for PHR stands on the TFL. This could be done by increasing the lower age of the sample population (e.g., to 20 from 15 years) or by dropping some grid points from the sample (Section 4.8).

5.3 STRATIFICATION AFTER SAMPLING

The data collected for the target population can be post-stratified by species, age, volume, or other attribute. This will only be useful where the sample size is large enough to provide meaningful information on the strata of interest. Statistics calculated for any particular stratum can only be used to make inferences about that stratum. For example, one type of post-stratification that will be done is to divide plots into those with and without merchantable volume. Comparison of measured volumes to predicted volumes will only be done for the stratum with merchantable volumes and as a consequence inferences will only be able to be made to that stratum.

5.4 Time 1 – Year 2000

5.4.1 Summary

The first measurement of the monitoring plots is to install the 59 plots in the year 2000.[4] The yield tables for MP 9 have been completed for the timber supply analysis that is planned for the fall of 2000. Consequently, the first measurement of these plots will not contribute to the MP process until 2005 and MP 10.

5.4.2 Yield

Comparisons of yield can be made after the 59 plots have been installed, trees measured, and data compiled. The merchantable volume[5] yield measured in the 59 sample plots can be compared to an area-weighted yield curve for all stands in the sample population (Figure 2). This curve represents all species and areas and shows the distribution of plot yield compared to predicted polygon yield. This comparison shows the magnitude of actual yield but does not accurately portray differences in yield for individual polygons.

A more meaningful comparison to indicate the precision of individual yield curves and polygon predictions is to compare the difference in yield between the plot measurements and the yield predicted for the polygon in which the plot is located (Figure 3). This shows how actual volume differs from predicted volume across the range of ages in the sampled polygons.

The average yield difference and associated confidence interval can also be calculated for

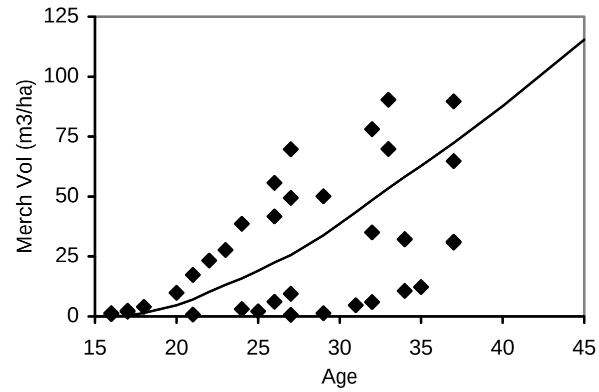

Figure 2. Simulated yield measurements to check projections in 2000.

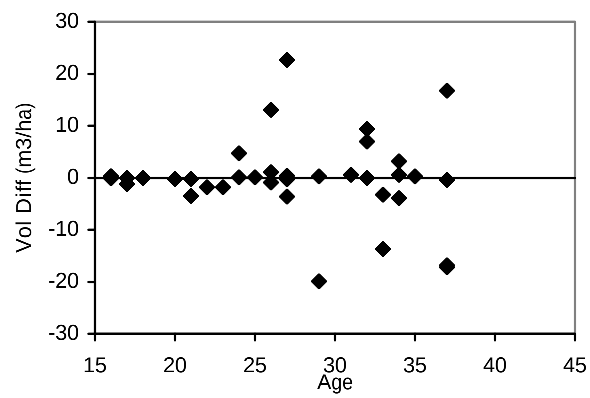

Figure 3. Simulated yield differences (plot measured yield – polygon predicted yield) to check projections in 2000.

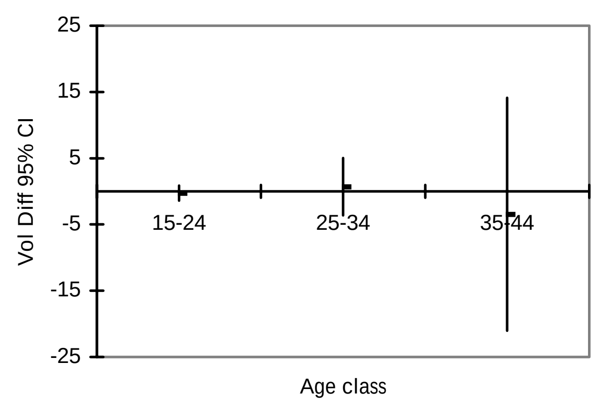

Figure 4. Confidence intervals (95%) for the average difference between measured and predicted merchantable volumes by age class to check projections in 2000.

[4] The pilot project will not install all plots this year, thus this simulation does not exactly reflect how the actual program will be implemented.

[5] We estimate that approximately 37 of the 59 plots will have merchantable volume.

different age classes (Figure 4). This provides information to examine trends of under- or over-prediction across groups of ages. The wide confidence interval for the 35-44 age class in Figure 4 is because of the small sample size.

5.4.3 Growth

Growth cannot be estimated at time 1 as this requires two or more measurements of the same plots.

5.5 TIME 2 – YEAR 2005

5.5.1 Summary

Five years after the installation of the initial 59 plots, 19 additional sample points should be included in the sample. Thus yield can be checked using 78 samples and growth can be checked using the 59 plots with two measurements.

5.5.2 Yield

The most recent measurement from all 78 plots[6] can be used to check overall yield for the target population in the same manner illustrated for the 59 plots in Section 5.4.2.

5.5.3 Growth

The growth for those of the 59 re-measured plots that have some merchantable volumes can be compared to an overall area-weighted yield curve (Figure 5). This shows a visual comparison of growth trends but does not accurately portray the difference in growth for individual polygons. More meaningful comparisons are to examine differences between measured and projected growth over age as used in timber supply analysis (Figure 6) or measured versus predicted growth (Figure 7).

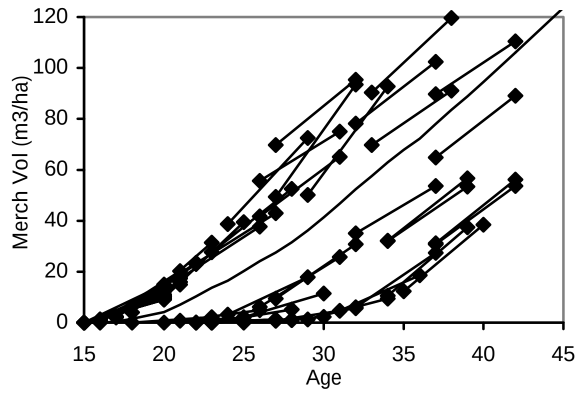

Figure 5. Merchantable volume (m^3/ha) re-measurements simulated for 2005 and an area-weighted overall yield curve.

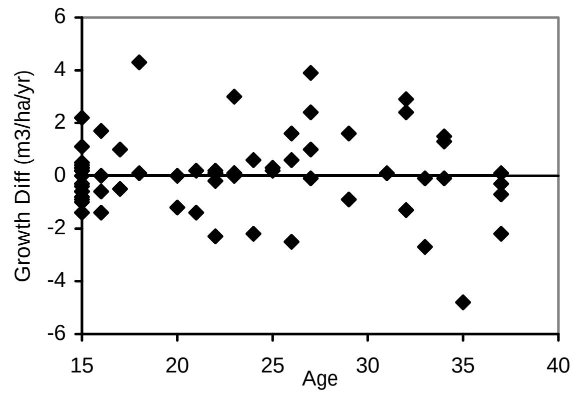

Figure 6. Simulated differences between measured and predicted merchantable volume growth between years 2000 and 2005.

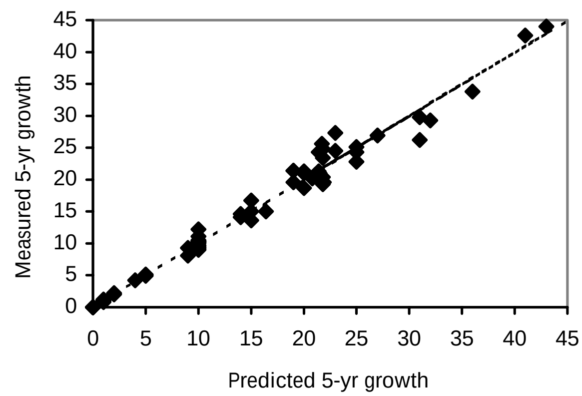

Figure 7. Simulated measured and predicted merchantable volume growth (m3/ha) between years 2000 and 2005.

[6] We estimate that approximately 54 of the 78 plots will have merchantable volume.

The average growth difference and its associated confidence interval can also be calculated by age classes (Figure 8). This allows detection of under- or over-prediction trends across the range of ages sampled.

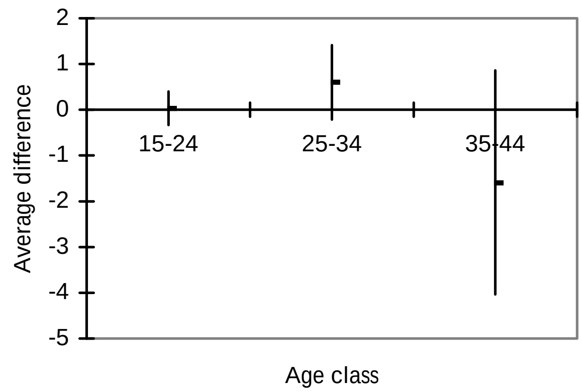

Figure 8. Confidence interval (95%) of the average difference between measured and predicted growth in the first 5-year period. (age on the x-axis is at start of the growth period).

5.6 TIME 3 – YEAR 2010

5.6.1 Summary

At the third measurement (10 years after installation of the initial 59 plots in the year 2000) a total of 96 plots will have been established. The most recent measurement of all the plots can be used to check yield. Growth over 10-years can be estimated from the 59 plots with three measurements and over 5-years from the 78 plots with two measurements.

5.6.2 Yield

The most recent measurement from all 96 plots[7] can be used to check overall yield for the target population in the same manner illustrated for the 59 plots in Section 5.4.2.

5.6.3 Growth

Growth comparison can be completed similarly to those illustrated in Section 5.5.3. The 5-year growth can be estimated for the 78 plots that have two measurements. This growth estimate applies only to the area from where the measurements were taken. The same restriction applies to the 10-year growth estimates.

5.7 SHOULD DIFFERENCES OCCUR

The graphical and statistical analyses presented here are intended as tools to examine the data for general trends of over- or under-prediction – these are definitive tests. If analyses suggest over- or under-prediction, then possible sources of the differences should be identified. For example, potential sources of difference in volume prediction could caused by differences in inventory inputs to model projections, e.g., site index, stocking, species composition, treatments, stand structure, pest, and disease incidence.

The monitoring program will have limited ability to determine the potential causes of differences; the main objective is to detect differences, not why they may occur. Consequently, additional samples or special studies may be needed to identify possible sources of differences if they occur.

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[7] We estimate that approximately 71 of the 96 plots will have merchantable volumes.

6. APPENDIX I – PROPOSED FIELD SAMPLING METHODS

6.1 PREFACE

6.1.1 Further Modification and MOF Approval

These proposed field sampling methods provide the basis for further refinement and review by the MOF prior to approval and testing on TFL 35 in phase II of this project (to be completed this summer). More work will be needed to evaluate the potential to use VRI field cards for these plots prior to field-testing. These proposed methods are based on the *VRI Ground Sampling Procedures Manual* Version 4.1 (March 2000) (referred to subsequently as the VRI Manual), the *Preliminary Field Procedures for Change Measurement*,[8] and the *Forest Productivity Council* (FPC) definition[9] of top height for estimating site index.

6.1.2 Relation to VRI Methods

These proposed methods use VRI definitions where possible; however, the VRI standards were not designed for this purpose, thus there are some small differences. The largest difference is probably that information from these plots is recorded by 100-m^2 quadrants from a 400-m^2 main plot. This plot type can be considered as a cluster of four 100-m^2 plots. The other major difference is that estimating site index is critically important to these plots, thus more information is taken than specified in the VRI standard.

6.1.3 Relation to the Preliminary Change Estimation Methods

These methods also differ slightly from the first draft of the MOF preliminary field procedures for measuring change.[8] The main difference from the preliminary methods is dividing the sample plot into four quadrants and recording more site tree information. This enhancement of the preliminary methods is the result of the intended integration with sampling for site index adjustment projects and the general need to collect more information on site index. The methods proposed here for TFL 35 do not include collecting information on ecology, coarse woody debris, or range data as contained in the preliminary procedures. This is because Weyerhaeuser's business needs did not identify this as important information at this time, however, this and other information can be collected from these sample points in the future if needed.

6.1.4 Relation to the FPC Definition of Top Height

The FPC definition of top height was considered in these standards. These plots include sampling more trees for site index than is permitted under the restrictive FPC definition of Top Height, however, sampled trees meeting the FPC definition are noted and can be identified.

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[8] Ministry of Forests. 2000. Vegetation Resources Inventory Change Measurement: Preliminary Field Procedure. Version 1.0. Contract Report to the BC MOF Resources Inventory Branch. Victoria, BC 10 pp. March 31, 2000.

[9] http://www.forestproductivity.gov.bc.ca/Standards/topheight/top_height.htm

6.2 Overview

The major steps in the following field methods (described in this order below) proposed for the pilot test in TFL 35 are:

Navigation and Plot Location

1) Navigate to **Sample Point**.
2) Establish the **Integrated Plot Center** (IPC) at the Sample Point.

Main Plot Measurements

3) Establish **Main Plot** (11.28 m radius) and **Quadrant** boundaries.
4) Measure tree attributes in each Quadrant.
5) Measure site tree attributes in each Quadrant.
6) Measure inventory top-height tree in Quadrant 1.
7) Estimate Tree Heights in all Quadrants.

Small Tree Plot Measurements

8) Establish **Small Tree Plot** (5.64 m radius) and **Quadrant** boundary.
9) Measure tree attributes in Small Tree Plot (100-m^2).

Regen Plot Measurements

10) Establish **Regen Plot** (2.5 m radius) and **Quadrant** boundary.
11) Tally tree regeneration and stump information from Regen Plot.

6.3 Navigate To Sample Point

1) Use procedures in Section 2 of the VRI Manual as guidelines to navigate to the sample point.
2) On TFL 35 the 1-km grid point intersections are the IPC.
3) Measuring the last 15-m from the tie point to the IPC (as required in the VRI standard) may not be required if the sample point can be accurately located on the ground using photos or GPS (the objective is to get as close as possible to the intended location and to not bias the location of the sample point).
4) The procedures for establishing “hidden” plots in the VRI Manual Appendix provide guidelines, however, these plots will not be totally hidden as trees will be tagged.

6.4 Establish The IPC

1) Follow the guidelines in Section 3 of the VRI Manual to locate and establish the IPC (do not establish the VRI plots as described in the VRI Manual).
2) Use steel pins to mark the IPC.
3) Take ground and stand photos.

6.5 ESTABLISH MAIN PLOT

1) Locate the plot boundary at 11.28-m from the IPC at each of the four cardinal directions.
2) These quadrants are numbered 1-4 starting in the NE quadrant and proceeding clockwise.
3) Mark the boundary of each quadrant with a steel pin. Note on plot sketch map where pins could not be located.
4) Use a yellow nylon (or similar) rope on the ground to identify boundaries among quadrants.
5) Ignore polygon boundaries; a sample plot may straddle more than one polygon.
6) Map distinct polygon boundaries if a plot straddles polygons.

6.6 MEASURE TREE ATTRIBUTES IN EACH QUADRANT

1) Start measurements in Quadrant 1 and proceed clockwise.
2) Tag each tree in the quadrant at breast height (using high side and standard PSP tagging procedures). Do not paint trees. Use a plot cord to help identify borderline trees.
3) Record tree attributes according to Section 4.2 of the VRI Manual (where applicable) including:
   a) Quadrant number (not specified in VRI Manual).
   b) Tree number.
   c) Species.
   d) Tree status (live, dead, standing, fallen).
   e) Diameter (for trees ≥4.0 cm) measured above the tag nail.
   f) Crown class (dominant, codominant, intermediate, suppressed).
4) Height will be measured or estimated for all trees in subsequent steps (described below).

6.7 MEASURE SITE TREES IN EACH QUADRANT

1) The height and age of two suitable trees (different species) will be measured in each Quadrant to estimate site index. These trees may or may not meet the requirements of VRI or FPC top height trees and will be recorded accordingly (Table 2).
2) Start measurements in Quadrant 1 and proceed clockwise.
3) Complete measurements for the largest diameter tree in the Quadrant, or another suitable tree of the same species.
   a) Identify the largest diameter tree in the Quadrant.
   b) Measure the height and age of this tree if the tree is:
      i) Dominant or codominant.
      ii) Not a residual.
      iii) Free of damage, suppression, or the effects of non-site factors that may have resulted in a loss of height growth of 5% or more.

Table 2. Top height and site tree codes cross reference.

Monitoring Code	Definition / Description	VRI Definition	FPC Definition
T	*Top Height Tree* – the largest diameter tree in a Quadrant that is suitable for estimating site index according to the FPC definition. This differs from the VRI in that the VRI does not have any suitability criteria. This can be considered the Top Height Tree for estimating site index of the Quadrant.	NA	Top Height Tree
S	*Site Tree* – the largest diameter tree suitable for estimating site index of a given species – other than the species of the largest diameter tree in the Quadrant. This can be considered the Top Height tree for estimating site index for the second and subsequent species in the Quadrant.	NA	NA
O	*Other Site Tree* – any other tree of a given species that is suitable for estimating site index, but that is not the largest diameter of that species. This tree is not defined by the FPC or VRI, but is needed for Monitoring and Site Index Adjustment samples.	NA	NA
I	*Inventory Top Height Tree* – the largest diameter tree in a Quadrant, regardless of species or condition. This is the VRI definition of a Top Height tree. This tree may also be suitable for estimating site index, and thus will be noted accordingly (see below).	Top Height Tree	NA
B	*Trees that meet both the "T" and "I" criteria* – trees that are the largest diameter in a Quadrant (thus meet the VRI definition of a Top Height tree) and are also suitable for estimating site index according to the FPC definition (thus meet the FPC definition of a Top Height tree).	Top Height Tree	Top Height Tree

iv) Not open-grown or a wolf tree.

c) Record as a "T" tree (*Top Height* according to FPC definition).

d) If the largest diameter tree is not suitable, complete measurements for the next largest diameter tree of the same species using the above criteria.

e) Record as an "O" tree (*Other* tree according to the VRI definition).

4) Complete measurements for the largest diameter tree of the next species in the diameter list, or another suitable tree of the same species.

a) Identify the largest diameter tree of the second species in the diameter list.

b) Measure the height and age of this tree if it meets the above suitability criteria.

c) Record as an "S" tree (*Site Tree* for that species – this is not the VRI "S" tree which denotes the tree of the secondary species ranked by plot cluster basal area).

d) If the largest diameter tree is not suitable, complete measurements for the next largest diameter tree of the same species using the above suitability criteria.

e) Record as an "O" tree (*Other* tree according to the VRI definition).

5) Complete measurements for additional species until one suitable tree is found for the first two species in the diameter list. Code measured trees as "S" if they largest diameter tree of that species, otherwise code as "O".

6.8 Measure Inventory Top Height Tree

1) Measurements are taken for the largest diameter tree in Quadrant 1 only. This provides an estimate of inventory top height that is consistent with the VRI.
2) Identify the largest diameter tree in Quadrant 1.
3) Measure the height and age of this tree, regardless of tree condition, if possible.
4) Record as an "I" tree (*Inventory Top Height* tree - the VRI top height tree (coded "T" under the VRI standards).
5) Note the suitability codes for measuring age and height using the VRI standards (Section 4.8 of VRI Manual).
6) Record as a "B" tree (both) if the tree was already measured as a "T" tree.

6.9 Estimate Tree Heights in Main Plot

1) Tree heights can now be estimated as some will have been measured for site index estimation.
2) Measure the height of 3-5 additional trees (or as needed) in the plot across the range of heights. The intent is to have some trees from a range of heights to use as a visual reference to make ocular estimates of the height for the remaining trees.
3) Record height as "M" where measured.
4) Start in Quadrant 1 and proceed clockwise.
5) Estimate the height of all trees (≥4.0 cm in diameter).
6) Record height as "E" where estimated.

6.10 Establish Small Tree Plot Boundary

1) Locate the plot boundary (5.64 m) from the IPC at the four cardinal directions that delimit the Quadrants.
2) Use a plot cord to help identify borderline trees and mark limits with flagging tape.

6.11 Measure Small Tree Attributes in Each Quadrant

1) Start tally in Quadrant 1 and proceed clockwise.
2) Tally the number of trees by 1.0 cm diameter class by species (for trees < 4.0 cm in diameter and >1.3 m in height).
3) Do not tag trees
4) Do not split plots.

6.12 ESTABLISH THE REGEN PLOT BOUNDARY (2.5 M RADIUS)

1) Locate the plot boundary (2.50 m) from the IPC at the four cardinal directions that delimit the Quadrants.
2) Use a plot cord to help identify borderline trees and mark limits with flagging tape if needed.

6.13 MEASURE SMALL TREE AND STUMP ATTRIBUTES IN EACH QUADRANT

1) Start tally in Quadrant 1 and proceed clockwise.
2) Tally the number of trees (between 10 cm and 130 cm in height) by species.
3) Tally the number of stumps by species by 10-cm diameter class (for stumps ≥4.0 cm).
4) Do not split plots.