TFL 52 – BLOCKS A & B
CHANGE MONITORING INVENTORY:
TIME 2 MEASUREMENT RESULTS

Prepared for:

Earl Spielman, RPF
Inventory Forester
West Fraser Mills Ltd.
Quesnel, BC

Prepared by:

Timberline Natural Resource Group Ltd.
Victoria, BC

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West Fraser Mills Ltd

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.[1] The CMI program is also a critical tool for tracking change in the forest resulting from forest health infestations such as mountain pine beetle (MPB).

This report documents West Fraser Mills Limited (West Fraser) Time 2 Tree Farm License (TFL) 52 CMI program results.[2] The objectives of this CMI program were to:

1. Monitor change in net merchantable volume and site index in post-harvest and regenerated stands between Time 1 and Time 2;
2. Compare CMI program results to the predicted values used in timber supply analysis in support of the most recent Management Plans (MP)[3];
3. Compare CMI plot results against select inventory attributes at each location; and
4. Report on the incidence of forest health agents in the target population.

The target population was all stands established after 1961 (Block A – formerly TFL 52) or 1964 (Block B – formerly TFL 5) with a minimum total age of 15 years in 2001.[4] Eighty-two (82) CMI plots were re-measured on a standardized 2.0 km grid across the target population; 48 plots were established in managed stands (≤ 20 years in 2000 for Block A and ≤ 50 years in 2001 for Block B) and 34 were established in young natural stands (>21 years). The key findings from this analysis are:

- The CMI program successfully detects differences between modelled assumptions in the timber supply analysis and that which is being observed in CMI plots;
- The net merchantable volume observed in the CMI plots is not significantly different from that predicted in managed stands, and 35 m^3/ha higher than predicted in young natural stands;
- The net annual growth rate predicted in managed stands is higher than observed in the CMI plots, while young natural stands show no significant difference;
- Site index estimates appear somewhat conservative. Interior spruce (Sx) potential site index estimates appear to be underestimated in managed stands by about 3 m, while

[1] CMI can also be used to track the impact of forest health agents (such as Mountain Pine Beetle) and climate change impacts, and can be a key part of a Management Unit carbon accounting program.

[2] West Fraser purchased Weldwood of Canada Ltd. in 2004 and amalgamated TFL's 52 and 5 into TFL 52 Block A (formerly TFL 52) and Block B (formerly TFL 5).

[3] Analyses were compared against the TFL 52 MP #3 and former TFL 5 MP #10.

[4] 2001 is the year the TFL 52 CMI programs was initiated.

lodgepole pine (Pli) showed no significant difference between potential and observed site index;

- The Time 2 CMI plot data showed the Vegetation Resources Inventory (VRI) leading species in young natural stands appeared correct approximately half the time. Sx was predicted as the dominant inventory leading species in over half the stands, while CMI plot data showed the leading species distribution as Pli (42%), Sx (24%), and subalpine fir (Bl) (19%);
- CMI plot leading species matched the timber supply analysis managed stand leading species 36% of the time. The vast majority of managed stands were projected as Pli-leading; less than half were actually Pli leading, with the remainder being either Sx or Bl leading;
- The VRI ages used in the timber supply analysis are under-estimated by about 3 years;
- MPB attack was observed for the first time at Time 2 (there was no record of MPB attack at Time 1). If all Time 2 MPB attacked stems die, observed volumes at Time 2 will be reduced by 1.7 m^3/ha and 5.2 m^3/ha, in managed and natural stands, respectively; and
- At Time 2, the majority of pests on Pli include MPB, where 40% of the total Pli basal area had evidence of attack. Other pests on Pli were stem diseases (24%). Sx pests included aphid (35%) and weevil (7%) damage.

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

1) Continue to monitor the CMI plots on a 5-year schedule, specifically to track apparent differences of timber supply analysis-based assumptions with managed stand growth rates, species composition, and Sx site index predictions. The Time 3 measurement results will provide a greater level of comfort in the inventory and timber supply analysis inputs.
2) Re-run the analysis with CMI plots whose leading species match the leading species in the timber supply analysis. Compare volume and growth rates (at a minimum) between the two.
3) Explore why Sx site index was underestimated by 3 m in the original SIA program with the goal of improving Sx site index estimates in future timber supply analyses.
4) Re-evaluate the timber supply analysis assumptions used to generate managed stand yield tables, specifically the silviculture regime leading species, operational adjustment factors, and age cut-off for use of VDYP or TIPSY.
5) Re-run the CMI analysis once a new set of standardized managed and natural stand yield tables are generated for the combined Block A and Block B.
6) Explore options to quantify pest-related growth reductions in managed stand yield tables.
7) Establish remaining 2-km grid samples that were not established in Block B at initial establishment.
8) Establish recruitment plots that grow into the target population.

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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 randomly or systematically across the Management Unit. The plot data is used as an independent check of inventory attributes and timber supply analysis assumptions (e.g., silviculture regimes, height, age, site index, volume [total, and net merchantable], 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 - TFL 52 CMI Program Amalgamation

In 2004, West Fraser purchased Weldwood of Canada Ltd. (Weldwood) and amalgamated TFL's 52 and 5 into TFL 52 Block A (formerly TFL 52) and Block B (formerly TFL 5). Both Blocks maintained ongoing CMI programs that were amalgamated for this analysis. Their CMI program history is as follows:

- **Block A**[5]**:** 75 CMI plots were established on a 2.0 km grid between 2001 and 2003 (Time 1) in post harvest regenerated (PHR) stands 15 years and older.[6] These plots were remeasured five years post-establishment between 2006 and 2008 (Time 2).
- **Block B**[7]**:** 30 CMI plots were established on a 1.0 km grid in 2003 (Time 1) in PHR stands 15 years and older.[8] Following amalgamation, seven of the original CMI plots were remeasured in 2008 (Time 2).[9,10]

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[5] J.S. Thrower & Associates Ltd. 2001. West Fraser Mills Ltd. TFL 52 Pilot CMI Sample Plan. Project # WFQ-025.

[6] At the time of establishment the oldest managed stands were 40 years (as of 2001).

[7] J.S. Thrower & Associates Ltd. 2003. TFL 5 Change Monitoring Inventory Sample Plan. Project # WWQ-036.

[8] At the time of establishment the oldest managed stands were 39 years (as of 2002).

[9] Thrower, J. April 30, 2008. Memo To: Earl Spielman Re: Amalgamating CMI programs on TFL 52 & 5.

[10] Only 7 CMI plots occurred on the consistent 2km grid as the Block A CMI plots. Therefore, the Block B set of CMI plots does not currently represent the complete Block B target population, and will subsequently be expanded as part of a future analysis.

Between the Time 1 and Time 2 measurements, the timber profile on both Blocks was significantly impacted by the mountain pine beetle (MPB) epidemic. The Time 1 and 2 measurements provide an unbiased assessment of the change in the amalgamated target population.

1.3 Monitoring Objective

The overall goal is to report on the inventory attributes and forest attribute inputs used in the timber supply analyses for TFL 52's Management Plan (MP) #3 (Block A) and MP #10 (Block B). The primary objectives of the CMI program are to:

1) Monitor the change in net merchantable volume and site index in managed stands[11] from Time 1 to Time 2 measurements 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) Report on the incidence of forest health agents.

1.4 Project Objectives

The objectives of this project are to:

1) Compile the ground data from both Time 1 and Time 2 measurements and calculate change estimates; and
2) Compare Time 2 plot and change estimates for volume, site index, age, and species composition against select inventory attributes and timber supply assumptions for those stands where CMI plots are located.

1.5 Terms of Reference

This project was completed by Timberline Natural Resource Group (Timberline). The West Fraser project leader is Earl Spielman, *RPF*. The Timberline project team included René de Jong, *RPF* (project manager), Eleanor McWilliams, *MSc, RPF* (analysis support) and Stephanie Ewen, *FIT* (project analyst and reporting). Funding was provided through West Fraser's Forest Investment Account (FIA) allocation.

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

2.0 SAMPLING DESIGN

2.1 Target Population

The Time 2 Block A and B target population included all managed stands[11] established after 1961 (Block A) or 1964 (Block B) with a minimum total age of 15 years (as defined in the Vegetation Resources Inventory [VRI]) at the time of project establishment (2001 in Block A, and 2003 in Block B). This age range was used to limit sampling to stands that have merchantable volume (minimum of 15 years) and were previously harvested. The target population covers approximately 9% of the 293,595 ha total TFL area, as summarized in the first measurement sample plans and establishment reports (Table 1).[12, 13]

Table 1. TFL and target population area by Block.

Block	Total TFL Area		CMI Target Population	
	(ha)	(%)	(ha)	(%)
Block A	258,955	88	19,666	73
Block B	34,640	12	7,298	27
Total	***293,595***	***100***	***26,964***	***100***

2.2 Sample Population

The CMI plots are located on a 2.0 km square grid using NAD 83 UTM coordinates evenly divisible by 1,000. In total, 82 plots were established and subsequently re-measured on a 5-year interval over the entire TFL 52 target population.

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 Time 1 analysis reports and sample plans.[5,7]

2.4 Sample Weights

Not all Block B grid points were sampled in 2008. As a result, the Block B samples were assigned weights proportional to the intensity with which the grid points were sampled within the Block B target population.

[12] Block A: total area = 258,955 ha; target population area = 19,666 ha. JST. 2003. West Fraser Mills Ltd. TFL 52 Growth & Yield Monitoring Sample Plan: Third Year. Project #: WFQ-036. Appendix I. P.10.

[13] Block B: total area = 34,640 ha; target population area = 7,298 ha. JST. 2004. TFL5 Change Monitoring Inventory Establishment Report. Project #: WWQ-036. Appendix I. p. 8-9

3.0 DATA MANAGEMENT

3.1 Overview

This section identifies the datasets used in the analysis, including the CMI plot compilation, inventory coverages, and yield table inputs used in the Block A and B timber supply analyses. The CMI plot compilation discussion outlines the error checking routines, and the merchantable volume, in-growth, mortality and periodic annual increment (PAI) definitions used in this project.

3.2 Plot Data Compilation

All Time 2 plot data were entered into TIMVEG by the field crews.[14] Individual tree data was complied for both the Time 1 and 2 measurements using the VRI / CMI compiler.[15] Plot level summaries were compiled for volume, site index, and species distribution using custom programs developed by Timberline.

3.2.1 Error Checking

Individual tree level comparisons were made between the Time 1 and 2 measurements, and included checks for abnormal changes in diameter, height, live / dead status, and species labeling. While the majority of anomalies were corrected through field card reviews, a few anomalies could not be resolved. A summary of suspect tree measurements is found in Appendix I – Data Error Checking Results.

3.2.2 Merchantable Volume

Plot data were compiled using similar standards as done for the natural and managed stand yield tables.[16] All Block A trees were compiled using a minimum DBH utilization limit of 12.5 cm[17] and all Block B trees were compiled using a minimum DBH utilization limit of 12.5cm for Pli and 17.5cm for all other species.[18] Net merchantable volume was based on reduction from whole stem volume[19] which included 10 cm top diameter, 30 cm stump height, and applicable decay and

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

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

[16] Yield tables corresponding to each sample location were provided by Bill Kuzmuk, *RPF* (Timberline), timber supply analyst for MPs on both Blocks. Yield tables originated from Timberline projects WFQ-017 (Block A) and WWQ-035 (Block B).

[17] 12.5cm was the lowest utilization limit generated by the Block A MSYTs for all species.

[18] The minimum utilization limits generated by the Block B MSYTs were species-specific.

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

waste loss factors.[20] Net merchantable volume was grouped as live or dead at Time 1, and as live, dead, mortality, or ingrowth at Time 2.[21]

3.2.3 Ingrowth

Ingrowth was defined as those trees that exceeded the utilization limits at Time 2, but were less than the utilization limits, or not measured in Time 1.

3.2.4 Mortality

Mortality is defined as trees alive at Time 1 and dead or missing at Time 2. Dead trees in Time 1 were tracked separately from mortality.

3.2.5 Periodic Annual Increment

Net PAI was computed as the live growth plus ingrowth minus mortality, over the five-year measurement period.

3.3 Inventory Data and Yield Tables

3.3.1 Inventory and TEM Coverage

The adjusted VRI and Terrestrial Ecosystem Map (TEM) used in this analysis were provided by West Fraser.[22] VRI and TEM attributes for each GPS-corrected CMI plot location were derived through a GIS overlay of the GPS points on the VRI and TEM spatial coverages.

3.3.2 Natural and Managed Stand Yield Tables

Natural and managed stand yield tables used for this analysis were created separately for Block A under TFL 52 MP #3[23], and Block B under TFL 5 MP #10.[24] Yield tables were assigned to each GPS-corrected CMI plot location through a spatial overlay of the yield table cluster IDs on the VRI data.[25] For TFL 52 Block A, managed stand yield tables were assigned to stands 20 years and younger (as of 2000). For TFL 52 Block B, managed stand yield tables were assigned to stands 50 years and younger (as of 2001) based on three different forest management eras. All remaining stands were assigned natural stand yield tables.

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

[21] While net merchantable volume was compiled for all trees alive and dead, only live volumes were compared to the yield table volumes.

[22] VRI and TEM coverages were provided by West Fraser in July 2008, (projected to 2008). West Fraser confirmed (January 2009) that these coverages were the most appropriate for this analysis.

[23] J.S. Thrower & Associates Ltd. 2000. Yield Table Summary Report West Fraser Mills TFL 52 – Quesnel. Project # WFQ-017.

[24] J.S. Thrower & Associates Ltd. 2002. Yield Tables for Natural and Managed Stands: Management Plan 10 on TFL 5. Project # WWQ-035.

[25] This methodology was based on Timberlines most recent timber supply analysis for TFL 52 Block A and Block B.

4.0 ANALYSIS METHODS

4.1 Analysis Overview

The analysis compares the CMI measured plot attributes to the timber supply analysis predictions, and includes the key attributes of volume, volume growth, site index, species composition, and age. In addition, forest health indicators are tracked to assess change between the Time 1 and 2 measurements.

4.2 Volume Comparisons

4.2.1 All Live Trees

Live net merchantable plot volumes as well as net five-year PAI between Time 1 and 2 were compared against natural and managed stand yield table projected volumes and five-year PAI, using the inventory age adjusted from 2008 to the year of plot establishment or re-measurement. Average volume and PAI differences (expressed as actual – predicted), stratified by yield table source (VDYP or TIPSY)[26] and 95% confidence intervals were computed for both measurements.

4.2.2 Excluding Mountain Pine Beetle Infested Trees

Given the impact that the MPB epidemic has had on the timber profile of both Blocks, a separate MPB evaluation was completed. All live lodgepole pine (Pli) trees identified as having MPB-related damage in Time 2 were re-classified as dead. Remaining live volumes were then compared against managed stand yield table projections using the same methods as for the live volume (4.2.1).

4.3 Site Index Comparisons

The potential site index (PSI) estimates used in the timber supply assumptions originated from separate site index adjustment (SIA) projects. The current measurement of site trees as part of the CMI program provides an independent check of these SIA results.

Site index was assessed independently at Time 1 and 2 meaning that the average site index estimated from a given plot may not be from the same trees at Time 1 and 2. CMI plot site index (SI) was computed *using SiteTools Version 3.3*[27,28] for each suitable site trees using consistent SI equations at both Time 1 and 2. CMI plot SI estimates were calculated as the average for all site trees in each CMI plot by species.

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[26] VDYP was used for development of all NSYTs, and TIPSY for all MSYTs.

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

[28] The MFR-recommended default growth intercept (GI) and SI equations were used. The plot field cards included a mix of Englemann spruce (Se), white spruce (Sw) and hybrid spruce (Sx) labeling, while the inventory classified all interior spruce as Sx. Therefore, only the white spruce (Sw) based GI and SI equations were used in this analysis for all interior spruce.

PSI originated from SIA projects completed separately for each Block on the TFL.[29,30] PSI estimates from the SIA project were derived for each CMI plot for Pli, interior Douglas-fir (Fdi), interior spruce (Sx), and subalpine fir (Bl) based on site series information from the TEM.[31] Inventory site index was used for aspen (At) leading stands site index[32] comparison.

Two separate site index comparisons were completed. First, PSI for the leading species in the inventory was compared to corresponding CMI species. This provided an examination of the potential bias in the site index estimates feeding into the timber supply analysis. Second, PSI was compared to any suitable CMI SI observation available for each species. This increased the sample size, as it allowed for the comparison of more than one species per plot. This allowed for a general comparison of predicted to actual site index.

In both comparisons, average SI differences (actual – predicted) and 95% confidence intervals were calculated for each Time period by species as well as for all species combined.

4.4 Age Comparison

Age is a key input into timber supply as it defined the starting point on the yield curve to assign predicted volume. A subset of the site tree data was used to compare total age[33] from the CMI samples against projected VRI ages. Only those site tree species that were suitable for age and that matched the leading species in the VRI were compared for each plot. Age was averaged for all site trees of a single species at each plot. The average total age difference (actual – predicted) and 95% confidence intervals were computed by species as well as for all species combined.

4.5 Species Comparison

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

The species proportion in each CMI plot was based on tree basal area (BA) with a minimum DBH limit of 12.5 cm. The leading species of each CMI plot (as determined by highest basal area) was compared against VRI leading species, and a cross-table matrix (based on number of CMI plots) was created for Time 1 and 2 measurements. The values in each matrix represent the total percentage of all plots sampled.

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[29] J.S. Thrower & Associates Ltd. 2000. Potential Site Indices for Major Commercial Tree Species on TFL 52. Contract report to West Fraser Mills, Limited. Quesnel, BC. WFQ-018. March 15, 2000. 24 pp.

[30] J.S. Thrower & Associates Ltd. 2000. Updating Potential Site Index Estimates for Commercial Tree Species on TFL 5. Project # WWQ-022. March 31, 2000. 16 pp.

[31] PSI was computed for each CMI plot using the preliminary PSI estimates and adjustment ratios from SIA projects on TFL 52 (WFQ-018) and TFL 5 (WWQ-022), together with the TEM site series and decile class attributes at each CMI plot location.

[32] At was not included in the SIA programs.

[33] Total age is estimated from breast height age using SiteTool's "years to breast height" equations for each species.

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.

4.6 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. Further, revisiting these locations provides the opportunity to report on how the level of pest and damage incidence has changed during the time period.

The occurrence of pest and damage indicators were summarized by Time 1 and 2, 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 Plot Level Volume Summary

The total net merchantable volume (live and dead) across all 82 CMI plots increased from about 36 m^3/ha at Time 1 to 60 m^3/ha at Time 2 (Table 2, Figure 1). Approximately 3.0 m^3/ha (or 6%) of the Time 2 net merchantable volume showed being attacked by MPB, but still live. Approximately 6.4 m^3/ha (or 12%) of the net merchantable volume at Time 2 originated from live ingrowth trees that were less than the minimum utilization limits at Time 1. About 9.0 m^3/ha (or 14%) of the total net merchantable volume died between Time 1 and 2. Approximately 1.3 m^3/ha is assumed to have died and fallen between Time 1 and 2.

Table 2. CMI plot net merchantable volume breakdown by time period.

		Measurement 1		Measurement 2		Change	
		Merch Vol (m^3/ha)	% of Total Standing (l+d)	Merch Vol (m^3/ha)	% of Total Standing (l+d)	Merch Vol (m^3/ha)	% Change in Live or Dead
Live	Live	34.5	96%	40.1	66%	5.6	37%
	MPB attack	0	0%	3.0	6%	3.0	20%
	Ingrowth	-	-	6.4	12%	6.4	43%
	Total	***34.5***	*96%*	***49.5***	***84%***	***15.0***	*100%*
Dead Standing	Dead	1.5	4%	0.5	1%	-1.0	-10%
	Ingrowth	-	-	0.7	1%	0.7	6%
	Mortality	-	-	9.0	14%	9.0	91%
	Total	***1.5***	*4%*	***10.2***	***16%***	***8.7***	*87%*
Dead Fallen	Dead	-	-	1.3	-	1.3	13%
	Total	***1.5***	*-*	***11.5***	*-*	***10.0***	*100%*
Total Standing (live + dead)		***36.0***	***100%***	***59.7***	***100%***	***25.0***	

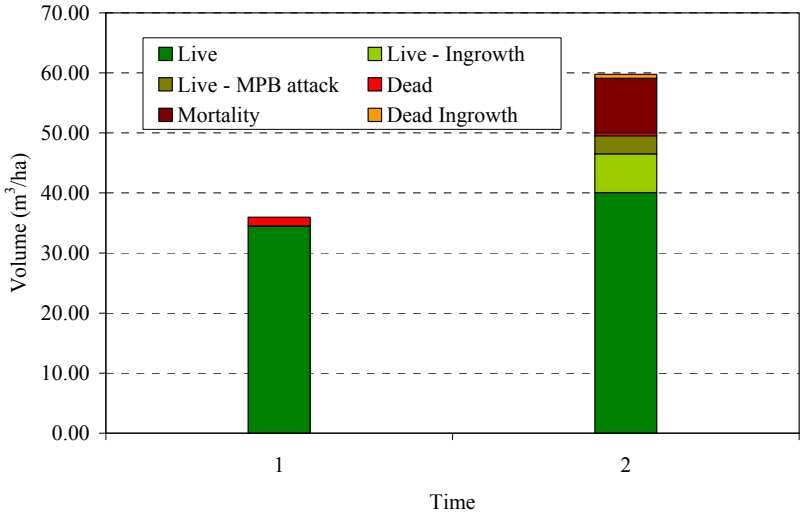

Figure 1. Standing net merchantable volume breakdown by measurement.

5.2 Net Merchantable Volume and PAI Comparison

5.2.1 Managed Stands

Forty-eight (48) CMI plots were established in polygons assigned TIPSY-based managed stand yield tables in the timber supply analysis. A comparison of the CMI plot volumes to the predicted volumes showed that the live net merchantable ground volume is 15 m^3/ha greater than predicted in the timber supply analyses at Time 1 (Table 3, Figure 2, Figure 4). However, at Time 2 there is no significant difference between the CMI plot and predicted volumes. Even with the removal of the MPB-impacted live trees, volumes are still not significantly different. In contrast, the five-year PAI growth rates are over-predicted by approximately 2 m^3/ha/yr (Table 3, Figure 3, Figure 5). The likely conclusion is that while predicted managed stand yield table volumes at Time 1 and 2 appear reasonable or slightly conservative, the predicted growth rate (based on one 5-year remeasurement period) may be optimistic.

5.2.2 Young Natural Stands

Thirty-four (34) CMI plots were in polygons assigned VDYP-based natural stand yield tables in the timber supply analysis. A comparison of plot volumes to the predicted volumes showed that live net merchantable ground volume was significantly greater than predicted in the timber supply analysis at Time 1 and 2 (Table 3, Figure 2, Figure 4). However, the predicted five-year PAI was not significantly different from CMI plot measurements (Table 3, Figure 3, Figure 5). The likely conclusion is that natural stand yield table volume predictions are conservative, and will likely remain so into the future due to similar growth rates between predictions and CMI plot measurements.

Table 3. Merchantable volume (m^3/ha) and PAI (m^3/ha/yr) difference between CMI plot and predicted estimates by measurement. Live ground volumes summarized for all stems, both without and with expected MPB mortality, stratified by yield table source (managed vs. natural stand yield tables).

Time	Volume Source	n	Actual	Predicted	Avg. Diff.	Std. Err.	95% C.I.	
							Lower	Upper
Managed Stand Volume Comparison								
1	All Live Trees (m^3/ha)	48	28.4	13.4	15.0	5.6	3.8	26.2
	Live Trees less MPB (m^3/ha)	48	28.4	13.4	15.0	5.6	3.8	26.2
2	All Live Trees (m^3/ha)	48	41.7	36.0	5.7	6.5	-7.3	18.8
	Live Trees less MPB (m^3/ha)	48	40.0	36.0	4.0	6.5	-9.1	17.0
	PAI: All live trees (m^3/yr)	48	2.7	4.5	-1.9	0.6	-3.1	-0.6
	PAI: Live trees less MPB (m^3/yr)	48	2.3	4.5	-2.2	0.7	-3.6	-0.9
Natural Stand Volume Comparison								
1	All Live Trees (m^3/ha/yr)	34	45.0	15.9	29.1	6.6	15.7	42.4
	Live Trees less MPB-infested (m^3/ha/yr)	34	45.0	15.9	29.1	6.6	15.7	42.4
2	All Live Trees (m^3/ha/yr)	34	63.0	28.3	34.7	8.8	16.7	52.6
	Live Trees less MPB-infested (m^3/ha/yr)	34	57.8	28.3	29.5	8.9	11.5	47.5
	PAI: All live trees (m^3/yr)	34	3.6	2.5	1.1	1.1	-1.2	3.4
	PAI: Live trees less MPB (m^3/yr)	34	2.6	2.5	0.1	1.4	-2.7	2.8

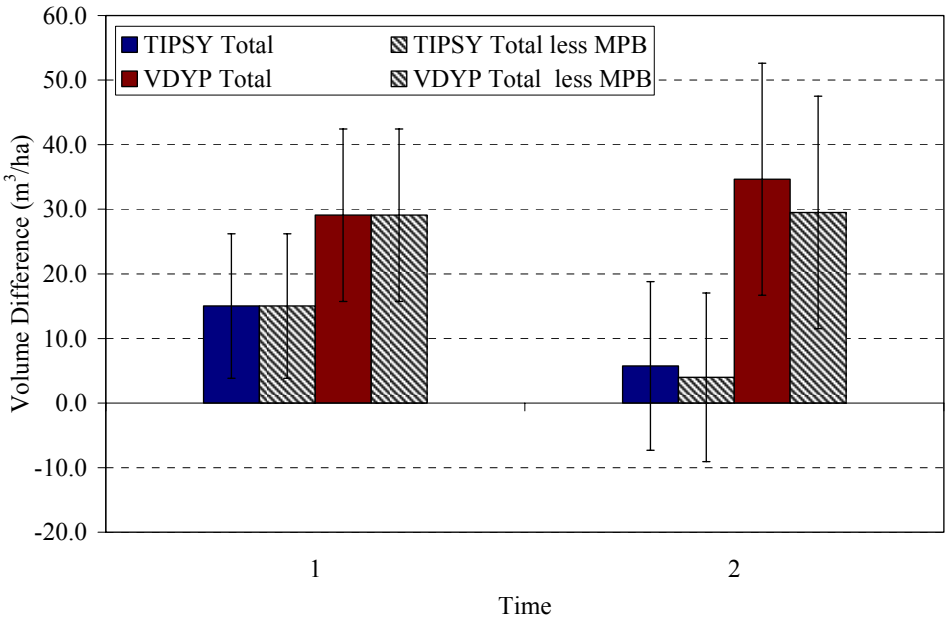

Figure 2. Comparison of average volume differences (actual – predicted) among different volume sources. Mean differences and 95% confidence bars are displayed by Time period.

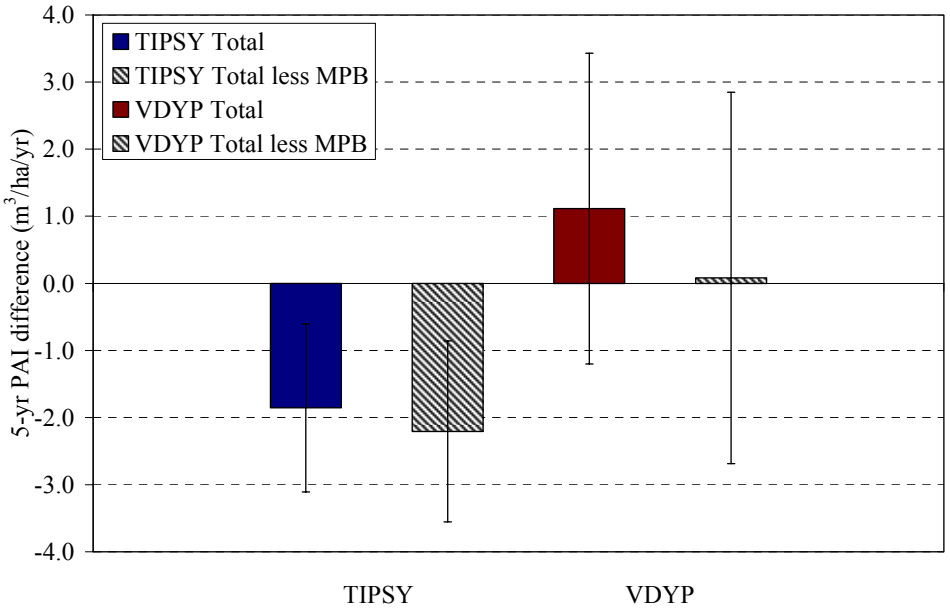

Figure 3. Comparison of average PAI differences (actual – predicted) among different volume sources. Mean differences and 95% confidence bars are displayed by Time period.

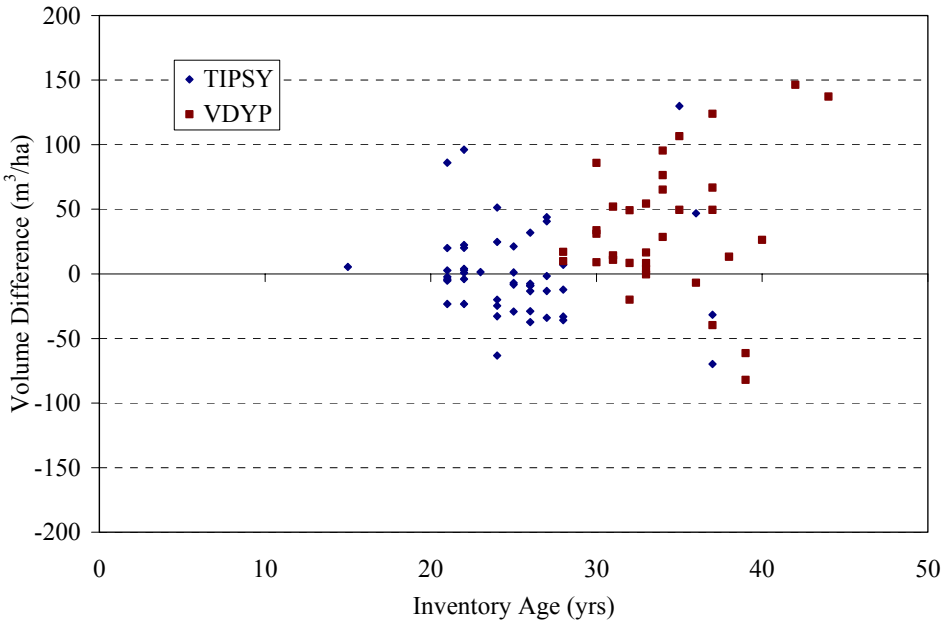

Figure 4. Comparison of Time 2 live net merchantable volume differences (actual – predicted) by inventory age and volume source.

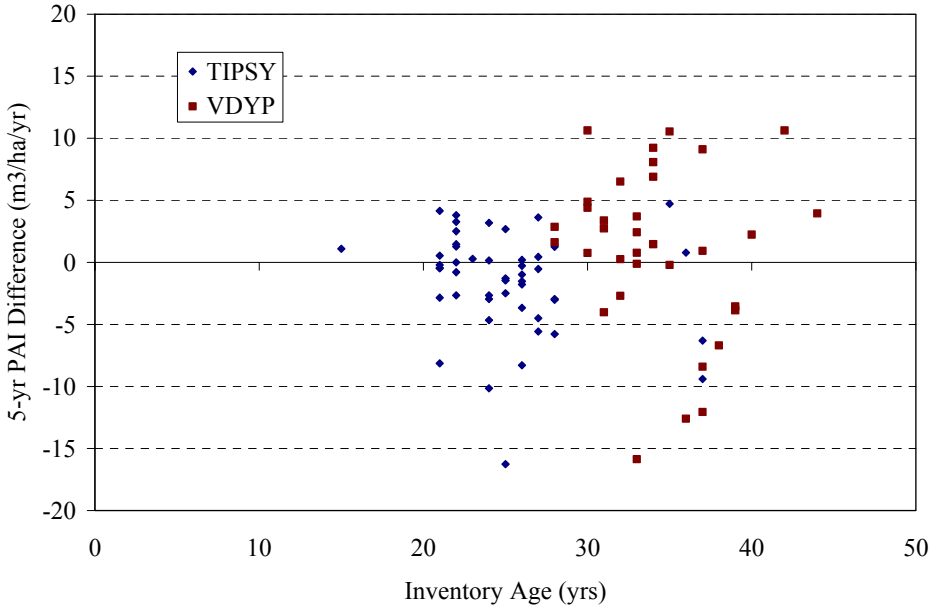

Figure 5. Comparison of PAI differences (actual – predicted) by inventory age and volume source.

5.3 Site Index Comparison

5.3.1 Site Index of Inventory-Leading Species

Site index comparisons were completed where there was a match between the leading species in the inventory, the SIA PSI and the CMI SI (69 matches). The results show that PSI is under-estimated by 1.9 m at Time 2 (Table 4, Figure 6). The only species where there is a significant difference between CMI plot SI and SIA PSI is Sx, where SIA PSI is under-estimated by 2.8 m at Time 2.

Table 4. Average site index and differences (actual – predicted) by species, for the leading inventory species at first and second measurements.

Inventory-Leading Species[34]	Time 1					Time 2				
	PSI (m)	CMI SI (m)	SI Diff. (m)[35]	n	SE	PSI (m)	CMI SI (m)	SI Diff. (m)	n	SE
Sx	19.2	21.7	2.4	40	0.5	19.2	22.0	2.8	40	0.5
Pli	21.1	21.3	0.2	18	0.5	21.2	21.5	0.3	18	0.5
Fdi	17.5	18.1	0.6	3	1.5	17.5	19.6	2.0	3	2.4
At	21.7	20.5	-1.2	4	1.5	20.2	21.7	1.5	5	1.6
Bl	20.8	21.1	0.2	4	3.3	20.8	20.6	-0.2	4	3.1
Total			*1.4*	*69*	*0.4*			*1.9*	*70*	*0.4*

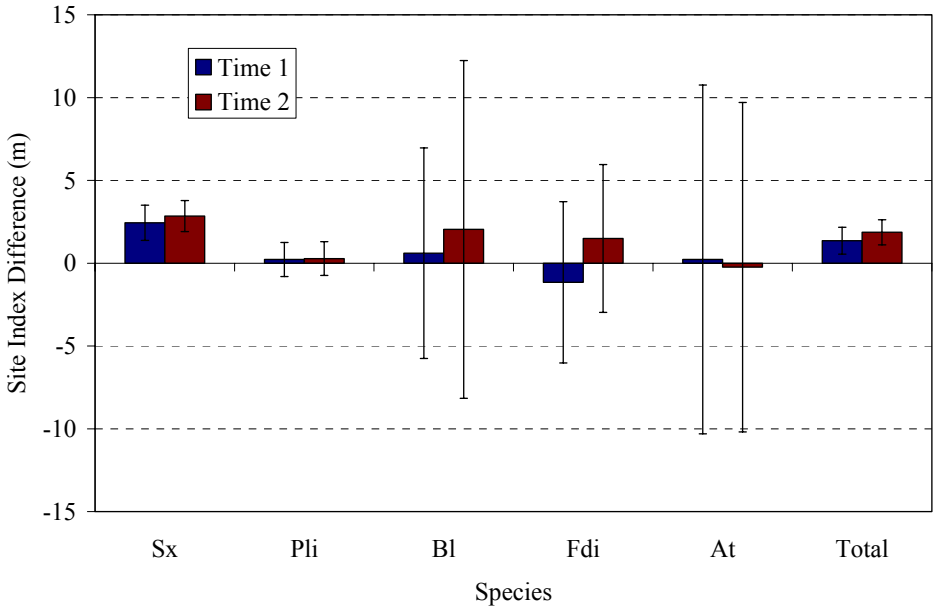

Figure 6. Site index difference (actual – predicted) and 95% confidence limits by species, for the leading inventory species at Time 1 and 2.

[34] Only those plots are included where suitable ground site tree data exists for the inventory leading species.

[35] Differences are calculated at a plot-level, and then averaged. Therefore, this value will not be the same as the overall actual average value minus the overall predicted average value.

5.3.2 Site Index for All Suitable Site Trees

For all species sampled in the SIA program (Pli, Sx, Bl, and Fdi), SIA PSI observations were compared to all relevant CMI site tree data (this more than doubled the number of observations as compared to the leading species site index comparison).[36] The CMI site tree data suggests that SIA PSI is under-estimated by 1.7 m overall (Table 5, Figure 7), and that Sx and Bl[37] PSI were underestimated by 3.1 m and 1.4 m, respectively, at Time 2. The CMI SI for each species did not change appreciably from Time 1 to Time 2.

Table 5. Average site index estimates and differences (actual – predicted) by species, for all suitable ground site tree data at Time 1 and 2.

Species	Time 1					Time 2				
	PSI (m)	CMI SI (m)	SI Diff (m)	n	SE	PSI (m)	CMI SI (m)	SI Diff. (m)	n	SE
Sx	19.2	22.2	3.0	59	0.4	19.2	22.2	3.1	60	0.4
Pli	20.9	21.5	0.6	49	0.4	21.2	21.6	0.4	48	0.3
Bl	17.2	18.1	0.9	35	0.6	17.2	18.6	1.4	37	0.6
Fdi	21.8	20.1	-1.7	5	1.4	20.4	21.9	1.5	8	1.2
At	20.8	21.1	0.2	4	3.3	20.8	20.6	-0.2	4	3.1
Total			*1.5*	*152*	*0.3*			*1.7*	*157*	*0.3*

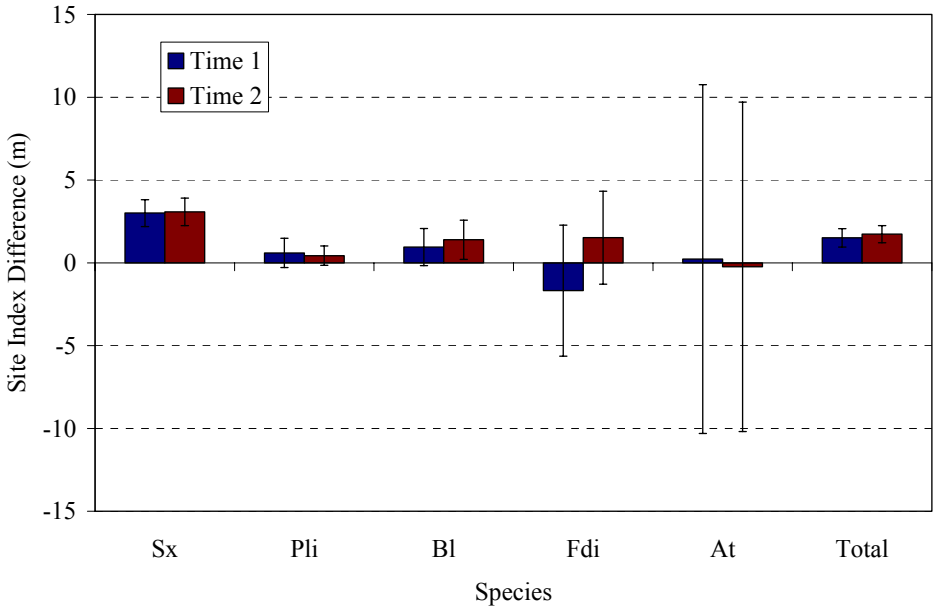

Figure 7. Site index difference (actual – predicted) and 95% confidence limits by species, for all suitable ground site tree data at 1st and 2nd measurement.

[36] At was the only species not included in the SIA.

[37] The underestimation of Bl PSI originates from Sx, since MFR SI conversion equations were used in the SIA program to estimate Bl PSI from Sx PSI.

5.4 Age Comparison

Overall, inventory ages were significantly lower than the CMI plot ages (difference = 3.4 years, 95% CI = [0.2, 6.5]) (Table 6, Figure 8). At-leading stand ages were underestimated by six years (four observations).

Table 6. Average total age difference by species for CMI vs. projected VRI age. Only the ages of those species defined as leading in the VRI (and age-suitable from the CMI plots) were compared.

VRI Leading Species	Time 1					Time 2				
	VRI Age (yrs)	CMI Age (yrs)	Diff. (yrs)	n	SE	VRI Age (yrs)	CMI Age (yrs)	Diff. (yrs)	n	SE
Sx	23	28	5	40	2	28	32	4	40	2
Pli	25	24	-1	18	1	30	29	-1	18	1
Fdi	28	35	7	3	9	33	41	8	3	8
At	26	32	6	4	3	28	39	11	5	7
Bl	27	21	-6	4	2	32	26	-6	4	2
Total	*24*	*27*	*3*	*69*	*2*	*29*	*32*	*3*	*70*	*2*

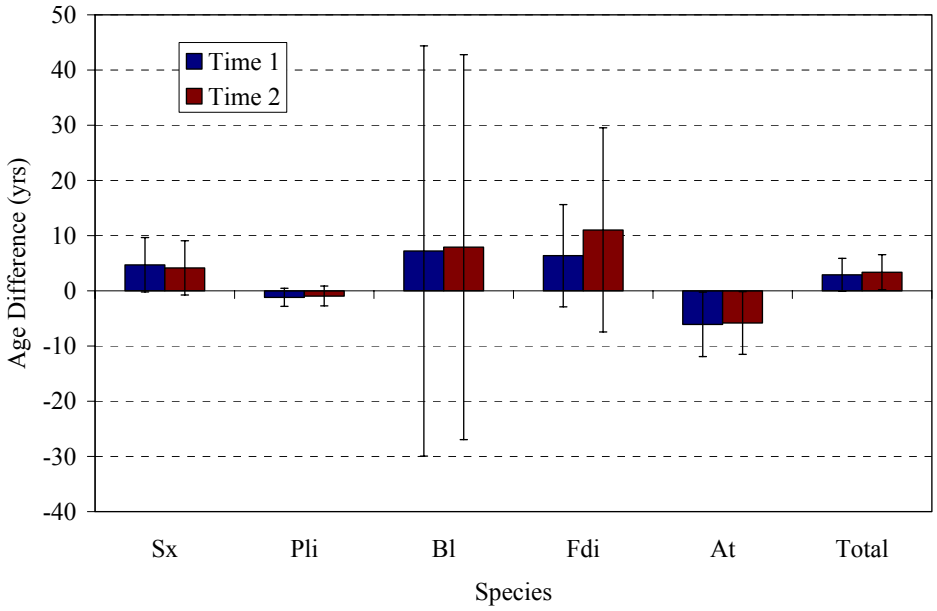

Figure 8. Comparing total age difference by species. Only the ages of those species defined as leading in the inventory and age-suitable from the ground plots were compared.

5.5 Species Composition: CMI plots vs. Inventory

The percentage of plots with the same leading species between ground samples and VRI was 40% at Time 1 measurement, and 46% at Time 2 measurement (Table 7, Table 8). This increase is mostly attributed to stands that had no BA at Time 1 (with no leading species), but exceeded minimum utilization limits at Time 2.

Overall, the Time 1 vs. Time 2 comparison shows the VRI appears to overestimate the proportion of Sx- and Fdi-leading stands and underestimate the proportion of Bl- and Pli-leading stands. Most notably, 54% of the sampled stands were labelled in the VRI as Sx-leading, while 24% of the CMI plots were actually Sx-leading at Time 2.

Table 7. Time 1 CMI plot leading species vs. VRI label.
"Blank" species are those plots with zero merchantable volume.

CMI Leading Species Time 1	VRI Leading Species					Total
	Sx	Pli	Bl	Fdi	At	
Sx	16%	2%				*18%*
Pli	16%	19%			1%	*36%*
Bl	15%	1%	2%	8%		*26%*
Fdi				2%		*2%*
Ac	4%		1%		2%	*7%*
At		1%		3%	1%	*5%*
Xc	1%					*1%*
(blank)	2%	1%			1%	*4%*
Total	*54%*	*24%*	*3%*	*13%*	*5%*	*100%*

Table 8. Time 2 CMI plot leading species vs. VRI label.

CMI Leading Species Time 2	VRI Leading Species					Total
	Sx	Pli	Bl	Fdi	At	
Sx	19%	1%		3%	1%	*24%*
Pli	15%	21%		5%		*42%*
Bl	16%	1%	2%			*19%*
Fdi				2%		*2%*
Ac	4%		1%		3%	*8%*
At		1%		3%	1%	*5%*
Total	*54%*	*24%*	*3%*	*13%*	*5%*	*100%*

5.6 Species Composition: CMI plots vs. Timber Supply Assumptions

Recall that 48 of the CMI plots were modelled using TIPSY and 34 stands were modelled using VDYP in timber supply analyses. Of these, 36% of the Time 2 CMI plots properly matched the leading species that was modelled in TIPSY, and 59% of the plots matched the leading species modelled in VDYP (Table 9).

For those polygons modelled in TIPSY, 72% of the stands were modelled as Pli-leading, 19% were modelled as Sx-leading, and 4% modelled as Bl-leading. The CMI plots showed Pli was leading 42% of the time, and Sx and Bl led 23% of the time.

The stands modelled using VDYP had a closer match to the timber supply assumptions, likely because they used the inventory species (versus the site series based silviculture regimes modelled in TIPSY).

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.

Table 9. Time 2 CMI plot leading species distribution vs. MP assumptions.

Model	CMI Leading Species Time 2	Management Plan Leading Species					Total
		Sx	Pli	Bl	Fdi	At	
TIPSY	Sx	4%	19%				*23%*
	Pli	6%	32%			4%	*42%*
	Bl	4%	19%				*23%*
	Fdi						*0%*
	Ac		3%	4%			*8%*
	At	4%					*4%*
	Total	*19%*	*72%*	*4%*	*0%*	*4%*	*100%*
VDYP	Sx	18%	9%				*26%*
	Pli	9%	32%				*41%*
	Bl	6%	3%	3%			*12%*
	Fdi				6%		*6%*
	Ac		3%	3%		3%	*9%*
	At		6%				*6%*
	Total	*32%*	*53%*	*6%*	*6%*	*3%*	*100%*
Total		*24%*	*65%*	*5%*	*2%*	*4%*	*100%*

5.7 Pest and Damage Incidence Reporting

The occurrence of pest and damage indicators are summarized by Time period 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) MPB was not observed at Time 1, but 23% of Pli trees (40% of total BA) were attacked at Time 2;
2) Stem disease was prevalent in Pli at Time 1 (43% of trees) and 2 (26% of trees);
3) Aphids were prevalent in Sx at Time 1 (52% of trees) and 2 (49% of trees); and
4) Weevil was recorded in 4% of Sx trees at Time 1 and 6% at Time 2.

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. Once the remaining Block B points are sampled, this will provide further ability to report on pest and damage, particularly that of MPB.

Table 10. Pest incidence by Time period as a percentage of all measured trees (total number of stems, and total basal area).

		Pest Incidence as % of Total Stems							Pest Incidence as % of Total BA						
Msmt	Species	Aphid	Weevil	MPB	Stem Disease	Animal	Abiotic	Other	Aphid	Weevil	MPB	Stem Disease	Animal	Abiotic	Other
1	Sx	52	4						28	4				4	
	Pli				43		2	11				45		2	10
	Bl											1		2	1
	Fdi	1							1						
	At				1										
	Oth						3							4	
2	Sx	49	6						35	7			1		2
	Pli			23	26	1	3				40	24	3	1	
	Bl	1		1			4	1					7		
	Fdi						1						1		
	At					12	10	1				1	12	21	1
	Oth	1	1				2	2					2		4

[a] An individual stem may have more than one pest.

The associated incidence of damage indicators is generally related to the pest incidence, but not always.[38] The most significant findings from the tree data is that:

1) Time 1 shows a high level of forking in Sx, Pli and Bl (40 – 50% of all trees);
2) The amount of forking in Sx, Pli, and Fdi decreases from Time 1 to Time 2;
3) Crooks are observed in about 10 – 20% of all trees of all species; and
4) Scarring is present in all species, but decreases from Time 1 to Time 2.

Table 11. Damage incidence by Time period as a percentage of all measured trees.

Time	Species	Damage Incidence as % of Total Stems Affected by Species[b]						
		Broken Top	Dead Top	Crook	Fork	Scar	Frost Crack	Other
1	Sx	2	1	14	43	1		
	Pli	1	1	13	47	14		
	Bl	5	1	14	59	8	1	
	Fdi			23	30			
	At	4		13	15	36		
2	Sx	1	2	8	30	2		
	Pli	1		10	28	11		
	Bl	3	2	7	32	6	1	1
	Fdi			15	25	10		
	At	3		18	13	23		

[b] An individual stem may have more than one type of damage.

[38] The damage indicators are not always associated with pests, as the cause of the underlying damage was often recorded as unknown by field crews.

6.0 DISCUSSION

6.1 Volume & Species Comparison

A key observation in this analysis was that the average predicted growth rate for stands modelled with TIPSY was significantly greater than that observed in the CMI plots. There are likely a few causes of this, but the difference between the leading species modelled in the timber supply versus that which was observed in the CMI plots impacts both the growth rates and volume (Section 6.1.1). Data from future measurements will further refine and confirm leading species, growth rates, and expected volumes. In addition, there are a few other variables which may explain differences between the timber supply assumptions and the re-measured CMI plot data. These include:[39]

1) The OAF assumptions may not be appropriate (Section 6.1.2);
2) Modelling criteria used to define managed vs. natural stands may not be appropriate (Section 6.1.3)

6.1.1 Leading Species Assumptions in the timber supply analysis

The leading species used to develop TIPSY yield curves originated from site series based silviculture regimes where one leading species was assigned to each TEM site series combination. The result is that while the majority of managed stands were projected as Pli-leading, the Time 2 CMI plot data showed that less than half were Pli-leading and the remainder were either Sx- or Bl-leading. The impact of projecting a managed Sx or Bl stand using a Pli-based yield curve is that the yield curve will likely overstate volume expected from a Sx or Bl stand in the short term.

If the immature profile significantly alters the timber supply forecast, it may be beneficial to revise the silviculture regime definitions to reflect the higher Sx and Bl proportions. There are several ways to do this including stratifying the regimes by a geographic or elevation band and refining estimates in these areas.

6.1.2 Operational Adjustment Factors

The operational adjustment factors (OAF) used as TIPSY yield inputs for Block A included an OAF1 of 7.5% and OAF2 of 5%. The OAF 1 reduction was based on additional non-productive areas that were mapped and excluded by the TEM. However, any increase in managed stand growth over that observed, may suggest a re-evaluation of OAF 1.

The OAF 2 was set at a provincial standard of 5%, which is generally used to account for growth losses associated with pests among other criteria. MPB has caused mortality on the TFL between Time 1 and 2, and the impact is expected to increase in the Pli population on the TFL. The incidence of other pests and damage agents suggests that the OAF2 estimates should be reviewed and quantified to ensure that future volumes appropriately capture forest health impacts.

[39] These comparisons involve only MP assumptions for Block A. No specific assessment was made of the Block B silviculture regimes because of its current small sample size (7).

6.1.3 Modelling Criteria Used to Define Managed vs. Natural Stands

In the development of managed and natural stand yield tables, the criteria to separate existing managed from existing natural stands was an inventory age of 20 years for Block A (as of 2000) and 50 years for Block B (as of 2001). It is possible that some Bl-residual stands may have been included as managed stands, as some measured Bl site trees in the CMI plots were up to 60 years old. A suggested alternative method to separate managed stands from natural stands could be use of a harvest history coverage instead of inventory age.

6.2 Site Index Comparison

Only Pli and Sx were statistically adjusted in the original SIA programs, while Fdi and Bl PSI were estimated from MFR SI conversion equations. As a result, the most reliable comparisons to previous SIA results are Pli and Sx. Pli PSI estimates were almost identical to ground based measurements, suggesting that the SIA program predicted Pli PSI estimates well. However, ground measured Sx SI is considerably higher than the SIA results (by 3m), suggesting the PSI for Sx may be conservative.[40] An under-estimation of site index should translate to an under-prediction of volume and volume growth if all other model inputs are correct.

[40] The TFL 52 final SIA report also suggested that Sx adjusted PSI estimates may be conservative.

7.0 CONCLUSIONS

The CMI plot program provides a statistically-valid sample of the growth performance of trees in stands 15 years and older on TFL 52. These results are compared against the assumptions modelled in the timber supply analysts supporting the MP. 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 re-measured CMI plot data; the program results demonstrate this value. However, since only one 5-year measurement interval has been completed, conclusions drawn about the timber supply analysis assumptions should be done with some caution. The Time 3 measurement results will provide a greater ability to assess the inventory and timber supply analysis inputs.

2) **Managed stand volumes were similar to that predicted in the timber supply analysis at Time 2.** Stands modelled in TIPSY showed the average observed net merchantable ground volume was significantly greater than predicted volume (15 m^3/ha) in the timber supply analysis at Time 1 and not significantly different from timber supply analysis volume at Time 2.

3) **Time 1 and 2 young natural stand volumes were significantly greater than modelled in the timber supply analysis.** The average observed net merchantable volume was significantly greater than predicted volume at Time 1 and 2 (29 m^3/ha and 35 m^3/ha, respectively).

4) **The timber supply analysis assumptions over-predicted growth rates of managed stands.** The CMI plots show that timber supply analysis assumptions over-predicted net annual growth by 1.9 m^3/ha/yr.

5) **The timber supply analysis assumptions well predicted the growth rates of young natural stands.** No difference was observed between the predicted and observed growth rates for stands modelled with VDYP.

6) **MPB attack was observed for the first time at Time 2.** There was no record of MPB attack at Time 1. If all Time 2 MPB attacked stems die, observed volumes at Time 2 will be reduced by 1.7 m^3/ha and 5.2 m^3/ha, respectively, in stands modelled with TIPSY and VDYP..

7) **The timber supply analysis assumptions predict Pli site index well, but under-predict Sx site index:** The observed site index for Pli was not significantly different from the PSI estimates included in the latest timber supply analysis; however, Sx site index was 3 m greater than predicted in the timber supply analysis.

8) **The VRI leading species identified in young natural stands was considerably different than observed in the CMI plots**. The CMI plot data showed that VRI leading species was correct 46% of the time at Time 2. Sx was predicted to be the dominant inventory leading species in 54% of the stands while CMI measurements showed Pli being dominant in 42% of the stands, with Sx at just 24%. Bl-leading stands were under-represented in the VRI, with the VRI identifying 3% of stands as Bl-leading, while 26% of stands sampled were actually Bl-leading.

9) **The managed stand leading species used in the timber supply analysis was substantially different than observed in the CMI plots.** The timber supply analysis leading species used to develop managed stand yield tables originated from site series based silviculture regimes. The CMI data showed that the timber supply analysis leading species assumptions was correct 36% of the time. Specifically, the majority of managed stands were projected as Pli leading, while less than half were actually Pli leading, and were instead Sx- or Bl-leading.

10) **The VRI ages used in the timber supply analysis are under-estimated.** Total inventory age is significantly less than total measured age by about 3 years.

11) **Besides MPB, there are other significant pest and damage agents that 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 other pests on the TFL (i.e., stem disease on Pli, aphid and weevil damage on Sx) has the potential to reduce growth in managed stands.

8.0 RECOMMENDATIONS

The primary recommendations related to the CMI Time 2 results are for West Fraser to:

1) Continue to monitor the CMI plots on a 5-year schedule, specifically to track apparent differences of MP-based assumptions with managed stand growth rates, species composition, and Sx site index predictions. The Time 3 measurement results will provide a greater ability to assess the inventory and timber supply analysis inputs.
2) Re-run the analysis with CMI plots whose leading species match the leading species in the timber supply analysis. Compare volume and growth rates (at a minimum) between the two.
3) Explore why Sx site index was underestimated by 3m in the original SIA program with the goal of improving Sx site index estimates in future timber supply analyses.
4) Re-evaluate the timber supply analysis assumptions used to generate managed stand yield tables, specifically the silviculture regime leading species, operational adjustment factors, and age cut-off for use of VDYP or TIPSY.
5) Re-run the CMI analysis once a new set of standardized managed and natural stand yield tables are generated for the combined Block A and Block B.
6) Explore options to quantify pest-related growth reductions in managed stand yield tables.
7) Establish remaining 2-km grid samples that were not established in Block B at initial establishment.
8) Establish recruitment plots that grow into the target population.

9.0 APPENDIX I – DATA ERROR CHECKING RESULTS

Of the over 2,900 trees collected in this project, the following errors were found:

1. There were a total of thirty-three (33) trees above the utilization limits for the volume compilation that were either alive (13) or dead (20) at first measurement but missing at second measurement. It was assumed that these trees had died and fallen between measurements. All missing trees were assumed to be coarse woody debris (CWD) and therefore assigned zero volume at second measurement.

2. There were five (5) trees above the utilization limits for the volume compilation that had different species labels between measurements (Table 12). None of the trees were site trees, so were not used for species-specific comparisons. No changes were made.

Table 12. Species discrepancies.

Sample #	Tree #	Msmt 1 Species	Msmt 2 Species
1004	358	Bl	Fd
1004	363	Bl	Fd
1013	270	Ac	At
2001	753	Xh	Ac
2028	050	At	Ac

3. There were twenty-seven (27) trees above the utilization limits for the volume compilation that had a smaller DBH at the second measurement. Twelve (12) of these trees were dead at the first measurement and twenty (20) were dead at the second measurement, and diameter loss can be attributed to expected bark loss and stem shrinking due to moisture loss. Of the seven (7) live trees, the average DBH reduction was 0.6 cm. These differences were left unchanged.

4. There were eight (8) site trees that decreased in height at the second measurement. The height of the three (3) site trees that decreased by more than 0.5 m were all deciduous (Table 13), and were dropped from the site index comparison. The remaining trees were greater than 10m tall and lost 0.5m or less in height. As this is within the allowable error for tree height measurement, no changes were made.[41]

Table 13. Site Tree height discrepancies between measurements.

Sample #	Tree #	Species	Height 1 (m)	Height 2[42] (m)	Height Difference
1019	395	Ac	7.0	5.1	-1.9
2008	993	Ac	6.3	1.31	-4.99
3009	449	At	9.2	1.31	-7.89

[41] MFR VRI: Quality Assurance Procedures and Standards for VRI Ground Sampling. March 31, 2008.

[42] The 2009 VRI compiler assigns a height of 1.31 m to trees that are missing a height in the input files.

10.0 APPENDIX II – PLOT ATTRIBUTES

Note: Block A : samples # 1001 – 3024; Block B: samples # 0001 – 0027.

Sample #	Species Label			Current Merchantable volume (m^3/ha)					Site Index (m)				Total Age (yrs)			Basal Area (m^2/ha)		Density (SPH)	
	Time 1	Time 2	VRI Forest Cover	MSYT Leading Species	Total Live Time 1	Total Live Time 2	MSYT Time 1	MSYT Time 2	Inventory Leading Species	Plot SI Time 1	Plot SI Time 2	Predicted SI	Site Tree Age Time 1	Site Tree Age Time 2	Predicted Age Time 2	Plot BA Time 1	Plot BA Time 2	Plot SPH Time 1	Plot SPH Time 2
0001	PLI100	PLI100	PLI65AT20FDI10EP5	AT	0	6	9	29	PLI	24.6	24.5	24.3	15	21	21	14.9	24.1	1451	1701
0004	PLI36SX29FDI16BL15	PLI34SX30FDI16BL13	FDI63SX20PLI10AT5EP2	PL	130	94	3	8	FDI		22.6	16.0		54	21	24.3	17.1	751	450
0006	AT41SX34EP22FDI4	AT41SX33EP22FDI4	FDI54SX25EP15AT5BL1	SX	120	172	14	42	FDI	22.3	20.9	22.0	33	37	35	27.8	34.7	1076	1226
0007	BL73SX27	BL60SX40	SX65AT15BL15FDI5	SX	7	13	45	83	SX	24.1	23.2	22.3	21	27	37	2.9	5.5	150	250
0016	AC39SX28EP20PLI9	AC41EP24SX23PLI7	SX45FDI25PLI20AT5EP4BL1	BL	67	99	24	52	SX	26.8	25.6	20.4	40	45	36	19.0	22.5	1101	851
0023	PLI97SX3	PLI93SX7	FDI70SX20AT10	SX	30	4	15	36	FDI			22.2			37	16.9	7.8	1051	751
0027	PLI45SX29EP26	SX46PLI32EP19FDI4	FDI40SX35PLI15EP10	SX	32	40	1	8	FDI	17.0	20.8	21.6	34	32	26	20.0	27.1	1726	1926
1001	PLI80AC14SX6	PLI75AC16SX9	SX69AT9EP8PLI7FDI7	SX	56	104	1	9	SX	23.3	23.7	21.6	30	35	34	18.9	25.3	1101	1351
1002	PLI96SX4	PLI95SX3BL2	SX40PLI30BL20AT10	PL	16	2	12	39	SX	15.0	15.0	17.3	41	46	26	15.6	3.6	1401	550
1003	PLI97SX3	PLI96SX4	PLI51BL34SX15	PL	38	68	2	14	PLI	19.4	19.7	18.0	32	37	33	18.8	25.9	1426	2101
1004	SX88BL12	SX73FDI27	SX85PLI10BL5	PL	1	9	11	32	SX	25.2	22.7	19.6	16	21	22	1.6	7.2	150	650
1005	SX89BL11	SX59BL30AC6PLI6	SX64CW19BL15AC1AT1	PL	1	7	4	12	SX	21.7	22.7	19.4	21	26	21	1.8	5.7	200	500
1006	PLI87XC10AT3	PLI96AT4	PLI90EP8AT2	PL	140	124	31	57	PLI	24.5	24.7	23.5	30	32	37	28.6	20.3	1451	951
1007	AT52BL37SX11	AT45BL44SX10FDI2	PLI47BL32SX11AT10	PL	72	102	116	163	PLI			16.1			39	17.4	21.9	876	1026
1008	FDI69AC31	FDI73AC27	FDI95SX3PLI1BL1	FD	20	51	19	37	FDI	24.0	23.2	22.7	30	32	31	10.0	16.4	625	776
1009	PLI95BL5	PLI94BL4SX2	SX50PLI20BL10EP10AC10	PL	49	99	14	48	SX			19.4			24	15.9	23.8	826	1176
1010	BL100	BL100	BL61SX38PLI1	PL	0	0	0	4	BL	17.9	21.9	15.2	16	19	22	0.0	9.6	0	1551
1011	PLI100	PLI66SX25FDI5BL4	SX86BL9PLI2FDI2AC1	SX	3	18	0	1	SX	22.8	23.0	19.4	18	21	28	4.6	14.5	475	1201
1012	BL55SX42PLI3	BL58PLI27SX15	PLI77SX14BL9	PL	58	5	6	34	PLI			18.6			25	11.6	4.0	375	250
1013	AC75SX25	AC67SX30AT3	SX67PLI23AT7BL2AC1	PL	55	111	29	67	SX	24.8	25.4	21.3	27	32	27	13.2	21.2	550	725

Sample #	Species Label			Current Merchantable volume (m^3/ha)					Site Index (m)				Total Age (yrs)			Basal Area (m^2/ha)		Density (SPH)	
	Time 1	Time 2	VRI Forest Cover	MSYT Leading Species	Total Live Time 1	Total Live Time 2	MSYT Time 1	MSYT Time 2	Inventory Leading Species	Plot SI Time 1	Plot SI Time 2	Predicted SI	Site Tree Age Time 1	Site Tree Age Time 2	Predicted Age Time 2	Plot BA Time 1	Plot BA Time 2	Plot SPH Time 1	Plot SPH Time 2
1014		PLI100	PLI94BL6	PL	0	1	0	3	PLI	16.0	16.8	17.0	15	21	21	0.1	4.5	25	475
1015	XC61AT39	SX44AT41AC16	SX60PLI40	SX	5	23	1	7	SX	21.6	22.7	21.6	24	29	33	5.5	17.6	550	1676
1016	PLI87AT13	PLI72SX17BL8AT4	SX51PLI21AT15BL9FDI2AC2	PL	3	32	4	12	SX	24.2	23.8	18.4	17	22	21	8.2	16.3	826	1151
1017	BL87SX11AC2	BL79SX18AC3	SX80BL20	PL	81	113	4	17	SX			19.4			22	19.9	28.4	801	1376
1018	SX35PLI32AC23BL10	SX41PLI28AC19BL12	SX80PLI15BL5	PL	12	30	12	39	SX	21.0	22.5	19.3	30	24	26	5.1	8.8	250	325
1019		AC66AT34	AT41AC26SX24BL6PLI3	PL	0	1	0	0	AT	18.3	18.7	27.0	13	18	23	0.1	4.1	25	525
1020	SX100	SX100	SX73BL15PLI12	PL	1	8	4	12	SX	22.9	24.6	19.4	16	21	21	1.0	8.1	75	700
1021	BL54SX46	BL50SX50	SX81BL15PLI2AC1AT1	PL	30	53	6	28	SX	21.2	22.0	16.0	27	32	24	9.3	16.1	450	826
1022		BL54SX46	SX90BL10	PL	0	6	0	3	SX	23.4	24.1	15.7	17	21	21	1.4	9.2	175	976
1023	PLI59BL41	PLI61BL39	PLI40SX40BL20	PL	7	22	5	12	PLI	19.3	18.3	17.7	19	25	28	6.1	13.9	450	1051
1024	PLI76SX24	PLI74SX26	PLI46BL38SX15HW1	PL	16	36	79	118	PLI	19.3	19.7	19.8	25	30	39	7.5	11.6	375	475
2001	AC73BL10PLI6XH4	AC69BL14PLI8EP5	AT80PLI10SX7BL3	AT	77	108	32	59	AT			28.7			37	14.3	20.2	525	776
2002	PLI90SX10	PLI54SX46	PLI80SX20	PL	16	14	23	50	PLI	19.3		20.9	21		28	10.2	12.1	776	1126
2003	SX71BL17XC11	SX80BL16XC4	SX87BL10PLI2AT1	SX	55	110	1	3	SX	23.5	24.0	19.8	31	36	35	20.4	28.3	1101	1151
2004	PLI100	PLI75SX25	SX56BL39PLI3AC2	PL	4	23	14	48	SX	22.6	24.5	21.0	17	22	24	5.0	11.5	475	876
2005	PLI85SX8AT7	PLI79SX8AT7EP7	SX58PLI20BL14AC4AT4	PL	14	11	26	74	SX	21.0	21.0	22.9	29	34	24	12.1	11.0	1126	1201
2006	PLI76SX24	PLI58SX40AC3	SX50AT20BL10AC10PLI10	PL	29	55	15	54	SX	23.3	24.1	21.2	26	31	25	10.3	14.9	625	725
2007	SX73PLI21BL6	SX73PLI21BL6	PLI80AT10SX5EP5	PL	47	77	12	25	PLI		23.7	23.1		34	31	11.0	14.4	425	425
2008	PLI88AC12	PLI89AC8AT3	SX39PLI25BL25AC8FDI3	PL	7	36	11	32	SX			19.3			22	7.4	14.2	675	851
2009	SX100	SX100	SX67BL16PLI15AC1AT1	PL	7	35	11	32	SX	23.9	23.9	19.0	17	24	22	9.2	23.5	776	1876
2010	SX67XC25BL4CW4	SX89CW7BL5	SX94AT2CW2BL1AC1	PL	31	65	0	0	SX	22.5	21.2	22.4	31	34	34	12.8	20.4	625	951
2011	PLI48BL47SX5	BL47PLI40SX13	SX52PLI25AT11BL8AC4	PL	20	38	32	72	SX	22.7	22.0	19.8	19	24	27	11.2	14.8	826	876
2012	PLI100	PLI100	PLI73FDI19SX4BL4	PL	84	62	63	102	PLI	21.1	19.5	20.3	38	43	37	21.8	14.1	1426	951
2013	PLI53BL35XC12	PLI55BL37XC5AT3	PLI82SX16BL1AT1	PL	9	31	1	10	PLI	20.3	19.8	15.7	20	25	25	7.6	16.0	600	1051

Sample #	Species Label			Current Merchantable volume (m^3/ha)					Site Index (m)				Total Age (yrs)			Basal Area (m^2/ha)		Density (SPH)	
	Time 1	Time 2	VRI Forest Cover	MSYT Leading Species	Total Live Time 1	Total Live Time 2	MSYT Time 1	MSYT Time 2	Inventory Leading Species	Plot SI Time 1	Plot SI Time 2	Predicted SI	Site Tree Age Time 1	Site Tree Age Time 2	Predicted Age Time 2	Plot BA Time 1	Plot BA Time 2	Plot SPH Time 1	Plot SPH Time 2
2014	BL87SX13	SX51BL37PLI13	SX60BL30PLI10	PL	6	26	0	4	SX	22.7	23.7	16.0	19	24	22	4.5	17.0	350	1401
2015	BL89SX11	BL78SX19AT3	SX60PLI30BL10	PL	19	52	11	32	SX	23.6	24.8	19.8	19	24	22	9.5	17.8	675	1076
2016	PLI100	PLI100	PLI50SX30AT10EP10	PL	81	45	25	52	PLI	22.7	22.6	21.4	29	32	36	17.6	8.6	700	350
2017	PLI84EP10AC3AT3	PLI75EP17AC4AT4	PLI80SX10EP10	PL	99	39	16	35	PLI	24.0	21.1	24.2	30	35	33	20.5	10.2	851	625
2018	PLI83AC17	PLI89EP11	PLI40EP40AT20	PL	7	10	14	30	PLI	21.8	21.7	24.0	30	35	32	3.4	3.1	250	200
2019	BL71AC18SX10	BL52SX33AC11AT5	SX80AT20	PL	7	28	14	48	SX	21.7		20.2	27		24	5.6	11.9	450	826
2020	BL65SX31AC4	BL62SX33AC5	BL50SX30AC10EP8PLI2	BL	128	199	35	52	BL	16.8	17.9	19.0	62	66	42	28.0	37.4	1101	1551
2021	AC43BL29SX28	AC37BL34SX30	BL55SX41AC2PLI1FDI1	BL	46	73	25	44	BL	19.8	18.9	18.4	28	37	34	15.1	21.4	575	650
2022	PLI42XC39BL19	PLI60BL21SX13AT7	PLI50SX30BL20	PL	8	33	1	2	PLI	19.2	19.8	20.3	21	26	30	7.4	15.0	650	1101
2023	SX55XC29AC13AT3	SX58XC20AC16AT4	SX82PLI7AC5BL4AT2	PL	13	43	17	45	SX	24.2	23.5	18.0	24	31	27	8.4	16.8	625	926
2024	PLI90BL10	PLI83BL11SX6	SX40PLI40BL20	PL	8	30	12	39	SX		25.1	18.8		27	26	10.7	19.3	1126	1926
2025	BL68SX27XC5	BL71SX29	SX64BL35PLI1	PL	117	137	0	0	SX	20.0	19.8	16.0	32	37	44	22.8	25.4	600	575
2026	PLI52XC29AC11EP8	PLI52XC18EP13AC11	PLI70EP10SX10AT10	PL	20	44	16	36	PLI	18.8	19.3	23.5	29	34	33	7.2	13.0	450	725
2027	SX79AT10PLI9EP2	SX79AT11PLI7EP3	SX70PLI30	SX	83	139	5	15	SX	23.7	23.6	21.6	34	39	37	24.5	32.5	1251	1401
2028	AT55AC38BL7	AT51AC35BL12SX2	AT35SX25PLI16AC13BL11	PL	33	86	0	0	AT	25.1	24.4	18.0	21	27	30	14.3	28.8	1076	2151
3001	BL43SX31EP26	BL47EP31SX17SB5	SX45AT40PLI5AC5EP5	SX	7	9	0	1	SX	6.7	6.3	10.8	120	##	32	2.5	3.3	125	150
3002	PLI57AT27BL16	PLI43AT37BL18SX2	PLI94AC2EP2AT2	PL	83	75	36	62	PLI	24.3	24.8	23.5	29	35	38	21.7	17.7	1426	1151
3003	PLI75XC12X10AT3	PLI80XC11AT8EP2	SX40AT20PLI20BL10AC10	SX	90	92	21	51	SX			21.6			27	23.5	21.3	1451	1401
3004	PLI44AC32AT14EP6	AC35PLI33AT16EP12	AT75PLI20EP5	PL	51	50	0	0	AT	22.6	22.4	20.0	26	31	35	18.9	23.9	1451	2151
3005	FDI82PLI13SX5	FDI84PLI10SX6	FDI50AT25SX10PLI10EP5	FD	31	88	1	12	FDI	21.5	22.1	19.9	30	34	34	19.5	28.8	1376	1501
3006	AC50SX40AT10	SX45AC36FDI12AT7	AT45EP35SX15PLI3BL2	PL	15	26	0	0	AT	18.3	17.0	18.3	24	29	40	4.3	8.2	250	400
3007	SX100	SX100	SX59PLI21AT10BL6FDI4	SX	1	7	1	7	SX	18.3	18.5	19.5	31	35	33	3.5	9.9	400	1126
3008	SX35BL33PLI26EP7	SX45BL28EP15PLI12	SX60AT20EP15AC3PLI2	SX	17	53	0	4	SX	21.8	19.4	22.3	27	33	32	9.8	17.8	700	1001
3009	PLI73AT27	PLI69AT31	PLI80AT10SX10	PL	6	26	12	39	PLI	23.7	24.4	20.3	19	24	26	3.7	8.6	300	500

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	Time 1	Time 2	VRI Forest Cover	MSYT Leading Species	Total Live Time 1	Total Live Time 2	MSYT Time 1	MSYT Time 2	Inventory Leading Species	Plot SI Time 1	Plot SI Time 2	Predicted SI	Site Tree Age Time 1	Site Tree Age Time 2	Predicted Age Time 2	Plot BA Time 1	Plot BA Time 2	Plot SPH Time 1	Plot SPH Time 2
3010	PLI63AC37	PLI65AC27SX5AT2	SX65PLI15BL10AC10	PL	24	57	23	50	SX	22.6	22.0	19.0	25	31	28	11.6	19.3	826	1401
3011	PLI47SX36AT17	SX67PLI17AT16	SX85BL5PLI5EP5	PL	6	31	12	39	SX	23.4	24.0	19.0	21	26	26	6.0	22.3	600	2126
3012	BL54SX46	BL54SX46	SX63AT20BL8PLI7AC2	SX	13	35	1	1	SX	26.3	26.2	18.8	19	28	30	6.0	12.2	375	650
3013	SX100	SX81BL19	SX70BL10AC10AT10	PL	1	10	12	39	SX	22.6	21.8	18.0	19	25	26	3.0	10.3	325	926
3014		BL100	SX72BL18PLI10	PL	0	5	0	0	SX	18.4	17.8	15.3	19	25	15	3.1	12.1	400	1601
3015	PLI83BL17	PLI94BL6	PLI62SX18BL14AC5AT1	PL	6	27	6	34	PLI	22.4	22.4	20.3	20	26	25	11.6	24.3	1351	2727
3016	BL45PLI40SX14	PLI40BL34SX25	SX60PLI20BL20	PL	5	18	4	17	SX	6.7	17.5	16.0	37	25	22	3.6	7.8	250	375
3017	BL86SX8AC6	BL78SX15AC8	SX80BL10AC10	PL	43	68	40	80	SX	18.9	20.0	20.6	37	45	28	13.9	21.5	851	1476
3018	PLI84AC9SX7	PLI76AC12SX12	SX60PLI31BL5AC4	SX	32	13	1	2	SX			14.6			31	18.3	15.3	1476	1626
3019	SX85BL15	SX93BL7	SX80BL20	PL	13	44	14	52	SX	21.8	23.1	19.8	25	30	25	7.3	13.9	500	625
3020	BL53SX42PLI5	SX62BL34PLI4	SX83AC12BL3PLI1AT1	PL	21	59	32	72	SX	21.2	22.9	19.8	22	27	27	13.7	22.3	901	1051
3022	SX55BL45	SX53BL47	SX80BL20	SX	6	10	1	1	SX	13.3	13.0	13.8	35	41	30	3.4	4.6	225	250
3023	SX55PLI45	PLI50SX50	PLI60AT20SX10AC10	PL	5	17	23	50	PLI	18.7	20.1	20.3	19	23	28	2.9	7.5	150	500
3024	SX63BL37	BL57SX43	SX85BL5EP5AT5	PL	4	15	14	48	SX			19.1			24	3.3	9.6	225	725