TFL 55
CHANGE MONITORING INVENTORY:
ESTABLISHMENT RESULTS

Prepared for:

Fernando Cocciolo, *RPF*
Louisiana-Pacific Canada Ltd.
Malakwa, BC

Prepared by:

Timberline Natural Resource Group Ltd.
Kamloops, BC

Project Number: BC0610506

March 22, 2010

LP®
BUILDING PRODUCTS

Timberline
Natural Resource Group

EXECUTIVE SUMMARY

Change Monitoring Inventory (CMI) is the Ministry of Forests and Range (MFR), Forest Analysis and Inventory Branch (FAIB) standard for measuring stand attributes over time. The plot data is used as an independent check of inventory attributes and timber supply analysis modeling assumptions to ensure that estimates of height, age, site index, net merchantable volume, total volume, leading species, and silviculture regimes are being observed on the ground.

This report documents Louisiana-Pacific Canada Limited (LP) Tree Farm License (TFL) 55 CMI program establishment results. "LP's goal for the CMI program is to monitor and track changes in key G&Y attributes over time in managed stands on the TFL. The key attributes include volume, site index, top height, and species composition. The intent is that the data from this program will be used to compare the predicted and actual G&Y of managed stands to support future timber supply analyses."

The initial target population was all stands established after 1970 with a minimum total age of 20 years in 2008. Twenty-six (26) CMI plots were established on a standardized 1.0 km grid across the target population. The key findings from this analysis are:

- The CMI program is successfully detecting differences between modelled assumptions in the timber supply analysis and that which is being observed in CMI plots.
- Statistically, managed stand volumes were significantly less than that predicted in the timber supply analysis. However, this difference may not be practically different.
- DBH distributions suggest that volume predictions may come more in line as stands age.
- Yield table heights were reflective of actual top heights, while inventory top heights were underestimated.
- The timber supply analysis assumptions predict site index well.
- The VRI leading species matched that observed in the CMI plots 69% of the time.
- The managed stand leading species used in the timber supply analysis matched that observed in the CMI plots 54% of the time.
- The VRI ages used in the timber supply analysis are under-estimated.
- Reported pest and damage agents have the potential to significantly influence the growth performance of regenerating trees.

As a result of the findings of this program, the recommendations are for LP to:

- Continue to monitor the CMI plots on a 5-year schedule, specifically to be able to assess managed stand growth rates, standing volumes, and monitor forest health agents. The Time 2 measurement results will provide a greater ability to assess the inventory and timber supply analysis inputs.
- Review the timber supply analysis assumptions used to generate managed stand yield tables, specifically the silviculture regime leading species, and age cut-off for used to define "existing managed stands".
- Establish recruitment plots that grow into the target population.

This page was intentionally left blank.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

1.1 Change Monitoring Inventory

Change Monitoring Inventory (CMI) is the Ministry of Forests and Range (MFR), Forest Analysis and Inventory Branch (FAIB) standard for measuring stand attributes over time. This program is usually done at the Management Unit level (e.g., Tree Farm License [TFL] or Timber Supply Area [TSA]) in managed and/or natural stands. Plots are established systematically across the Management Unit. The plot data is used as an independent check of inventory attributes and timber supply analysis assumptions (e.g., net merchantable volume, age, site index, height, DBH, leading species, and forest health impacts).

Forest managers are increasingly concerned about the impact of forest health agents and climate change upon BC's forests. A well-designed CMI program provides valuable data on the actual growth of stands and can be used to assess and report on these issues. Further, an enhanced CMI program can be one of the key tools in tracking the carbon balance of a Management Unit.

Finally, CMI is a critical component of an adaptive management framework and is key for third-party certification schemes that require validation of timber supply sustainability on a Management Unit.

1.2 Background

In 2008, LP initiated a Change Monitoring Inventory (CMI) program in a continued effort to improve management of the forest resources of TFL 55. LP improved the growth and yield (G&Y) information for its current management plan[1]. Included were new managed stand yield tables that incorporated the results from a site index adjustment project, new ecological mapping, and a new Vegetation Resources Inventory (VRI). This updated management plan was submitted to the Deputy Chief Forester in June 2006 and resulted in the release of the rationale for determination for the TFL in March 2007. In the rationale, the Deputy Chief Forester requested that LP:

> "monitor growth in natural and managed stands to assess its site productivity estimates and ensure the yield projections used in future analyses appropriately reflect volumes per hectare realized in harvesting operations"

To address this request, LP is implementing a CMI program to monitor growth in managed stands. Natural stands are not included in this project because the risk and uncertainty to future timber supply is much greater in managed versus natural stand yield projections.

[1] LP Building Products Ltd. 2006. Timber Supply Analysis Information Package: Selkirk Tree Farm Licence 55 (TFL 55) Management Plan No. 4. Accepted by the Ministry of Forests and Range June 16, 2006.

1.3 Monitoring Objective

The overall goal is to report on the inventory and forest attribute inputs used in the timber supply analyses for TFL 55's Management Plan (MP) #4. The primary objectives of the CMI program are to:

1) Monitor the change in net merchantable volume and site index in managed stands[2] and compare these to predicted values used in timber supply analysis;
2) Compare CMI plot results against select inventory attributes and timber supply assumptions at each location; and
3) Summarize species and diameter distributions on the plots.

1.4 Project Objectives

The objectives of this project are to:

1) Compile and summarize the ground data from plot establishment measurements;
2) Compare plot estimates for net merchantable volume, age, site index, height, and leading species against select inventory attributes and timber supply assumptions for those stands where CMI plots are located;
3) Summarize plot estimates for DBH;
4) Present DBH and height distributions for each plot sampled; and
5) Report on the incidence of forest health agents.

1.5 Terms of Reference

This project was completed by Timberline Natural Resource Group (Timberline). The LP project leader is Fernando Cocciolo, *RPF*. The Timberline project team included Jamie Skinner, *RPF* (project manager), Eleanor McWilliams, *MSc, RPF* (analysis support) and Stephanie Ewen, *RPF* (project analyst and reporting). Funding was provided through LP's Forest Investment Account (FIA) allocation.

[2] Managed stands are assumed to be those that were previously harvested and have regenerated.

2.0 SAMPLING DESIGN

2.1 Target Population

TFL 55 covers 92,696 ha, of which 26,447 hectares (29%) are in the productive operable forest (Table 1)[3]. The initial target population is all managed stands 20 to 39 years of age[4]. The upper age limit roughly corresponds to when clearcut logging began on the TFL and includes 3,617 hectares (14%) of the productive operable TFL area. The intent is to include all harvested stands with some measurable volume (i.e., at least 20 years of age). Two key points are that:

1) the target population will expand over time to include more stands as they meet the minimum target population age of 20 years (13% (3,401 ha) of the productive operable forest is under 20 years of age); and
2) stands currently in the target population (20 to 39 years of age) will not be dropped as they pass 40 years of age.

Table 1. TFL and target population area summary.

Land Class	Area (ha)	% TSA
Total TFL	92,696	
No PEM data	27	0%
Inoperable	65,601	71%
Non-Productive	622	1%
Productive, Old	19,429	21%
Productive, Young	3,401	4%
Target Population	***3,617***	***4%***

2.2 Sample Population

The sample plots are located on a 1.0 km square grid using NAD 83 UTM coordinates evenly divisible by 1,000 meters. Nominally, the 1.0 km grid provides a sample point every 100 hectares. The actual sample intensity will depend on the spatial distribution of the population. For this target population the 1.0 km grid gives an approximate sample intensity of one plot for each 140 hectares. Twenty-six (26) grid points were identified in the VRI as being in the target population and located on the sample grid (Figure 1). All 26 plots were established over the 2008 and 2009 field seasons.

2.3 Sample Plot Design

The CMI plots are 400 m^2 circular plots with two nested subplots. The design and plot measurements are largely consistent with MFR CMI plot design standards. Additional documentation on the sampling design and variances to data collection standards can be found in the sample plan.[5]

[3] In the netdown summary, "Productive, Old" stands are those classified as productive, but 40 years old or greater. "Productive, Young" stands are those classified as productive, but less than 20 years old.

[4] Ages were all projected to the end of the 2008 growing season in order to define the target population. 2008 is the year the initial TFL 55 CMI target population was identified.

[5] Timberline Natural Resource Group Ltd. 2008. TFL 55 Change Monitoring Inventory Sample Plan. Project # BC0608020.

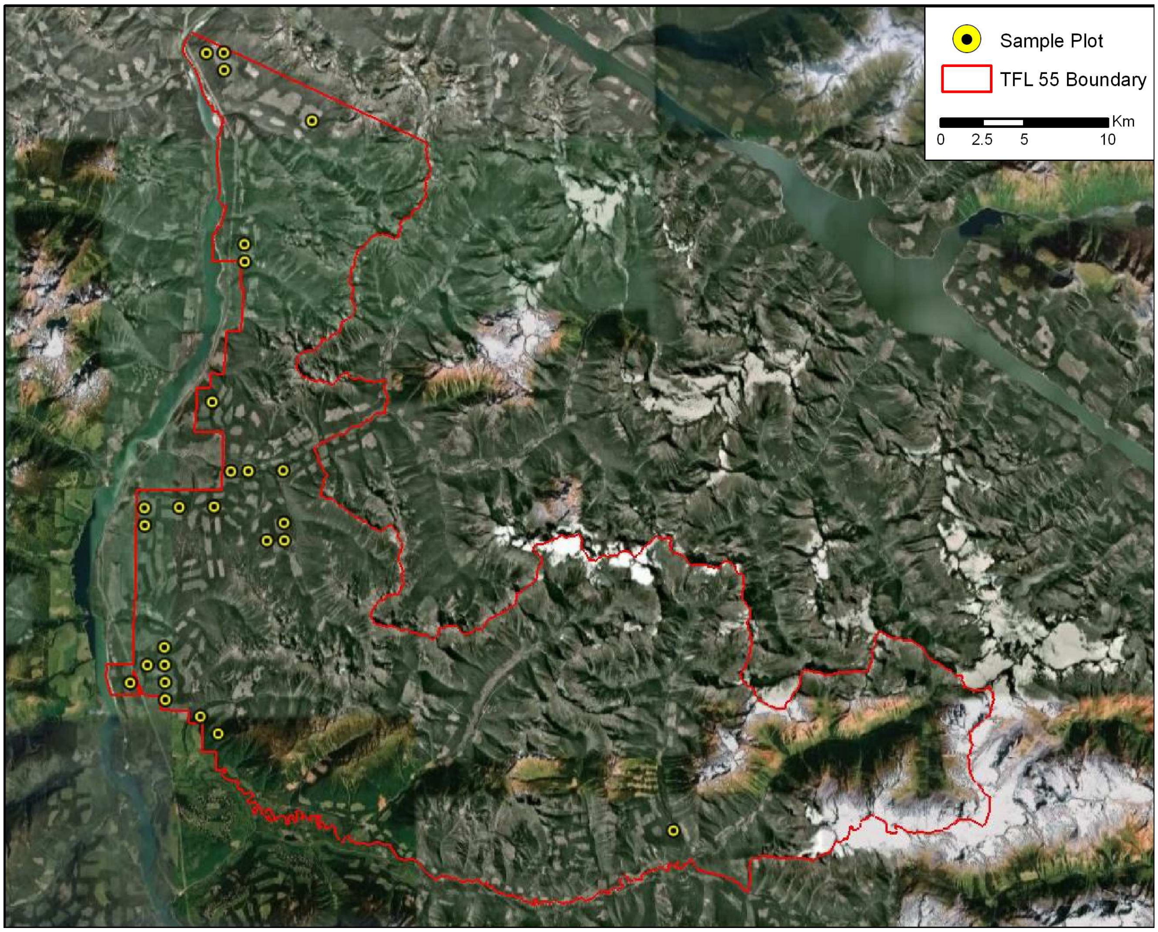


Figure 1. TFL 55 CMI sample plot locations.

3.0 DATA MANAGEMENT

3.1 Overview

This section identifies the datasets used in the analysis, including the CMI plot compilation, inventory coverage, and yield table inputs used in the MP #4 timber supply analyses. The CMI plot compilation discussion outlines the error checking routines, and the merchantable volume definition used in this project.

3.2 Plot Data Compilation

All plot data was entered into TIMVEG by the field crews.[6] Individual tree data was complied using the VRI / CMI compiler.[7] Plot level summaries were compiled for volume, age, site index, height, DBH, leading species and forest health factors using custom programs developed by Timberline.

3.2.1 Error Checking

Individual tree level error checking is built into the VRI / CMI compiler. No notable errors were flagged by the compiler. Key plot attributes were also plotted in scatter graphs to identify outliers. Again, no notable outliers were identified.

3.2.2 Merchantable Volume

Plot data were compiled to best reflect the managed stand yield tables.[8] All live trees with a DBH greater than or equal to 17.5cm were compiled to generate plot-level volume estimates.[9] Net merchantable volume was based on reduction from whole stem volume[10] which included 10 cm top diameter, 30 cm stump height[11], and applicable decay and waste loss factors.[12]

---

[6] TIMVEG is the standard data entry software for all VRI/CMI plot data, version updated to July 27, 2005.

[7] Vegetation Resources Inventory Compiler has been updated to February 4, 2009.

[8] Yield tables corresponding to each sample location were provided by Dave Myers, *BSc* (Timberline), timber supply analyst for MP #4.

[9] The minimum utilization limits used for the TFL 55 yield tables was 17.5cm+.

[10] Whole stem volumes computed in MFR's VRI / CMI compiler use Kozak's 1994 BGC zone-based volume taper equations.

[11] 30 cm stump heights are built into the VRI compiler for the field data. Additional investigation would be required to change this value.

[12] Volume reduction to account for decay, waste and breakage were minimal in these young stands.

3.2.3 Age

Total age was re-calculated for each suitable site tree using *SiteTools version 3.3*[13,14] to ensure standardized "years to breast height" estimates were used. Plot age was compiled as the average total age of all suitable site trees measured within the plot. In this analysis, it is not a species-specific value.

3.2.4 Site Index

Site indices (SI) were re-calculated for each suitable site tree using *SiteTools version 3.3*[13,14] to ensure standardized site index curves were used. SI is a species-specific attribute, and therefore each plot may have more than one value, depending on how many species site tree data was collected for. Plot-level SI corresponds to the average SI for the plot leading species.

3.2.5 Top Height

Top Height is a species-specific attribute, and therefore each plot may have more than one value, depending on how many species site tree data was collected for. Plot-level top-height corresponds to the average top-height for the plot leading species. Height distributions by species were also completed for each plot, and are included in Appendix III.

3.2.6 Diameter (DBH)

Plot-level DBH was compiled as the mean DBH of all measured trees, weighted by the number of stems per hectare represented by each tree. Field diameters are collected for trees with diameters greater than 4.0 cm; smaller trees are only tallied. Therefore, mean DBH calculations only include those trees greater than 4.0 cm DBH. Histograms of DBH distribution, by species, are included in Appendix II. Histograms include those tallied trees where the DBH is less than 4.0 cm.

3.2.7 Leading Species

Plot data was compiled for leading species using similar standards as done for Phase II VRI adjustments. Species percentages were based on percent of live plot basal area above a 7.5cm DBH limit.

3.2.8 Pest and Damage Indicators

Percent incidence of pests and damage indicators is presented as a percentage of the total stems per hectare. Each tree with an occurrence of a pest or damage indicator was weighted by the

[13] Site Tools version 3.3 software available from: http://www.for.gov.bc.ca/hre/software/download.htm

[14] The MFR-recommended default growth intercept (GI) and SI equations were used. Species codes were standardized. The white spruce GI equation was manually assigned for all Sx site trees. Interior Cw and Hw SI and GI curves were manually assigned for all Cw and Hw.

number of stems per hectare it represented. Trees may have more than one pest or damage indicator, and can therefore contribute to the values for more than one pest or damage indicator.

3.3 Inventory Data and Yield Tables

3.3.1 Inventory and TEM Coverage

The adjusted VRI, Predictive Ecosystem Map (PEM), and operability map used in this analysis were provided by LP.[15] VRI, PEM and operability attributes for each CMI plot location were derived through a GIS overlay of the 1-km grid on the VRI and PEM spatial coverages. VRI data was used to obtain the predicted plot-level ages, VRI-leading species, and inventory heights[16]. PEM data was used to assign plot-specific potential SI (PSI) estimates.

3.3.2 Managed Stand Yield Tables

Managed stand yield tables used for this analysis were created in TIPSY for the TFL 55 MP #4.[17] Yield tables were assigned to each CMI plot location through a spatial overlay of the 1-km grid on the yield table analysis unit (AU) IDs.[18] From this overlay, three plots did not have a corresponding AU. Sample 0010 is located on a road (confirmed in field card review), and was therefore netted out of the productive forest landbase (PFLB) for the timber supply analysis. It was manually assigned to the AU corresponding to the surrounding polygon.[19] Two other samples were assigned to AU 99, which does not have corresponding yield tables. AUs were reassigned using the PEM and leading species attributes for the sample point.[20,21] All stands measured were projected using managed stand yield tables (consistent with MP #4).

Yield curves were used to obtain the predicted plot-level volume, DBH, MP #4 PSI, and MP #4 top-height[16] corresponding to the inventory age projected to the year of sampling.

---

[15] VRI and PEM coverages were provided to Timberline by LP for use in MP #4. LP confirmed (January 2010) that these coverages are the most appropriate and updated for this analysis.

[16] Inventory heights were determined using inventory SI (calculated from 2005 height and age), whereas MP #4 heights are TIPSY outputs where PSI was used.

[17] Timberline Forest Inventory Consultants, Ltd. 2005. Timber Supply Analysis Information Package: Selkirk Tree Farm License 55 (TFL55) Management Plan No. 4. Timberline Reference # 7051011.

[18] This methodology was based on Timberline's most recent timber supply analysis for TFL 55.

[19] Sample 0010 is located in mapsheet 082M087 polygon 2532 which was in analysis unit 216 for MP #4.

[20] AU 99 was area in the PFLB, but outside of the Timber Harvesting Landbase (THLB). Forest cover polygons would have been initially assigned to an AU with corresponding yield tables, then removed and put into AU 99 for analysis. The initial AU assigned is the best representation of growth rates assumed for that polygon. Personal communication with Kelly Sherman, *RPF*, Feb 2010 (Timberline TFL 55 TSR Analyst).

[21] Sample 0018 (mapsheet = 082M088; polygon = 1503; leading species = Sx; BEC label = ICHvk1; site series 1 = 05) was reassigned to AU 209. Sample 0019 (mapsheet = 082M098; polygon = 2118; leading species = Cw; BEC label = ICHvk1; site series 1 = 04) was reassigned to AU 212.

4.0 ANALYSIS METHODS

4.1 Analysis Overview

This analysis compares the CMI measured plot attributes to the timber supply analysis predictions, and includes the key attributes of volume, age, site index, top-height, DBH, and leading species. In addition, the incidence of tree damage agents and loss indicators is summarized.

4.2 Volume Comparisons

Managed stand yield table projected net merchantable volumes were generated by inputting the inventory ages adjusted to the year of plot establishment into the assigned yield curves. These projected values were then compared to net merchantable volumes observed on the plots. Average differences (expressed as actual – predicted), and 95% confidence intervals were computed.

4.3 Age Comparison

Age is a key input into timber supply as it defines the starting point on the yield curve to assign predicted volume and height. VRI ages were projected to the year of plot establishment, and compared to the average site tree age from the CMI samples. The average total age difference (actual – predicted) and 95% confidence intervals were computed.

4.4 Site Index Comparisons

The PSI estimates used in the timber supply assumptions originated from a separate site index adjustment (SIA) project for Sx and Fdi.[22] The current measurement of site trees as part of the CMI program provides an independent check of these SIA results. For timber supply analysis, an average PSI estimate was computed for each analysis unit. Therefore, for each CMI point sampled, there is a corresponding "MP PSI" derived for the analysis unit. There is also a point PSI estimate for Sx and Fdi derived from the PEM attributes for the point. Four SI comparisons were made (Figure 2):

1) Where the plot leading species matched the AU leading species, the difference between the SI for the plot leading species and the average AU (MP) PSI was computed;
2) Where the plot leading species matched the VRI leading species and was either Sx or Fdi, the difference between the SI for the plot leading species and the point estimate PSI for the VRI-leading species was computed;

[22] J.S. Thrower & Associates, Ltd. 2005. TFL 55 Site Index Adjustment Final Report. JST project # LPA-002. 23pp.

3) Where there were any plot SI estimates corresponding to the AU leading species, the difference between the plot SI for that species and the average AU (MP) PSI was computed; and
4) Where there were any plot SI estimates for Sx or Fdi, the difference between the plot SI for that species and the point estimate PSI was computed.[23]

For each of the above methods, average SI difference (actual – predicted) and 95% confidence intervals were calculated for all observations combined.[24]

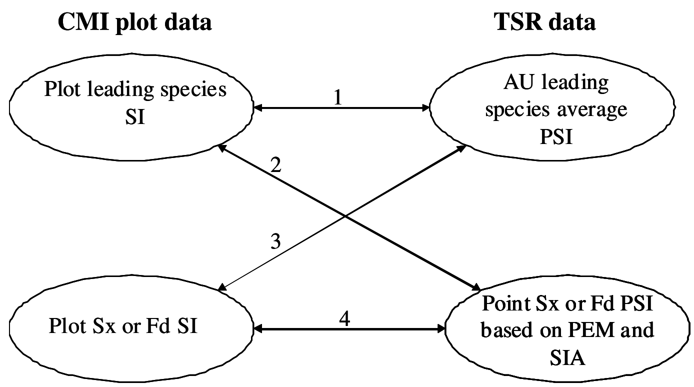


Figure 2. Diagram describing the four SI comparisons completed.

4.5 Top Height Comparisons

Top heights were available from both the inventory and the yield tables. Inventory heights represent the baseline for what is existing on the landbase, and yield table heights represent what is predicted as the stands age. Inventory height was projected in *SiteTools version 3.3*[13,14] to the year of plot establishment.[25] MP heights were obtained from yield curves using the inventory age adjusted to the year of plot establishment. As with SI, four height comparisons were made (Figure 3):

1) Where the plot leading species matched the AU leading species, the difference between the top-height for the plot leading species and the MP height was computed;
2) Where the plot leading species matched the VRI leading species, the difference between the top-height for the plot leading species and the projected inventory height was computed;
3) Where there were any plot top-height estimates corresponding to the AU leading species, the difference between the plot top height for that species and the MP height was computed; and

[23] In this comparison, if field SI was available for both Sx and Fdi within one plot, both estimates were used.

[24] There were not enough observations of any particular species to stratify results by species.

[25] For this projection, "inventory" SI was first derived in *SiteTools* using the 2005 age and height estimates (from the MP #4 VRI coverage).

4) Where there were any plot top-height estimates corresponding to the VRI leading species, the difference between the plot top height for that species and the projected inventory height was computed.

For each of the above methods, average top-height difference (actual – predicted) and 95% confidence intervals were calculated.

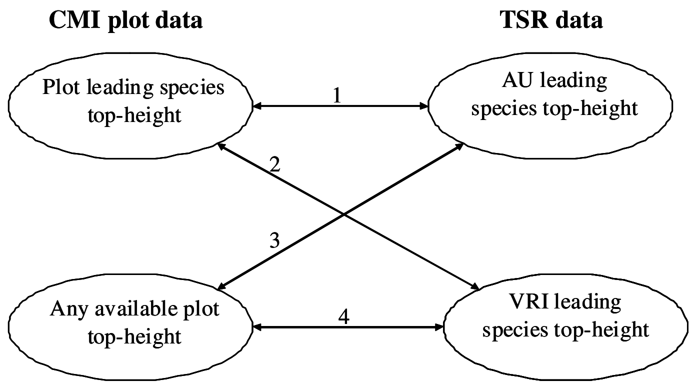


Figure 3. Diagram describing the four top-height comparisons completed.

4.6 DBH Summary

For this analysis, a direct DBH comparison would have been inappropriate due to different assumptions and standards. TIPSY-generated average DBH values include all trees, whereas average plot DBH only includes those trees greater than 4.0 cm. In order to utilize the tree data collected, and better understand the trends in the target population, DBH distribution histograms are presented in Appendix II.

4.7 Leading Species

Leading species comparisons provide an accuracy assessment of the VRI species composition and also provide an assessment of the leading species that were assigned in the managed stand yield table regeneration assumptions.

The leading species of each CMI plot was compared against VRI leading species, and a cross-table matrix (based on number of CMI plots) was created. The values in each matrix represent the total number of all plots sampled.

A separate comparison was made against the leading species from the timber supply assumptions to assess the accuracy of species being modeled from the site series-based silviculture regimes for managed stands.

4.8 Pest and Damage Incidence

The CMI program design provides the opportunity to derive a random sample of the level of pest and damage incidence within a target population.

The occurrences of pest and damage indicators were summarized and expressed as a percent of the total number of stems affected (standardized to stems per hectare). If more than one pest or damage indicator was present for a given tree, all occurrences were included in the summary regardless of how it was ranked.

5.0 RESULTS

5.1 Field Data Summary

The majority (54%) of plots measured were Sx-leading. Across all twenty-six (26) plots, the total live net merchantable volume was 1.1 m^3/ha (Table 2). Average DBH of the stands measured is only 11.0 cm. A large range of average SIs were observed with the smallest average SI for Hw (7.8 m), and the largest average SI for Fdi (29.3m).

Table 2. Summary, by plot leading species, of measured attributes for all plots.

Leading Species	n	Height (m)	CMI SI (m)	Age (yrs)	DBH (cm)	Live Merch. Vol (17.5cm+)
Sx	14	9.7	24.2	28	11.8	1.0
Bl	6	10.0	17.2	38	9.5	0.7
Cw	3	12.3	22.0	29	9.6	2.0
Fdi	1	14.3	29.3	27	13.1	2.4
Hw	1	5.3	7.8	42	12.2	0.0
Hm	1	6.9	13.9	49	8.0	0.8
Total	***26***	***9.9***	***21.5***	***31***	***11.0***	***1.1***

5.2 Net Merchantable Volume Comparison

All twenty-six (26) CMI plots were used for comparison to MP #4 yield tables for existing managed stands. A comparison of the CMI plot volumes to the predicted volumes showed that the live net merchantable ground volume is 5.5 m^3/ha (95% CI = [-8.2, -2.9]) less than predicted in the timber supply analyses (Table 3).

Table 3. Merchantable volume (m^3/ha) difference between CMI plot and predicted estimates.

n	Actual	Predicted	Avg. Diff.	Std. Err.	95% C.I.	
					Lower	Upper
26	1.1	6.6	-5.5	1.3	-8.2	-2.9

Volume differences appear to increase with inventory stand age (Figure 4).

5.3 Age Comparison

All twenty-six CMI plots were included in the age comparison. Overall, inventory ages underpredicted, compared to the CMI plot ages (difference = 7.3 years, 95% CI = [2.7, 11.8]) (Table 4, Figure 5).

Table 4. Total age (yrs) difference between CMI plot and predicted estimates.

n	Actual	Predicted	Avg. Diff.	Std. Err.	95% C.I.	
					Lower	Upper
26	31.5	24.2	7.3	2.2	2.7	11.8

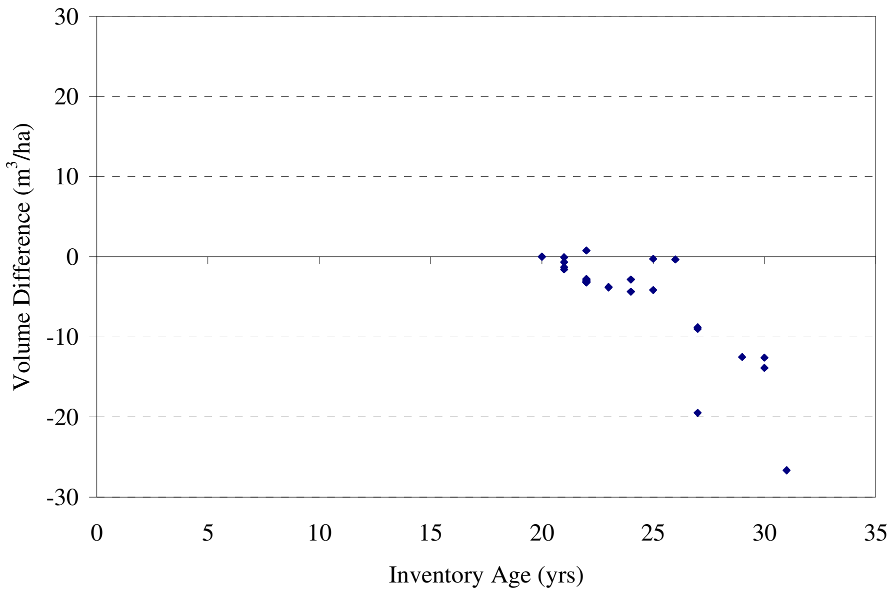


Figure 4. Comparison of live net merchantable volume differences (actual – predicted) by inventory age.

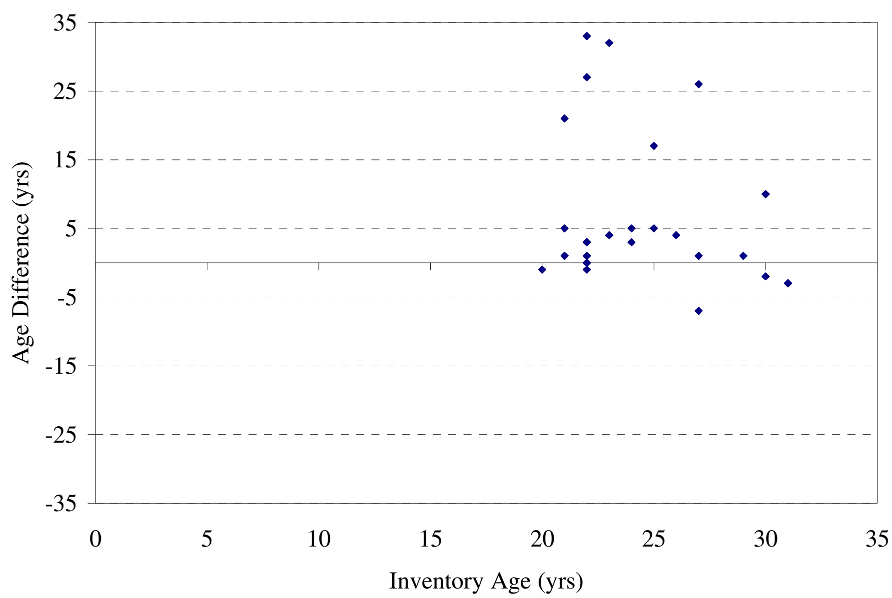


Figure 5. Comparison of total age differences (actual – predicted) by inventory age.

5.4 Site Index Comparisons

In all four SI comparisons, there was no significant difference between the plot SI and the PSI (Table 5; Figure 6). The greatest difference observed was when comparing point PSI estimates to field SI values where the plot leading species matched the VRI leading species. In this comparison, PSI estimates were under-predicted by 1 m. However, at the 95% confidence level, this difference is not significantly different from zero. In all cases, there were not enough observations to stratify by species.

Table 5. Average site index estimates and differences (actual – predicted), by source, for all comparisons completed.

Source	n	Actual	Predicted	Avg. Diff.	Std. Err.	95% C.I.	
						Lower	Upper
Plot leading species matches MP leading species	14	24.2	23.4	0.8	0.6	-0.5	2.1
Plot leading species matches VRI leading species	15	24.5	23.5	1.0	0.6	-0.3	2.3
All CMI estimates matching MP leading species	22	23.1	23.2	-0.1	0.5	-1.2	1.0
All CMI estimates for Sx and Fdi	24	23.8	23.3	0.5	0.6	-0.8	1.7

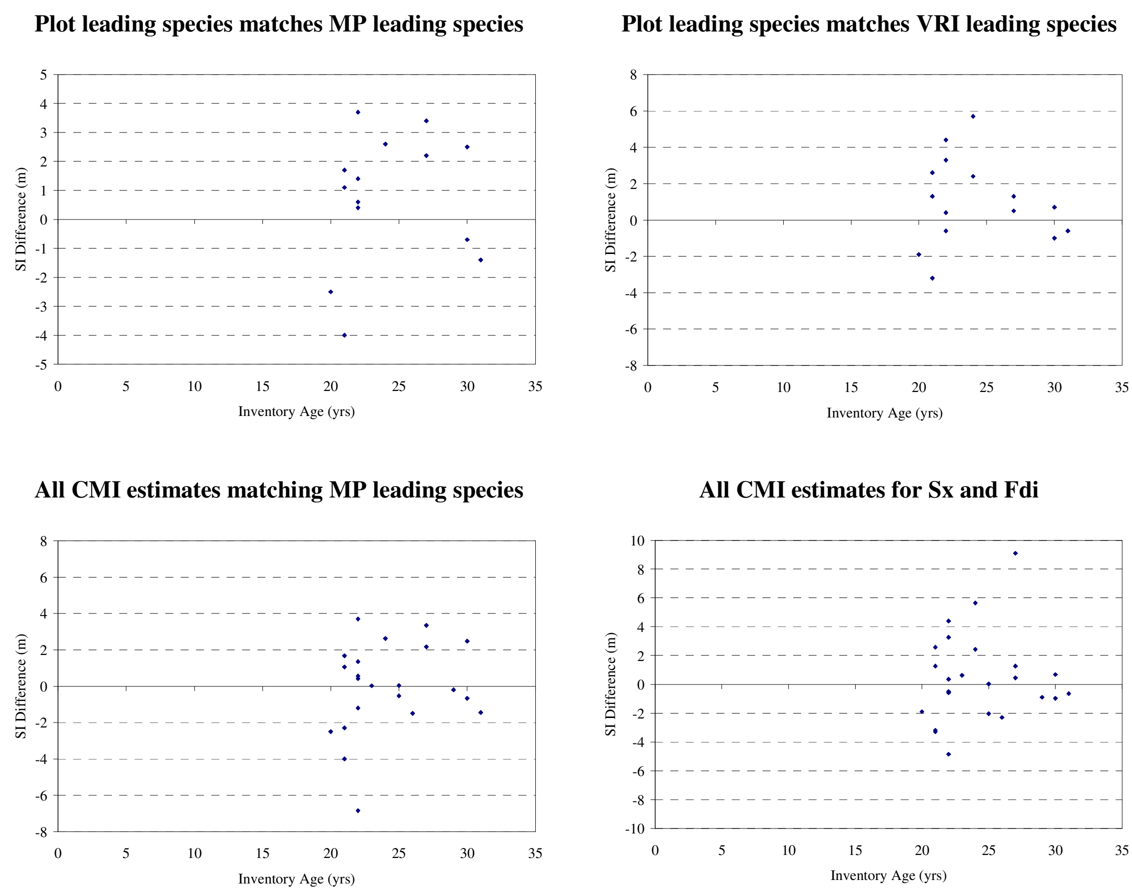


Figure 6. Comparison of SI differences (actual – predicted) by inventory age, by source, for all comparisons completed.

5.5 Height Comparisons

Top height was significantly underestimated in the inventory (Table 6; Figure 7). However, top height estimates from the yield curves used in MP #4 were not significantly different from top heights measured in the field. Heights predicted by yield tables appear to be a more accurate estimate of actual top height. Appendix III shows plot-level height distributions.

Table 6. Average top height estimates and differences (actual – predicted), by source, for all comparisons completed.

Source	n	Actual	Predicted	Avg. Diff.	Std. Err.	95% C.I.	
						Lower	Upper
Plot leading species matches MP leading species	14	9.7	9.0	0.8	0.5	-0.3	1.9
Plot leading species matches VRI leading species	18	10.0	5.7	4.7	0.7	3.3	6.1
All CMI estimates matching MP leading species	22	9.4	8.7	0.7	0.5	-0.4	1.8
All CMI estimates matching VRI leading species	24	9.4	5.1	4.4	0.5	3.3	5.5

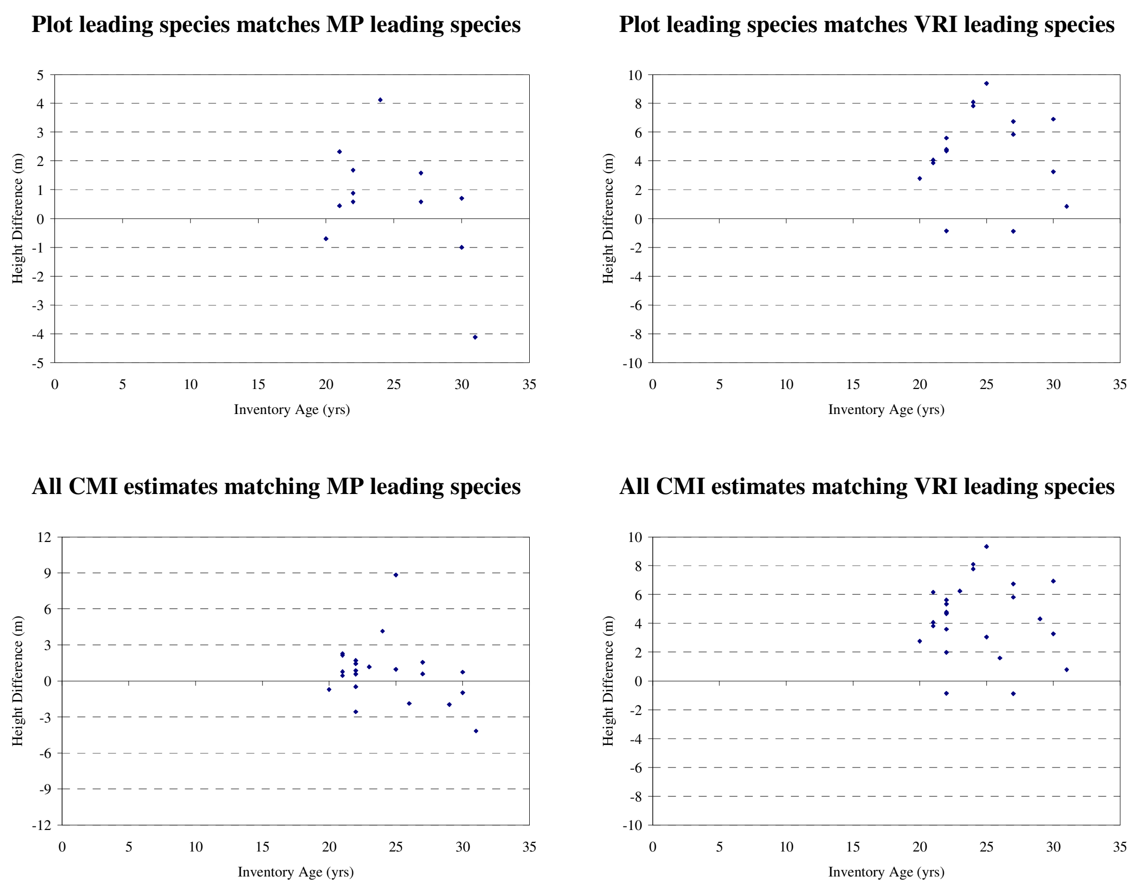


Figure 7. Comparison of height differences (actual – predicted) by inventory age, by source, for all comparisons completed.

5.6 DBH Summary

The average plot DBH was 11.0 cm for trees with diameters greater than 4.0 cm (Table 2). The DBH histograms in Appendix II show that many of the plots have a high density of trees in the 0.0-7.4 cm DBH range. This range includes stems less than 4.0 cm DBH tallied in the small tree plot. TIPSY-predicted average DBH was 8.5 cm.

5.7 Leading Species

5.7.1 CMI plots vs. Inventory

Sixty-nine percent (69%) of plots had the same leading species in the ground sample and VRI (Table 7). Overall, the comparison shows the VRI appears to overestimate the proportion of Sx-leading stands and underestimate the proportion of Bl-leading stands. Most notably, 81% of the sampled stands were labelled in the VRI as Sx-leading, while only 54% of the CMI plots were actually Sx-leading.

Table 7. Plot leading species vs. VRI label.

Plot Leading Species	VRI Leading Species				Total	Percent
	Sx	Cw	Fdi	Hm		
Sx	14				*14*	*54%*
Bl	6				*6*	*23%*
Cw	1	2			*3*	*12%*
Fdi			1		*1*	*4%*
Hm				1	*1*	*4%*
Hw		1			*1*	*4%*
Total	*21*	*3*	*1*	*1*	*26*	*100%*
Percent	*81%*	*12%*	*4%*	*4%*	*100%*	

5.7.2 CMI plots vs. Timber Supply Assumptions

All twenty-six (26) of the CMI plots were modelled as existing managed stands using TIPSY for MP #4. Of these 26 plots, 12 (54%) of the CMI plots properly matched the leading species that was modelled in TIPSY (Table 8). All of the stands were modelled as Sx-leading. The CMI plots showed Sx was leading only 54% of the time.

Table 8. Plot leading species vs. MP 4 assumptions.

Plot Leading Species	MP4 AU Leading Species	Percent
	Sx	
Sx	14	*54%*
Bl	6	*23%*
Cw	3	*12%*
Fdi	1	*4%*
Hm	1	*4%*
Hw	1	*4%*
Total	*26*	*100%*
Percent	*100%*	

5.8 Pest and Damage Incidence Reporting

The occurrence of pest and damage indicators are summarized and expressed as a percent of the total number of stems affected (standardized to stems per hectare). The key results from the CMI target population are that:

1) Weevil was observed in 25% of spruce trees; and
2) Abiotic damage was most prevalent in most species.

Each pest has its own potential impact on tree growth and for those with significant incidence, their impact on future timber supply should be investigated.

Table 9. Pest incidence as a percentage of all measured trees (total number of stems).

	Pest Incidence as % of Total Stems[a]							
Species	**Aphid**	**Weevil**	**Defoliator**	**Stem Disease**	**Animal**	**Treatment**	**Abiotic**	**Other**
Sx	1.0	24.8	3.6	5.8		0.7	8.3	14.4
Bl				0.7		2.8	25.9	20.2
Cw					8.1		58.1	10.5
Fdi			3.0		18.2		21.2	30.3
Hm						8.3	97.9	2.1
Hw						10.7	33.3	32.0
Other[b]				11.1		77.8		11.1

[a] An individual stem may have more than one pest.
[b] "Other" species include lodgepole and white pines and unidentified conifers.

The incidence of damage indicators is generally related to the pest incidence, but not always. The most significant findings from the tree data is that:

1) Cw and Hw show a high level of scarring (57% and 24% of all trees, respectively);
2) Forks are observed in about 6 – 56% of all trees of all species; and
3) Crooks are present in 1 – 15% of all trees of all species.

Table 10. Damage incidence as a percentage of all measured trees.

	Damage Incidence as % of Total Stems[b]					
Species	**Broken Top**	**Dead Top**	**Crook**	**Fork**	**Scar**	**Frost Crack**
Sx	2.0	2.6	14.4	31.1	4.1	
Bl	4.3		8.2	20.9	7.1	0.4
Cw	3.2	1.6	8.9	13.7	56.5	1.6
Fdi	6.1	9.1	15.2	39.4	18.2	
Hm			4.2	6.3	4.2	
Hw	1.3	1.3	1.3	56.0	24.0	
Other[b]	77.8		11.1	11.1		

[a] An individual stem may have more than one type of damage.
[b] "Other" species include lodgepole and white pines and unidentified conifers.

6.0 DISCUSSION

6.1 Discussion Overview

This section identifies the key points of interest identified in the analysis for each attribute of interest, and provides professional opinions of the reasons for and implications of these findings.

6.2 Volume Comparison

An observation in this analysis was that the volume was significantly over-predicted by 5.5 m^3/ha, five times that actually observed on the ground. The most likely reason for this is the young stand ages, with a large (17.5 cm+) utilization limit.[26] As stands grow, more trees should reach the minimum diameter requirements, and contribute to the measured ground volume, thus hopefully displaying volumes comparable to those predicted. While difference observed is statistically significant, the magnitude of the difference is not cause for concern in timber supply predictions. Data from future measurements will further refine and confirm average DBHs, top heights, growth rates, and expected volumes.

6.2.1 Planted Density Assumption

For all stands modelled as "existing managed stands" in the Timber Supply Analysis[27], it was assumed that there was an initial planting density of 1,450 stems per hectare. While this is reflective of current management practices, it may not be appropriate for older "existing managed stands". Older stands had the greatest difference between predicted and actual volumes. If older stands were regenerated at lower densities with natural ingress, it is expected that the current managed stand yield curves will over-predict the volume growth of these stands.

If the immature volume projections significantly alter the timber supply forecast, it may be beneficial to revise the silviculture regime definitions to reflect the actual dates when stands were planted to 1,450 stems per hectare. Potentially, the age cut-off used to define "existing managed stands" should be decreased.

6.2.2 Stump Height Assumptions

One potential reason for the statistical difference between the predicted volumes and the plot volumes is differences in stump height. The VRI / CMI compiler calculates net merchantable volume using a 30 cm stump height, while the TIPSY curves were generated using a 20 cm stump height. In young stands, a large proportion of the merchantable volume is in the lower third of the trees, and different stump heights may account for the difference observed. For the Time 2 analysis, further investigation should be done to determine if a plot-level net merchantable

[26] Plot and predicted volumes are both small (1.1 and 6.6 m^3/ha, respectively) as a result of using a 17.5 cm+ utilization limit.

[27] According to the MP #4 data package, "existing managed stands" included all stands established post-1975.

volume can be calculated for a stump height of 20 cm if that stump height is deemed reflective of actual management practices.

6.3 Age Comparison

Inventory age was statistically under-predicted by approximately 7 years. Again, the difference is not necessarily cause for concern in timber supply predictions. It is difficult to assume that the average age of the site trees (largest diameter) in a CMI plot are the best indicator of actual average stand age. Plot ages may include ages of trees that are advanced regeneration. However, there is a small subset of the plots sampled where the age difference is greater than 15 years. It may be beneficial to note these plots before the Time 2 measurement, and ask field crews to note whether the measured ages appear reflective of overall stand age.

6.4 SI Comparisons

Only Fdi and Sx were statistically adjusted in the original SIA program. Therefore, only Fdi and Sx SI estimates were used for comparison. On average, PSI estimates were almost identical to ground based measurements, suggesting that the SIA program predicted SI well. In most cases, there was a general trend that SI may even be slightly conservative. There were not enough suitable observations of Fdi site trees to separate the SI analysis by species.

6.5 Top-Height Comparisons

Height comparisons showed that the MP #4 TIPSY outputs, determined using PSI values, predicted heights well. However, the inventory heights, determined using inventory-derived SI, under-predicted heights. Inventory heights provide a baseline for what currently exists on the TFL, but should not directly influence volume estimates in the timber supply analysis. This CMI analysis provides confidence that PSI estimates are reasonable, and should therefore be used for determining inventory heights in any future analyses.

6.6 DBH Summary

Plot DBH values were greater[28] than those predicted in TIPSY because trees less than 4.0 cm DBH are not measured. Given that there are trees present in the plots that are less than 4.0 cm DBH (as displayed in the DBH histograms in Appendix II), it is expected that the actual average plot DBH is similar to the predicted average DBH. As stands age, crown closure increases, and trees pass the 4.0 cm DBH threshold, DBH difference may be an appropriate comparison.

[28] This difference was not quantified, as this comparison is not appropriate given different standards for determining values.

6.7 Leading Species Comparisons

While species proportions should be similar on average, it is unreasonable to assume a 1:1 match between the CMI plot leading species and that observed in the inventory or assumed in the MP assumptions. The reason for this is that there is significant within polygon variability, and the CMI plots only capture data at a single point. The inventory leading species matched the plot leading species 69 % of the time. This percentage is better than that observed by Timberline in many other management areas.

The leading species used to develop TIPSY yield curves originated from site series based silviculture regimes where one leading species was assigned to each PEM site series combination. The result is that while all of the stands measured were projected as Sx-leading, the CMI plot data showed that only approximately half were actually Sx-leading with a large proportion being either Bl- or Cw-leading. The impact of projecting a managed Bl or Cw stand using a Sx-based yield curve is that the yield curve will potentially overstate volume expected from a Bl or Cw stand in the short term.

If the immature volume projections significantly alter the timber supply forecast, it may be beneficial to revise the silviculture regime definitions to reflect the higher Bl and Cw proportions.

6.8 Pest and Damage Incidence

The pest and damage report did not raise any concerns at this point. As plots are re-measured, changes in pest and damage incidence can be tracked to identify any sudden increases. Also, as growth information is collected, pest and damage incidence may be further investigated to help understand growth trends observed.

7.0 CONCLUSIONS

The CMI plot program provides a statistically-valid sample of the current stand conditions in existing managed stands 20 years and older on TFL 55. These results are compared against the assumptions modelled in the timber supply analysis supporting MP #4. The primary conclusions from this initiative are:

1) **The CMI program is successfully detecting differences between modelled assumptions in the timber supply analysis and that which is being observed in CMI plots.** The intent of a CMI program is to check timber supply analysis assumptions based on CMI plot data; the program results demonstrate this value. However, since plots have only been measured once, no growth comparisons can be made and conclusions drawn about the timber supply analysis assumptions should be done with some caution. The Time 2 measurement results will provide the opportunity to assess growth rates and a greater ability to assess the inventory and timber supply analysis inputs.

2) **Statistically, managed stand volumes were significantly less than that predicted in the timber supply analysis.** Stands modelled in TIPSY showed the average observed net merchantable ground volume was significantly less than the predicted volume (by 5.5 m^3/ha). However, these differences may not be practically different.

3) **DBH distributions support the theory that volume predictions may come more in line as stands age.** Diameter distributions in Appendix II show that most plots have a high number of stems per hectare below the merchantability limit of 17.5 cm. This suggests that as these stems cross the merchantability threshold, predicted volumes may be more reflective of actual volumes.

4) **Inventory top heights were significantly underestimated, while yield table heights were reflective of actual top heights.** The average observed top heights were significantly greater than the heights predicted in the inventory, and similar to the heights predicted by the yield tables. This may result from inventory site index being used to determine inventory height, while PSI was used to calculate yield table heights.

5) **The timber supply analysis assumptions predict site index well.** The observed site indices were not significantly different from the PSI estimates included in the latest timber supply analysis.

6) **The VRI leading species matched that observed in the CMI plots 69% of the time**. Sx was predicted to be the dominant inventory leading species in 81% of the stands while CMI measurements showed Sx being dominant in just 54% of the stands. Bl-leading stands were under-represented in the VRI, with the VRI identifying no stands measured as Bl-leading, while 23% of stands sampled were actually Bl-leading.

7) **The managed stand leading species used in the timber supply analysis matched that observed in the CMI plots 54% of the time.** The timber supply analysis leading species used to develop managed stand yield tables originated from site series based silviculture regimes. Specifically, all of the stands measured were projected as Sx leading, while only approximately half were actually Sx leading, with a large proportion of Bl- or Cw-leading.

8) **The VRI ages used in the timber supply analysis are under-estimated.** Total inventory age is significantly less than total measured age by about 7 years.

9) **Reported pest and damage agents have the potential to significantly influence the growth performance of regenerating trees.** The pest incidence and its growth influences should continue to be monitored. The incidence of pests on the TFL has the potential to reduce growth in managed stands.

8.0 RECOMMENDATIONS

The primary recommendations related to the CMI establishment results are for LP to:

1) Continue to monitor the CMI plots on a 5-year schedule, specifically to be able to assess managed stand growth rates, standing volumes and monitor forest health agents. The Time 2 measurement results will provide a greater ability to assess the inventory and timber supply analysis inputs.
2) Review the timber supply analysis assumptions used to generate managed stand yield tables, specifically the silviculture regime leading species, and age cut-off used to define "existing managed stands".
3) Establish recruitment plots that grow into the target population.

APPENDIX I – PREDICTED & ACTUAL SAMPLE DATA

Table 11. Predicted estimates for sampled polygons.

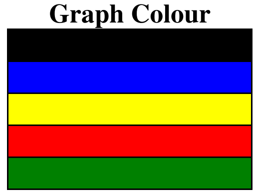
Proj.	Samp. #	MP4 AU	Leading Species		Species Label		Height (m)		Age (yrs)	SI (m)			DBH (cm)	Vol. 17.5 (m^3/ha)
			MP4	VRI	MP4	VRI	MP4	VRI		Sx SIA	Fdi SIA	MP4		
4792	1	215	Sx	Sx	Sx62Cw31Fdi7	Sx100	13.5	9.3	30	25.5	25.7	23.7	11.90	16.0
4792	2	215	Sx	Sx	Sx62Cw31Fdi7	Sx80Bl20	11.2	5.1	27	24.6	24.8	23.7	10.34	11.2
4792	3	215	Sx	Sx	Sx62Cw31Fdi7	Sx100	5.9	2.4	20	23.1	22.6	23.7	6.70	0.0
4792	4	215	Sx	Sx	Sx62Cw31Fdi7	Sx90Bl10	8.2	3.1	23	23.1	22.8	23.7	8.26	4.8
4792	5	215	Sx	Sx	Sx62Cw31Fdi7	Sx70Cw20AC10	11.2	7.0	27	26.6	26.6	23.7	10.34	11.2
4792	6	215	Sx	Sx	Sx62Cw31Fdi7	Sx70Bl30	12.7	6.5	29	24.4	24.1	23.7	11.38	14.4
4792	7	215	Sx	Sx	Sx62Cw31Fdi7	Sx70Bl30	13.5	7.3	30	24.0	23.3	23.7	11.90	16.0
4792	8	209	Sx	Sx	Sx65Cw30Fdi5	Sx60Bl20Hm10Hw10	14.1	9.2	31	23.0	20.7	23.8	12.38	27.0
4792	9	223	Sx	Sx	Sx69Bl24Hw7	Sx80Bl20	6.5	4.4	25	21.1	22.5	19.6	6.90	0.5
4792	10	216	Sx	Cw	Sx62Cw31Fdi7	Cw50Sx20Fdi20Hw10	12.1	8.5	27	24.1	24.2	24.8	10.95	19.6
4792	11	222	Sx	Hm	Sx69Bl24Hw7	Hm40Sx30Bl30	3.6	7.8	22	18.6	20.5	18.0	4.96	0.0
4792	12	223	Sx	Sx	Sx69Bl24Hw7	Sx70Bl30	7.1	3.6	26	20.4		19.6	7.32	0.6
4792	13	215	Sx	Sx	Sx62Cw31Fdi7	Sx80Bl20	6.7	3.0	21	22.9	22.0	23.7	7.22	1.6
4792	14	215	Sx	Sx	Sx62Cw31Fdi7	Sx100	7.4	3.5	22	24.7	24.7	23.7	7.74	3.2
4792	15	210	Sx	Cw	Sx65Cw30Fdi5	Cw60Sx20Hw20	10.1	7.6	25	24.2	22.6	24.2	9.50	10.0
4792	16	215	Sx	Sx	Sx62Cw31Fdi7	Sx100	7.4	3.5	22	24.7	24.7	23.7	7.74	3.2
4792	17	211	Sx	Sx	Sx53Cw27Fdi20	Sx90Bl10	7.6	3.5	22	23.1	23.3	23.8	7.84	3.0
4792	18	209	Sx	Sx	Sx65Cw30Fdi5	Sx80Cw10Hw10	9.0	5.0	24	24.0	21.6	23.8	8.72	6.4
4792	19	212	Sx	Cw	Sx53Cw27Fdi20	Cw80Sx20	6.6	7.1	21	24.5	23.9	23.5	7.21	1.3
4792	20	211	Sx	Sx	Sx53Cw27Fdi20	Sx80Bl20	8.3	2.2	23	23.5	23.8	23.8	8.36	4.5
4792	21	223	Sx	Sx	Sx69Bl24Hw7	Sx80Bl20	4.2	2.6	21	18.7		19.6	5.22	0.1
4792	22	215	Sx	Sx	Sx62Cw31Fdi7	Sx90Cw10	7.4	3.3	22	21.0	20.8	23.7	7.74	3.2
4792	23	215	Sx	Sx	Sx62Cw31Fdi7	Sx80Bl10Cw10	7.4	2.9	22	21.7	21.0	23.7	7.74	3.2
4792	24	212	Sx	Fdi	Sx53Cw27Fdi20	Fdi80Cw10Sx10	8.8	6.5	24	22.6	23.6	23.5	8.74	5.2
4792	25	215	Sx	Sx	Sx62Cw31Fdi7	Sx100	6.7	2.6	21	23.5	22.9	23.7	7.22	1.6
4792	26	215	Sx	Sx	Sx62Cw31Fdi7	Sx80Cw10Hw10	7.4	3.5	22	23.0	22.7	23.7	7.74	3.2

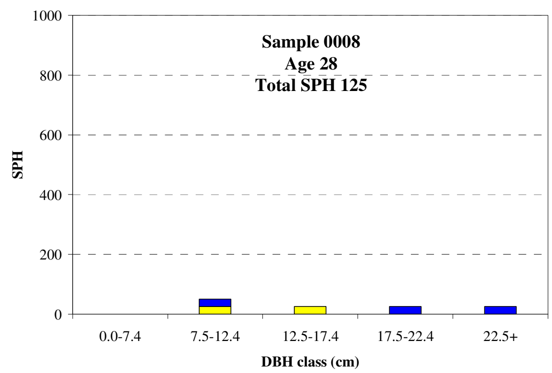
Table 12. Actual ground data from sampled polygons.

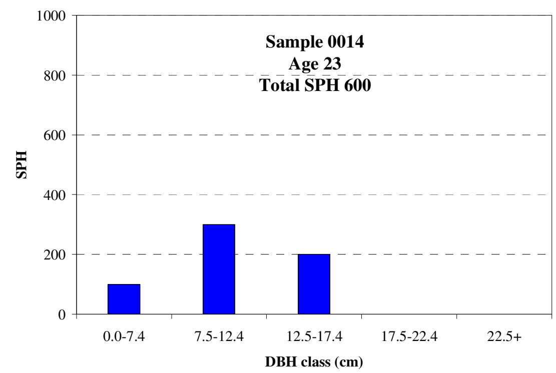
Samp #	Samp Year	UTMs			Mapsheet	Poly	BEC subzone	Ldg Sp.	Species Label	Total BA (m^2/ha)	Ht (m)	Age (yrs)	SI (m)	DBH (cm)	Vol. 17.5 (m^3/ha)
		Zone	Northing	Easting											
1	2008	11	5731000	387000	082M077	2434	ICH-vk-1	Sx	Sx83Bl10Hw6Fdi1	28.4	12.5	28	26.2	14.9	3.40
2	2008	11	5732000	388000	082M077	2436	ICH-vk-1	Sx	Sx61Bl39	18.9	11.8	53	25.9	16.9	2.37
3	2008	11	5740000	388000	082M077	2406	ICH-vk-1	Sx	Sx100	3.7	5.2	19	21.2	8.6	0.00
4	2008	11	5741000	388000	082M087	2011	ICH-vk-1	Bl	Bl42Sx35Cw23	11.9	8.9	27	19.1	13.3	0.97
5	2008	11	5730000	389000	082M077	2451	ICH-vk-1	Sx	Sx75Cw18Bl4Hw3	27.2	12.8	28	27.1	13.0	2.20
6	2008	11	5731000	389000	082M077	2442	ICH-vk-1	Bl	Bl53Sx46Hm1	22.7	11.3	30	21.7	10.5	1.89
7	2008	11	5732000	389000	082M077	2445	ICH-vk-1	Sx	Sx68Bl32	16.1	14.2	40	23.0	12.5	2.13
8	2008	11	5733000	389000	082M077	2423	ICH-vk-1	Sx	Sx77Hm23	3.3	10.0	28	22.4	17.4	0.34
9	2008	11	5741000	390000	082M088	1438	ESSFvc--	Bl	Bl44Hm31Sx24	8.1	9.5	30	18.9	8.1	0.22
10	2008	11	5729000	391000	082M078	2532	ICH-vk-1	Cw	Cw34Fdi32Sx27Pw6	5.0	7.6	20	20.9	9.6	0.12
11	2008	11	5728000	392000	082M068	2402	ESSFvc--	Hm	Hm42Bl35Cw23	10.2	6.9	49	13.9	8.0	0.77
12	2008	11	5741000	392000	082M088	1454	ESSFvc--	Bl	Bl76Sx24	6.1	8.6	30	17.3	6.7	0.24
13	2008	11	5747000	392000	082M088	1168	ICH-vk-1	Sx	Sx98Bl2	8.8	7.1	26	19.7	7.1	0.92
14	2009	11	5767000	392000	083D008	2400	ICH-vk-1	Sx	Sx100	6.2	9.1	23	25.1	11.2	0.00
15	2008	11	5743000	393000	082M088	1431	ICH-vk-1	Cw	Cw58Sx24Hw18	33.0	17.0	42	23.1	12.9	5.84
16	2009	11	5766000	393000	083D008	2400	ICH-vk-1	Sx	Sx100	9.0	8.3	22	24.1	12.7	0.17
17	2008	11	5767000	393000	083D008	2401	ICH-vk-1	Bl	Bl62Sx38	4.5	11.1	55	10.3	7.4	0.22
18	2008	11	5743000	394000	082M088	1503	ICH-vk-1	Sx	Sx65Cw20Hw15	21.5	13.1	29	26.4	12.7	2.04
19	2008	11	5755000	394000	082M098	2118	ICH-vk-1	Hw	Hw61Sx39	0.6	5.3	42	7.8	12.2	0.00
20	2008	11	5756000	394000	082M098	2120	ICH-vk-1	Bl	Bl93Sx7	5.0	10.7	55	15.8	10.7	0.72
21	2008	11	5739000	395000	082M078	2506	ESSFvc--	Sx	Sx93Pli7	2.7	6.5	22	21.3	7.4	0.00
22	2009	11	5739000	396000	082M078	2507	ICH-vk-1	Sx	Sx100	7.1	8.0	21	24.3	9.5	0.00
23	2009	11	5740000	396000	082M088	1580	ICH-vk-1	Cw	Cw100	1.0		25		6.4	0.12
24	2008	11	5743000	396000	082M088	1398	ICH-vk-1	Fdi	Fdi86Hw10Cw3Sx2	19.9	14.3	27	29.3	13.1	2.35
25	2009	11	5763000	398000	083D008	2431	ICH-vk-1	Sx	Sx100	11.9	8.8	22	24.8	10.0	0.00
26	2009	11	5722000	418000	082M070	2615	ICH-vk-1	Sx	Sx62Hw38	10.4	8.9	25	27.4	11.9	0.30

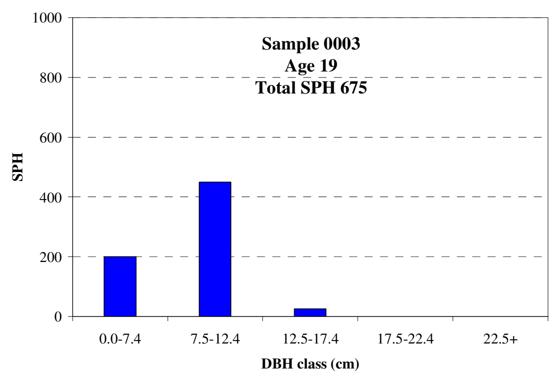
APPENDIX II – DBH DISTRIBUTIONS[29]

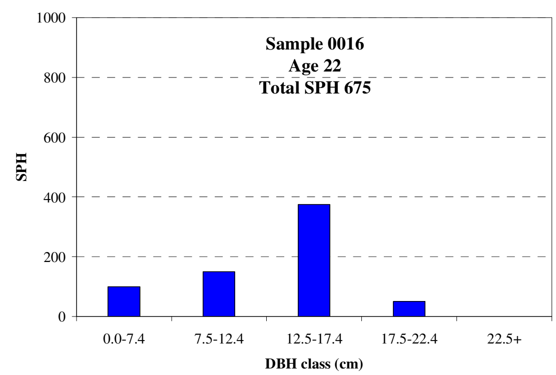
Graph Colour	Species
	Fdi & Pli
	Sx
	H
	Cw
	Bl

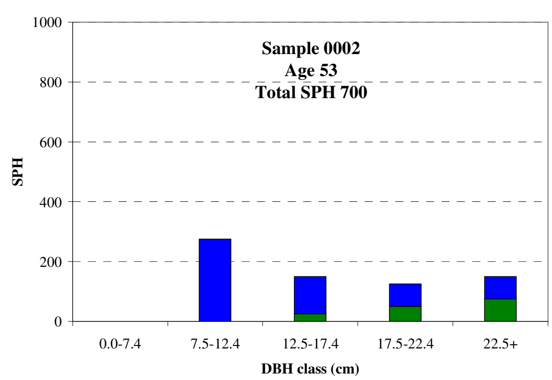


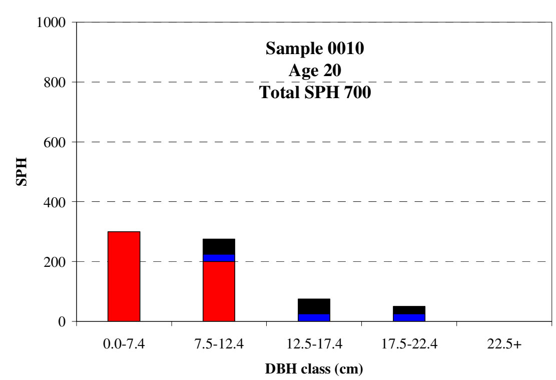




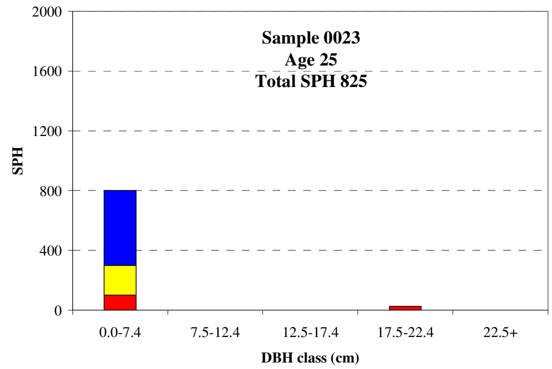


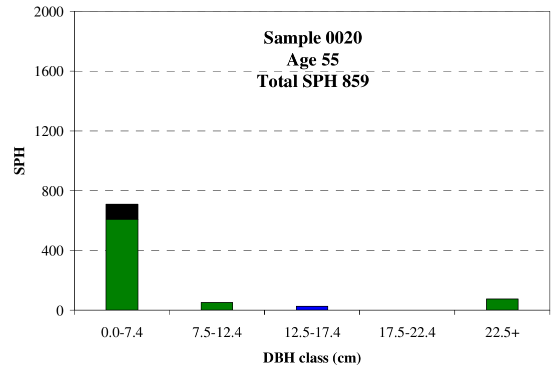


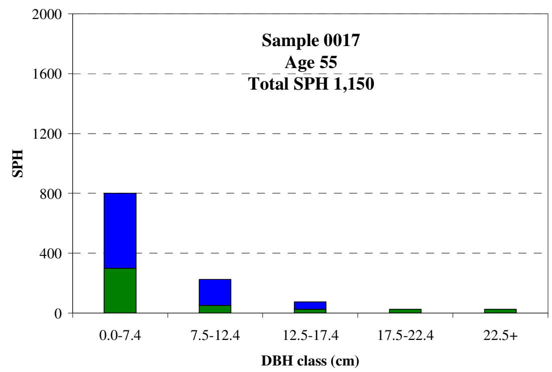


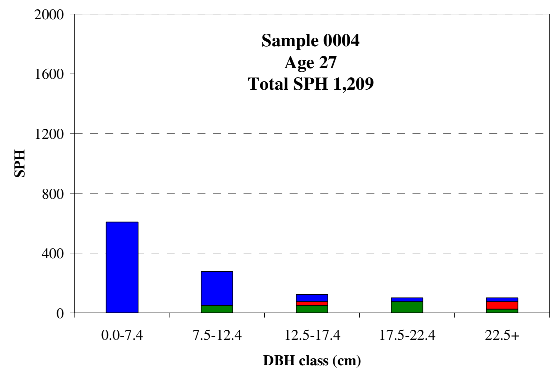


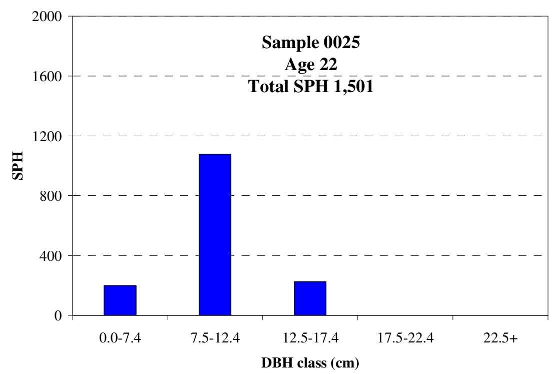
[29] "Age" and "Total SPH" values are actual plot values.

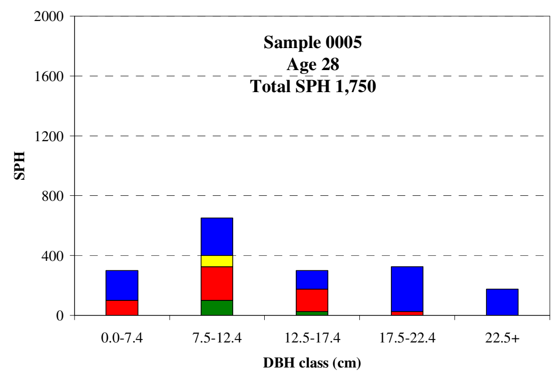

Sample 0023
Age 25
Total SPH 825
SPH
2000
1600
1200
800
400
0
0.0-7.4
7.5-12.4
12.5-17.4
17.5-22.4
22.5+
DBH class (cm)

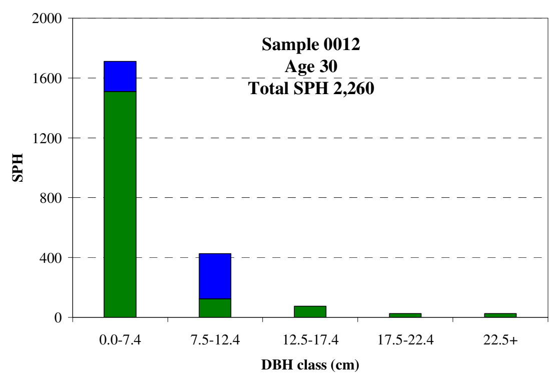

Sample 0020
Age 55
Total SPH 859
SPH
2000
1600
1200
800
400
0
0.0-7.4
7.5-12.4
12.5-17.4
17.5-22.4
22.5+
DBH class (cm)

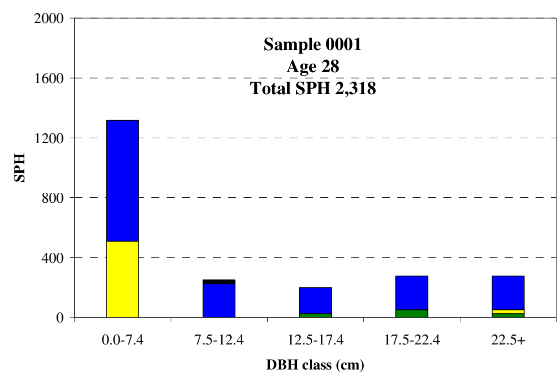

Sample 0017
Age 55
Total SPH 1,150
SPH
2000
1600
1200
800
400
0
0.0-7.4
7.5-12.4
12.5-17.4
17.5-22.4
22.5+
DBH class (cm)

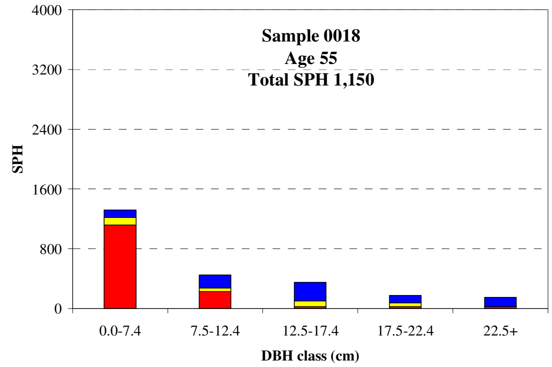

Sample 0004
Age 27
Total SPH 1,209
SPH
2000
1600
1200
800
400
0
0.0-7.4
7.5-12.4
12.5-17.4
17.5-22.4
22.5+
DBH class (cm)

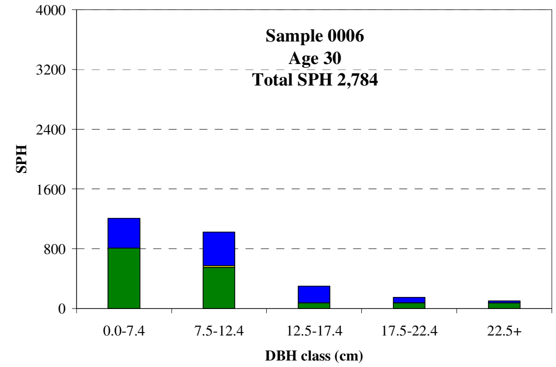

Sample 0025
Age 22
Total SPH 1,501
SPH
2000
1600
1200
800
400
0
0.0-7.4
7.5-12.4
12.5-17.4
17.5-22.4
22.5+
DBH class (cm)

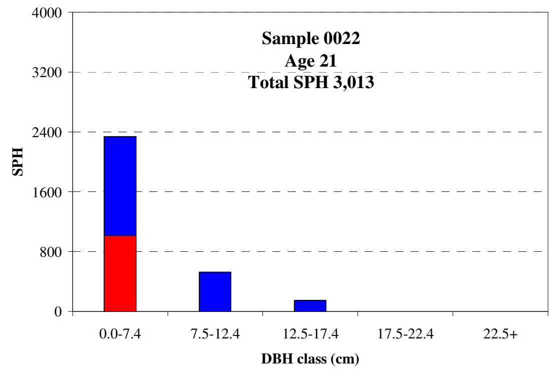

Sample 0005
Age 28
Total SPH 1,750
SPH
2000
1600
1200
800
400
0
0.0-7.4
7.5-12.4
12.5-17.4
17.5-22.4
22.5+
DBH class (cm)

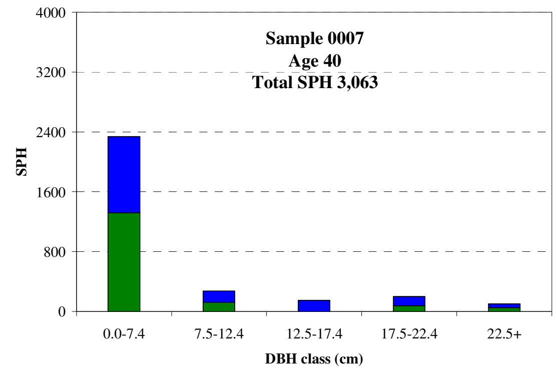

Sample 0012
Age 30
Total SPH 2,260
SPH
2000
1600
1200
800
400
0
0.0-7.4
7.5-12.4
12.5-17.4
17.5-22.4
22.5+
DBH class (cm)

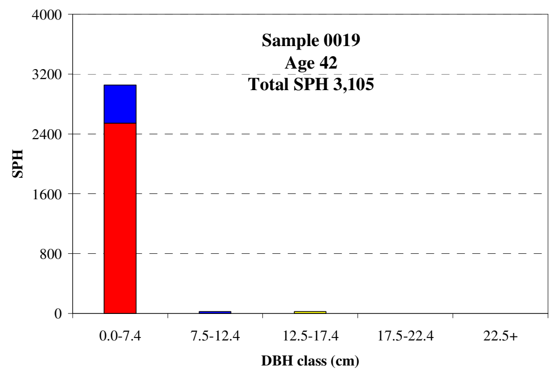

Sample 0001
Age 28
Total SPH 2,318
SPH
2000
1600
1200
800
400
0
0.0-7.4
7.5-12.4
12.5-17.4
17.5-22.4
22.5+
DBH class (cm)

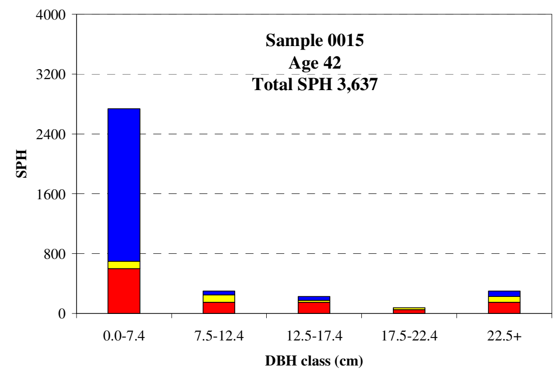

Sample 0018
Age 55
Total SPH 1,150
SPH
4000
3200
2400
1600
800
0
0.0-7.4
7.5-12.4
12.5-17.4
17.5-22.4
22.5+
DBH class (cm)

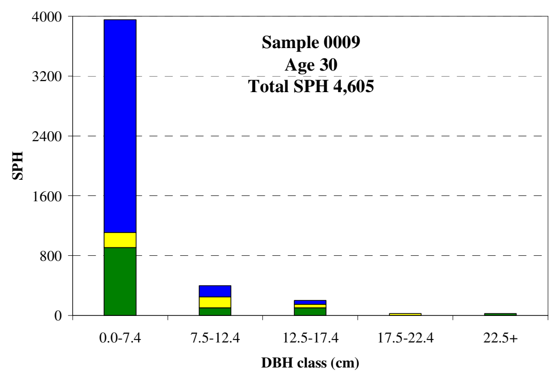

Sample 0006
Age 30
Total SPH 2,784
SPH
4000
3200
2400
1600
800
0
0.0-7.4
7.5-12.4
12.5-17.4
17.5-22.4
22.5+
DBH class (cm)

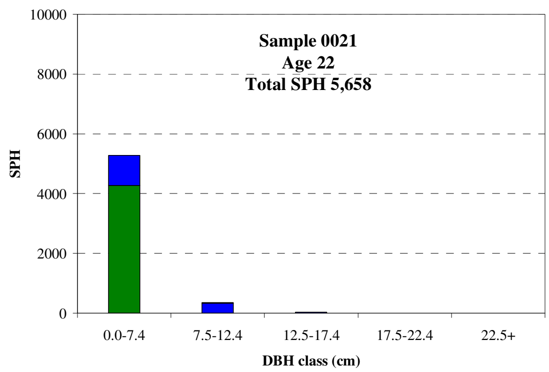

Sample 0022
Age 21
Total SPH 3,013
SPH
4000
3200
2400
1600
800
0
0.0-7.4
7.5-12.4
12.5-17.4
17.5-22.4
22.5+
DBH class (cm)

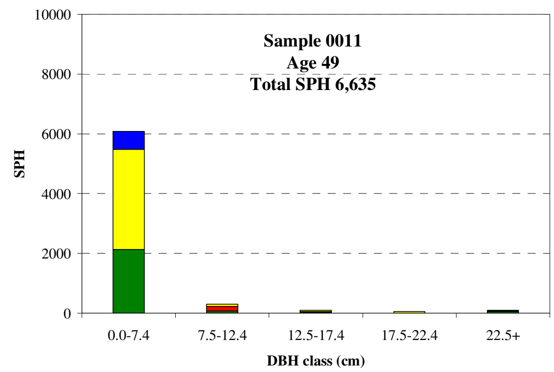

Sample 0007
Age 40
Total SPH 3,063
SPH
4000
3200
2400
1600
800
0
0.0-7.4
7.5-12.4
12.5-17.4
17.5-22.4
22.5+
DBH class (cm)

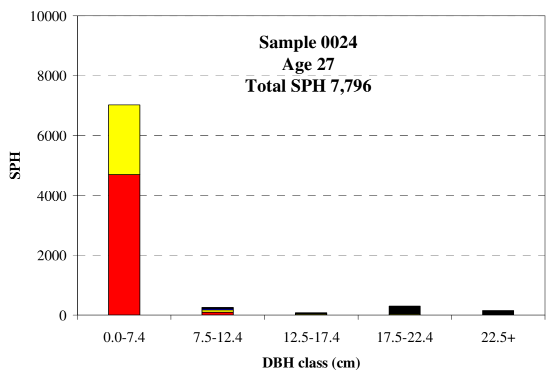

Sample 0019
Age 42
Total SPH 3,105
SPH
4000
3200
2400
1600
800
0
0.0-7.4
7.5-12.4
12.5-17.4
17.5-22.4
22.5+
DBH class (cm)

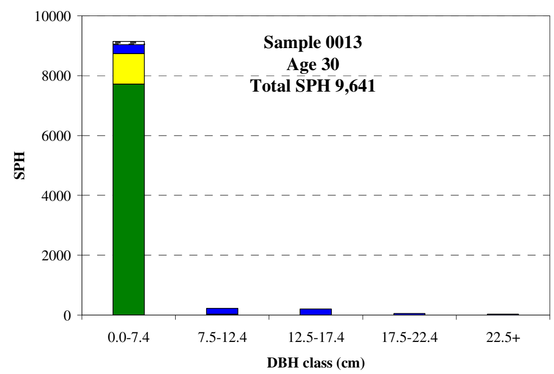

Sample 0015
Age 42
Total SPH 3,637
SPH
4000
3200
2400
1600
800
0
0.0-7.4
7.5-12.4
12.5-17.4
17.5-22.4
22.5+
DBH class (cm)

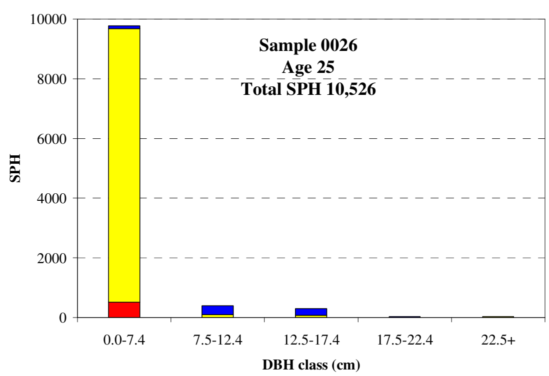

Sample 0009
Age 30
Total SPH 4,605
SPH
4000
3200
2400
1600
800
0
0.0-7.4
7.5-12.4
12.5-17.4
17.5-22.4
22.5+
DBH class (cm)


Sample 0021
Age 22
Total SPH 5,658
SPH
DBH class (cm)
0.0-7.4
7.5-12.4
12.5-17.4
17.5-22.4
22.5+


Sample 0011
Age 49
Total SPH 6,635
SPH
DBH class (cm)
0.0-7.4
7.5-12.4
12.5-17.4
17.5-22.4
22.5+

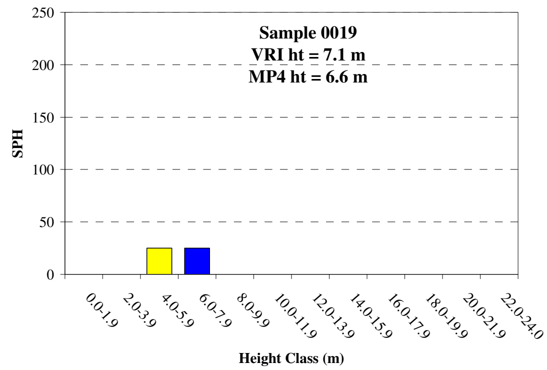

Sample 0024
Age 27
Total SPH 7,796
SPH
DBH class (cm)
0.0-7.4
7.5-12.4
12.5-17.4
17.5-22.4
22.5+

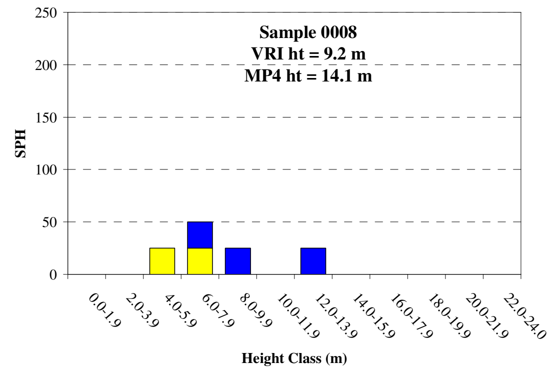

Sample 0013
Age 30
Total SPH 9,641
SPH
DBH class (cm)
0.0-7.4
7.5-12.4
12.5-17.4
17.5-22.4
22.5+

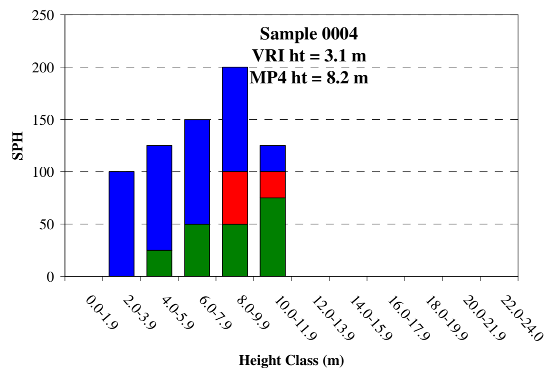

Sample 0026
Age 25
Total SPH 10,526
SPH
DBH class (cm)
0.0-7.4
7.5-12.4
12.5-17.4
17.5-22.4
22.5+

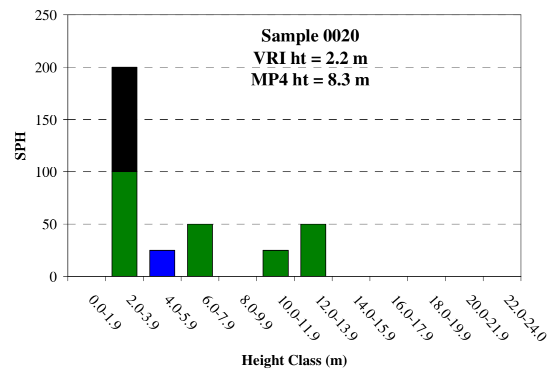
APPENDIX III – HEIGHT DISTRIBUTIONS

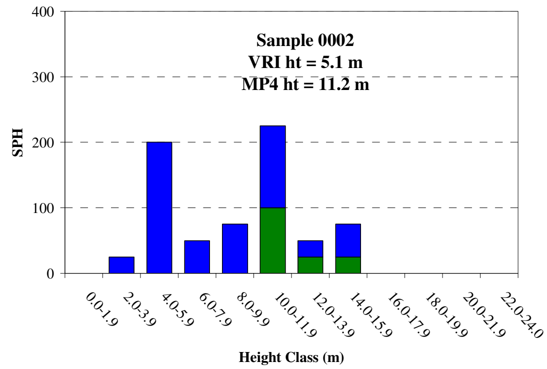
Graph Colour	Species
	Fdi & Pli
	Sx
	H
	Cw
	Bl

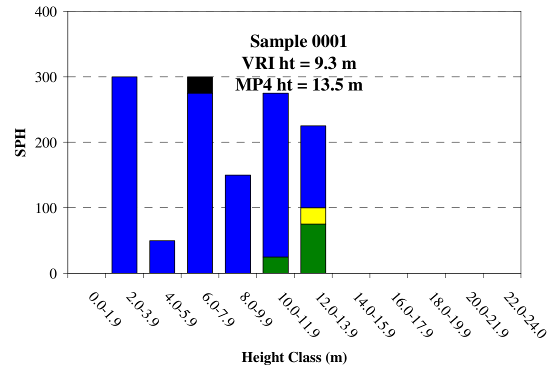


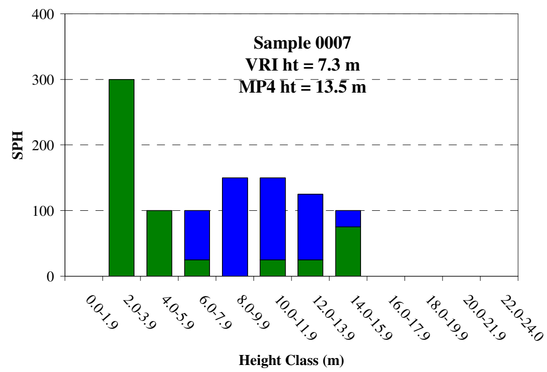


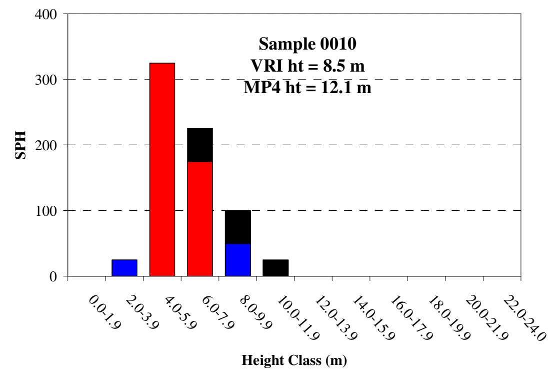


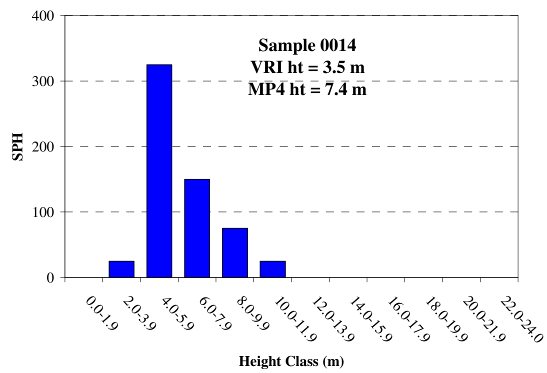


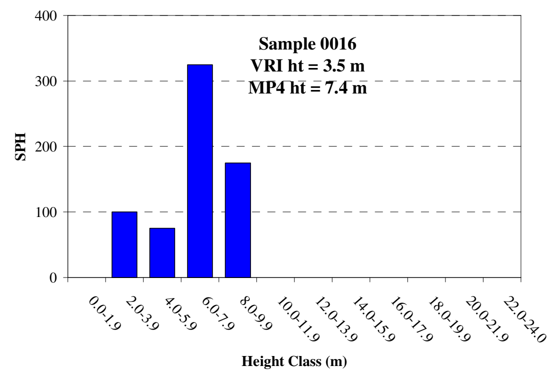

Sample 0002
VRI ht = 5.1 m
MP4 ht = 11.2 m
SPH
0
100
200
300
400
0.0-1.9
2.0-3.9
4.0-5.9
6.0-7.9
8.0-9.9
10.0-11.9
12.0-13.9
14.0-15.9
16.0-17.9
18.0-19.9
20.0-21.9
22.0-24.0
Height Class (m)

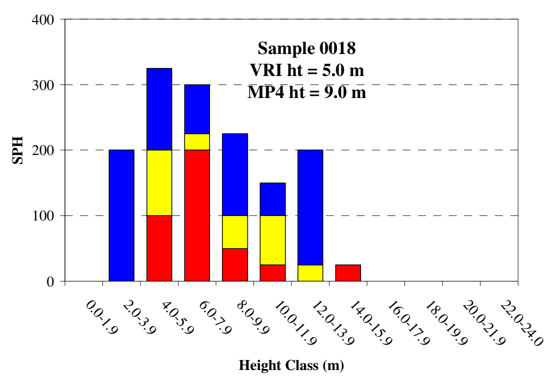

Sample 0001
VRI ht = 9.3 m
MP4 ht = 13.5 m
SPH
0
100
200
300
400
0.0-1.9
2.0-3.9
4.0-5.9
6.0-7.9
8.0-9.9
10.0-11.9
12.0-13.9
14.0-15.9
16.0-17.9
18.0-19.9
20.0-21.9
22.0-24.0
Height Class (m)

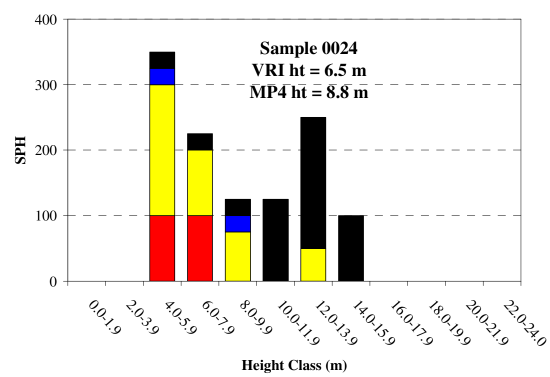

Sample 0007
VRI ht = 7.3 m
MP4 ht = 13.5 m
SPH
0
100
200
300
400
0.0-1.9
2.0-3.9
4.0-5.9
6.0-7.9
8.0-9.9
10.0-11.9
12.0-13.9
14.0-15.9
16.0-17.9
18.0-19.9
20.0-21.9
22.0-24.0
Height Class (m)

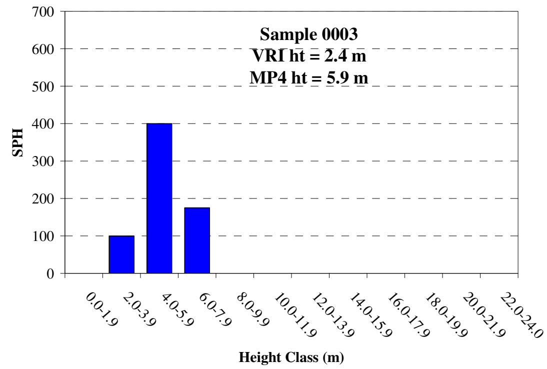

Sample 0010
VRI ht = 8.5 m
MP4 ht = 12.1 m
SPH
0
100
200
300
400
0.0-1.9
2.0-3.9
4.0-5.9
6.0-7.9
8.0-9.9
10.0-11.9
12.0-13.9
14.0-15.9
16.0-17.9
18.0-19.9
20.0-21.9
22.0-24.0
Height Class (m)

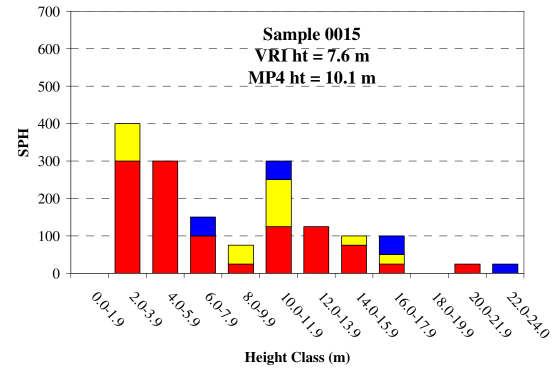

Sample 0014
VRI ht = 3.5 m
MP4 ht = 7.4 m
SPH
0
100
200
300
400
0.0-1.9
2.0-3.9
4.0-5.9
6.0-7.9
8.0-9.9
10.0-11.9
12.0-13.9
14.0-15.9
16.0-17.9
18.0-19.9
20.0-21.9
22.0-24.0
Height Class (m)

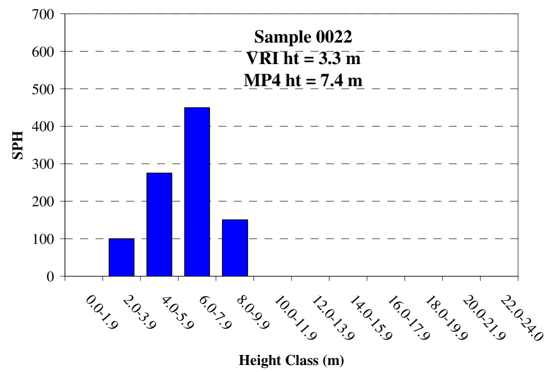

Sample 0016
VRI ht = 3.5 m
MP4 ht = 7.4 m
SPH
0
100
200
300
400
0.0-1.9
2.0-3.9
4.0-5.9
6.0-7.9
8.0-9.9
10.0-11.9
12.0-13.9
14.0-15.9
16.0-17.9
18.0-19.9
20.0-21.9
22.0-24.0
Height Class (m)

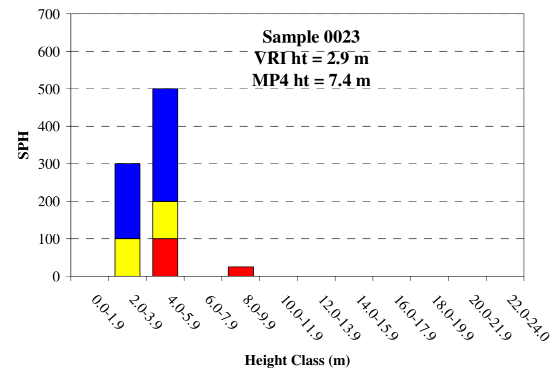

Sample 0018
VRI ht = 5.0 m
MP4 ht = 9.0 m
SPH
0
100
200
300
400
0.0-1.9
2.0-3.9
4.0-5.9
6.0-7.9
8.0-9.9
10.0-11.9
12.0-13.9
14.0-15.9
16.0-17.9
18.0-19.9
20.0-21.9
22.0-24.0
Height Class (m)

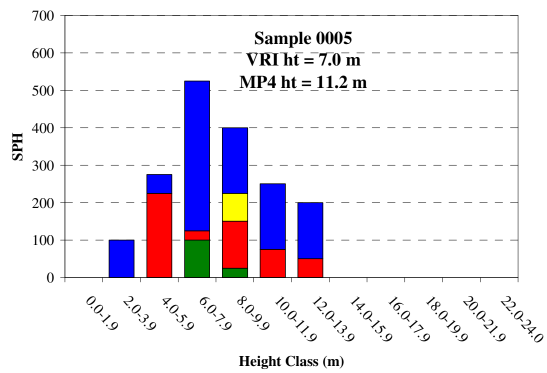

Sample 0024
VRI ht = 6.5 m
MP4 ht = 8.8 m
SPH
0
100
200
300
400
0.0-1.9
2.0-3.9
4.0-5.9
6.0-7.9
8.0-9.9
10.0-11.9
12.0-13.9
14.0-15.9
16.0-17.9
18.0-19.9
20.0-21.9
22.0-24.0
Height Class (m)

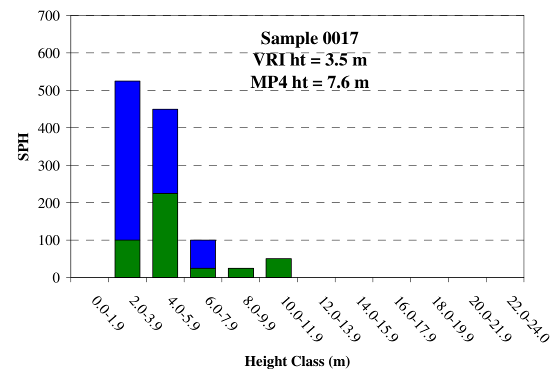

Sample 0003
VRI ht = 2.4 m
MP4 ht = 5.9 m
SPH
Height Class (m)

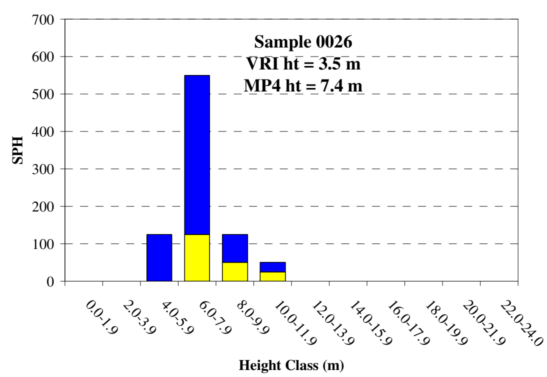

Sample 0015
VRI ht = 7.6 m
MP4 ht = 10.1 m
SPH
Height Class (m)

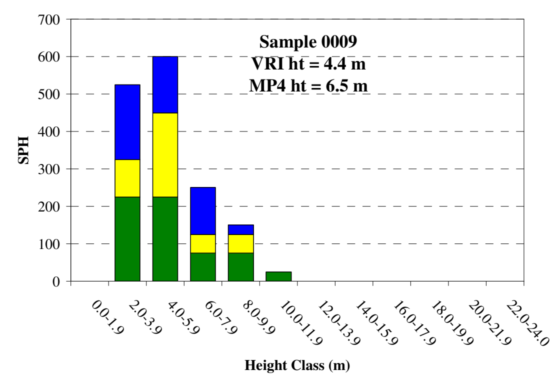

Sample 0022
VRI ht = 3.3 m
MP4 ht = 7.4 m
SPH
Height Class (m)

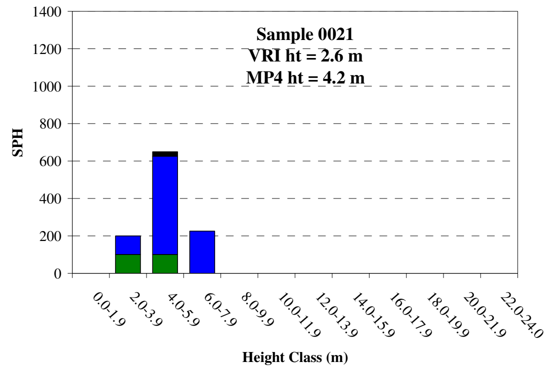

Sample 0023
VRI ht = 2.9 m
MP4 ht = 7.4 m
SPH
Height Class (m)

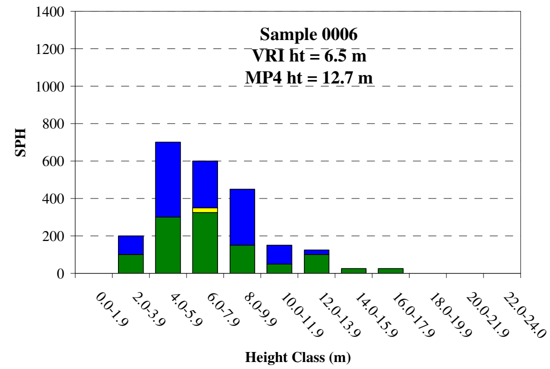

Sample 0005
VRI ht = 7.0 m
MP4 ht = 11.2 m
SPH
Height Class (m)

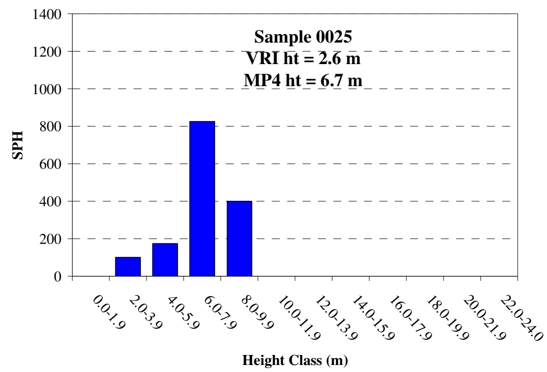

Sample 0017
VRI ht = 3.5 m
MP4 ht = 7.6 m
SPH
Height Class (m)

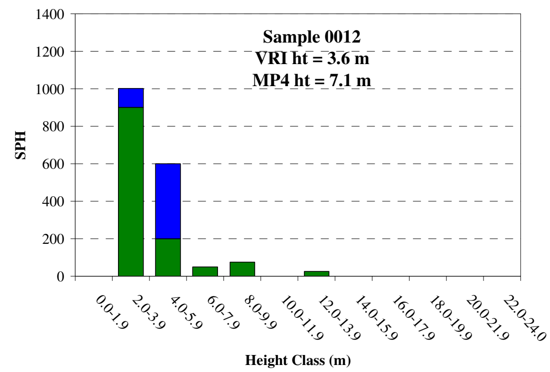

Sample 0026
VRI ht = 3.5 m
MP4 ht = 7.4 m
SPH
Height Class (m)

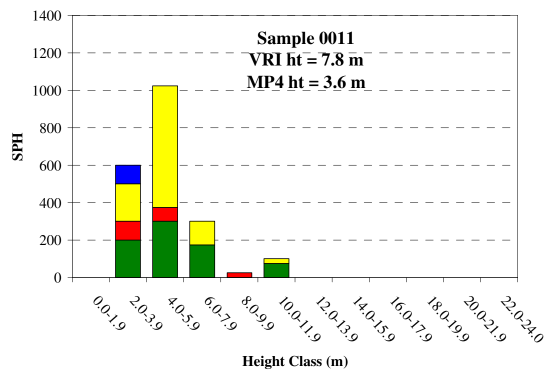

Sample 0009
VRI ht = 4.4 m
MP4 ht = 6.5 m
SPH
Height Class (m)

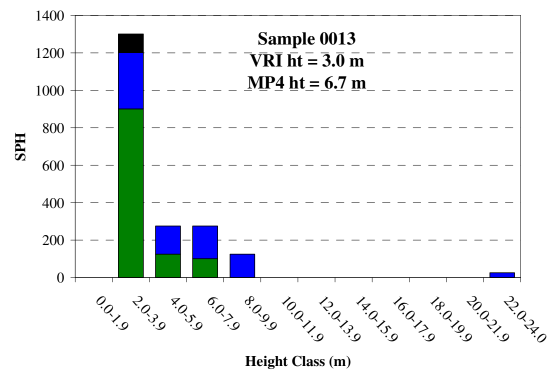

Sample 0021
VRI ht = 2.6 m
MP4 ht = 4.2 m
SPH
Height Class (m)


Sample 0006
VRI ht = 6.5 m
MP4 ht = 12.7 m
SPH
Height Class (m)


Sample 0025
VRI ht = 2.6 m
MP4 ht = 6.7 m
SPH
Height Class (m)


Sample 0012
VRI ht = 3.6 m
MP4 ht = 7.1 m
SPH
Height Class (m)


Sample 0011
VRI ht = 7.8 m
MP4 ht = 3.6 m
SPH
Height Class (m)


Sample 0013
VRI ht = 3.0 m
MP4 ht = 6.7 m
SPH
Height Class (m)