TFL 35 Growth & Yield Monitoring Pilot Project: An Example Analysis of First Measurement Results

Prepared for

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Executive Summary

A pilot test of the Ministry of Sustainable Resource Management's (MSRM) new growth and yield monitoring program was completed in Weyerhaeuser Company Limited's Tree Farm License (TFL) 35 near Kamloops, BC. Sixty-five (65) plots were located in post-harvest regenerated stands across the TFL using a 1.0 km grid constructed using Universal Transverse Mercator (UTM) coordinates. The 400 m^2 sample plots were installed in the 2000 and 2001 field seasons with all trees ≥ 4.0 cm diameter measured and tagged. Some modification to the MSRM methods were made to meet Weyerhaeuser's business needs including: 1) tagging and measuring smaller trees than indicated in the MSRM standards to provide information on the dynamics of young stands, and 2) measuring tree branches to track indicators of wood quality in post-harvest regenerated stands.

Data analysis from the first measurement of these 65 plots was limited to an inventory audit (i.e., yield audit), where plot attributes were compared with the inventory at one point in time. Analyses for subsequent measurements can include comparison of growth between the measurement periods in addition to another yield audit at the time of the future measurements.

The analyses showed that the sample design tested in this project provides useful information and feedback on the growth and yield of the sampled stands. Comparison of the monitoring plot and inventory data were made for merchantable volume, stand age, site index, stand density, and species composition. The analyses showed a significant positive bias (under prediction) in net merchantable volume and age. The plot data showed an average of about 17 m^3/ha more volume than is indicated in the inventory for these young stands, and the average age of site trees in the plots was also about 8-9 years older than indicated in the inventory. The results also indicate there is a significant amount of balsam in the sampled stands that is not included in the inventory. There was no significant difference in stand density or site index between the monitoring sample plots and the inventory.

Existing MSRM data management procedures were not efficient for the measurements included in this pilot project. This was primarily because the measurement modifications to address Weyerhaeuser's business needs were not easily handled with the MSRM data entry, error checking, and compilation procedures. In addition, the TFL yield curves were not in a format that allowed easy comparison with the field data.

From this pilot test we conclude that the methods worked well, and the results are very useful to help manage the TFL. We recommend that changes be made to the MSRM data management procedures, and that Weyerhaeuser follow-up on the result of these comparisons.

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1. INTRODUCTION

1.1 Background

Weyerhaeuser Company Limited (Weyco) has just completed the first measurement of sample plots installed under a growth and yield (G&Y) monitoring program for Tree Farm License (TFL) 35 near Kamloops, BC. Weyco considered designing and implementing a G&Y monitoring program on the TFL for several years; however, plans in the early 1990s were delayed because the Ministry of Forests (MOF) was in the process of developing a similar system. Weyco did not want to risk developing an incompatible monitoring system, thus delayed the program until 1999. Weyco subsequently secured Forest Renewal BC (FRBC) funding to test the new MOF protocol[1] for G&Y monitoring on TFL 35.

This project was developed in conjunction with the MOF, Inventory Branch to pilot test the newly developed G&Y monitoring program on TFL 35. The project began in the spring of 2000 with confirmation of business needs and design of the program.[2] The primary business need for G&Y monitoring on the TFL identified by Weyco staff was to periodically measure actual G&Y of post-harvest regenerated (PHR) stands to check projections used in timber supply analysis. The most important secondary business need was to provide monitoring data and information to support future certification requirements.

The first set of 20 monitoring plots were installed under this pilot project in the late summer and early fall of 2000.[3] An additional 45 plots to complete the monitoring sample were installed in the summer of 2001. There are now 65 G&Y monitoring plots established on the TFL that are a representative sample of all PHR stands between 15 and 40 years of age (as of January 1, 2001).

1.2 Monitoring Objectives

The primary objective of the G&Y monitoring program[2] is to:

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

The secondary objective of the program is to:

> *Use a sample design that can be modified to provide information to support future 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. The goal is to develop a high 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.

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[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. March 31, 2000. 10 pp.

[2] J.S. Thrower & Associates Ltd. 2000. Pilot test of a growth and yield monitoring program for Weyerhaeuser's TFL 35: Sample plan. Contract report to Weyerhaeuser Company Limited. Kamloops, BC. May 31, 2000. 16 pp.

[3] J.S. Thrower & Associates Ltd. 2001. TFL 35 growth and yield monitoring pilot project: Year end report. Contract report to Weyerhaeuser Company Limited. Kamloops, BC. March 30, 2001. 19 pp.

1.3 REPORT OBJECTIVES

The objectives of this report are to:

1) Summarize the sampling design and data management used in the TFL 35 G&Y monitoring pilot project, including procedures that were successful and those that need refinement.
2) Present an example of the analyses and interpretations that can be completed after the first measurement of G&Y monitoring plots is complete in a management unit. This example summarizes data from the first 65 plots established under this pilot project, and compares the data to projections of stand attributes for the stands in which the plots were located.

1.4 TERMS OF REFERENCE

This project was completed by J.S. Thrower and Associates Ltd. (JST) for Don Brimacombe, *RPF* of Weyerhaeuser Company Limited, Kamloops, BC. Sean Curry, *RPF* (Weyco, Kamloops) provided information from the Management Plan (MP) 9 data package for the comparisons in this report. The JST project team was Eleanor McWilliams, *MSc RPF* (project manager and analyst), Jim Thrower, *PhD RPF* (project leader), Mike Ciccotelli, *ForTech* (field operations manager), Scott MacKinnon, *BNRSc*, Kendra Wood, *BScF*, and Morgan Jumbo (primary field crew). The Ministry of Sustainable Resource Management (MSRM) contacts were Bob Macdonald, *RPF* (Kamloops Forest Region) and Jon Vivian, *RPF* (Terrestrial Information Branch, Victoria).

Figure 1. Trees in plot 840-600 with 3,300/ha Bl and 1,400/ha Pl. The balsam site trees had an average age of 25 years while pine site trees had an average age of 16 years. The species composition of this 16-year-old stand was Bl 44% and Pl 40% based on stand density. There was no net merchantable volume for either the inventory or plot measurements.

2. SAMPLING DESIGN

2.1 OVERVIEW

The key features of the sampling design are:

1) Potential sample points are located on a 1.0 km grid across the TFL.
2) Sample plots are installed where grid points are in PHR stands between 15 and 40 years of age.
3) Sample plots are circular and 400 m^2 in size, centered at these grid points.
4) All trees $\geq$ 4.0 cm in diameter at breast height (DBH) are tagged and measured.
5) All sample plots in the initial target population were installed over two years.
6) Sample plots will be remeasured every five years (funding permitting) to correspond with preparation of management plans for the TFL.

2.2 PURPOSE

The purpose of the sampling 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 Weyco's primary business needs, be compatible with the MSRM preliminary protocol for monitoring, and provide information in a cost-effective manner. For the first measurement period, the data can be used to audit the yield tables and other inventory attributes used for PHR stands with inventory ages between 15 and 40. Growth estimates (i.e., change) can be computed from the second and subsequent measurements.

2.3 TARGET POPULATION

The target population was all PHR stands that are 15 years of age and older. The initial definition of the target population also included a maximum age of 40 years to reflect the start of clearcutting on the TFL in the late 1950's. The target population covers approximately 18% of the 36,445 ha TFL (Appendix I) and will expand over time as more stands are harvested and subsequently regenerated.

2.4 SAMPLE PLOT LOCATION

The sample plots are located on a 1.0 km square grid created using NAD 83 UTM coordinates evenly divisible by 1,000. The 1.0 km grid gives an approximate sample intensity of one plot for each 100 ha of PHR stand area. Sixty-five (65) plots were established for this pilot project: 20 in the 2000 field season and 45 in the 2001 field season.

2.5 PLOT NUMBERING

All UTM Easting coordinates on the TFL start with 6 (i.e., 6xx,xxx), and all UTM Northing coordinates start with 56 (i.e., 5,6xx,xxx). All points on the 1.0 km grid are therefore Easting 6xx,000 and Northing 5,6xx,000. Plot numbers were assigned by removing the first 6 from the Easting, the first 56 from the Northing, and the last two zeros from each. For example, a plot located at 684,000 Easting and 5,656,000 Northing would have a plot number of 840-560. If there was certainty that all future plots would only be established on the 1.0 km grid or a larger grid based on an even number of kilometers, then the plot numbers could have been assigned by removing the last three zeros from both coordinates (e.g., 84-56). Three digits were retained for both Easting and Northing to allow flexibility for different grid sizes (multiples of 100 m) in the future. In the compiled data received from the MSRM the plot numbers (which are referred to as sample numbers) are recorded as four digits (e.g., 8456).

2.6 Sample Plot Design

The monitoring plots are 400 m^2 circular plots with two nested subplots (Figure 2). This design follows the MSRM Change Monitoring Inventory (CMI) plot design with some modification to address Weyco's business needs. For example, these plots used a smaller tree tagging limit and included measurement of branch diameters (Appendix II).

Main plot (11.28 m) – trees 4.0 cm and greater in DBH were tagged and measured.

Small-tree plot (5.64 m) – trees less than 4.0 cm in DBH and taller than 1.3 m were measured.

Regen plot (2.50 m)– trees less than 1.3 m in height were tallied and stumps measured.

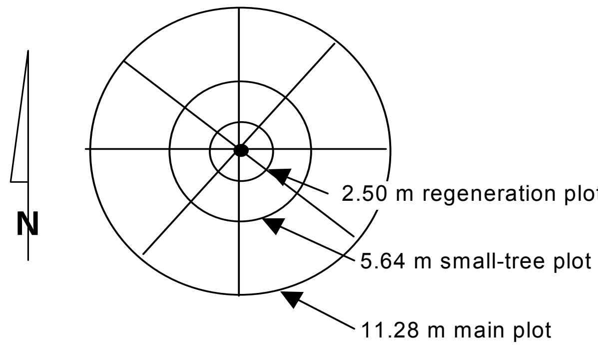

Figure 2. Monitoring sample plot for TFL 35.

2.7 Tree Tags

Special plastic tree tags were made for this project (3.8 cm in diameter [1.5 in]).[4] The tags are brown in color instead of the usual blue. Brown was selected to help keep the tags and sample plots hidden to avoid the plots being treated differently from the rest of the TFL landbase.[5] The tags are numbered from 001 to 999 (Figure 3).

Figure 3. Tree tags used on the TFL 35 G&Y monitoring sample plots.

2.8 Future Plot Establishment and Remeasurement

The current harvest rate on TFL 35 is about 400 ha/year, thus approximately four new plot locations move into the target population each year (i.e., one plot/100 ha). We propose that new plots be established and existing plots remeasured on a five-year cycle to correspond with MP preparations. Measurements should take place at least two years prior to MP submission to allow time for data analysis, and to take corrective action if necessary.

[4] Tags were made by T.B. Vets, Vancouver, BC.

[5] The intent is that these monitoring plots are a representative sample of PHR stands on the TFL. To ensure that they stay a representative sample over time, they are not to be buffered or protected; they are to be treated according to the management regimes assigned to the area where they are located.

3. DATA MANAGEMENT

3.1 DATA ENTRY AND ERROR CHECKING

Field data were keypunched and checked for errors using the MSRM software Vegetation Inventory Data Entry (VIDE version 1.2.02). The MSRM requires that all CMI data be entered using VIDE. Modifications to the plot design caused several problems as the VIDE program had limited ability to accept data other than for which it was designed. This resulted in a considerable amount of time spent on data entry and error checking in this pilot project; this should be reduced in the future with improved data entry procedures. The data were submitted to the MSRM for compilation after data entry and editing were complete.

3.2 DATA COMPILATION

Data compilation was completed by the MSRM.[6] Modifications to the compiler were necessary to handle the non-standard data collected in this project (Appendix II).[7]

3.3 DATABASE DESIGN

We developed an MS Access database to store compiled data, including individual tree information and plot summaries. Predicted values for each plot were included in the database using the information for MP 9.

3.4 INVENTORY DATA AND YIELD CURVES

Two versions of the inventory were used to select sample plot locations. An August 2000 version used for the initial selection indicated 64 points in the target population. Based on this information, 20 locations were randomly chosen for plot establishment in the late summer and fall of 2000.

In February 2001, an updated version of the inventory indicated 65 points in the target population. Of these two sets of points, 63 were the same; the August 2000 inventory included one point not in the February 2001 inventory and the February 2001 inventory included two points not in the August 2000 inventory (Table 1). Plot 890-510 was randomly chosen for establishment in 2000 and therefore remained in the sample despite the February 2001 inventory data indicating it was not in the target population. This plot had 187 m^3/ha net merchantable volume, despite the February 2001 inventory indicating that it was located in an NSR stand (Table 1). This plot was dropped from the analysis because there was no yield curve for this stand.[8] One point included in both sets (UTM coordinates 686,000, 5,667,000) was not established as the plot center was on the Jamieson mainline.

Table 1. Plot locations not included in both the August 2000 and February 2001 inventories.

Plot	Aug 00 Inventory	Feb 01 Inventory	Plot Established
890-600	Age 82	Age 21	2001
900-570	Age 9	Age 21	2001
890-510	Age 25	NSR	2000

[6] Gitte Churlish, *BSc* and Bob Krahn, *RPF* were the contacts at the MSRM.

[7] The branch data were not compiled in the VIDE program and thus are not included in this analysis.

[8] The reason for this has not been confirmed, but may be due to changes in inventory line work and attributes during the annual inventory update on TFL 35.

Information on the yield curves assigned to each stand in which plots were located was provided by Weyco. Yield curves were produced with TIPSY where possible and VDYP in all other cases.[9] For MP 9, yield curves were assigned using a 1999 version of the inventory. The predicted values compared to the monitoring plot values in this analysis were determined using the same 1999 inventory data.[10]

3.5 UTILIZATION STANDARDS

The yield curves were developed using a minimum DBH of 12.5 cm for Pl and 17.5 cm for other species. Plot data were compiled using these same standards. Both yield curves and plots were adjusted for decay, waste, and breakage to compare net merchantable volumes. The term MVOL is used in this report to describe net merchantable volume with these utilization limits.

Figure 4. Trees in plot 820-600 with 2,052/ha Pl and 1,076 /ha Bl. The pine site trees had an average age of 16 years while balsam site trees had an average age of 18 years. The inventory information for this stand was Pl 100% and age 16 years. There was no net merchantable volume for either the inventory or plot measurements.

[9] Curry, Sean. 2000. Weyerhaeuser Timber Supply Analysis information package for Management Plan #9 on TFL 35. December 29, 2000 Revision.

[10] Plot 890-600 was included in the sampled population as the February 2001 inventory age was 21 years. The 1999 inventory age for this point was 84 years. This age was used in the analysis, but due to scale issues this point is not shown on any graphs with age on the x-axis.

4. ANALYSIS AND RESULTS

4.1 OVERVIEW

The 65 plots established on TFL 35 are an unbiased sample of the PHR stands with inventory ages between 15 and 40 years.[11] The first measurement data can be used to audit predicted values (projected yields and inventory attributes) used in MP 9 for this population of stands; however, results cannot be inferred to the remaining stands on the TFL. One plot (890-510) was dropped from the analysis as the inventory and yield curve data were not available, thus 64 plots remained for the analysis.

4.2 COMPARISON OF MEASURED AND INVENTORY ATTRIBUTES

Sample plot and predicted values were determined for merchantable volume (MVOL), age, site index, species composition, and stand density (Table 2). For each attribute, except species composition, the difference between the plot and the predicted values was calculated as:

Difference = plot value – predicted value

The average difference across all plots, or a subset of plots, is referred to as bias. A positive bias indicates predicted values underestimate the observed value in the monitoring plots, and a negative bias indicates predicted values over-estimate the values in the sample plots. Graphs showing the differences by inventory age are presented for each attribute except species composition. The 95% confidence intervals for the biases (average differences) were also calculated. A comparison of plot and predicted leading species was tabulated for species composition.

Table 2. Attributes compared between the inventory and the monitoring sample plots.

Attribute	Plot	Predicted
MVOL	Total MVOL was compiled and MVOL by coniferous, deciduous, and individual species.	Yield curve assigned to the stand for MP 9; 1999 inventory age (corrected to year of plot establishment) used as age input.
Age	Average age of the site trees by species.	1999 inventory age[12] (corrected to the year of plot establishment).
Site Index	Average site index by species based on the site tree data collected in each plot.	Potential site index for the stand for Pl, Bl, Fd, and Sx from a site index adjustment (SIA) project Weyco completed in 2000.[13]
Species composition	The percentage of each species in the plot was calculated based on the total stems/ha greater than 1.3 m height.	1999 inventory values.
Stand density	Total stems/ha greater than 1.3 m height.	1999 inventory values.

[11] A summary of MVOL and stand density by species in each plot is provided in Appendix III.

[12] The 1999 and 2001 inventory ages were only one year different when they should be two. For example if the age from the 1999 inventory with a projection date of Jan 1, 1999 is 23, then the age from the 2001 inventory with a projection date of Jan 1, 2001 is 24. Which of the two years is correct is unknown.

[13] J.S. Thrower and Associates Ltd. 2000. Site index adjustments using BEC classification on TFL 35. Contract report Weyerhaeuser Company Limited. Kamloops, BC. February 22, 2000. 25 pp.

4.3 NET MERCHANTABLE VOLUME

The ground sample data from the CMI plots showed a significant positive bias (under prediction) for MVOL (Table 3, Figure 5). The ground sample showed an average of 17.2 m^3/ha more volume than the inventory (with a 95% confidence interval of [2.9, 31.6 m^3/ha]). Forty-three (43) plots had a predicted MVOL of zero, and 28 of these (65%) had plot volumes greater than zero. In contrast, only four of 21 plots (20%) with predicted MVOL greater than zero had zero plot volumes.

Table 3. MVOL (m^3/ha) statistics for the 64 plots.

	Plot	Predicted
Mean	28.7	11.4
Min	0.0	0.0
Max	297.2	167.9
95% CI	[16.4, 40.9]	[3.4, 19.5]

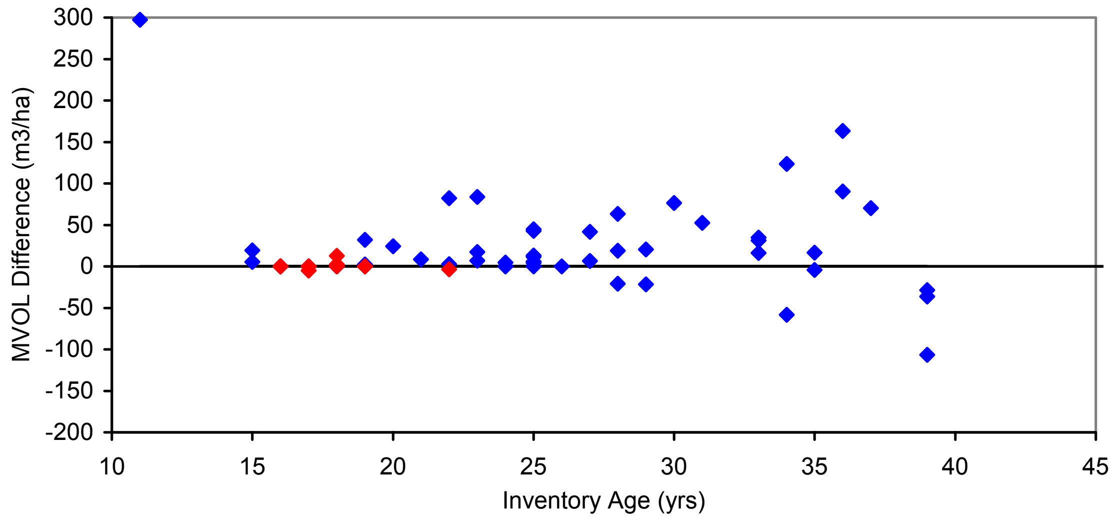

Figure 5. Plot MVOL – predicted MVOL versus inventory age by silviculture era (♦<1977, ♦1978-1989)

The under prediction of merchantable volume seemed to occur primarily in younger stands, thus we post-stratified the data into plots with ages greater than or less than 25 years (Figure 6). Stands with age ≤ 25 years showed significant positive bias, with no significant trend for plots > 25 years of age.

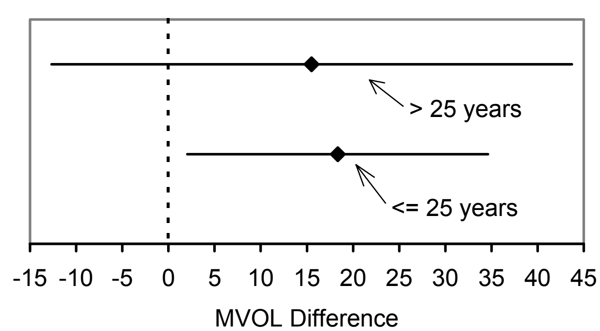

Figure 6. 95% confidence intervals on MVOL for stands ≤ 25 years and > 25 years.

The distribution of MVOLs was further analyzed by species (Appendix IV). This more detailed comparison showed significantly more Bl MVOL than was included in the inventory and yield predictions.

4.4 AGE

The average age of site trees in the CMI sample plots was significantly older than indicated in the inventory (Table 4). The average difference between sample plot and inventory age was 8.5 years with a 95% confidence interval of [4.0, 13.1 years]. Further analysis shows that Bl trees were the largest contributor to this age difference (Figure 7). This difference was reduced to 3.7 years (95% confidence interval of [1.3, 6.1 years] when the Bl leading stands were eliminated from the comparison.

Table 4. Age (years) statistics based on the inventory leading species for each plot. (In four plots there were no site trees of the inventory leading species.)

	Plot	Predicted
N	60.0	64.0
Mean	34.2	25.5
Min	16.0	11.0
Max	99.0	84.0
95% CI	[29.3,39.2]	[22.9,28.1]

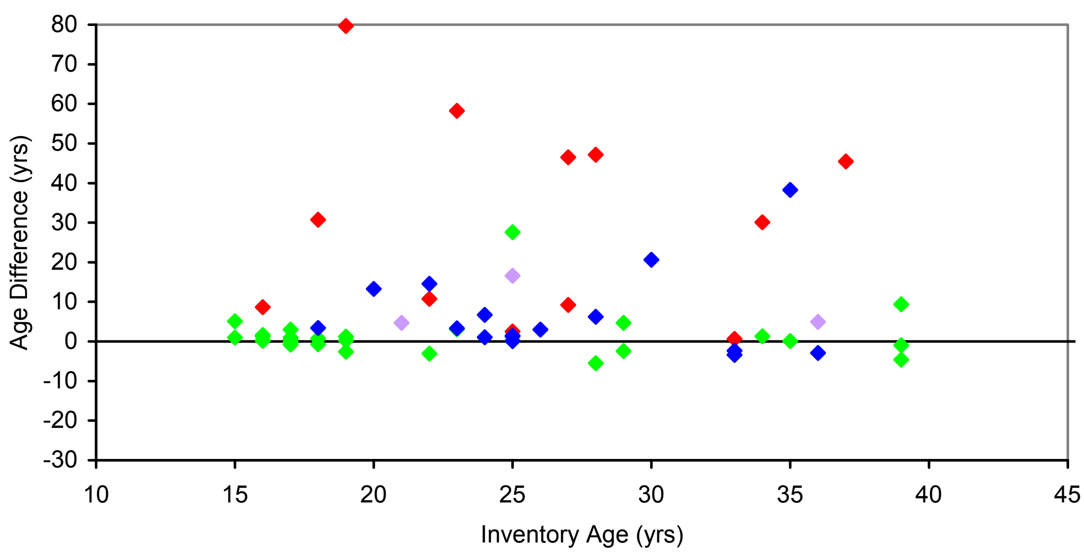

Figure 7. Age difference (plot age - inventory age) by inventory age (based on leading species) and species (Pl ◆, Bl ◆, Fd ◆, Sx ◆).

4.5 SITE INDEX

There was no significant bias when the site indices from the ground plots were compared to the inventory (Table 5). The average site index difference was -0.8 m with a 95% confidence interval of [-1.8, 0.2 m]. A more detailed comparison shows that the Bl site indices may be over-predicted in the inventory (Figure 8).

Table 5. Site index statistics (m) using the inventory leading species for each plot. (In five plots, there were no site index values available for the leading species).

	Plot	Predicted
N	59.0	63.0
Mean	19.6	20.5
Min	7.5	15.9
Max	28.1	22.9
95% CI	[18.6, 20.6]	[20.1, 20.9]

To further examine these trends, the average site index of each species in each plot was compared to the potential site index from the inventory (Table 6). There were no significant differences in the site indices for Pl, Fd, or Sx; however, the site index of Bl was

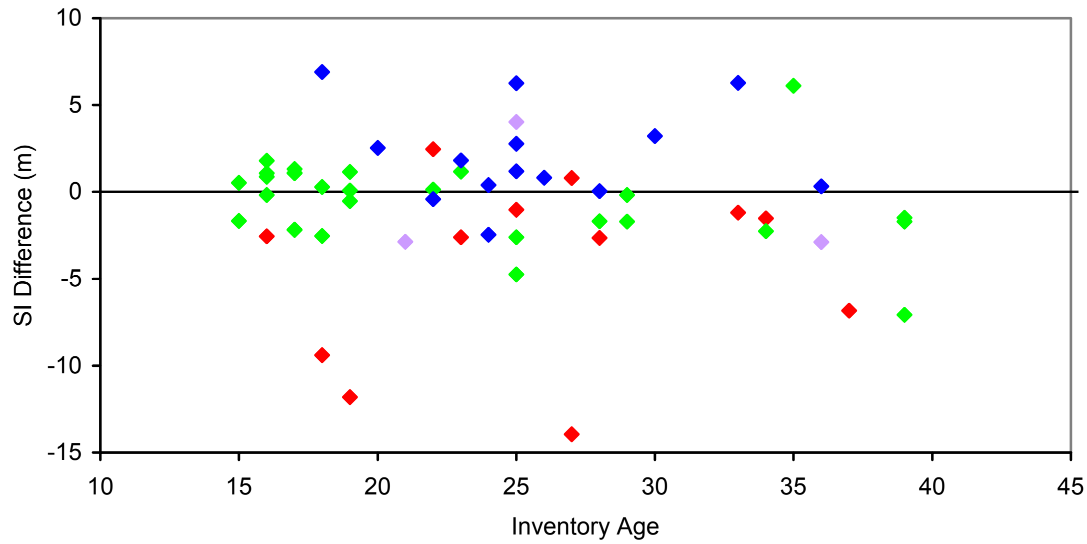

Figure 8. Site index difference versus inventory age (based on leading species) by species (Pl ♦, Bl ♦, Fd ♦, Sx ♦).

Table 6. Site index statistics (m) based on all occurrences of Pl, Bl, Sx and Fd site trees in the plots.

	Pl		Bl		Sx		Fd	
	Plot	Predicted	Plot	Predicted	Plot	Predicted	Plot	Predicted
N	46	46	45	45	39	39	10	10
Mean	20.1	20.6	17.0	19.6	20.7	21.2	19.8	20.6
Min	15.0	18.0	7.7	15.1	7.8	15.9	13.1	18.4
Max	28.1	22.3	25.1	21.7	27.8	23.6	23.6	21.3
95% CI	[19.4,20.8]	[20.2,21.0]	[16.0,18.0]	[19.1,20.2]	[19.4,22.0]	[20.6,21.7]	[17.6,22.0]	[19.8,21.3]

significantly over-predicted where the average difference between plot and inventory site index was -2.7 m with a 95% confidence interval of [-3.9, -1.4 m]. This is likely due to Bl residuals being selected as site trees.[14] If the 21 plots with an average Bl site tree age greater than 40 years were removed from the sample then the average difference between plot and predicted site index for the remaining 24 plots would be -1.2 m with a 95% confidence interval of [-2.5, 0.1].

4.6 Species Composition

The leading species in 61% of the sampled plots matched the inventory (Table 7). Even if the inventory was 100% correct, a match between every plot and the inventory label is not expected because of within-stand variation. The major discrepancies were between Pl and Bl leading stands (Figure 9). The 1999 inventory indicated 48% (31) of the plots should be in Pl leading stands, but only 22% (14) of the plots are

[14] Further work is needed to determine the amount of suppression these trees may have experienced.

Table 7. Number of plots with combinations of inventory and plot leading species (based on total stems/ha). Bold values indicate where plot and predicted values matched.

Plot Leading Species	At	Bl	Ep	Fd	Pl	Sx	*Total*
	1999 Inventory Leading Species						
At					1		*1*
Bl		**12**		1	6	4	*23*
Ep					2		*2*
Fd				**2**	2		*4*
Pl	1				**13**		*14*
Sx		1			7	**12**	*20*
Total	*1*	*13*	*0*	*3*	*31*	*16*	*64*

in Pl leading stands. In contrast, the 1999 inventory indicated 20% (13) of the plots should be in Bl leading stands and 36% (23) of the plots are in Bl leading stands.

4.7 Stand Density

Comparisons of stand density also did not show any significant difference between the monitoring sample plots and the inventory. The average density was 4,274/ha for the sample plots and 3,327/ha for the inventory, for a difference of 948/ha (95% confidence interval of [-129, 2,024 stems/ha]). This average difference, though large, was not significant due to the large variation in plot stand density (Figure 10).

Figure 9. Trees in plot 840-630 with 7,180/ha Bl and 25/ha Sx. The Bl site trees had an average age of 74 years. The inventory information for this stand was Pl 80%, Sx 20% and age 27 years. The plot had 42 m^3/ha more MVOL than indicated in the inventory.

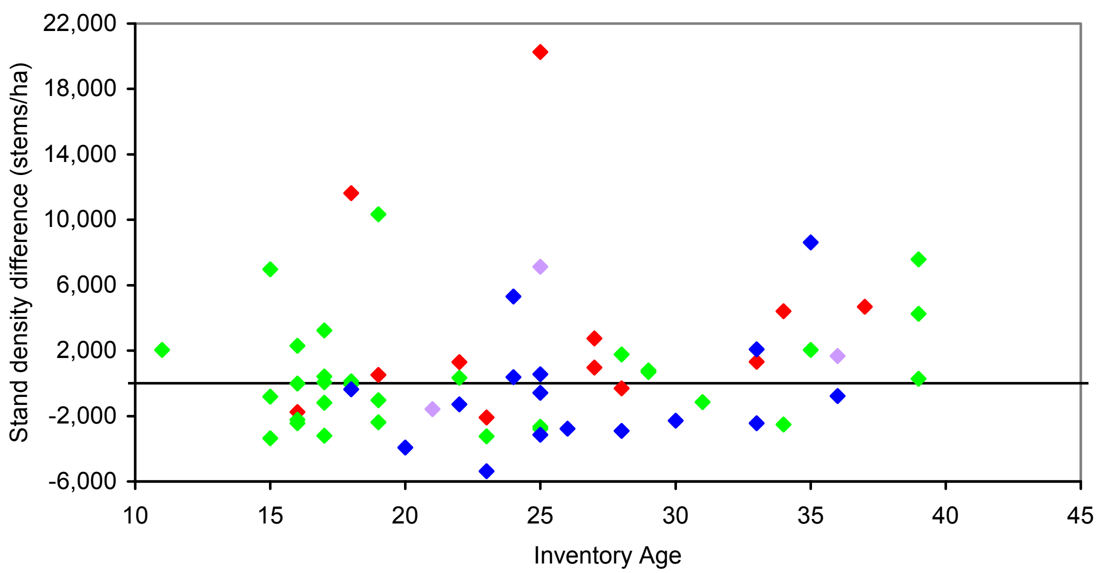

Figure 10. Stand density (stems/ha) difference versus inventory age by species (Pl ♦, Bl ♦, Fd ♦, Sx ♦).

5. CONCLUSIONS

5.1 SAMPLE DESIGN AND METHODS

1. ***The monitoring data from this pilot test provided a credible source of information to check inventory and yield curve predictions for the target population.***

   The sample size of 65 plots used in this pilot test was sufficient to examine overall trends and averages for the target population of PHR stands. The sample size was also large enough to post-stratify the data and examine trends by species. This pilot project demonstrates that the proposed sampling design and analyses can be successfully implemented.

2. ***Existing MSRM data management procedures were not efficient for this project.***

   The modifications made to the standard MSRM plot design to meet Weyco business needs were not easily handled with the existing data entry, error checking, and compilation procedures. Documentation of the Weyco yield curves also was not in a format that allowed easy comparison with the field data.

3. ***The definition of the target population is sensitive to inventory changes.***

   Two different versions of the inventory were used to select sample plot locations in 2000 and 2001. Changes in stand classification resulted in one plot included in the 2000 selection not being included in the 2001 selection, and in two plots in the 2001 selection not being included in the 2000 selection. This indicates that the definition of the target population is very sensitive to changes in the inventory that may impact which areas are included in the target area to sample.

4. ***Measuring small trees (below utilization standards) increased sample cost.***

   Small trees were tagged in this pilot study to address Weyco's interest in tracking the dynamics of small trees in young stands. We estimate that this increased sampling cost by 20-30%. Data from these small trees are needed for special studies but do not contribute to the analyses of merchantable volumes presented in this report.

5.2 INTERPRETATION OF RESULTS

5. ***The analyses provide a high level of comfort in the TFL 35 inventory.***

   The comparisons in this report show that the overall average for most inventory attributes was similar to the same attributes measured in the monitoring plots, and suggest that merchantable volume may be under-estimated in the inventory. This provides a high level of comfort that information used in timber supply analysis is reasonable, and may be conservative.

6. ***The analyses suggest there is a significant amount Bl that is not included in the inventory.***

   This analysis suggests there is significant Bl volume in these PHR stands that is not included in the inventory. This could be the result of Bl not being adequately included in the inventory or could indicate a potential problem with the yield curves used to assign volumes to the inventory polygons.

6. RECOMMENDATIONS

6.1 SAMPLE DESIGN AND METHODS

1. ***Design the yield curve database to facilitate comparisons with G&Y monitoring data.***
   The inventory and yield curve databases should be designed to provide easy linkage with monitoring data. This could be done by using the map/stand number as the key to link different sources of information. This was not an objective when the MP 9 yield curves were developed, which resulted in about one-half of our analysis time spent on organizing the data. Ideally, silviculture surveys, inventory, yield curve development, and G&Y monitoring data would become part of an integrated information system with the ability for standard and custom reporting.

2. ***Consider including net merchantable and whole stand volume in the yield curve database.***
   Including whole stand volumes allows a check of stands below merchantable size. In this study, there were 15 sampled stands that had both zero predicted and plot MVOLs. All these plots were given a MVOL difference of zero in the calculations indicating no bias when in fact the sampled stands may be behind what is predicted. There is no possibility of recording an over prediction of MVOL for stands with a predicted MVOL of zero. If the corresponding whole stand volumes were available, the status of these stands could be better checked.

3. ***Modify data entry and compilation procedures.***
   The MSRM data entry program (VIDE) was not appropriate for these monitoring plots. Thus, we recommend that Weyco carefully consider developing an in-house data entry program and compiler for the next measurement. The MSRM programs should be revisited at that time; however, they will not be appropriate unless significant changes are made. Weyco should also consider using hand-held electronic data recorders for the next measurement.

4. ***Archive versions of the inventory used for sample selection.***
   It is important to archive a complete copy of the inventory used to select G&Y monitoring samples. Inventory updates will change the G&Y monitoring population, and sample points will move in and out of the target population accordingly. Future analyses may need to determine how plots were selected and which areas were included in the target population; this can only be done by reconstructing the process with inventory files and GIS.

5. ***Review inventory update procedures considering the impact on G&Y monitoring.***
   The best way to minimize fluctuations in the G&Y monitoring population is to implement inventory update procedures that minimize unforeseen changes to attributes used to determine the population. Current update procedures may be as efficient as possible in this respect; however, it is probably worth the effort to review these procedures considering this new use of the data on TFL 35.

6. ***Use years since harvest to identify the target population of PHR stands.***
   Years since harvest is a more stable variable than stand age to define the target population of PHR stands for G&Y monitoring.

7. ***Consider altering the 5-year plot remeasurement cycle to coincide with the MP cycle.***
   The 5-year remeasurement cycle of the 65 plots established in this project schedules remeasurement in 2005 and 2006; however, MP 10 is due in 2006. This means that the data from the next plot remeasurement will not be available for use in MP 10. The next measurement could be taken in three years (2003, 2004), which would provide G&Y monitoring data for the next MP. The alternative is to lengthen this remeasurement period to eight years before the next measurement, which would not provide data for MP 10, but would provide data for MP 11. For both options, a five-year remeasurement cycle could be followed for subsequent measurements.

6.2 Interpretation of Results

8. ***Examine the timber supply implications of the results of this analysis.***
   Sensitivity analyses on the volume yield for PHR stands 15-40 years should indicate the potential timber supply impact of the under-estimates of PHR stand volume for this age group. The results of these sensitivities will determine the importance of upgrading the inventory and yield projections for these stands. This could be completed in conjunction with the timber supply analysis for MP 10.

9. ***Use the proposed mid-rotation survey to improve the inventory of young stands.***
   Weyco is currently designing a mid-rotation survey that will help address some of the issues identified in this example analysis.[15] The intent is that this survey will be used to update the inventory when PHR stands reach 20-25 years of age. This updated inventory should result in minimal differences between the G&Y monitoring sample for these young stands and the inventory attributes. The role of monitoring will then be to track these PHR stands beyond these relatively young ages.

10. ***Conduct further analyses on the possible over prediction of Bl site index.***
    Forty-five (45) of the 65 monitoring plots contained Bl site trees. The average age of the Bl site trees was greater than 40 years in about one-half of these plots. More work is needed to clearly identify the selection of suitable Bl site trees, particularly which residuals have undergone suppression, and the impact on the analyses done with these G&Y monitoring data.

[15] J.S. Thrower and Associates Ltd. 2002. A first approximation mid-rotation survey for TFL 35. Draft report to be submitted March 31, 2002 to Weyerhaeuser Company Limited. Kamloops BC.

APPENDIX I – LANDBASE CHARACTERISTICS

Geographic Location

TFL 35 is located about 25 km north of Kamloops, BC west of Highway 5 (Figure 11). The TFL is characterized by mid-elevation plateaus and gently rolling slopes. The total TFL area is 36,445 ha, of which 97% (35,291 ha) form the productive forest landbase (PFLB) (Table 8).[16]

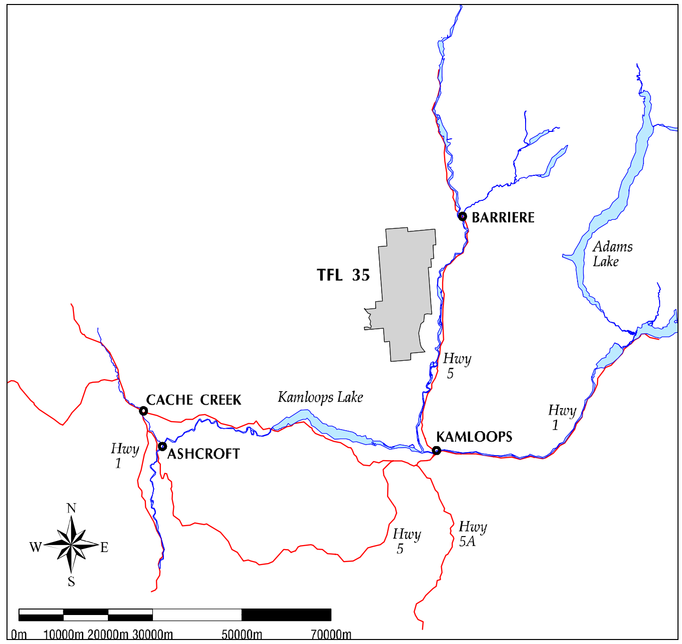

Figure 11. Location of TFL 35 near Kamloops, BC.

Ecological Classification

The PFLB is located primarily in the Northern Thompson Upland (94%) with a much smaller portion situated in the Thompson Basin (6%). The area is represented by four BEC zones, within six subzones (Figure 12). The MSdm2 and the ESSFdc2 are the two most important subzones on the TFL, comprising 86% of the PFLB.

Forest Cover

The primary commercial tree species on the TFL are Pl and Sx; secondary species are Fd, Bl, with minor At and Cw (Table 9). The age class distribution is weighted to the youngest and oldest ages with only 22% of the PFLB occurring in the mid-age classes of 2 to 5 (Figure 13). About 78% of the stands are in the 15- and 20-m site classes.

Table 8. Area (ha) summary of TFL 35.

Entire TFL	*36,445*	
Productive Forest	35,291	
Non-Productive Forest	1,154	
Swamp		523
Lake		361
Non-Productive		216
Open Range		41
Rock		13

16 This area summary was taken from the intersection of forest cover and TEM provided by Ryan Strank, Dec. 7, 1999 for the TFL 35 site index adjustment project.

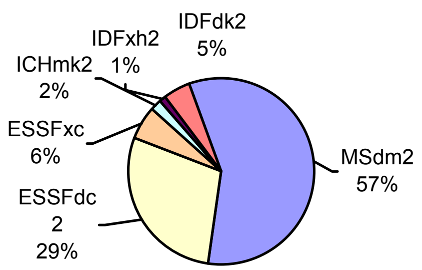

Figure 12. Distribution of BEC subzones.

Table 9. Area (ha) by BEC subzone and leading species.

	Leading Species					
Subzone	Pl	Sx	Fd	Bl	Other	*Total*
MSdm2	7,499	5,760	4,622	1,950	487	*20,318*
ESSFdc2	5,384	3,634	4	822	278	*10,122*
ESSFxc	501	1,199		296	1	*1,996*
IDFdk2	204	59	1,433		15	*1,710*
ICHmk2	185	45	440	4	16	*689*
IDFxh2			373			*373*
Unclass.	15	56	7	3	2	*82*
Total	*13,788*	*10,752*	*6,879*	*3,075*	*797*	*35,291*
Prop.	39%	30%	19%	9%	2%	100%

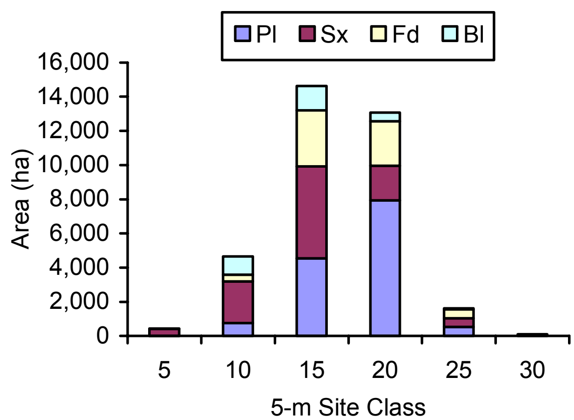

Figure 13. Area (ha) distribution of leading species by 20-Year Age Class and 5-m Site Class.

APPENDIX II – CHANGES TO THE CMI FIELD AND DATA ENTRY PROCEDURES

The following documents additions, deletions, and changes to the CMI field and data entry procedures used in the TFL 35 growth and yield monitoring pilot project. This information was required to facilitate a non-standard compilation of the data.

1 Header Card (CH) (Version 99/3)

- UTM coordinates not recorded in the field. They are entered into the database from post-processed GPS data.
- Plot sample and polygon identifier not recorded. This will be obtained from the MOF to be consistent with their codes.
- Our plot numbers are XXX-YYY. These are recorded in the Sample Tag No. (Reference Tree) field. XXX represents the UTM Easting with the first and last two digits removed (the first digit is always 6, and the last two are 00). YYY represents the UTM Northing with the first two and last two digits removed (the first two digits are always 56, and the last two are 00).
- It would be preferable to have VIDE, or any other data entry software, accept plot numbers greater than four characters. To enter our plot numbers in VIDE, the last X and the last Y were stripped (these all happened to be zeros), and the plot number was entered as XXYY. For example, a plot located at 684,000 Easting and 5,656,000 Northing was given a plot number of 840-560. This was entered in VIDE as 8456.

2 Compass Card (CP) (Version 99/3)

- Completed and entered following CMI procedures.
- Tie Point Tag No. and Sample Tag No. (Reference Tree) are the same number. This same number is entered in the appropriate fields.

3 Cluster Layout (CL) (Version 99/3)

- Completed and entered following CMI procedures.

4 Range Sampling (RS) Shrub Transect #1

- Not used.

5 Range Sampling (RT) Shrub Transect #2

- Not used.

6 Coarse Woody Debris (EW) Transect #1

- Not used.

7 Coarse Woody Debris (EC) Transect #2

- Not used.

8 Tree Details (TD) (Version 99/3)

- Plot radius / Size Limits
  - Different tree size limits than those specified in the CMI manual were used (Table 10).

Table 10. Plot sizes and tree size limits.

Plot radius	CMI	TFL 35
11.28m	≥ 9.0cm dbh	≥ 4.0 cm dbh
5.64m	9.0 cm < dbh ≥ 4.0 cm	> 1.3 m height, < 4.0 cm dbh
2.50m	> 0.3 m height, < 4.0 cm dbh	1.3 m ≤ height ≥ 0.1 m

  - As VIDE will not allow two card 8s, all the tree data for the 5.64 m radius plot was entered on the card 8 with the 11.28 m radius data. The compilation of this data will have to account for the different diameter and height limits used.
  - Diameters of small trees (< 2 cm) were measured with a 15 cm ruler.
- Height to live crown
  - CMI procedures specify recorded height to live crown to the nearest m.
  - In the 2000 field season height to live crown was recorded to the nearest decimeter.
  - The 2000 data entered into VIDE (columns 21 and 22) is in decimeters, not meters. For example, 0.4 m was entered as 04.
  - In 2001 CMI procedures were followed and height to live crown was recorded and entered to the nearest m.
- Data were not collected on log grades, wildlife codes, or broken tops.
  - For compilation assume that there is only 1 log/tree, and that the log is the same length as the tree, Grade "A", and 100% sound.
- Branch measurements
  - This is additional information not recorded under current CMI procedures.
  - Recorded for all trees ≥ 4.0 cm in diameter in the first quadrant (Sectors 1 and 2).
  - The diameter (mm) of the largest branch in the first whorl above breast height is recorded in columns 24-25. Whether the diameter was measured or estimated is recorded in column 26. The live/dead status of this branch is recorded in column 23.
  - The diameter (mm) of the largest branch in the first 3.0m above the ground is recorded in columns 29-30. Whether the diameter was measured or estimated is recorded in column 31. The live/dead status of this branch is recorded in column 28.
- Sector number is recorded in column 55.
- Veteran (Y/N) is recorded in column 56.

9 Tree Loss Indicators (TL) (Version 99/3)

- Damage agents and loss indicators were recorded. Damage severity was recorded if applicable as per CMI standards. There are limited severity codes available, and therefore few were recoded.
- Trees were not stem mapped.

10 Small Tree, Stump, and Site Tree Data (TS) (Version 99/3)

- Top height tree (T) measured as per CMI standards.
- Leading species (L) and second species (S) as defined in the CMI procedures were not measured.
- Height and age were measured on the largest diameter tree of each species in each quadrant. These trees were coded as * (or mistakenly as S). They were all entered in VIDE as *. For all * trees the suitability of the height and age measurements for determining site index were recorded. If a tree was not suitable, the height and diameter of the next largest diameter suitable tree of the same species were measured. These trees were recorded as O trees.
    - Physiological age (column 49-51) was not recorded.
    - Age counts included the current (2000 or 2001) growing season.
- The species, frequency, DIB, length, and % sound for stumps in the 2.5 m radius was recorded. Wildlife codes and wildlife use for stumps were not recorded.
- The number of small trees in the 10 - 30 cm and 31 cm - 1.3 m classes were tallied. Trees in the > 1.3 m class were not tallied as they were recorded in the 5.64 m radius plot (Table 10).

11 Auxiliary Plot Card (TA)

- Not used.

12 Ecological Description 1 (EP) (Version 97/1)

- Completed following CMI procedures.
- Reconnaissance standard used to estimate field site series.

13 Ecological Description 2 (ED)

- Completed as necessary following CMI procedures.

14 Tree and Shrub Layers (ET) (Version 97/1)

- Completed following CMI procedures, with the exception of plot size for plots established in 2000.
- In 2000, an 11.28 m radius plot was used instead of a 10.0 m radius plot.
- In 2001, a 10 m radius plot was used as per CMI standards.

15 Herb and Moss Layers (EH) (Version 97/1)

- Completed following CMI procedures.

16 Succession Interpretations (EO) (Version 97/3)

- Completed following CMI procedures.

APPENDIX III – SAMPLE PLOT DATA

Table 11. Stand density (stems/ha) by plot above and below utilization standards and greater than 1.3 m in height. Plot 890-510 was dropped from the analysis as inventory and yield curve data were not available.

	Stems/ha > utilization standards						Stems/ha < utilization standards					
Plot	Pl	Bl	Sx	Fd	Other	*Total*	Pl	Bl	Sx	Fd	Other	*Total*
810-440	0	0	0	0	0	*0*	25		1,451		0	*1,476*
810-450	25	50	25	0	0	*100*	50	4,278	3,177		125	*7,730*
810-460	175	0	0	0	0	*175*	575	375			1,026	*2,151*
810-600	0	0	0	0	0	*0*	1,551	2,627			200	*4,378*
810-660	0	0	0	0	0	*0*	1,001	400			0	*1,401*
820-600	0	0	0	0	0	*0*	2,502	1,076			0	*3,577*
820-610	0	0	0	0	0	*0*	1,926	17,962			375	*20,264*
830-450	50	0	25	0	0	*75*	75	1,751	3,652		0	*5,554*
830-670	0	0	0	0	0	*0*	1,326	200			300	*1,826*
840-430	0	125	0	0	0	*125*	75	8,631	275		200	*9,306*
840-450	0	100	25	0	0	*125*		600	325		0	*1,051*
840-460	0	275	0	0	0	*275*		2,051	525		250	*3,102*
840-530	0	0	0	0	0	*0*	1,026	175	200		75	*1,476*
840-560	0	0	0	0	0	*0*	1,276		300		575	*2,151*
840-590	0	0	0	0	0	*0*	801	300	0	0	475	*1,576*
840-600	0	0	0	0	0	*0*	1,351	3,227	250	0	0	*4,828*
840-610	25	0	0	0	0	*25*	1,751	325	3,202	0	0	*5,304*
840-630	0	225	0	0	0	*225*	0	6,955	25	0	0	*7,205*
840-640	25	150	0	0	0	*175*	150	500	0	0	1,376	*2,201*
850-430	0	0	0	0	0	*0*	1,451	0	0	350	7,405	*9,206*
850-480	0	0	50	0	0	*50*	0	625	7,655	0	1,001	*9,331*
850-490	0	25	0	0	0	*25*	0	2,502	3,352	25	50	*5,954*
850-590	0	50	25	0	0	*75*	0	250	275	0	0	*600*
850-610	50	50	25	0	0	*125*	250	2,126	901	0	0	*3,402*
850-650	0	0	0	0	0	*0*	1,126	175	75	0	0	*1,376*
850-660	0	0	0	0	0	*0*	25	450	2,452	0	50	*2,977*
850-670	75	25	0	0	50	*150*	125	1,026	0	0	2,977	*4,278*
850-710	0	0	0	0	0	*0*	876	25	25	0	0	*926*
860-540	0	25	0	0	50	*75*	1,026	1,976	6,930	4,303	776	*15,085*
860-560	50	25	25	0	0	*100*	350	375	250	0	75	*1,151*
860-570	75	175	25	0	0	*275*	300	7,330	175	25	0	*8,105*
860-580	200	50	275	0	0	*525*	150	1,851	926	0	150	*3,602*
860-590	100	25	50	0	0	*175*	1,076	400	3,052	0	0	*4,703*
860-630	50	25	50	0	0	*125*	0	725	2,377	0	0	*3,227*
860-650	0	275	25	0	0	*300*	0	725	450	0	0	*1,476*
860-680	0	50	0	0	0	*50*	1,626	300	1,501	0	0	*3,477*
860-690	25	0	0	0	0	*25*	851	776	926	0	0	*2,577*
870-500	0	0	0	0	0	*0*	1,126	25	700	0	11,408	*13,259*
870-520	50	0	0	0	0	*50*	1,526	0	75	25	525	*2,201*
870-630	0	100	25	0	0	*125*	0	1,801	125	0	0	*2,051*
870-670	0	525	0	0	75	*600*	0	3,677	0	0	976	*5,254*
870-680	100	0	0	0	0	*100*	225	1,426	1,501	0	125	*3,377*
870-700	0	0	0	0	0	*0*	1,051	250	2,126	0	0	*3,427*
880-530	0	200	125	25	0	*350*	0	2,402	2,377	1,201	25	*6,354*
880-600	0	100	50	0	0	*150*	0	1,651	400	0	0	*2,201*
880-650	0	0	0	0	0	*0*	0	1,526	6,529	125	0	*8,180*
880-660	0	150	50	0	0	*200*	0	400	700	0	0	*1,301*
880-670	0	75	75	0	25	*175*	0	851	600	0	450	*2,076*
880-690	0	300	25	0	0	*325*	0	7,480	200	0	0	*8,005*
880-700	0	0	0	0	25	*25*	826	901	100	0	150	*2,001*

Plot	Stems/ha > utilization standards						Stems/ha < utilization standards					
	Pl	Bl	Sx	Fd	Other	*Total*	Pl	Bl	Sx	Fd	Other	*Total*
890-510	0	50	150	150	50	*400*	0	725	300	3,602	1,026	*6,054*
890-530	0	0	0	25	0	*25*	1,276	0	0	150	400	*1,851*
890-600	0	25	0	0	0	*25*	75	3,803	1,801	0	725	*6,429*
890-630	75	25	0	0	0	*100*	150	1,376	1,801	325	100	*3,853*
890-640	0	50	25	25	0	*100*	75	400	1,401	75	300	*2,352*
890-650	25	25	0	0	0	*50*	25	325	1,826	100	0	*2,327*
900-540	25	0	0	0	200	*225*	25	325	700	125	3,077	*4,478*
900-550	0	25	0	0	0	*25*	25	1,951	500	150	100	*2,752*
900-570	0	25	0	325	0	*350*	0	150	50	2,577	0	*3,127*
900-680	50	50	0	175	0	*275*	0	400	25	7,105	2,277	*10,082*
910-640	0	50	0	50	0	*100*	0	325	50	575	300	*1,351*
910-660	0	0	0	0	0	*0*	1,026	300	125	751	0	*2,201*
910-700	0	50	25	0	0	*75*	350	1,201	0	0	0	*1,626*
920-640	0	0	0	25	0	*25*	1,251	250	0	926	0	*2,452*
920-660	0	0	0	0	0	*0*	25	50	250	475	175	*976*
Average	*19*	*55*	*18*	*12*	*7*	*112*	*536*	*1,699*	*1,169*	*451*	*609*	*4,302*

Table 12. Net merchantable volume (m^3/ha) in each plot above and below the utilization standards. Plot 890-510 was dropped from the analysis as inventory and yield curve data were not available.

	Stems/ha > utilization standards						Stems/ha < utilization standards					
Plot	Pl	Bl	Sx	Fd	Other	*Total*	Pl	Bl	Sx	Fd	Other	*Total*
810-440												*0.0*
810-450	1.0	11.5	3.6			*16.1*		7.6	0.9			*24.6*
810-460	17.2					*17.2*	19.4	0.3			1.5	*38.4*
810-600								1.3				*1.3*
810-660							0.3					*0.3*
820-600												*0.0*
820-610								0.6				*0.6*
830-450	5.0		2.1			*7.1*			2.3			*9.5*
830-670							2.0					*2.0*
840-430		16.8				*16.8*	0.9	10.0	1.5			*29.1*
840-450		19.6	4.8			*24.3*		4.4				*28.7*
840-460		63.3				*63.3*		13.6	1.7		4.6	*83.2*
840-530												*0.0*
840-560							3.8					*3.8*
840-590							0.3					*0.4*
840-600												*0.0*
840-610	2.2					*2.2*	15.3	2.4	1.4			*21.4*
840-630		41.6				*41.6*		18.1	1.8			*61.5*
840-640	3.9	30.8				*34.7*	6.4	6.2			1.2	*48.6*
850-430												*0.0*
850-480			4.7			*4.7*		2.4	0.2			*7.3*
850-490		2.6				*2.6*		7.1	5.1	0.9		*15.8*
850-590		29.5	2.4			*31.9*		2.7	1.4			*36.0*
850-610	17.5	21.7	13.6			*52.8*	0.3	1.1	8.0			*62.2*
850-650							5.9					*5.9*
850-660							0.3		7.3		2.0	*9.7*
850-670	8.9	8.2			4.1	*21.2*	3.2	1.4			7.9	*33.8*
850-710							1.0		0.3			*1.3*
860-540		3.4			9.5	*12.9*	1.1		0.1		0.8	*15.0*
860-560	1.6	1.2	2.6			*5.4*	0.5	0.7	0.1			*6.7*
860-570	11.2	50.1	20.3			*81.6*	5.9	38.1	1.7	0.2		*127.5*
860-580	10.6	5.2	66.4			*82.2*		8.3	3.4		0.1	*94.0*
860-590	36.4	3.5	34.0			*73.9*	10.1	3.4	2.7			*90.1*
860-630	10.9	3.8	4.4			*19.1*		3.4	8.3			*30.7*
860-650		89.2	3.0			*92.2*		7.6	1.9			*101.7*
860-680		7.6				*7.6*	42.5	7.4				*57.5*
860-690	3.5					*3.5*	16.0	3.2	3.3			*26.0*
870-500							7.3					*7.3*
870-520	6.9					*6.9*	12.8					*19.7*
870-630		19.4	74.4			*93.8*		19.2				*113.0*
870-670		117.5			6.1	*123.6*		55.2			6.3	*185.1*
870-680	13.0					*13.0*	2.9	0.2	7.2			*23.3*
870-700							4.2	0.4	0.1			*4.7*
880-530		86.4	74.1	3.1		*163.7*		13.1	6.5	1.6		*184.8*
880-600		79.1	4.6			*83.7*		4.7	2.7			*91.0*
880-650								1.4				*1.4*
880-660		58.3	18.0			*76.3*		10.3	3.8			*90.4*
880-670		9.7	18.1		4.5	*32.2*		2.0	2.0			*36.2*
880-690		64.1	6.6			*70.7*		45.8	2.7			*119.2*
880-700					2.5	*2.5*	3.2	1.9			1.4	*9.0*
890-510		9.1	35.0	131.7	11.2	*187.1*		2.8	6.0		2.6	*198.4*
890-530				1.7		*1.7*						*1.7*

Plot	Stems/ha > utilization standards						Stems/ha < utilization standards					
	Pl	Bl	Sx	Fd	Other	*Total*	Pl	Bl	Sx	Fd	Other	*Total*
890-600		3.4				*3.4*	0.9	5.6				*9.9*
890-630	10.3	1.9				*12.2*	2.1	4.4	1.1	0.9		*20.6*
890-640		8.7	1.2	1.7		*11.6*	0.6		2.2	0.9		*15.3*
890-650	2.3	3.5				*5.8*	1.0	1.0	3.8			*11.7*
900-540	6.4				35.4	*41.8*	0.1	0.8	0.4		42.6	*85.6*
900-550		6.5				*6.5*	0.5	12.4	0.1	1.0	1.5	*22.1*
900-570		3.2		294.0		*297.2*		0.3	0.8	5.7		*304.0*
900-680	8.4	8.6		25.7		*42.8*		6.4	0.5	19.2		*68.9*
910-640		5.1		3.5		*8.6*		1.3		2.0		*11.9*
910-660							0.7			0.2		*0.9*
910-700		17.8	1.4			*19.2*		3.7				*22.9*
920-640				2.4		*2.4*		0.3		1.1		*3.8*
920-660										0.1	2.3	*2.4*
Average	*2.7*	*14.0*	*6.1*	*7.1*	*1.1*	*31.1*	*2.6*	*5.3*	*1.4*	*0.5*	*1.2*	*42.2*

APPENDIX IV – DISTRIBUTION OF MVOL BY LEADING SPECIES

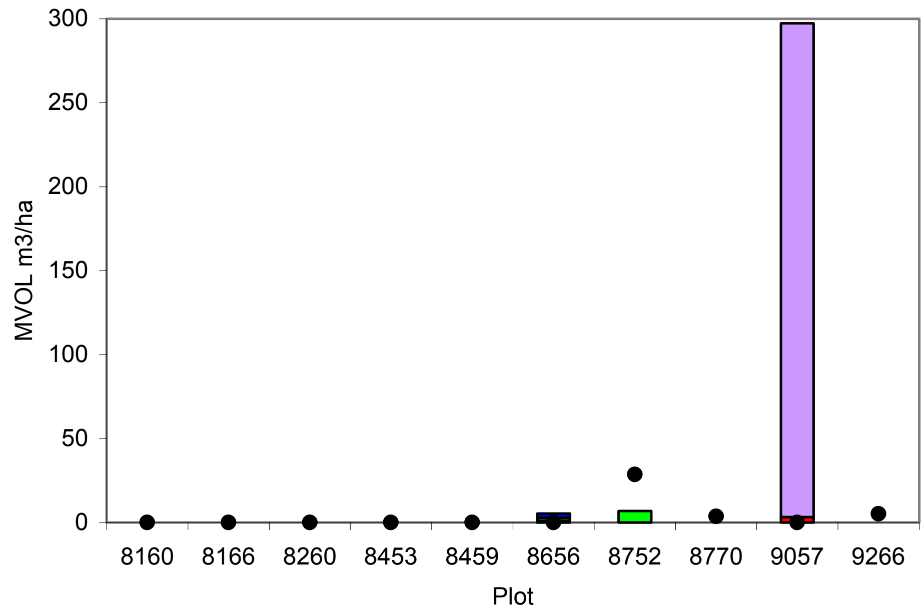

Figure 14. Plots in pure Pl (80%+) stands according to the 1999 inventory. Predicted MVOLs (●) versus plot MVOLs by species (Pl, Bl, Fd, Sx, other)

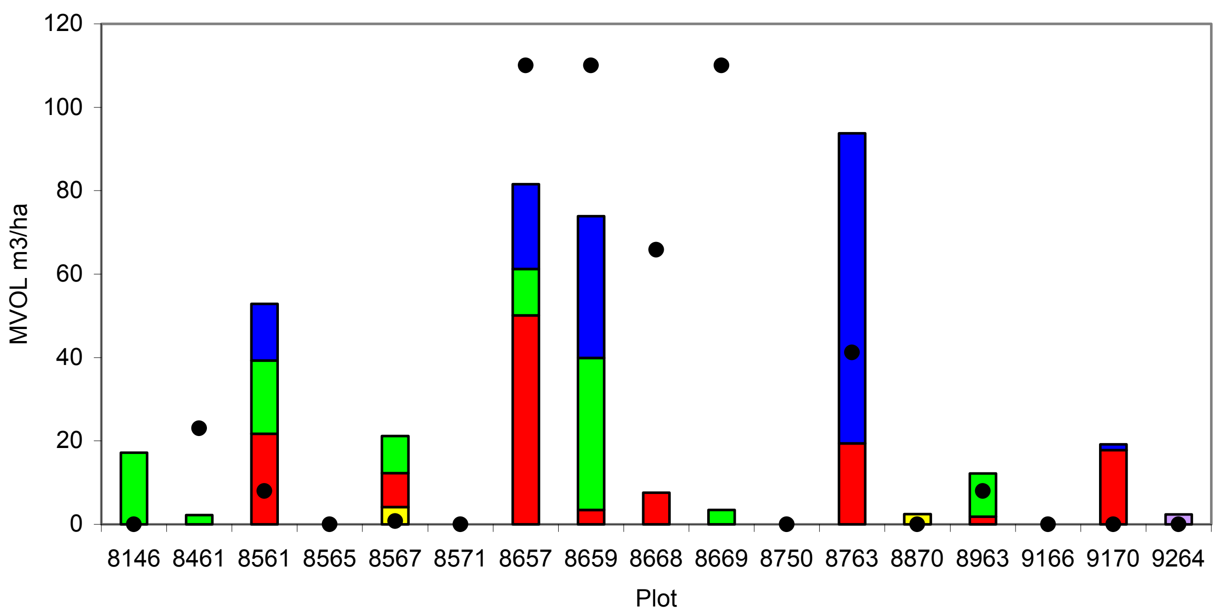

Figure 15. Plots in Pl leading coniferous stands according to the 1999 inventory. Predicted MVOLs (●) versus plot MVOLs by species (Pl, Bl, Fd, Sx, other)

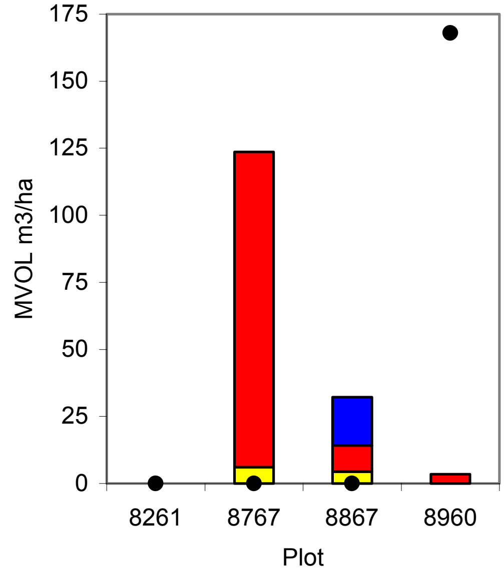

Figure 16. Plots in pure Bl (80%+) stands according to the 1999 inventory. Predicted MVOLs (●) versus plot MVOLs by species (Pl, Bl, Fd, Sx, other)

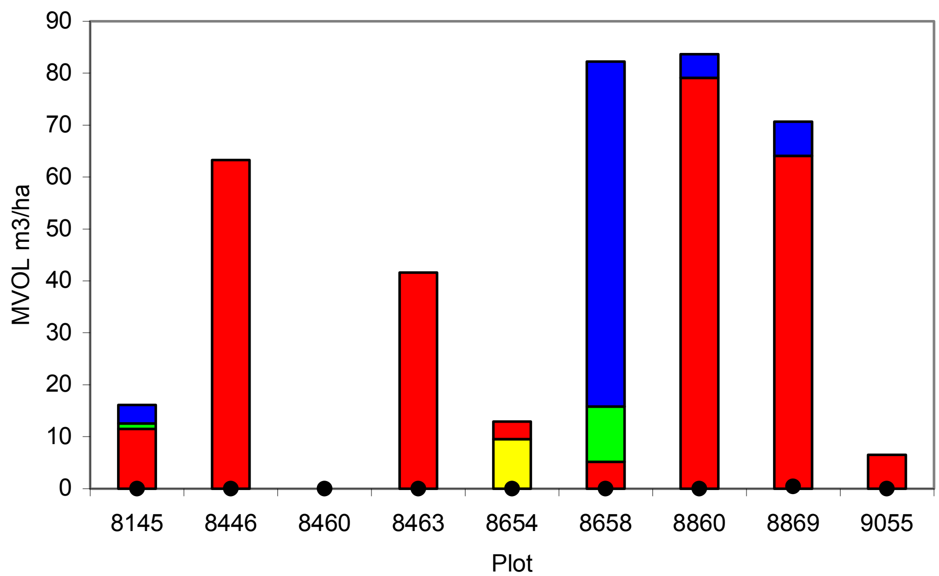

Figure 17. Plots in Bl leading coniferous stands according to the 1999 inventory. Predicted MVOLs (●) versus plot MVOLs by species (Pl, Bl, Fd, Sx, other)

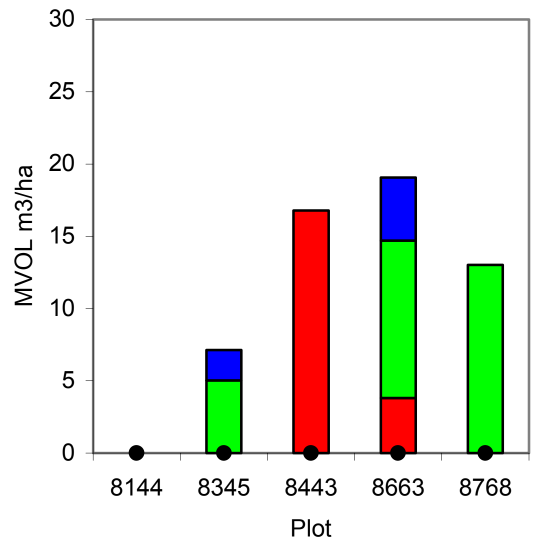

Figure 18. Plots in pure S (80%+) stands according to the 1999 inventory. Predicted MVOLs (●) versus plot MVOLs by species (Pl ■, Bl ■, Fd ■, Sx ■, other ■)

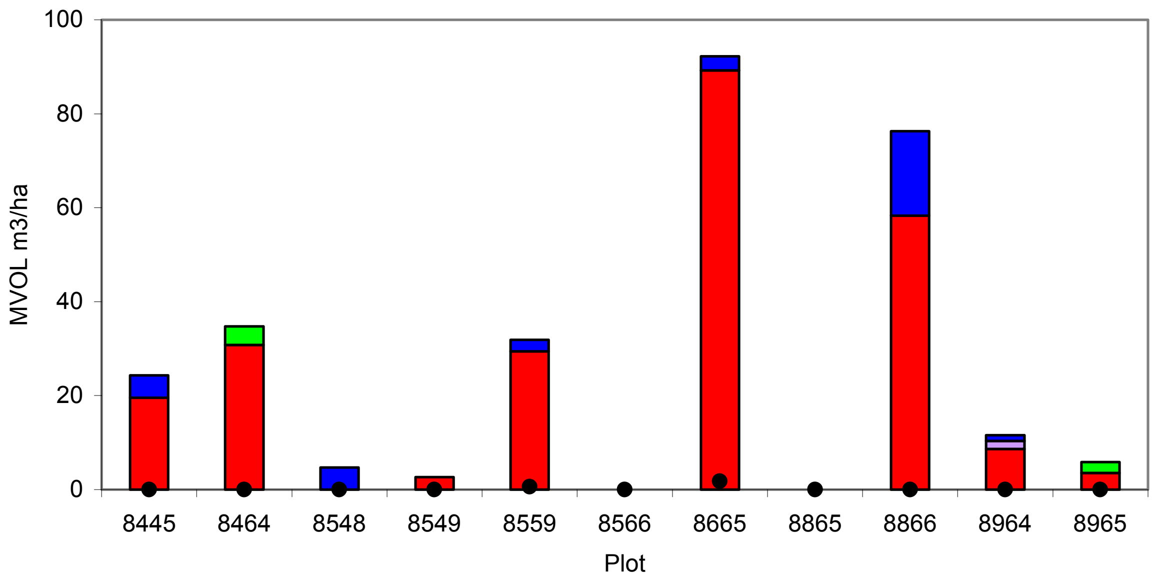

Figure 19. Plots in Sx leading coniferous stands according to the 1999 inventory. Predicted MVOLs (●) versus plot MVOLs by species (Pl ■, Bl ■, Fd ■, Sx ■, other ■)