Young Stand Monitoring in the Prince George TSA: Plot Establishment Report

A Technical Report

Ministry of Forests, Lands, and Natural Resource Operations

Forest Analysis and Inventory Branch

Revised July 2018

Version 4.0

EXECUTIVE SUMMARY

Seventy-five ground plots were established in the Prince George Timber Supply Area (TSA) in young stands and met the Young Stands Monitoring (YSM) target population definition for this report. The YSM population definition is 15 to 50 year old stands, representing approximately 700,000 ha within a total TSA area of approximately 8 million ha.

The sampled polygons are young and therefore the ground compilations are sensitive to utilization level. The average basal area (Dbh ≥ 7.5 cm) on the ground plots was 15.6 ± 1.1 m^2/ha (ranging from 0 – 40 m^2/ha) including 0.5 m^2/ha in residual trees (larger, older trees assumed to part of a residual cohort). The average stems/ha was 988 ± 68 (ranging from 0 – 2,577). The average age of the leading species was 34.4 ± 2.6 years (ranging from 15 – 154 years) and height was 11.7 ± 0.5 m (ranging from 4.0 – 20.1 m). Thirty of the samples were pine-leading followed by spruce (28), balsam (7), aspen/birch (6), and Douglas-fir (1). Three samples had no live trees with Dbh ≥ 4.0 cm. There was an average of 45 dead stems/ha, mostly small pine. Approximately two thirds of the live stems had signs of damage. Pine had the highest fraction of stems with damage (74%) and the cause of most of the damage was unknown (72%) followed by insect and disease. Most of the unknown damage was related to stem form (scars, forks and crooks) that may not have a significant effect on volume. If the unknown, stem form related damage was excluded the fraction of live stems with damage dropped to 18%.

The ground whole stem volumes are approximately double the volumes estimated from the Phase I photo interpreted inventory attributes, the Provincial Site Productivity Layer (PSPL) and TIPSY. About 63% of the bias is due to attribute bias (Table 1). The volumes net of decay waste and breakage are closer.

The SI estimates from the PSPL are approximately 6% lower than the ground SI estimates and not statistically significant.

Table 1. The results of comparing the ground plots to the inventory and to the YSM assumptions are summarized. A p-value < 0.05 is generally considered an indication of statistically significant differences (or bias). Residual trees are not included.

Attribute	N	Source	Ground mean	Inventory mean	Bias			2015
					Magnitude	% of ground mean	p-value	Magnitude
Whole stem volume (m^3/ha)	60	TIPSY	70.7	33.3	37.4 ± 7.4	53%	0	46.8 ± 6.3
Volume model bias (m^3/ha)	60	TIPSY			-6.9 ± 7.6	10%	0.366	19.6 ± 6.0
Volume attribute bias (m^3/ha)	60	TIPSY			44.3 ± 10.1	63%	0.000	27.2 ± 5.9
Basal area (m^2/ha)	75		15.1	8.4	6.8 ± 1.3	45%	0.000	8.3 ± 1.1
Species matched age (years)	64		34.3	28.6	5.7 ± 2.4	17%	0.019	1.5 ± 1.3
Species matched height (m)	65		11.7	8.6	3.1 ± 0.6	26%	0.000	4.4 ± 0.5
Site index (m)	53	PSPL	20.6	19.5	1.1 ± 0.5	5%	0.039	1.6 ± 0.4

A VRI volume audit analysis of the Prince George TSA is documented in a separate report as are the associated stand and stock tables. Both documents are available from the Ministry of Forests, Lands and Natural Resource Operations.

Table of Contents

1 INTRODUCTION 1

2 OBJECTIVE 1

3 CHANGES FROM 2015 1

4 SAMPLE DESIGN 2

4.1 POPULATION 2
4.2 TARGET POPULATION 3
4.3 SAMPLE SELECTION 4
4.4 PLOT DESIGN & ESTABLISHMENT 5

5 DATA COMPILATION 5

5.1 GROUND PLOT ATTRIBUTES 5
5.2 GROUND PLOT DATA SCREENING 5
5.3 GROUND SAMPLING YEAR AND PROJECTION YEAR 8
5.4 GROUND SI AND YEARS TO BREAST HEIGHT 8
5.5 PHASE I (PHOTO INTERPRETED INVENTORY) DATA 9
5.6 PROVINCIAL SITE PRODUCTIVITY LAYER 10
5.7 HEIGHT AND AGE MATCHING 10
5.8 STRATIFICATION 11

6 STAND STRUCTURE AND HEALTH 11

7 GROUND VS. INVENTORY 14

7.1 STAND AGE AND HEIGHT 14
7.2 SITE INDEX 17
7.3 LEADING SPECIES 20
7.4 BASAL AREA AND TREES/HA 21

8 GROUND VS. TIPSY VOLUMES 22

8.1 GROUND PLOT DATA SCREENING 22
8.2 ANALYSIS UNITS 22
8.3 PREDICTED (PROJECTED) YIELD ESTIMATES 23
8.4 TOTAL BIAS - GROUND COMPILER VS. TIPSY VOLUME 25
8.5 MODEL BIAS - GROUND VS. TIPSY VOLUME USING GROUND ATTRIBUTES 25
8.6 BIAS ANALYSIS 26
8.7 GROUND VS. AU VOLUMES 28
8.8 FUTURE YIELDS 29

9 DISCUSSION 30

10 RECOMMENDATIONS 31

11 LIST OF REFERENCES 31

12 APPENDIX A – PLOT DATA SUMMARIES 32

13 APPENDIX B – PLOT DATA SUMMARIES 35

1 Introduction

The Forest Analysis and Inventory Branch (FAIB) of the British Columbia Ministry of Forests, Lands and Natural Resource Operations has developed a framework for a Young Stand Monitoring (YSM) program to monitor the performance of young forest stands, especially those in high risk forest management units . The primary focus of YSM is to check the accuracy of the growth and yield assumptions and predictions of key timber attributes in young stands for timber supply review in a management unit. This monitoring program helps to identify opportunities to improve the accuracy of timber supply forecasting for a management unit.

2 Objective

This report summarizes YSM for the Prince George TSA. The intent of the YSM is to monitor the performance of young forest stands. Specifically, the primary goals of FAIB's YSM are to:

1 Characterize the young stand population, including composition, structure, mortality, growth, yield, and health.
2 Assess the accuracy of some Phase 1 Vegetation Resources Inventory (VRI) photo-interpreted polygon attributes (e.g., age, height, density and site index) for young stands.
3 Assess the accuracy of site index estimates in the Provincial Site Productivity Layer (PSPL).
4 Compare observed stand yields (e.g., basal area/ha and trees/ha) to predictions generated from TIPSY.
5 Once remeasurements are available, compare observed growth to forecasts from growth and yield models for the young stand population.

Remeasurements are not yet available for the PG TSA. This report covers YSM goals 1 – 4.

3 Changes from 2015

A YSM analysis was undertaken in 2015 with the same raw data files used here. Minor changes to the ground compiler and to the analysis procedures prompted the re-analysis of the data presented here. The main changes are listed.

- The VRI ground sample compiler has been revised to deal with boundary plots.
- The ground sample trees used for estimation of site index were restricted to those with a breast height age from 10 – 120 years.
- The species matching for spruce was revised so that SB, SE and SS are matched at the species level and all other spruces are matched at the genus level (SW, SX, SXW).
- Fallen live trees and fallen dead trees are no longer included in the ground plot summaries.
- The site index for the VRI (Phase I) second species was estimated using SiteTools.
- The May 2018 VRI was used. Updates to the Phase I inventory since 2015 caused some plots to become part of the YSM population and some to not meet the YSM population definition.

The plots that were added or dropped from the YSM analysis are given in Table 2.

Table 2. The plots that were added and dropped from the 2015 analysis are described.

Clstr_id	Comment
024Y-0200-YO1	Not used in 2015 but used in 2018
024Y-0213-YO1	Used in 2015 but updated age is too old
024Y-0217-YO1	Used in 2015 but updated age is too old
024Y-0218-YO1	Used in 2015 but updated age is too young
024Y-0236-YO1	Used in 2015 but updated age is too old

Clstr_id	Comment
024Y-0238-YO1	Used in 2015 but updated age is too old
024C-0561-MO1	Not used in 2015 but used in 2018
024C-0908-MO1	Not used in 2015 but used in 2018
024C-0924-MO1	Not used in 2015, not used in 2018 – too young
024C-0925-MO1	Not used in 2015 but used in 2018
024C-5586-MO1	Too old, never used
024C-8711-MO1	Not used in 2015 but used in 2018
024C-8716-MO1	Not used in 2015 but used in 2018
CMI4-0083-FR1	Not used in 2015 - not used in 2018 – too old
CMI4-0298-FR1	Not used in 2015 - not used in 2018 – too young
CMI4-0381-FR1	Not used in 2015 but used in 2018
CMI4-0436-FR1	Not used in 2015 but used in 2018
CMI4-0064-FR2	Dropped in 2015 (plantation burned then planted) but used in 2018

4 Sample Design

A program of inventory field plot measurement is a key component of BC's provincial forest inventory of which YSM sampling is a sub-component. This program includes:

- Monitoring plots on a 20 x 20 km grid,
- Intensified sampling of young stands with monitoring plots on a 10 x 10 km grid, and
- Supplemental sampling to boost sample sizes in forest strata of special interest.

As of 2015, plot establishment covered 22 million hectares, providing continuous coverage over the Prince George, Quesnel, Williams Lake, 100-Mile House, Kamloops, Lillooet, Merritt and Okanagan TSAs. The ground sample in the Prince George TSA includes all three sampling components. This report is focussed on the intensive young stand sample.

4.1 Population

The monitoring unit, the geographic area of interest, is the Prince George TSA which is located in central British Columbia (Figure 1). The Prince George TSA covers approximately 8 million hectares, 56 percent of which is considered operable crown forest (Table 3).

Table 3. A summary of the land base (taken from the Prince George Timber Supply Area Timber Supply Review Data Package April 2015[1]). The reductions are not necessarily cumulative, some overlap.

Land base component	Gross area (ha)	Crown Forest (ha)
Total area	7,965,549	5,065,053
Slope reduction (slope > 62%)	390,831	92,304
Elevation reduction (elevation > 1492 m)	1,025,397	168,184
Distance reduction (cycle time to mill > 23 hours)	792,286	275,599
Terrain stability reduction (terrain stability class V (unstable) or ESA inventory class SI (highly sensitive soils))	360,430	216,533
Total reduction	1,756,376	614,577

[1] https://www.for.gov.bc.ca/hts/tsa/tsa24/current2015/24tsdp_2015.pdf

Land base component	Gross area (ha)	Crown Forest (ha)
Net area	6,209,173	4,450,476

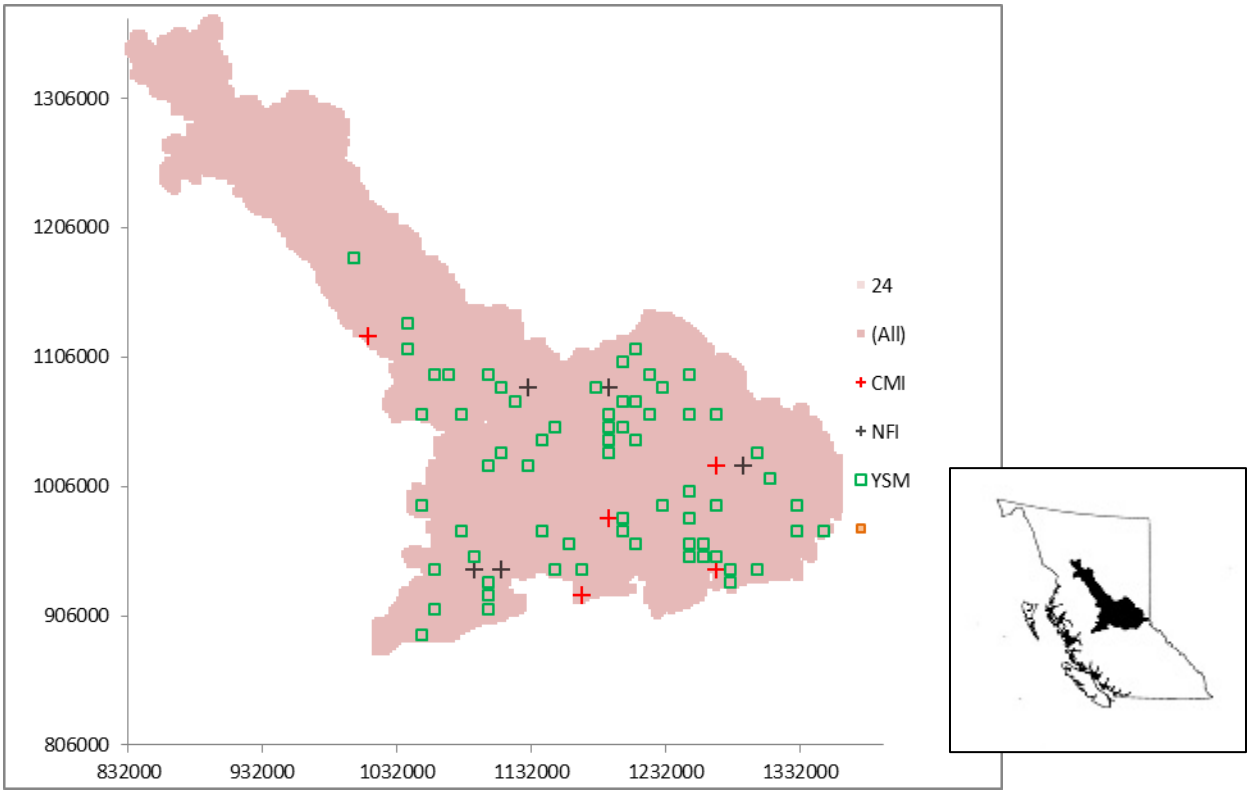

Figure 1. The location of the Prince George TSA and the YSM samples (from FAIB).

4.2 Target Population

Three subpopulations were defined (Table 4). The YSM and VA subpopulations constitute the original target population covered by the Vegetation Resources Inventory Project Implementation Plan (Nona Phillips Forestry Consulting 2014a). The portion of the TSA not covered by the YSM and VA strata is referred to as the *complement* and comprises additional sampling completed in the TSA and not included in the VA analysis or this YSM analysis.

Table 4. The subpopulations are defined.

Abbreviation	Subpopulation	Description
VA	Volume Audit	Vegetated treed, age 51+. Excludes the northern portion of Fort St. James, private and federal land as well as BEC zone BAFA and portions of the ESSF.
YSM	Young Stand Monitoring	Ages 15-50 (includes non-vegetated and non-treed). Excludes the northern portion of Fort St. James, private and federal land as well as BEC zone BAFA and portions of the ESSF.
Complement	Complement	Everything else, including the northern portion of Fort St. James, federal land,

Abbreviation	Subpopulation	Description
		ages < 15. Additional sampling completed in this unit is relevant to the overall state-of-the-forest analysis reported elsewhere.

The YSM target population consists of 15- to 50-year-old stands within the Prince George TSA (Table 4). The population was not restricted to vegetated treed polygons. It includes all stands in the age range (including silvicultural openings with crown closure < 10%). The ground sampling plan is described in Nona Phillips Forestry Consulting (2014a). The net down process for the YSM sample excluded the area in the TSA north of NTS Letter Block 093M, TFLs 30 and 53, private land, parks and federal land including Indian reserves and Military Reserves.

The main leading species in the YSM subpopulation are spruce and pine (Table 5).

Table 5. Prince George TSA YSM subpopulation is summarized by leading species. From Nona Phillips Forestry Consulting (2014b).

Inventory Leading Species	Area (ha)	% of YSM population
Spruce (S)	302,510	43.3%
Pine (P)	291,118	41.7%
Aspen (AT, ACT)	44,957	6.4%
Balsam (B)	36,210	5.2%
Birch (EP)	13,078	1.9%
Douglas-fir (FD)	8,878	1.3%
Cedar (CW)	653	0.1%
Hemlock (HW)	610	0.1%
Alder (DR)	33	0.0%
Tamarack (LT)	15	0.0%
Oak (QG)	9	0.0%
Total	698,071	100.0%

4.3 Sample Selection

The YSM ground sample data come from three data sources – YSM, CMI samples and NFI ground plots. The YSM, NFI and CMI samples were selected from various intensities of the same grid. All the samples on the grid that met the YSM population definition were used. As a result, the sampling weights (the area represented by each sample) are equal. All ground plots are fixed area, 0.04 ha plots.

Table 6. The number of samples are given by data source.

Data Source	Proj_id	N	Grid
YSM	024Y	65	10 x 10 km
CMI	CMI4	5	20 x 20 km
NFI	024C	5	20 x 20 km

There were no substitutions or movements of plots.

4.4 Plot Design & Establishment

Most plots were established in 2014 and some in 2015 following the plot design and establishment CMI protocol[2]. The CMI plot consists of three nested plots: a 400 m^2 (11.28 m radius) plot for measuring all trees with diameter at breast height (DBH) ≥ 9.0 cm; an 100 m^2 (5.64 m radius) for trees with DBH between 4.0 and 9.0 cm; and a 19.6 m^2 (2.50 m radius) plot for all trees at least 1.3 m tall and Dbh < 4.0 cm. The sample plots are centered at the grid intersection points.

The sampling intensity, the proportion of the area sampled, is approximately 0.0004% based on each 0.04 ha sample representing approximately 10,000 ha (10 x 10 km grid).

5 Data Compilation

5.1 Ground plot attributes

The tree level file was used to compile most attributes (volume, BA, etc.). The attributes are defined in published ground sampling standards and procedures[3] and summarized in Table 13.

5.2 Ground plot data screening

Several plots were removed from this analysis but are retained as part of the monitoring network. Sample 271 appears to be a borderline plot. Based on the ground GPS coordinates, it appears be in the adjacent mature polygon but the ground data indicate a young stand. It was not included here. CMI sample 64 was a plantation that, prior to the current measurement, was consumed by fire and re-planted. It was retained.

Samples 214, 233 and 245 were boundary plots and sampled using the walkthrough method (Ducey et al. 2004) and compiled accordingly.

Samples 64, 211 and 8716 did not have live trees with Dbh > 7.5 cm. Residual trees are identified in the field (Table 7). Unless otherwise indicated, these are included in summaries.

[2] http://archive.ilmb.gov.bc.ca/risc/pubs/teveg/nficmp2012/CMI%20Procedures_ver1_2012_Final.pdf
[3] https://www.for.gov.bc.ca/hts/vri/standards/RISC/2015/cmi_ground_sampling_procedures_2015.pdf

Table 7. The samples with residual or veteran trees are summarized.

clstr_id	Spp	Live	Resid	Vet	BA (m^2/ha)	TPH	Dbh (cm)	Height (m)	Comment
024C-0925-MO1	BL	D			0.7	125	9.2	4.9	more than half the BA In residual trees
024C-0925-MO1	BL	L			1.2	500	5.2	3.9	Residual layer is BL
024C-0925-MO1	BL	L	R		4.9	525	12.1	6.5	
024C-0925-MO1	BL	L	R	V	0.7	25	18.2	9.9	
024C-0925-MO1	PL	L			0.8	200	8.4	6.3	
024C-0925-MO1	PL	L		L	0.5	50	11.7	6.5	
024C-0925-MO1	SX	L			0.7	400	4.8	4.2	
024Y-0200-YO1	PLI	D	R		7.5	200	21.3	18.9	
024Y-0200-YO1	PLI	L	R		10.6	375	20.2	18.2	Majority of BA is in residual trees
024Y-0200-YO1	PLI	L	R	V	1.5	25	27.2	22.4	one live, non-residual tree
024Y-0200-YO1	SX	L			0.2	100	4.9	3.5	
024Y-0200-YO1	SX	L	R		4.5	200	15.9	9.6	
024Y-0200-YO1	SX	L	R	T	1.7	25	29.8	15.0	
024Y-0237-YO1	AC	L			0.4	125	7.6	7.6	
024Y-0237-YO1	BL	D			0.5	100	7.8	4.4	One veteran tree
024Y-0237-YO1	BL	L			2.5	350	10.6	7.4	
024Y-0237-YO1	BL	L		L	1.4	50	18.6	11.4	
024Y-0237-YO1	BL	L	R	V	2.2	25	33.3	15.9	
024Y-0237-YO1	SX	L			1.5	175	12.2	7.3	
024Y-0237-YO1	SX	L		S	1.9	25	31.5	14.1	
024Y-0269-YO1	ACT	L			1.7	325	9.5	9.1	Two residual trees
024Y-0269-YO1	ACT	L		S	1.8	75	16.9	11.9	
024Y-0269-YO1	BL	L	R		1.7	50	19.8	11.5	
024Y-0269-YO1	PL	L			6.3	926	10.2	9.6	
024Y-0269-YO1	PL	L		L	0.5	50	11.6	9.3	
024Y-0269-YO1	PL	L		T	0.3	25	13.3	11.3	
024Y-0272-YO1	BL	L			5.3	1251	8.2	6.2	Four residual trees, slightly larger
024Y-0272-YO1	BL	L		S	0.6	50	12.3	9.2	about 10% of BA
024Y-0272-YO1	BL	L	R		1.5	75	15.8	9.9	
024Y-0272-YO1	BL	L	R	V	0.3	25	13.3	7.8	
024Y-0272-YO1	PL	L			8.1	851	11.8	9.6	
024Y-0272-YO1	PL	L		L	1.4	75	15.2	9.5	
024Y-0272-YO1	PL	L		T	0.6	25	17.6	12.8	
024Y-0272-YO1	SW	L			1.3	150	11.8	8.8	
024Y-0273-YO1	BL	L			0.6	25	17.9	11.4	Two live residual trees
024Y-0273-YO1	BL	L		L	1.6	75	16.5	9.8	Four live, non-residual trees
024Y-0273-YO1	BL	L	R	V	2.0	25	32.0	18.3	
024Y-0273-YO1	SX	D	R		2.3	25	34.5	17.5	
024Y-0273-YO1	SX	L	R		1.8	25	30.1	16.3	
CMI4-0381-FR1	BL	L	R		0.2	25	11.1	10.2	Two residual trees
CMI4-0381-FR1	SXW	L			2.4	225	11.4	9.4	The one spruce is bigger
CMI4-0381-FR1	SXW	L		L	2.0	75	17.4	10.9	
CMI4-0381-FR1	SXW	L	R	V	1.5	25	27.4	14.9	

Plots with large, old trees and high volumes were also examined in more detail. The summaries are based on all live, measured trees. Some plots have trees with a total age greater than 50 (Table 8). These ages may represent residual trees after selective disturbance. None were identified as residual trees in the field. All were retained in the analysis.

Table 8. The age sample trees from plots that have trees with age_tot > 50, suit_tr = "Y" and suit_ht = "Y" are given. These are potential veteran trees. None were identified as residual trees in the field. One was identified as a veteran tree.

Sample	Spp	TH_TREE	Cr_cl	SI_TREE	Age_tot	Age_bh	Dbh	Ht	Comment
024C-8711-MO1	BL	L	D	7.5	180	159	24.4	20.1	All the trees are older
024C-8711-MO1	BL	L	C	6.9	158	136	23.1	17.1	No issues.
024C-8711-MO1	BL	T	C	7	126	104	18.9	14	
024C-8711-MO1	SW	S	C	11	101	86	20.8	17.6	
024Y-0220-YO1	BL	S	C	19	53	42	15.3	16.4	Several trees are older
024Y-0220-YO1	BL	S	C	9.9	94	76	15.4	14.5	No issues.
024Y-0220-YO1	BL	S	C	6.7	156	134	22.7	16.7	
024Y-0220-YO1	BL	S	C	11	95	79	25.6	16.9	
024Y-0220-YO1	SW	L	C	5	198	172	21.6	17.2	
024Y-0220-YO1	SW	L	C	15	62	51	23.6	15.5	
024Y-0220-YO1	SW	T	C	7.7	108	90	22.4	13.7	
024Y-0222-YO1	BL	L	C	8.6	142	123	30.8	18.7	One older tree
024Y-0222-YO1	BL	L	C	22	55	46	28	20.6	Several large trees
024Y-0222-YO1	BL	T	C	22	55	46	28.7	21.1	No issues
024Y-0222-YO1	FDI	S	C	25	51	43	25.6	22.1	
024Y-0222-YO1	FDI	S	C	24	43	35	17.4	18.7	
024Y-0222-YO1	FDI	S	C	23	52	44	26.2	20.7	
024Y-0222-YO1	SXW	O	C	20	52	42	25.2	17.6	
024Y-0228-YO1	PLI	L	C	21	23	17	13.3	9.6	One slightly older tree
024Y-0228-YO1	PLI	L	C	21	21	15	12.5	8.6	No issues
024Y-0228-YO1	PLI	L	C	19	20	14	11.9	7.2	
024Y-0228-YO1	PLI	T	C	21	23	17	14.6	9.8	
024Y-0228-YO1	SX	S	D	15	58	47	28.7	14.3	
024Y-0228-YO1	SX	S	C	24	27	18	17.6	10.2	
024Y-0228-YO1	SX	S	C	19	33	23	13.4	9.1	
024Y-0237-YO1	BL	L	C	9.2	74	55	18.7	10.1	Only slightly older
024Y-0237-YO1	BL	L	C	11	77	60	18.4	12.6	
024Y-0237-YO1	BL	V	D	.	75	60	33.3	15.9	
024Y-0237-YO1	SX	S	D	9.5	91	75	31.5	14.1	
024Y-0252-YO1	BL	L	C	19	59	48	22.7	18.4	Only slightly older
024Y-0252-YO1	BL	L	C	20	59	49	29.6	19.6	
024Y-0252-YO1	BL	L	C	19	66	55	30.4	20.8	
024Y-0252-YO1	BL	L	C	19	60	49	28	18.2	
024Y-0252-YO1	BL	T	C	18	70	59	25.7	20.4	

Six samples had ground basal area greater than 30 m^2/ha (Table 9). Based on the Phase I photo age, all are part of the YSM population.

Table 9. The samples with ground basal area > 30 m^2/ha are given.

	YSM Ground				Phase I Photo			
Sample	Basal area (m^2/ha)	Volume (m^3/ha)	Height (m)	Age (years)	Basal area (m^2/ha)	Volume (m^3/ha)	Height (m)	Age (years)
024Y-0222-YO1	39.5	305	20.1	84	188	27.1	18.0	49
024Y-0229-YO1	33.5	198	13.4	27	26	6.5	10.4	24
024Y-0252-YO1	40.0	296	19.5	63	.	6.0	7.3	42
024Y-0257-YO1	33.8	179	15.8	41	.	6.0	5.0	32
024Y-0261-YO1	30.8	204	16.7	41	.	8.0	6.9	38

Three samples had more than 50 m^3/ha of dead whole stem volume (Dbh ≥ 7.5 cm) (see Appendix A). These were sample 200 (73 m^3/ha), sample 226 (57 m^3/ha) and sample 258 (67 m^3/ha).

5.3 Ground sampling year and projection year

The ground sampling occurred in 2014 and 2015. The projection date for the Phase I photo interpreted inventory data was January 1, 2018. For ground measurements after June 30, the ground measurement year was increased by 1. The Phase I data were back-projected to the ground measurement year for the purpose of Objective 2: assessing the accuracy of some Phase 1 Vegetation Resources Inventory (VRI) photo interpreted polygon attributes for young stands.

5.4 Ground SI and years to breast height

Age and height were measured on some trees on the ground plots. The trees used in site index (SI) assessment had a breast height or total age, a height, and the height and age suitability flags = Y. Older trees tend to have lower SI (Figure 2), possibly due to early height suppression. The SIBEC standard of excluding trees with breast height age < 10 or > 120 was used here. Because of this screening, the trees used in the SI calculations are not necessarily the same as those used in the age and height calculations.

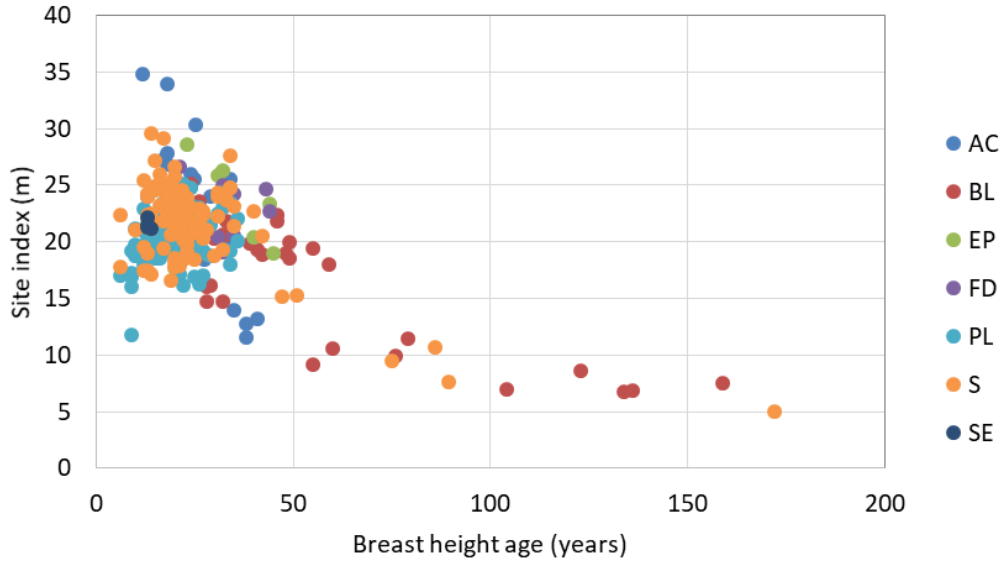

Figure 2. The trees with SI estimates are given.

Samples 64, 211 and 8716 did not have any live trees. Samples 200 and 231 did not have any suitable SI trees of the leading species.

5.5 Phase I (Photo Interpreted Inventory) data

Inventory information for recently disturbed polygons generally comes from the Reporting Silviculture Updates and Land status Tracking System (RESULTS) layer. These polygons are processed by VDYP7 to project them to the year of ground sampling. For stands less than 7 m tall, VDYP7 will project the age and height until the height is 7 m and then generate the remaining attributes. Until the projected height is 7 m, the other attributes are not altered and the utilization limit is unchanged from the original data collection. This is illustrated by sample 231 which, in the original inventory file, had a PROJ_HEIGHT_1 = 7.0 m and 5,000 trees/ha. The utilization limit is based on Dbh, implying that trees must be at least 1.3 m tall and thus have measurable basal area. However, the basal area estimate is zero, implying the attributes for sample 231 do not have a utilization limit. As a consequence, for young stands, the Phase I inventory may not be a good source for basal area and trees/ha.

Seven polygons had a non-primary layer. Two had a dead layer, two had a residual layer and one had a veteran layer. Two had a live, non-veteran or residual non-primary layer. Neither had estimates of BA. No polygons had a non-primary, non-veteran or non-residual one polygon layer with BA > 0.

Table 10. The samples with non-primary layers are summarized.

clstr_id	layer	CD	CC	BA	Stem /ha	Spp 1	Spp 2	Spp 3	Pct 1	Pct 2	Pct 3	Age 1	Ht 1	Age 2	Ht 2
024Y-0210-YO1	1	P	25	7.0	825	PLI	SX	AT	80	10	10	24	10.4		10
024Y-0210-YO1	2		25		1175	PLI	SX		50.1	49.9		20	8.3	14	2
024Y-0222-YO1	1	R	4	16.4	516	FD	BL	AT	50	25	25	144	21	144	21
024Y-0222-YO1	2	P	32	5.9	623	BL	S	PL	47	23	18	31	10.2	31	10.2
024C-8716-MO1	D	D		30.2	1533	PLI			100			130	20		
024C-8716-MO1	1	P	1	0.0	30	PLI			100			15	5		
024Y-0219-YO1	1	R	5	3.0	30	AT	SX		90	10		120	25	90	22
024Y-0219-YO1	2	P	15	5.0	500	AT	SX	PLI	50	30	20	30	10	30	8
024Y-0223-YO1	D	D		12.0	1400	PLI			100			30	10		
024Y-0223-YO1	1	P	35	15.0	1800	SX	PLI	AT	60	25	15	30	10	30	10
024Y-0239-YO1	1	V	3	2.0	20	FDI	BL		60	40	.	250	35	250	32
024Y-0239-YO1	2	P	70	30.0	3000	BL	SX	EP	40	20	15	40	12	40	13
024Y-0226-YO1	1	P	13	4.2	419	AT	SX	PLI	60	30	10	26	12.8		9.8
024Y-0226-YO1	2		3		560	SX	AT		90	10		9	1.2	15	6.6

The Phase I (Inventory) SI was taken from the provincial site productivity layer (section 5.6).

The Phase I data were projected to the year of ground sampling. For polygons with short stand heights VDYP7 only increments age and height. For these polygons, the basal area and volumes were set to zero and the trees/ha was copied from the input file.

5.6 Provincial Site Productivity Layer

The provincial site productivity layer (PSPL[4]), version 5.0 provides an alternative source of site index estimates, which is particularly useful for the YSM population. This layer provides site index estimates for up to 22 species. The intersection of the provincial site productivity layer and the ground plots was provided by the FAIB.

As noted in the PSPL documentation[5], the PSPL site indexes are more appropriately used for strategic, as opposed to operational, purposes. If used for site-specific applications, as is the case here, the site index estimates should be verified through a ground-based survey. The PEM/TEM data for the site productivity layer are approved for most of the Prince George and Fort St. James portions of the TSA, indicating they passed a third party accuracy assessment based on published standards and procedures. The original Vanderhoof PEM did not pass accuracy assessment in some areas. For these areas, the SI values in the PSPL are populated from the bio-physical model.

Site index field data are collected by site series within the Biogeoclimatic Ecosystem Classification system (SIBEC). The SIBEC SI estimates are then averaged by species for each site series with sufficient field data and applied spatially through the Predictive Ecosystem Mapping (PEM) or Terrestrial Ecosystem Mapping (TEM) processes. The data are collected from a large number of sample points across the province using standard, documented methods.

The SI's in the PSPL are all estimates from models, either from PEM/TEM/SIBEC or a biophysical model when a PEM/TEM derived SI is not yet available. In the case of PEM/TEM/SIBEC estimates applied to the Prince George TSA, two models are used to estimate SI: a PEM/TEM is used to estimate site series and the SIBEC model is used to estimate site index from the PEM/TEM site series estimate. As a consequence, users of the site index layer must be aware of the accuracies in these models, particularly if the SI estimates are used on a site specific basis as is the case here.

The site index layer was designed to assist with strategic-level decision-making where the effects of the any errors in the site index estimate are reduced from the grouping and averaging of individual site index values for points across a broader area such as an analysis unit. The site index estimates are provided on a 1 ha grid, giving the user a lot of flexibility in grouping points for weighting and averaging.

The ground samples were intersected with the current site productivity tile by an aspatial match of X and Y coordinates between ground samples and each 1ha grid point in the site prod tile.

Note for those few records without a model source (PEM/BIO), there was no ground sample match found with a 1ha grid point, so the grid was coarsened to a 2 × 2 ha grid. If the PSPL did not include a SI for the Phase I leading species, the SI for the next closest species was used.

5.7 Height and Age matching

The height and age data matching followed the FAIB (2011) VRI procedures except for spruce. The species matching for spruce was revised so that SB, SE and SS are matched at the species level and all other spruces are matched at the genus level (SW, SX, SXW). The ground plot data were matched with the corresponding VRI Phase I photo interpreted inventory data for the polygon. The ground plot heights and

[4] http://www.for.gov.bc.ca/hts/siteprod/download/FLNR_Provincial_Site_Productivity_Layer.pdf
[5] http://www.for.gov.bc.ca/hts/siteprod/provlayer.html

ages were based on the average values for the T, L, and X trees for the leading species. The objective was to match the ground leading species to the Inventory (Phase I) leading or secondary species and compare the ages and heights. If a match could not be made at the Sp0 (genus) level, conifer-to-conifer (or deciduous-to-deciduous) matches were allowed. However, conifer-deciduous matches were not acceptable. The five possible matching cases are given in Table 11.

Table 11. The height and age matching cases are described.

Case	Description
1	VRI polygon leading Sp0 matches the ground leading Sp0
2	VRI polygon second Sp0 matches the ground leading Sp0 at the Sp0 level
3	VRI polygon leading species and the ground leading species are both coniferous or are both deciduous.
4	VRI polygon second species and the ground leading species are both coniferous or are both deciduous.
5	No match

5.8 Stratification

The samples were stratified by BEC, leading species, leading species age and whether the Phase I data source was the RESULTS layer (Table 12). The stratification was based on the Phase I data for age and leading species. Samples with OPENING_ID=. or DATA_SOURCE_AGE_CD = 7 were assumed not to come from the RESULTS Layer and the rest were assumed to come from the RESULTS layer.

Table 12. The strata used to summarize the results are defined.

Stratification	Strata	Definition	N	N - 2015
BEC	Other	ICH, ESSF, MS, SBPS	11	13
	SBS	SBS	64	58
Leading species	Other	AT, BL, EP, FD	10	9
(Phase I inventory)	Pine	PL, PLI	26	25
	Spruce	S, SE, SW, SX , SXW	39	37
Age	Young	ages 15-30	49	45
(Phase I Inventory)	Older	ages 31-50	26	26
Data from RESULTS	Not results	OPENING_IND = blank or DATA_SOURCE_AGE_CD=7	36	65
Layer?	Results	All others	39	6

6 Stand structure and health

The ground data are summarized in Table 13.

Table 13. The Prince George TSA YSM ground plots are summarized. SE is the standard error of the mean and SE% is standard error expressed as a percent of the mean.

Attribute	Util	N	Statistic (includes residual trees)					No residuals	2015
	(cm)		Mean	Min	Max	SE	SE%	Mean	Mean
Basal area (m^2/ha)	4.0	75	16.8	0	41.0	1.1	7%	16.3	16.2
Trees per hectare (stems/ha)	4.0	75	1462	0	4778	107	7%	1448	1039
Gross volume live (m^3/ha)	4.0	75	86.6	0	310.5	7.5	9%	83	78.4
Basal area (m^2/ha)	7.5	75	15.6	0	40.0	1.1	7%	15.1	15.8
Trees per hectare (stems/ha)	7.5	75	988	0	2577	68	7%	975	897
Gross volume live (m^3/ha)	7.5	75	82.9	0	305.2	7.4	9%	79.4	77.3
Gross volume dead (m^3/ha)	7.5	75	6.4	0	72.8	1.8	28%	5.18	5.5
Volume net of decay, waste & breakage (m^3/ha)	7.5	75	55.4	0	240.3	5.8	11%	52.9	55.2
Dead trees per hectare (stems/ha)	7.5	75	45	0	475	11.3	25%	41.7	38

Attribute	Util (cm)	N	Statistic (includes residual trees) Mean	Min	Max	SE	SE%	No residuals Mean	2015 Mean
Leading species age (years)	7.5	69	34.4	15.1	154.4	2.6	8%		31.9
Leading species height (m)	7.5	69	11.7	4.0	20.1	0.5	4%		12.0

The YSM subpopulation is dominated by pine and spruce (Figure 3 and Figure 4).

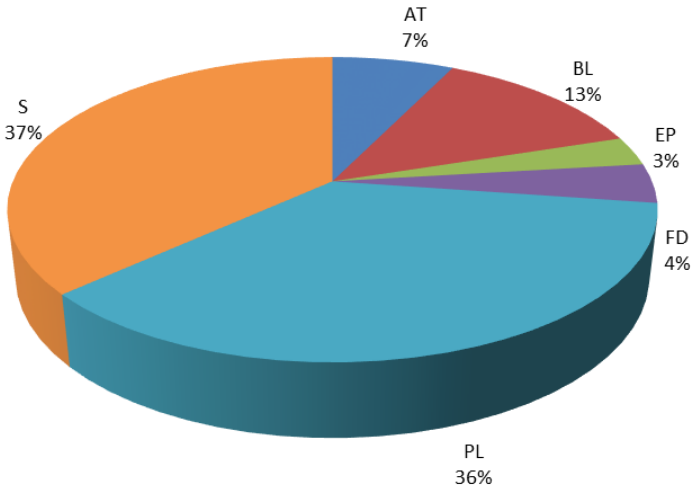

Figure 3. The live basal area is given by species. Residual trees are included.

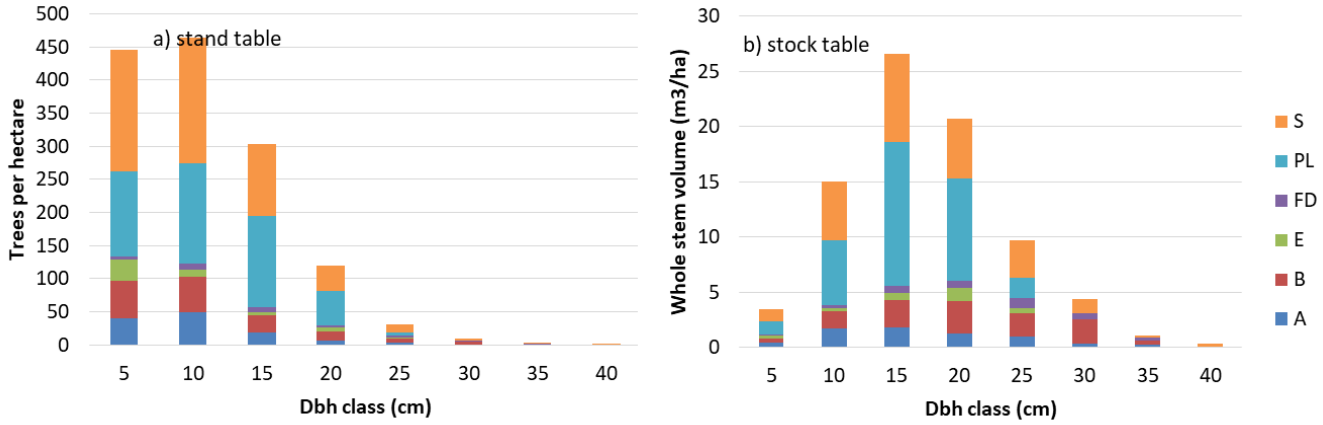

Figure 4. The stand and stock tables are given. Residual and veteran trees are included. More detailed stand and stock tables for the immature population can be found in the PG TSA stand and stock table addendum available on-line from FAIB.

The average number of dead trees (Dbh ≥ 4.0 cm) was 71 trees/ha (Table 14). Almost two-thirds of the dead trees have a Dbh < 12.5cm and about half are pine.

Table 14. The average number of dead trees/ha is given by species and Dbh class. Zeroes indicate there were dead trees but the average was less than 0.5 trees/ha. Residual trees are included

Species Group		Dbh Class (cm) 5	10	15	20	25	30+	Total	Fraction
A	Poplar	7	1	0			0	8	11%
B	Balsam	5	6	0	1	0	1	14	18%
E	Birch	7			1		0	8	10%
FD	Douglas-fir	1			0		1	3	4%
PL	Pine	5	11		7	9	2	33	45%
S	Spruce	4	0				0	4	6%
XC	Unknown conifer		0				1	2	2%
Total		29	18	1	9	9	5	71	100%
Fraction		40%	25%	1%	12%	12%	7%	100%	

Approximately 67% of the live trees show signs of damage (Table 15 and Figure 5). The cause of most of the damage is unknown, form-related (72%) followed by insect (9%) and disease (7%). If the Unknown, form-related damage is excluded, 64% of the trees are damage-free. Pine has the largest fraction of trees with damage (77%).

There is a relatively high incidence of unknown damage agent in the PG TSA inventory. Damage agent is coded as 'unknown' category when the sampler cannot confirm the primary damage agent with any reasonable degree of certainty because the damage may be old, or the damage agent not clear in terms of symptomology (characteristics of attack) and could be due to multiple causes. Samplers also record primary damage agent as "unknown" when there is indication of scars, forks or crooks which may affect wood quality. There are plans to record minor vs. major damage but at the time of field sampling, this was not done. The damage severity is not known and may or may not be a significant impact on volume or growth. The trees where the primary damage agent = "Unknown" were split into those with form-related primary loss indicators (loss1_in = BTP, CRO, DTP, FRK, SCA) and those with non-form related primary loss indicators.

Table 15. Live trees per hectare are given by species and primary damage agent. The data are graphed in Figure 5a. Data are for trees with Dbh ≥ 4.0 cm. Residual trees are included. If residual trees are excluded, the live trees with damage is 931.

	Damage Agent									TPH with damage (%
sp0	Abiotic	Animal	Disease	Insect	Treatment	Unknown non form-related	Unknown form-related	None	Dead	of live TPH)
AT	1			3		52		41	8	55 (57%)
BL	6		4		7	90		64	14	106 (62%)
EP	1					39		18	8	40 (68%)
FD	0					18		15	2	19 (56%)
PL	15	1	88	49		226	1	112	36	380 (77%)
S	7	1	6	79		253	2	225	5	346 (60%)
XC									2	0 (0%)
% of live TPH	2%	0%	7%	9%	0%	48%	0%	33%	5%	948 (66%)

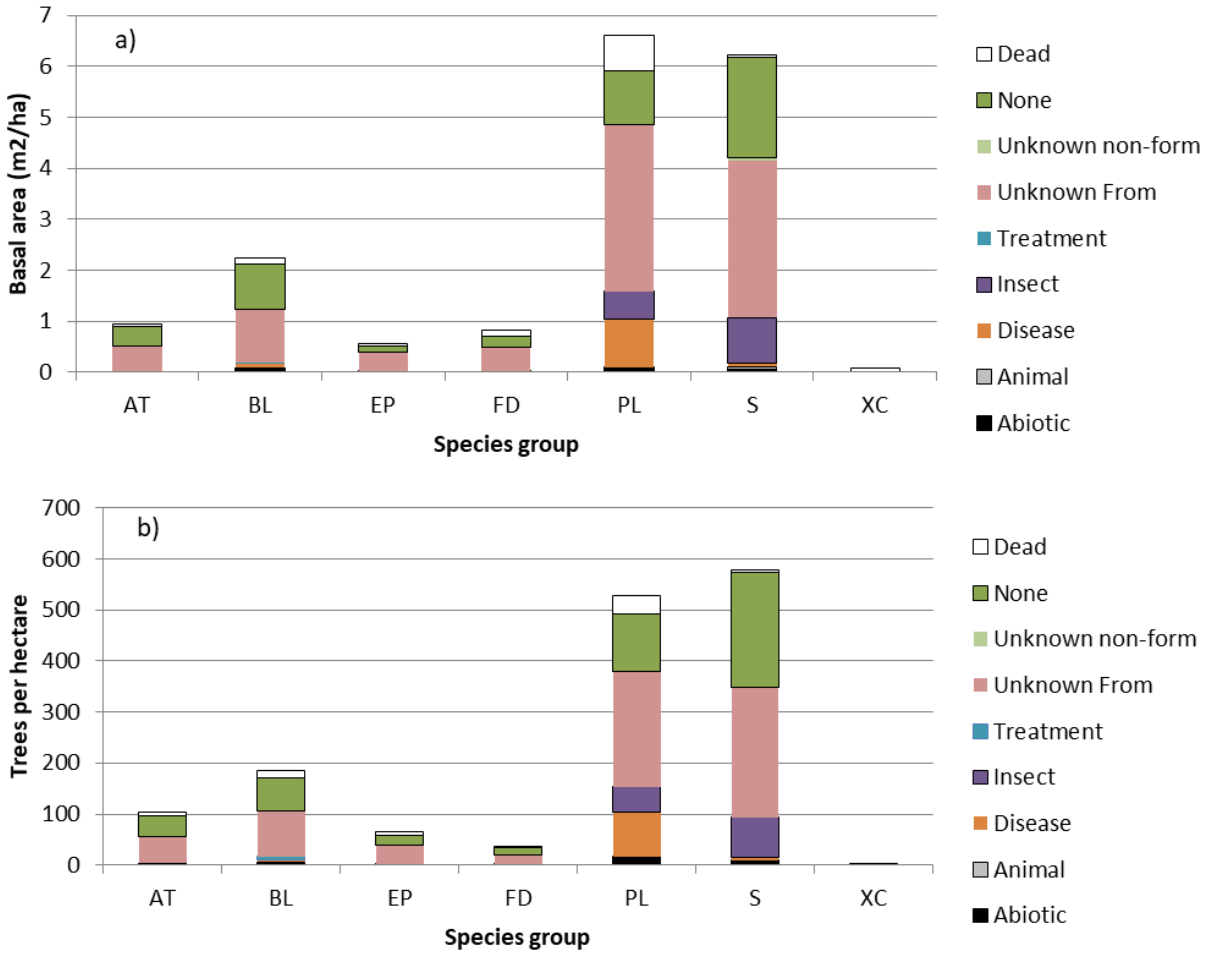

Figure 5. The basal area (a) and stems/ha (b) affected by each primary damage agent is given by species for live trees, Dbh ≥ 4.0 cm. Includes veteran and residual trees.

7 Ground vs. Inventory

7.1 Stand Age and Height

A total of 64 plots had acceptable age and height matches while 52 had acceptable SI matches (Table 16).

Table 16. The results of the age, height and SI matching are given.

Case	Number of plots	Age pairs	Height pairs	SI pairs
1	43	41	41	41
2	18	12	12	11
3	10	9	9	0
4	2	2	2	0
5	2	0	0	0
All	75	64	64	52

The leading species height and age are compared in Table 17 and Figure 6 and the species- or case-matched height and age are given in Table 18. Overall, the ground age is approximately 16% higher than the VRI age while the height is approximately 32% taller. The differences are statistically significant (Table 17). The age differences are largely due to two samples – 220 and 8711 (Figure 6). The case-matched ages had similar bias and the heights were less biased (Table 18). The height differences are greatest for the spruce stratum (Figure 7).

Table 17. The leading species ground plot and VRI Polygon ages and heights are compared. Statistically significant differences (p-value < 0.05) are shaded. No residual trees were suitable age or height trees.

Phase I	Age (years)					Height (m)				
Strata	N	Ground	VRI	Bias	p-value[6]	N	Ground	VRI	Bias	p-value
Other	10	24.7	26.8	-2.1 ± 1.7	0.244	10	7.9	5.3	2.6 ± 1.1	0.043
SBS	59	36.0	29.2	6.8 ± 2.7	0.013	60	12.5	8.6	3.9 ± 0.6	0.000
Other	10	38.1	34.0	4.1 ± 3.9	0.321	10	13.4	13.1	0.3 ± 1.2	0.808
Pine	21	32.2	26.2	5.9 ± 5.9	0.325	22	11.6	9.3	2.3 ± 0.8	0.009
Spruce	38	34.6	29.0	5.7 ± 2.6	0.033	38	11.7	6.2	5.5 ± 0.7	0.000
Age 15-30	44	26.9	23.9	3.1 ± 1.3	0.026	45	10.6	6.8	3.7 ± 0.6	0.000
Age 31-50	25	47.5	37.7	9.8 ± 5.9	0.110	25	14.3	10.5	3.8 ± 1.1	0.002
Not results	33	35.8	30.1	5.7 ± 2.7	0.042	33	12.1	7.9	4.2 ± 0.9	0.000
Results	36	33.1	27.7	5.3 ± 3.7	0.160	37	11.7	8.4	3.3 ± 0.7	0.000
All	69	34.4	28.9	5.5 ± 2.3	0.020	70	11.9	8.1	3.8 ± 0.5	0.000
All – no resid	69	34.4	28.9	5.5 ± 2.3	0.020	70	11.9	8.1	3.8 ± 0.5	0.000
2015 - All	67	31.9	28.9	2.9 ± 1.2	0.014	69	12.0	7.3	4.7 ± 0.5	0.000
2015 - no resid	67	31.9	28.9	2.9 ± 1.2	0.014	69	12.0	7.3	4.7 ± 0.5	0.000

Table 18. The case-matched ground plot and VRI Polygon ages and heights are compared. Statistically significant differences (p-value < 0.05) are shaded.

Phase I	Age (years)					Height (m)				
Strata	N	Ground	VRI	Bias	p-value	N	Ground	VRI	Bias	p-value
Other	9	23.1	24.6	-1.5 ± 1.8	0.431	9	7.6	4.8	2.8 ± 1.2	0.044
SBS	55	36.2	29.3	6.9 ± 2.7	0.014	55	12.1	9.3	2.8 ± 0.6	0.000
Other	8	38.2	31.9	6.3 ± 4.4	0.199	8	13.2	11.6	1.6 ± 1.9	0.421
Pine	20	31.9	25.2	6.7 ± 6.1	0.292	20	11.1	9.7	1.3 ± 0.7	0.054
Spruce	36	34.9	29.8	5.1 ± 2.4	0.042	36	11.4	7.4	3.9 ± 0.7	0.000
Age 15-30	43	27.0	24.5	2.5 ± 0.8	0.005	43	10.2	7.6	2.6 ± 0.6	0.000
Age 31-50	21	49.4	37.1	12.3 ± 6.9	0.089	21	14.2	11.0	3.2 ± 1.1	0.009
Not results	31	35.8	29.5	6.3 ± 2.8	0.033	31	11.9	8.2	3.7 ± 0.8	0.000
Results	33	33.0	27.8	5.2 ± 3.8	0.184	33	11.1	9.1	2 ± 0.7	0.005
All	64	34.3	28.6	5.7 ± 2.4	0.019	64	11.5	8.7	2.8 ± 0.5	0.000
All – no resid	64	34.3	28.6	5.7 ± 2.4	0.019	64	11.5	8.7	2.8 ± 0.5	0.000
2015 - All	60	32.4	30.9	1.5 ± 1.3	0.248	61	11.9	7.5	4.4 ± 0.5	0.000
2015 - no resid	60	32.4	30.9	1.5 ± 1.3	0.248	61	11.9	7.5	4.4 ± 0.5	0.000

[6] The p-value is the probability associated with the null hypothesis H_0: bias = 0 versus the alternative hypothesis H_1: bias ≠ 0. In this report, a p-value < 0.05 is considered grounds for rejecting H_0 and concluding the bias is statistically significant.

The Phase I age is used in Timber Supply Review (TSR) but the Phase I height and SI are not. The Phase I inventory is updated to the year of ground sampling using the Phase I age and SI. If the Phase I SI is biased, it will have an impact on the projected height. The comparison here indicates the projected Phase I inventory under predicts height. However, it should be kept in mind that the Phase I height does not affect TSR projections.

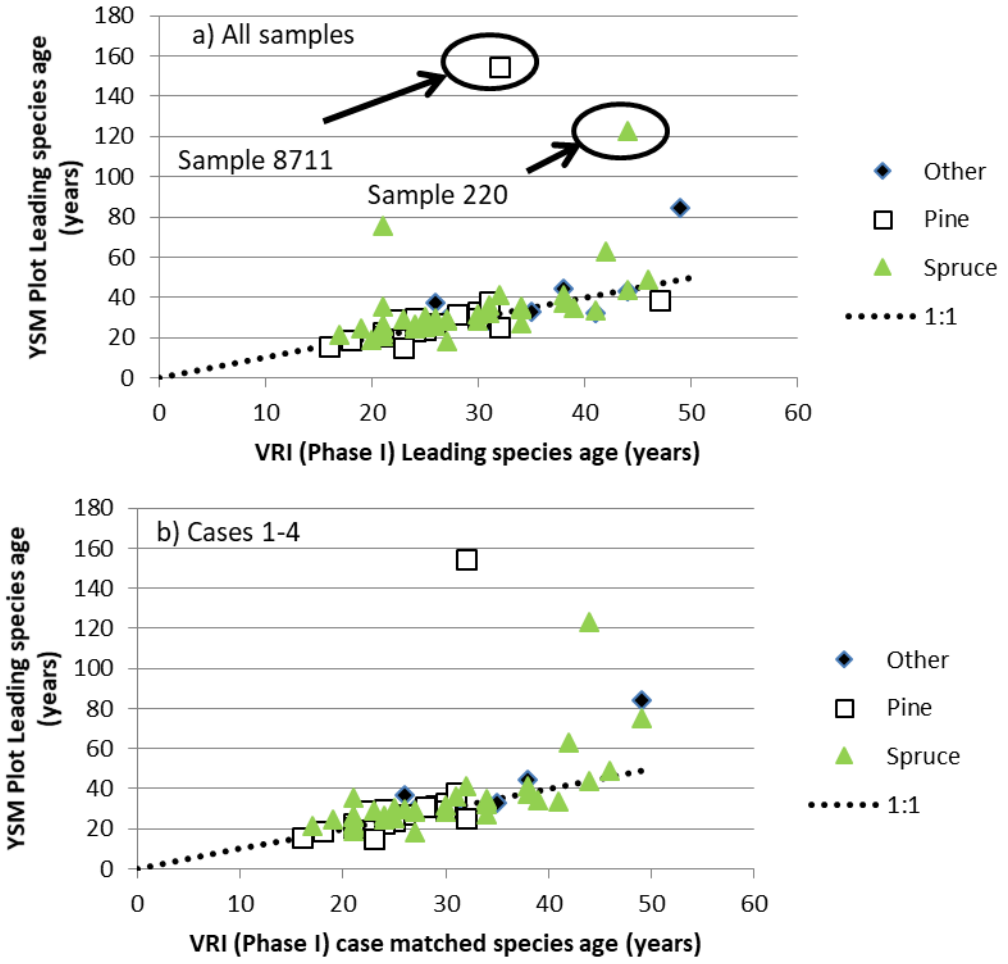

Figure 6. The VRI inventory (Phase I) and ground (YSM) leading species ages are compared (a) and the case-matched ages are compared (b). The age data for samples 220 and 8711 are given in Table 8.

The relationship between ground and inventory height was more variable (Figure 7) and the relative bias is greater, particularly for the spruce stratum (Table 17).

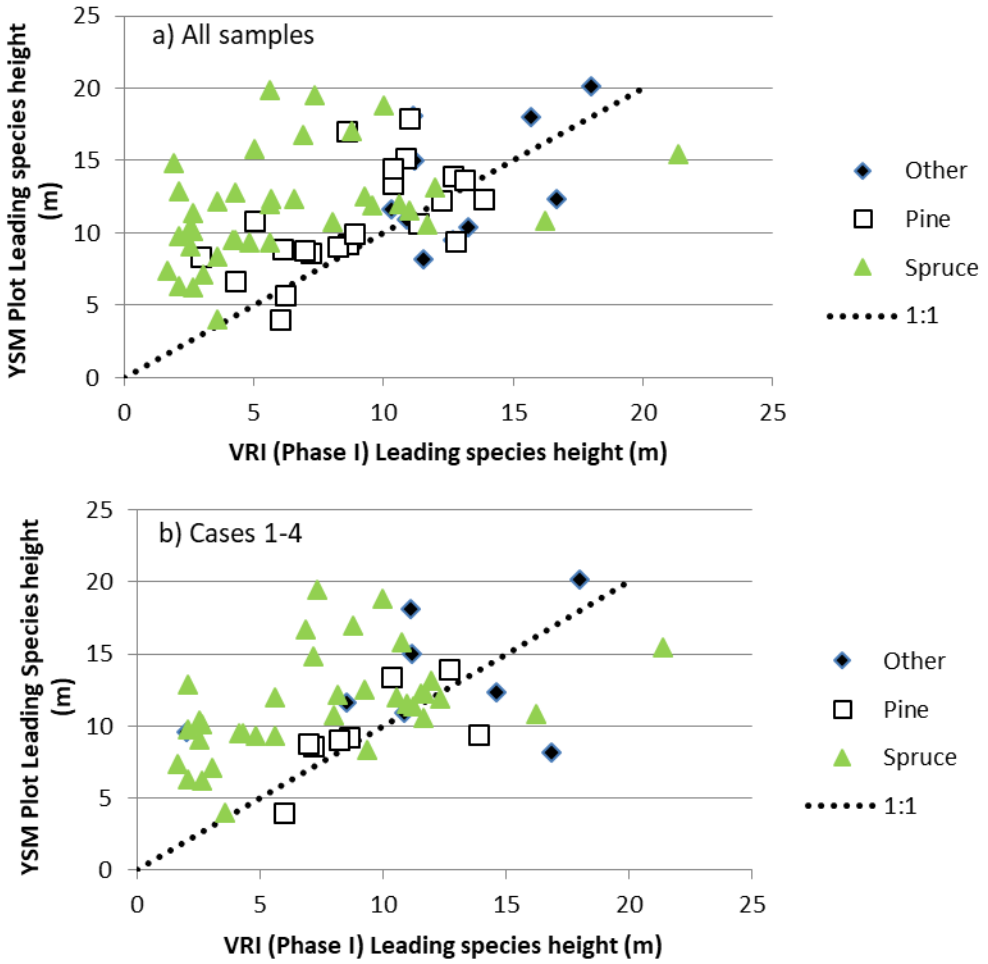

Figure 7. The VRI inventory (Phase I) and ground (YSM) leading species heights are compared (a) and the case-matched heights are compared (b).

7.2 Site index

The sample size for the PSPL SI is greater than the VRI inventory SI because of species matching – the PSPL has more species and more matches.

Both the Ground and PSPL SI were clustered around 20 – 21 m (Figure 8, Table 19). Overall, the difference between the ground SI and the PSPL SI was not statistically significant (Table 19).

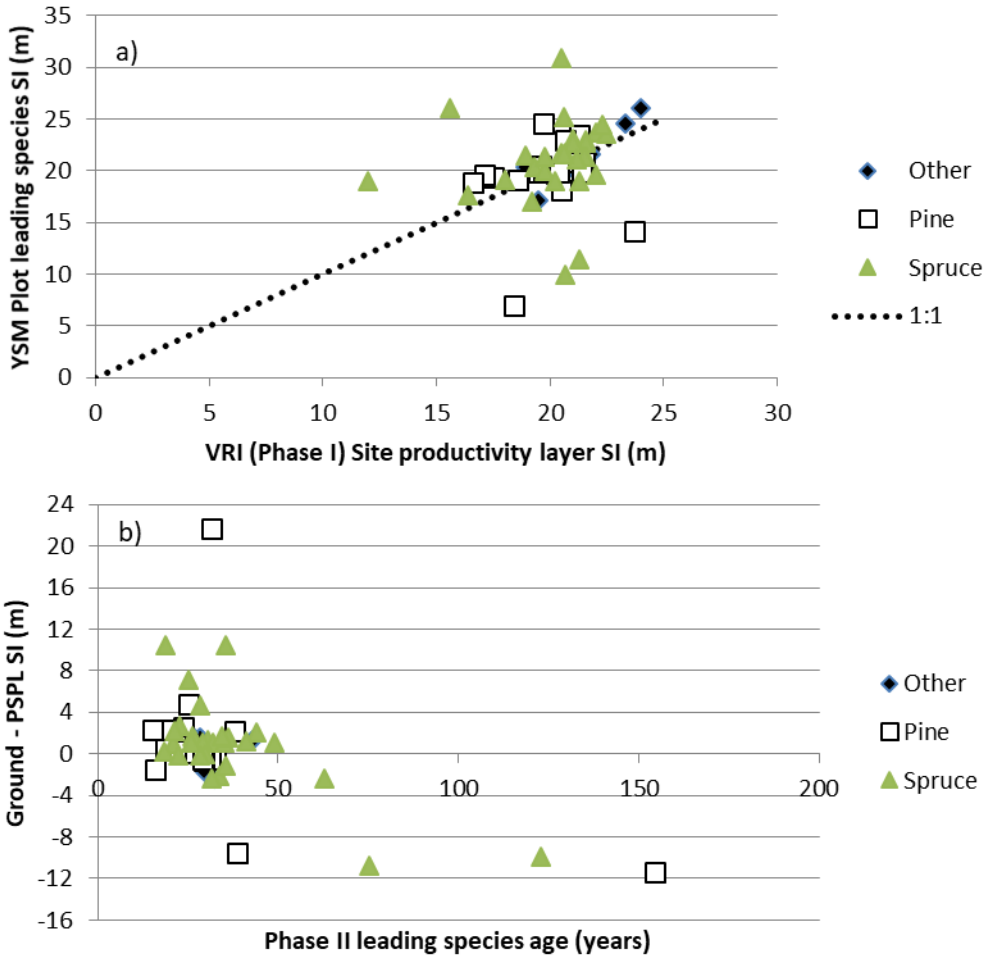

Figure 8. The inventory SI (from the PSPL) and ground leading species SIs are compared (a) and the differences plotted against the ground age (b). The site productivity layer SI corresponds to the ground leading species.

Table 19. The ground plot and PSPL SI are compared. Statistically significant differences (p-value < 0.05) are shaded.

Phase I		SI (m)			
Strata	N	Ground	PSPL	Bias	p-value
Other	8	20.9	18.5	2.4 ± 0.8	0.022
SBS	45	20.5	19.7	0.9 ± 0.6	0.148
Other	8	21.9	20.5	1.4 ± 1	0.186
Pine	17	19.7	19.1	0.6 ± 0.9	0.493
Spruce	28	20.8	19.5	1.3 ± 0.8	0.112
Age 15-30	36	20.9	19.4	1.5 ± 0.6	0.014
Age 31-50	17	20.0	19.7	0.3 ± 1.1	0.770
Not results	22	20.5	19.5	1 ± 0.7	0.143
Results	31	20.7	19.5	1.2 ± 0.8	0.135
All	53	20.6	19.5	1.1 ± 0.5	0.039
All – no resid	53	20.6	19.6	1.1 ± 0.5	0.045
2015 - All	54	21.2	19.6	1.6 ± 0.4	0.001
2015 - no resid	54	21.2	19.6	1.6 ± 0.4	0.001

The previous comparison looked at leading species height. Some of the ground samples also include SI information for the secondary and tertiary species. The PSPL was compared to all species that had ground SI estimates, regardless of whether they were leading species. As with the leading species comparison, the ground SIs are generally higher than the PSPL SI except for balsam and Douglas-fir (Table 20 and Figure 9).

Table 20. The ground and PSPL SI are compared by species group. No differences are statistically significant (p-value < 0.05).

Species		Breast	Height	Age	SI (m)			
Group	N	Mean	Min	Max	Ground	PSPL	Bias	p-value
At - trembling aspen	7	24	13	41	23.6	19.8	3.8 ± 2.3	0.144
Bl – balsam	9	50	15	133	16.1	18.8	-2.8 ± 1.7	0.146
Ep – birch	3	32	20	43	21.8	18.5	3.3 ± 1.8	0.200
Fd - Douglas-fir	2	28	24	33	22.0	23.9	-1.9 ± 1.7	0.455
Pl – lodgepole pine	26	21	10	32	20.3	19.7	0.6 ± 0.4	0.129
S – spruce	29	28	9	104	21.0	19.6	1.3 ± 0.7	0.082
SE – Engelmann spruce	1	13	13	13	21.5	19.5		

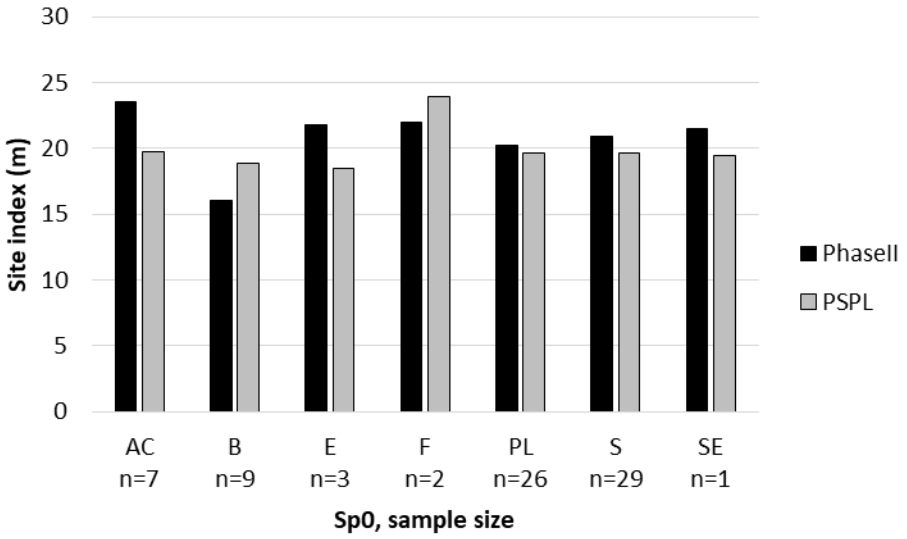

Figure 9. The ground and PSPL SI are compared by species. The data are given in Table 20.

7.3 Leading Species

Forty-four (59%) of the plots had the same inventory and ground leading species. The agreement for spruce was 82%, for Pine 60%, for Balsam 29% and for the remaining species (10 samples) 10%.

Table 21. The Ground and Phase I (Inventory) leading species are compared (4.0 cm utilization level). Agreement cells are shaded gray.

Ground Plot	VRI polygon leading species							%
Leading Species	A	B	E	F	P	S	Total	Agreement
None					3		3	0%
A	1				2	2	5	20%
B		2			2	3	7	29%
E						1	1	0%
F						1	1	0%
P	2	1			18	9	30	60%
S	1	1	1	1	1	23	28	82%
Total	4	4	1	1	26	39	75	
% agreement	25%	50%	0%	0%	69%	59%		59%

Twelve samples had 5% or less difference between the leading and second species in terms of species composition on the ground or in the inventory (Table 22). If the leading and second species in the ground composition were switched when the difference ≤ 5%, one additional sample would have become case 1 matches. If the leading and second species in the inventory composition were switched when the difference ≤ 5%, three additional samples would have become case 1 matches. The overall effect would be to increase the correct classification rate for leading species from 59% to 64%.

Table 22. The samples with 5% or less difference between the leading and second species in terms of species composition. "Approx Case" is the case matching if the leading and second species are switched.

Sample	Ground species composition	Inventory Species composition	Case	Approx Case
205	Pl 79 Bl 12 Sx 09	SX 40 PLI 40 BL 20	2	1
206	Pl 62 Sx 37 At 01	SX 50 PLI 45 AT 5	2	1
208	S 80 Bl 16 Fd 04	PLI 30 SX 30 AT 30 BL 10	2	1
220	Sw 42 Bl 37 Pl 20 At 01	SW 70 BL 20 PLI 10	1	1
230	Pl 40 At 35 Ac 14 Sb 11	SW 40 SB 30 AT 20 PLI 10	3	3
231	Sx 44 Ac 39 Ep 14 Bl 02 At 01	SX 80 BL 10 EP 10	1	1
232	At 49 Fd 44 Pl 07	PL 100	5	5
249	S 50 Pl 48 Ep 02	SX 60 PLI 30 AT 10	1	1
252	Bl 95 Pl 04 Sx 01	SXW 40 PL 40 BL 20	3	3
255	S 95 Ep 05	SX 40 EP 40 PLI 20	1	1
264	Pl 43 Sw 42 Bl 15	SW 90 PL 10	2	1
925	Bl 74 Pl 17 Sx 09	PLI 30 SX 30 AT 20 BL 20	3	3

7.4 Basal area and trees/ha

Phase I Inventory trees/ha (TPH) and basal area (BA) are compared (Table 23) to the YSM ground data in order to assess the accuracy of these Phase 1 photo interpreted polygon attributes for young stands. Note that the Phase I TPH and BA are not used in TSR. As noted in section 5.5, the original source of the Phase I TPH and BA may be photo interpretation or silviculture surveys provided by RESULTS. When the inventory is projected using VDYP7, the TPH and BA are modified to represent only trees with Dbh ≥ 7.5 cm in the projection year. However, BA and TPH are only updated by VDYP7 once the projected height is 7 m. The samples where the Phase I inventory BA and TPH have not been modified likely represent a smaller utilization limit or no utilization limit.

Table 23. The ground plot and VRI Polygon basal area are compared. Statistically significant differences (p-value < 0.05) are shaded.

Phase I		BA (m^2/ha)				Trees/ha			
Strata	N	Ground	VRI	Bias	p-value	Ground	VRI	Bias	p-value
Other	11	10.6	3.8	6.8 ± 3	0.046	819	2147	-1329 ± 588	0.047
SBS	64	16.4	9.1	7.3 ± 1.4	0.000	1017	2267	-1250 ± 309	0.000
Other	10	18.1	15.5	2.6 ± 2.3	0.284	911	1297	-387 ± 205	0.091
Pine	26	12.9	9.5	3.5 ± 1.8	0.066	973	2650	-1677 ± 735	0.031
Spruce	39	16.7	5.8	10.9 ± 1.8	0.000	1019	2227	-1208 ± 194	0.000
Age 15-30	49	13.4	6.1	7.3 ± 1.4	0.000	977	2520	-1543 ± 402	0.000
Age 31-50	26	19.6	12.6	7.1 ± 2.5	0.009	1010	1740	-730 ± 222	0.003
Not results	36	17.3	8.5	8.8 ± 2.1	0.000	1021	2104	-1083 ± 262	0.000
Results	39	14.0	8.2	5.8 ± 1.4	0.000	958	2384	-1426 ± 475	0.005
All	75	15.6	8.4	7.2 ± 1.3	0.000	988	2250	-1261 ± 276	0.000
All – no resid	75	15.1	8.4	6.8 ± 1.3	0.000	975	2250	-1274 ± 278	0.000
2015 - All	71	15.8	5.0	10.8 ± 1.3	0.000	897	1860	-962 ± 188	0.000
2015 - no resid	71	15.4	5.0	10.4 ± 1.2	0.000	884	1860	-976 ± 190	0.000

The average Phase I TPH is 2,250 stems/ha and the BA is 8.4 m^2/ha which corresponds to a quadratic mean Dbh of 6.9 cm, confirming the Phase I inventory utilization limit is less than 7.5 cm. The effect of

differing utilization levels and lack of updating BA and stems/ha is expected to be greater for younger samples. This is confirmed by the larger relative biases for BA and TPH associated with the 15 - 30 year age class (compared to the 31 – 50 year age class).

Overall, the biases associated with TPH and BA are statistically significant. The lower Inventory BA and higher trees/ha are consistent with the BA and trees/ha not being projected for some samples. This limits the usefulness of the comparison.

8 Ground vs. TIPSY Volumes

8.1 Ground plot data screening

The following is taken from the CMI procedures (MSRM 2005, p.42)

> Classify all trees assessed on the larger tree plot as to whether it is a residual from a former stand. In making this assessment, refer to the general area around the plot. Trees are classed as residual if they are present in even aged stands, are living remnants of a former stand, and occur as the occasional (< 25 per ha) large stem of an older age class than the stand as a whole. Typically these trees have larger diameters, a higher incidence or indication of decay, thicker bark, larger branching and “ragged” or flat tops. These trees must be clearly residual. Uneven-aged stands do not generally have residual trees.

Residual trees identified by the ground crews were removed from this volume analysis.

8.2 Analysis Units

The analysis units (AUs) were taken from the Timber Supply Review Data package (MFLNRO 2015)

The RESULTS database was used to develop the silviculture assumptions for managed stand AUs. Forest cover records were selected that were immature, not "UNEVEN" aged, had a leading species, had an age and height, and the total stems per ha and the uncapped well-spaced stems per ha was populated (however, if the uncapped number was missing the capped value was used if populated).

The AUs are modelled using data from two sources: regeneration survey for stands established after 2002, and free-growing surveys for stands established between 1986 and 2002. As a consequence of the YSM definition (ages 15 – 50), all the YSM samples fall in the pre-2002 population.

AUs for stands established after year 2002

Where stands were established post-2002 and the regeneration survey summaries form the primary data source, stocking is based on the area weighted uncapped well-spaced stems per hectare, genetic worth (GW) and the planted option in TIPSY is applied. Use of this methodology was advised by FLNROs TASS/TIPSY growth and yield research group. The well-spaced number implies a regular spatial configuration. Therefore the appropriate regeneration method to assume is ‘planted’ regardless of actual stand origin.

AUs for stands established between 1986 and 2002

For stands established post-1986 and prior to 2003, the free-growing survey summaries form the primary data source. When modelling, stocking is based on the weighted average total stems per hectare and the

natural regeneration option employed in TIPSY. Due to the substantial natural ingress occurring in these stand types, GW is not applied.

AU yield curves

Historically, in the absence of any better information, an OAF1 of 15% and an OAF2 of 5% have been applied to the managed stand yield curves. The rationale behind OAFs is to reduce the theoretical projected yields from those found in research plots to actual yields experience in managed stands. Table 24 shows the TIPSY input summary for the analysis units (AUs) in the TSA ground sample. The AUs are a combination of BEC and leading species. The AU assignments for each sample are given in Appendix B.

Table 24. The analysis unit (AU) definitions for the ground samples are given. OAF1 = 15% and OAF2 = 5%. All are curve type "ex_mgd_std_FG". The last five rows are either hardwood leading or have no sample trees on the ground. There are no corresponding AU assumptions.

				Stems														Lead	Regen	
		N	Regen		Un		Spc	Pct	Spc	Pct	Spc	Pct	Spc	Pct	Spc	Pct	Spp		
AU	label	samples	delay	Total	capped	Applied	1	1	2	2	3	3	4	4	5	5	SI	N or P	util
73	ESSF_P	4	2	5000	1400	5000	PL	62	BL	21	SE	17					16.2	N	12.5
74	ESSF_S	3	3	3100	1300	3100	SE	61	BL	29	PL	10					16.1	N	17.5
81	ICH_S	2	2	4200	1400	4200	SW	46	CWI	24	FDI	23	PL	7			22.2	N	17.5
86	SBS_B	7	2	3600	1300	3600	SW	54	PL	25	BL	20	FDI	1			19.6	N	17.5
89	SBS_F	1	3	4700	1300	4700	PL	44	SW	27	FDI	26	BL	3			20.7	N	12.5
91	SBS_P	26	2	5700	1400	5700	PL	69	SW	13	BL	11	FDI	7			20.0	N	12.5
92	SBS_S	23	3	3800	1300	3800	SW	44	PL	31	BL	13	FDI	11	LW	1	19.4	N	17.5
	ICH_A	1																	
	SBPS_	1																	
	SBS_	2																	
	SBS_A	4																	
	SBS_E	1																	

8.3 Predicted (Projected) Yield Estimates

For each sample plot, ground measured volumes were compared against two separate sets of TIPSY yield curves to quantify the overall volume bias as well as to partition the total bias into model bias and attribute bias. In addition, two types of volume were compared. Whole stem volume is the total stem volume of live trees with Dbh ≥ 7.5 cm. Net volume is the stem volume minus stump, top and net downs for all live trees with utilization depending on the leading species (Table 24).

VOL1: Ground based plot volume. All residual trees were removed. VOL1 is identical to the ground compiled volume except for the removal of residual trees. Net volume is vol_ntwb * l_nvaf.

VOL2: TIPSY estimated volumes using a combination of ground plot and AU assumption inputs. TIPSY simulations start with initial stand conditions. The main input attributes are species composition, SI, initial density and regeneration type (N = natural or P = planted). The species composition and SI were taken from the ground plot summaries. The initial density and the regen method for the ground plots was not known and was taken from the corresponding AU assumptions.

For each species, the average site index was computed as described in section 5.4. If SI was not available for the leading species, it was taken from the site productivity layer. If SI was not available for non-leading species, site index conversion equations were used to impute the SI from the SI of the leading species. If no conversion equations exist, the leading species SI was used for non-leading species.

The first four species in the ground species composition were run through TIPSY separately, as pure species using the species SI and the AU assumptions of regeneration method and initial density. A species weighted yield curve was then calculated using the species proportions as weights. If there was not enough information to generate a TIPSY yield curve for the non-primary species (e.g., missing SI), the species was ignored and the weighted average yield curve was generated by increasing the weight of the primary species. For instance, if the ground species composition was PL 60 Sw 20 At 20 and SI was not available for At, a yield curve was generated based on Pl 80 Sw 20 (the AT species composition was added to the primary species).

The TIPSY total age is the age since disturbance and not necessarily breast height age plus years to breast height. It includes a regen delay, years to breast height and assumes an initial stock height. As a consequence, when the TIPSY total age is equal to the ground age, the TIPSY height will not necessarily equal the ground height. The heights should match since the ground compiler and TIPSY use the same SI (SiteTools) curves. Rather than matching the ground and TIPSY at the same total age, the ground and TIPSY heights were matched and the corresponding TIPSY volume extracted. This is equivalent to matching the ground and TIPSY volumes at the same breast height age. The ground height was taken as the average height of the suitable height trees. If there were no suitable height trees, the average height of the six live trees of largest Dbh, excluding broken top trees, was used. The TIPSY height is the weighted average top height of all species.

TIPSY supports limited species mixtures. For samples with a birch component, the birch component was replaced with trembling aspen. SB was mapped to SX.

VOL3: TIPSY estimated volumes using the PSPL site index estimates, the VRI Phase I species composition and the AU initial density and regeneration type. The TIPSY runs were similar to those for VOL2 except the species composition was taken from the VRI Phase I layer and SI from the PSPL. The TIPSY age was matched to PROJ_AGE_1. As with VOL2, for samples with a with a birch component, the birch component was replaced with trembling aspen.

VOL4: AU volumes generated by FAIB. The samples were assigned to an AU based on the Phase I inventory leading species and the PSPL SI corresponding to the Phase I leading species. These volumes correspond to a utilization of 12.5 cm or 17.5 cm, depending on the leading species. Note there were no AU curves for hardwood leading plots. Five plots had hardwood leading species in Phase I. The AU curves were given in 10 year age classes. Volumes for intermediate ages were approximated using the SAS PROC TPSPLINE. VOL4 is the volume from the AU yield curve corresponding to PROJ_AGE_1.

The bias was defined a follows.

Total Bias = VOL1 – VOL3 = Model Bias + Attribute Bias
Model Bias = VOL1 – VOL2
Attribute Bias = VOL2 – VOL3

Model bias includes differences between using TIPSY versus the VRI compiler. This is generally referred to as model bias. Model bias also includes biases caused by using the AU regeneration assumptions of regeneration type (planted vs. Natural), initial density and the OAFs.

Attribute bias includes biases caused by incorrect Phase I attributes including species composition, age and SI from the PSPL layer.

8.4 Total bias - Ground compiler vs. TIPSY Volume

The ground volumes (VOL1) and the TIPSY volumes from Phase I species composition and the PSPL SI (VOL3) are not particularly close (Figure 10). Many samples had a VOL3 = 0.

Differences between the attributes associated with VOL1 and VOL3 include differences in species composition, SI, age and height.

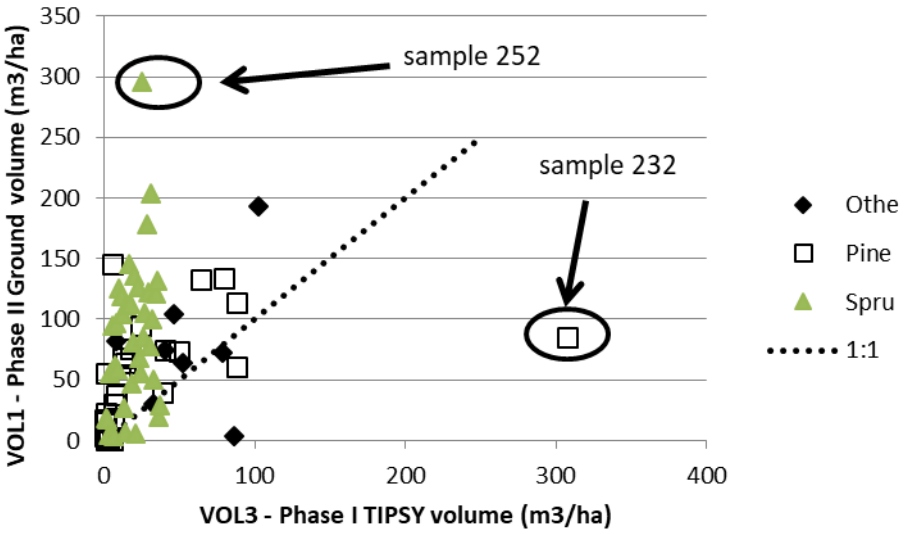

Figure 10. The ground volume is plotted against the TIPSY VOL3 predictions. Volumes are whole stem volume at the 7.5 cm utilization level.

As noted in Table 8, the ground data for sample 252 indicate an older stand (ground leading species age = 63 vs. and Phase I leading species age of 42). The volume differences for sample 252 in Figure 10 are due largely to height differences (ground height of 19.5 m compared to an inventory height of 7.3 m). For sample 232, the ground height is 10.8 m while the TIPSY height is 20.9 m.

8.5 Model bias - Ground vs. TIPSY Volume using ground attributes

The ground volumes (VOL1) were compared to the TIPSY volumes using the ground species composition and site index (VOL2) (Figure 11). This is an indication of the model-related volume bias but also includes errors in the AU assumptions. The initial density was taken from the AU assumptions. AU assumptions were not available for hardwood leading polygons so an initial density of 5,000 TPH was assumed. There were samples without measured trees on the ground. By default, these sample have VOL1 = 0 and VOL2 = 0 and consequently model bias = 0. This somewhat artificial allocation of all of the bias to attribute bias should be kept in mind when evaluating the results.

Some of the largest differences are associated with samples 226 and 258. Plot 226 had 57 m^3/ha of dead volume and sample had 67 m^3/ha of dead volume tallied in the ground sample.

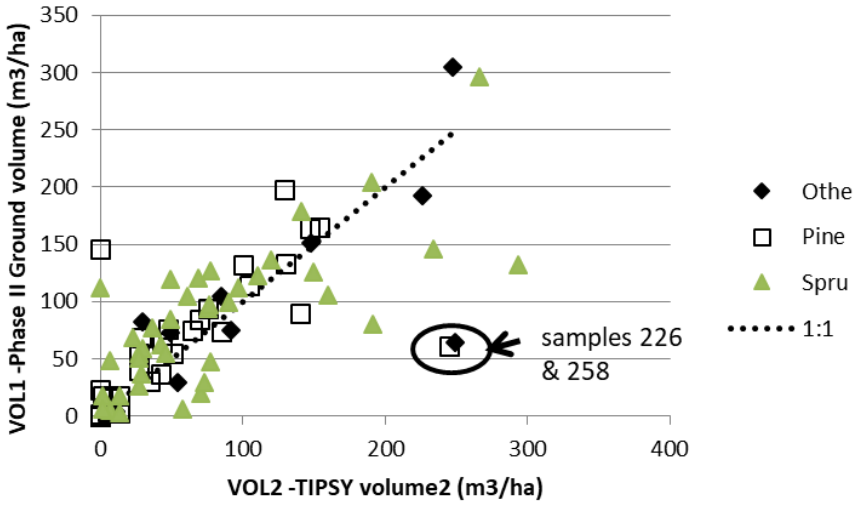

Figure 11. The ground volume is plotted against VOL2. Volumes are whole stem volume at the 7.5 cm utilization level.

8.6 Bias analysis

The differences between the ground attributes and the TIPSY estimates (e.g., VOL1 vs .VOL3) include errors from a number of sources. The initial density for the TIPSY runs is taken from the AU assumptions and are average values for the AU and may not reflect the individual sample. VOL3 is based on the Phase I species composition and PSPL site index while VOL1 is based on the ground measurements. The ground attributes represent a local 400 m^2 area while the Phase I attributes represent a larger polygon and the PSPL SI represents a 1 ha tile. There were some samples without PSPL information (e.g., sample 210). These did not have a VOL3 and were dropped from the comparison.

The results of TIPSY whole stem volume comparisons are given in Table 25. The overall total bias is about 37 m^3/ha, or approximately half of the ground volume. The total bias is dominated by attribute bias.

Table 25. Ground and TIPSY whole stem volumes are compared. The utilization level is 7.5 cm. Statistically significant differences (p-value < 0.05) are shaded.

Phase I	N	(m^3/ha)			Bias			p-value		
Strata		VOL1	VOL2	VOL3	Total	Model	Attribute	Total	Model	Attribute
Other	9	37.7	24.1	39.1	-1.4 ± 29.2	13.6 ± 6.3	-15 ± 28.2	0.962	0.065	0.609
SBS	51	76.5	87.1	32.3	44.2 ± 6.8	-10.5 ± 8.8	54.8 ± 10.3	0	0.236	0
Other	8	78.1	98.9	55.8	22.3 ± 19.5	-20.8 ± 25.5	43.1 ± 30.2	0.289	0.442	0.196
Pine	21	58.7	67.9	40.1	18.6 ± 14.3	-9.2 ± 13.5	27.9 ± 21.3	0.208	0.503	0.206
Spruce	31	76.9	78.7	22.9	54 ± 8.6	-1.8 ± 9.7	55.8 ± 10.9	0	0.858	0
Age 15-30	39	54.2	55.2	15.8	38.5 ± 6.3	-0.9 ± 8.3	39.4 ± 10.6	0	0.911	0.001
Age 31-50	21	101.3	119.3	65.9	35.4 ± 17.9	-18 ± 15.2	53.4 ± 21.5	0.063	0.25	0.022
Not results	27	76.5	71.2	35.3	41.2 ± 14	5.3 ± 10.1	35.9 ± 15.7	0.007	0.605	0.031
Results	33	65.9	82.8	31.6	34.3 ± 7.2	-16.9 ± 10.9	51.2 ± 13.2	0	0.132	0.001
All	60	70.7	77.6	33.3	37.4 ± 7.4	-6.9 ± 7.6	44.3 ± 10.1	0	0.366	0
All - 2015	71	73.9	54.3	27.2	46.8 ± 6.3	19.6 ± 6	27.2 ± 5.9	0.000	0.002	0.000

The volumes net of decay, waste and breakage are given in Table 26. The net volumes are smaller than the whole stem volumes and the model bias is a greater proportion of the total bias. The samples are young and should not have much decay but the trees are small with a high fraction of non-merchantable volumes and stand level volumes are very sensitive to utilization level.

Table 26. Ground and TIPSY volumes net of decay waste and breakage are compared. The utilization level is 12.5 cm or 17.5 cm, depending on the leading species. Statistically significant differences (p-value < 0.05) are shaded.

Phase I	N	(m^3/ha)			Bias			p-value		
Strata		VOL1	VOL2	VOL3	Total	Model	Attribute	Total	Model	Attribute
Other	9	17.4	5.7	30.4	-13 ± 29.1	11.7 ± 5.7	-24.7 ± 27.7	0.667	0.076	0.399
SBS	51	48.6	44.2	14.0	34.7 ± 5.3	4.5 ± 6.1	30.2 ± 6.4	0	0.469	0
Other	8	53.1	55.8	21.5	31.6 ± 13.6	-2.7 ± 16.6	34.4 ± 21.4	0.053	0.875	0.153
Pine	21	31.2	25.5	22.6	8.6 ± 13.8	5.7 ± 9.6	2.9 ± 14.2	0.541	0.558	0.842
Spruce	31	50.2	42.7	10.9	39.3 ± 7.2	7.6 ± 6.8	31.7 ± 8.1	0	0.277	0
Age 15-30	39	28.9	19.1	5.0	24 ± 4.3	9.9 ± 5.2	14.1 ± 4.3	0	0.065	0.002
Age 31-50	21	71.8	74.3	37.7	34.1 ± 17	-2.5 ± 11.6	36.6 ± 18.9	0.059	0.834	0.067
Not results	27	50.1	39.0	20.5	29.6 ± 13.1	11.1 ± 7.2	18.6 ± 13.5	0.032	0.135	0.18
Results	33	38.9	37.9	13.1	25.8 ± 5.3	1 ± 7.6	24.8 ± 7.2	0	0.892	0.002
All	60	43.9	38.4	16.4	27.5 ± 6.5	5.6 ± 5.3	22 ± 7.2	0	0.297	0.003
All - 2015	71	49.5	34.4	15.1	34.4 ± 4.8	15.1 ± 4.1	19.3 ± 4.6	0.000	0.000	0.000

The ground basal area (BA) and trees per hectare (TPH) were compared to those generated by TIPSY with the VOL3 scenario (Table 27). The Ground and TIPSY TPH both include all live trees with Dbh ≥ 7.5 cm. TIPSY generates estimates of BA for all trees (Dbh > 0cm). The closest equivalent in the ground compilation is BA for trees with Dbh ≥ 4.0 cm. The contribution of trees with Dbh < 4.0 to BA is likely to be small so the differences in ground and TIPSY BA due to utilization are anticipated to be small.

The TIPSY Bas are much closer to the VRI BA while the density is much lower (Table 23).

Table 27. The ground plot and TIPSY-generated trees/ha and basal area are compared. Statistically significant differences (p-value < 0.05) are shaded. The bias is total bias and includes both model and attribute bias, similar to the comparison of VOL1 vs. VOL3. Attribute bias potentially includes differences in species composition, height, age and site index.

Phase I		Trees/ha				BA (m^2/ha)			
		Ground	TIPSY			Ground	TIPSY		
Strata	N	Dbh≥7.5cm	Dbh≥7.5cm	Bias	p-value	Dbh≥4.0cm	Dbh≥0cm	Bias	p-value
Other	8	857	365	491 ± 149	0.013	11.6	5.7	5.9 ± 4.6	0.245
SBS	47	907	681	226 ± 99	0.028	15.9	4.9	11 ± 1.2	0
Other	8	841	1002	-161 ± 260	0.556	15.6	7.1	8.5 ± 3.3	0.035
Pine	21	893	667	226 ± 102	0.038	12.5	5.5	6.9 ± 1.9	0.001
Spruce	26	923	496	426 ± 140	0.005	17.4	3.9	13.5 ± 1.8	0
Age 15-30	34	870	448	422 ± 113	0.001	13.0	2.4	10.6 ± 1.4	0
Age 31-50	21	948	939	10 ± 126	0.939	18.9	9.2	9.7 ± 2.4	0.001
Not results	26	942	547	395 ± 117	0.002	16.5	5.1	11.4 ± 2.1	0
Results	29	862	714	148 ± 128	0.259	14.1	4.9	9.2 ± 1.4	0
All	55	900	635	265 ± 88	0.004	15.3	5.0	10.3 ± 1.2	0
All - 2015	71	884	368	515 ± 77	0.000	15.7	4.3	11.5 ± 1.2	0.000

8.7 Ground vs. AU volumes

The ground volumes (VOL1) were compared to the AU TIPSY volumes (VOL4) (Figure 12). The AU curves were obtained from FAIB and are TIPSY-generated volumes by 10 year age classes. Although it is generally reassuring when the two volumes are close, differences are not necessarily a cause for alarm. The AU yields represent the average condition while the ground plots may be at the higher or lower end of the productivity range. In addition, the assignment to an AU was based on the Phase I (Inventory) information. If the Phase I species is incorrect, differences between VOL1 and VOL4 are expected.

There were five samples that had a hardwood Phase I leading species. There are no hardwood AUs so these samples were dropped from the following comparison.

Two samples are circled in Figure 12. The ground measurements for sample 232 indicate a FD-dominated, 32 year old stand while the Phase I data indicated a PL-dominated, 48 year old stand. Sample 252 has a ground age of 63 compared to a Phase I age of 43.

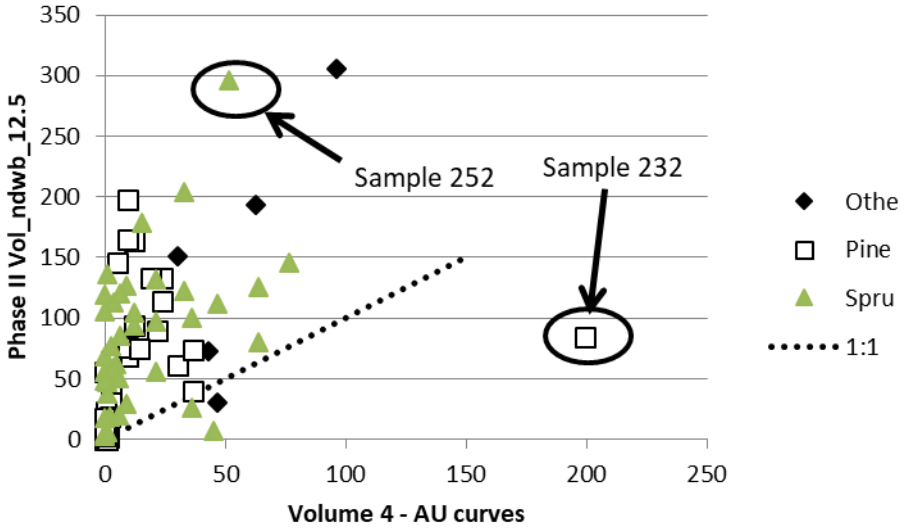

Figure 12. The ground volume is plotted against VOL4. Volumes are net of decay, waste and breakage at the 12.5 or 17.5 cm utilization level, depending on the leading species.

The AU volumes are summarized in Table 28 along with the Phase II ground volumes and VOL3. In general, the AU volumes are statistically smaller than the ground volumes. The volumes compared here are merchantable volumes net of decay, waste and breakage. The utilization is 17.5 cm for Spruce and Balsam leading polygons and 12.5 cm for all other leading species. The AU volumes and VOL3 are much closer. The differences between ground (VOL1) and AU volume observed here may have the same cause – attribute error. The ground samples tend to be taller (Table 17), with more basal area (Table 27). The relatively small ground sample may not adequately reflect the population.

Table 28. Average volume, net of decay waste and breakage, is given by strata. The utilization for Spruce and Balsam is Dbh ≥ 17.5cm and Dbh ≥ 12.5cm for all other leading species. Statistically significant differences (p-value < 0.05) are shaded. Bias is total bias and includes attribute and model bias.

Phase I		Volume (m^3/ha)			Ground vs. AU volume	
Strata	N	Ground (VOL1)	AU curves (VOL4)	VOL3	Bias	p-value
Other	8	9.2	29.9	33.6	-20.7 ± 22.5	0.387
SBS	47	39.7	18.8	9.3	20.8 ±5.3	0
Other	3	56.1	50.7	22.9	5.4 ± 39.8	0.904
Pine	21	31.2	20.1	22.6	11.1 ± 11.1	0.328
Spruce	31	35.9	17.7	5.3	18.2 ± 6.4	0.008
Age 15-30	35	21.0	4.8	3.8	16.2 ± 4.1	0
Age 31-50	20	60.0	47.7	28.7	12.3 ± 14.5	0.407
Not results	25	39.2	25.5	16.9	13.8 ± 11.1	0.227
Results	30	31.9	16.2	9.5	15.7 ± 5.5	0.008
All	55	35.2	20.4	12.8	14.8 ± 5.8	0.014
All - 2015	66	39.8	19.6	13.6	20.2 ± 5.6	0.001

8.8 Future yields

The VOL2 projections can give an indication of future yields. Ideally, the ground plots would be projected from the current measurement to the future. VDYP7 could be used to project the ground attributes but VYP7 is really designed to project older stands. TIPSY projects the development of young stands but is designed to project from stand establishment (rather than from a later measurement). The species composition and SI from the ground measurements could be used to initialize the TIPSY run but the initial density is not known. The VOL2 projections are based on the ground species composition and AU assumptions for initial density. This is a compromise and is used here to give an indication of potential yields. These projections are extrapolations, based on current data. The YSM plots should be remeasured to monitor growth and verify assumptions.

The VOL2 curve for each ground plot were generated and the volume-age curve shifted left or right so that the projected volume matched the ground volume. This point was taken as time 0 (the present). This ensured the VOL2 average volume at time 0 was equal to the actual ground volume. The volumes were projected 50 years into the future (Figure 13). Three plots had no ground volume and were not included here.

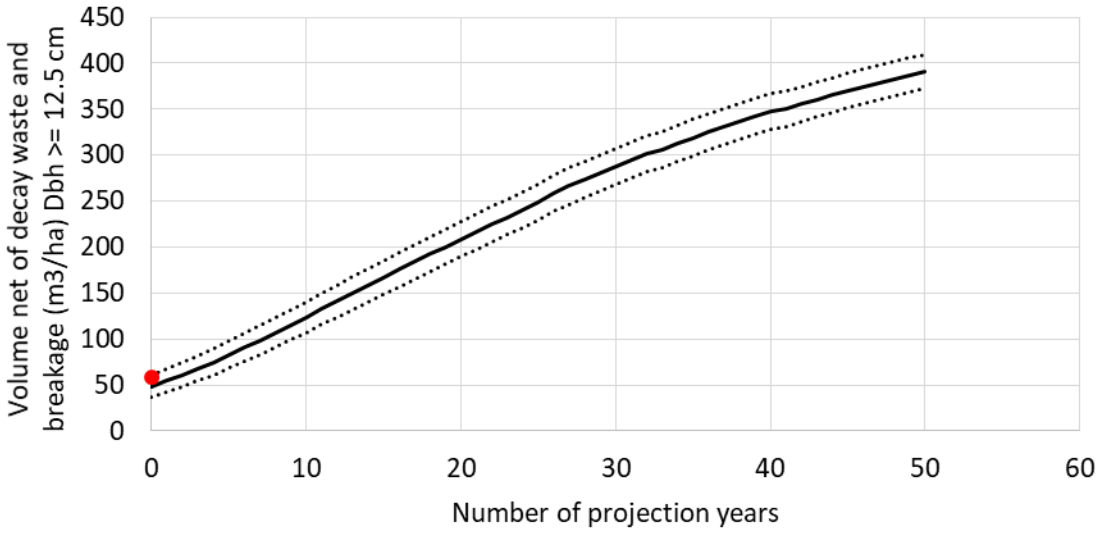

Figure 13. The VOL2 projections are given. The solid line is the average of the 72 ground plots with non-zero volume. The dashed lines are the 95% confidence intervals around the average line. This confidence interval only includes sampling error and assumes the projections are exact. It does not include model or attribute error. The red circle is the actual average ground volume.

TIPSY projects that in 50 years, the ground plots will have an average merchantable stem volume net of decay, waste and breakage of nearly 400 m^3/ha. Actual volumes are likely to be lower due to disturbances.

9 Discussion

The analysis has a number of complications. These are young samples and many of the trees may be smaller than the Dbh threshold.

Overall, the total volume bias is large. Approximately two-thirds of the bias is due to attribute bias and the remainder to model bias. The attribute bias is largely due to higher ground BA and to a lesser extent, higher ground SI.

Table 29. The results of comparing the ground plots to the inventory and to the YSM assumptions are summarized. A p-value < 0.05 is generally considered an indication of statistically significant differences (or bias).

Attribute	N	Source	Ground mean	Inventory mean	Bias			2015
					Magnitude	% of ground mean	p-value	Magnitude
Whole stem volume (m^3/ha)	60	TIPSY	70.7	33.3	37.4 ± 7.4	53%	0	46.8 ± 6.3
Volume model bias (m^3/ha)	60	TIPSY			-6.9 ± 7.6	10%	0.366	19.6 ± 6.0
Volume attribute bias (m^3/ha)	60	TIPSY			44.3 ± 10.1	63%	0.000	27.2 ± 5.9
Basal area (m^2/ha)	75		15.1	8.4	6.8 ± 1.3	45%	0.000	8.3 ± 1.1
Species matched age (years)	64		34.3	28.6	5.7 ± 2.4	17%	0.019	1.5 ± 1.3
Species matched height (m)	65		11.7	8.6	3.1 ± 0.6	26%	0.000	4.4 ± 0.5
Site index (m)	53	PSPL	20.6	19.5	1.1 ± 0.5	5%	0.039	1.6 ± 0.4

10 Recommendations

For young stands, not all attributes In the Phase I inventory are updated by VDYP7, particularly basal area and trees/ha. As a consequence, the utilization level associated with basal area and trees/ha are not fixed and this has implications for the comparison. This should be noted in any analyses involving young polygons.

The results here indicate a need to update the Prince George YSM Phase I attributes for young stands. A key monitoring objective is to compare observed to forecasted growth. The samples should be remeasured, as planned.

11 List of References

Ducey, M., Gove, J. H. and Valentine, H.T. 2004. A walkthrough solution to the boundary overlap problem. For. Sci. 50:427-435.

FAIB. 2011. Vegetation Resources Inventory: VRI sample data analysis procedures and standards. Version 1. Dated January 2011. 23p + app.

MFLNRO. 2015. Prince George Timber Supply Area Timber Supply Review – Data Package. April 2015. 62p.

MSRM. 2005. National Forest Inventory – British Columbia. Change Monitoring Procedures for Provincial and National Reporting. Ministry of Sustainable Resource Management. March 31, 2005. Version 1.4.

Nona Phillips Forestry Consulting. 2014a. Prince George Timber Supply Area – TSA 24: Vegetation resources inventory project implementation plan including volume audit sampling and young stand monitoring. March 24, 2014. 14p. + app.

Nona Phillips Forestry Consulting. 2014b. Prince George TSA VRI Sample Selection Report. March 2014. 14p. + app.

12 Appendix A – Plot Data Summaries

Table 30. The Plot data summaries are given.

	Phase I		Phase II								Phase I							Site	Prod	Layer	
samp_no	Strata	BA 7.5	TPH 7.5	WSV 7.5	WSV dead	Spp1	HT1	Age1	SI1	BA 12.5	TPH 12.5	Vol 12.5	Dead Vol	Spp1	HT1	Age1	SX	BL	PL	AT
219	Other	12.9	650	75	0	PL	11.6	29	20.4	5.5	532	8	0	AT	10.3	31	15.8	18.1	18.9	18.4
222	Other	39.5	1426	305	21	BL	20.1	84	22.1	27.1	1652	122	0	BL	18	49	0	0	0	0
224	Other	21.6	1251	82	0	SX	9.6	24	26	8.4	743	13	0	EP	12.7	24	22.3	18	24	19.8
226	Other	9.9	550	64	57	AT	18.1	37	22.8	4.2	419	5	0	AT	11.1	26	20.5	19.2	21.1	19.5
239	Other	24.1	951	151	9	BL	15	44	20.2	24.4	2481	37	0	BL	11.2	38	0	0	0	0
248	Other	20.4	1376	104	2	PL	12.4	25	23.2	22.7	1849	58	0	AT	16.7	25	19.6	16.6	21.1	19.9
268	Other	1	75	4	0	SX	8.2	30	19.6	11.6	1236	11	0	AT	11.5	27	22	20.2	21.3	21.7
272	Other	16	1501	73	0	PL	10.4	32	17.1	16.1	1398	44	0	BL	13.2	41	16.9	18.3	19.5	18.3
381	Other	6.1	350	30	0	SX	10.9	33	21.6	6.7	792	7	0	FDI	10.9	35	20.3	19.2	21.8	20.5
436	Other	29.9	976	193	4	SX	18	43	24.6	28.7	1872	93	0	BL	15.7	44	23	21	23.3	21.9
64	Pine	0	0	0	0	0	0	0	0	0	720	0	0	PLI	6.4	0	17	18.5	19.6	19.2
200	Pine	18.3	625	146	73	PL	0	0	0	6.6	853	4	0	PLI	9.4	0	13.4	17.1	16.7	16.1
201	Pine	16.6	1601	68	0	PL	8.6	23	19.3	10	1500	0	0	PLI	7.2	24	15.4	17.2	17.5	16.9
202	Pine	16.6	1126	64	0	PL	9.2	24	19.7	20.5	3458	0	0	PLI	8.6	25	15.5	16.5	17.1	16.3
208	Pine	9.7	675	40	0	S	9.4	25	24.5	19.1	2020	27	0	PLI	12.8	32	0	19.8	19.7	16
210	Pine	14.8	851	89	10	PL	13.9	32	21.6	10.8	1096	17	0	PLI	12.7	29	0	0	0	0
211	Pine	0	0	0	0	0	0	0	0	0	6133	0	0	PL	6.8	0	0	0	0	0
212	Pine	16.8	1776	76	0	PL	9.1	23	20	16	2283	8	0	PLI	8.2	24	18.3	18	19.7	18.8
227	Pine	0.6	125	2	0	PL	4	15	18.9	5	1500	0	0	PLI	6	23	0	15.5	16.6	16.1
228	Pine	8.4	700	37	6	PL	8.8	22	20.4	15	2000	0	0	PLI	7	21	17.5	18	19.6	18.8
229	Pine	33.5	2577	198	1	PL	13.4	27	22.8	6.5	730	7	0	PLI	10.4	24	0	0	0	0
232	Pine	19.8	2076	85	14	AT	10.8	39	14.2	3	300	0	0	PL	5	47	0	20.1	23.7	24.3
234	Pine	4.6	801	15	0	PL	6.7	19	19.1	15	4500	0	0	PLI	4.3	18	16.8	15.7	18.6	18.2
240	Pine	6.8	700	30	3	PL	8.9	23	19.8	10	2500	0	0	PLI	6.1	21	18.1	17.1	19.5	18.6
242	Pine	21.4	1401	133	4	PL	13.7	33	20.9	19.5	2090	29	0	PLI	13.1	30	16.5	16.9	20.9	17.3
243	Pine	14.9	1276	74	0	PL	10.6	27	19.8	21.9	3019	14	0	PLI	11.3	26	18	17.3	19.7	18.8
245	Pine	26.8	1701	163	0	AT	15.2	26	24.7	7.1	722	9	0	PL	10.8	25	0	0	0	0

		Phase I		Phase II							Phase I							Site	Prod	Layer	
samp_no	Strata	BA 7.5	TPH 7.5	WSV 7.5	WSV dead	Spp1	HT1	Age1	SI1		BA 12.5	TPH 12.5	Vol 12.5	Dead Vol	Spp1	HT1	Age1	SX	BL	PL	AT
246	Pine	21.9	1651	133	0	PL	12.3	31	19.8		18	2499	12	0	PLI	12.2	28	18.5	16.2	20.3	18.5
253	Pine	26.1	1401	165	7	PL	14.5	29	23.4		7.9	865	9	0	PLI	10.4	24	0	0	0	0
254	Pine	19.5	1201	114	3	PL	12.4	29	20.8		12	1146	25	0	PLI	13.8	30	19.5	20.4	21.5	18.8
258	Pine	8.2	550	61	67	PL	17.9	38	23.5		8.7	964	10	0	PLI	11	31	19.5	20.4	21.3	18.1
269	Pine	10.7	851	54	0	PL	9.9	21	23		4.5	642	2	0	PLI	8.9	21	16.5	16.4	20.7	18.4
561	Pine	1	200	4	0	PL	5.7	16	19.9		0	10588	0	0	PLI	6.2	16	19.8	19.9	21.4	19.2
925	Pine	6	475	23	2	BL	0	0	18.1		0	15900	0	0	PLI	7.3	0	19.3	16.3	20.5	19.6
8711	Pine	13.1	951	74	32	BL	17.1	154	7		8.9	845	10	0	PLI	8.6	32	17.1	17.4	18.4	17.6
8716	Pine	0	0	0	0	0	0	0	0		0	30	0	0	PLI	3.9	0	15.5	18	18.5	17.9
81	Spruce	5.2	475	18	0	SX	8.4	29	19.8		0	4358	0	0	SX	3	22	17.3	16.4	20.4	17.9
111	Spruce	5.9	826	17	0	SE	6.3	23	21.5		0	1475	0	0	SX	2.1	21	0	18.3	18.9	19.5
204	Spruce	1.4	200	5	0	SX	7.1	30	17.7		4	1800	0	0	SX	3	25	0	16.4	16.4	18.9
205	Spruce	15.3	951	55	0	PL	8.4	21	20.3		0	2200	0	0	SX	3.6	21	0	19.5	19.3	18.3
206	Spruce	18	1151	94	0	PL	11.9	32	19.1		21.1	2548	23	0	SX	9.5	31	16	17.8	18	17.1
207	Spruce	0.9	150	3	14	SX	4	18	20		0	1800	0	0	SX	3.6	27	0	19.5	19.8	15
214	Spruce	14.9	1201	62	1	PL	9.3	25	19.1		0	1400	0	0	SX	4.8	25	19.3	19.2	12	12
215	Spruce	21.1	851	97	0	SW	12	35	21.8		6	1500	0	0	SW	5.6	34	22.3	18.2	20.7	20.1
216	Spruce	16	926	59	0	SW	9.5	26	23.7		0.5	900	0	0	SW	4.2	24	21.8	21.4	22	20
220	Spruce	20.2	1076	125	22	SW	15.5	123	11.4		35	1487	193	0	SW	21.4	44	20.1	19.8	21.3	20.4
221	Spruce	26.9	1326	119	0	PL	10.2	26	19.7		1	2350	0	0	SW	2.6	21	0	0	0	0
223	Spruce	22.4	1576	105	0	SX	12	36	21.4		16.1	1868	16	0	SX	10.6	31	18.2	18.6	19.8	18.8
225	Spruce	8.2	976	26	0	SW	9.4	27	23		0	1864	0	0	SW	5.6	34	23	15.6	21.6	21.6
230	Spruce	1.3	50	7	0	PL	10.8	34	17.1		22.2	1779	61	0	SW	16.2	41	20.5	19.6	19.2	12
231	Spruce	21.1	1176	112	0	SX	0	0	0		0	5000	0	0	SX	6.1	0	23.2	20.8	21	19.5
233	Spruce	21.5	625	146	0	SX	18.8	49	22.7		5.3	578	8	0	SX	10	46	22	21.5	21.6	21.6
235	Spruce	21.3	1551	112	0	PL	12.3	25	23.5		0	4913	0	0	SX	5.7	24	0	0	0	0
237	Spruce	9.1	425	47	1	BL	11.4	75	9.9		0	1700	0	0	SX	2.6	21	0	20.3	20.7	19.1
241	Spruce	13.9	225	80	0	S	17	44	23.1		4.6	615	3	0	S	8.8	44	23	20.3	21	19.8
244	Spruce	24.5	1476	136	2	PL	12.9	27	22.9		0	1778	0	0	SXW	2.1	21	0	0	0	0

		Phase I		Phase II							Phase I							Site	Prod	Layer	
samp_no	Strata	BA 7.5	TPH 7.5	WSV 7.5	WSV dead	Spp1	HT1	Age1	SI1	BA 12.5	TPH 12.5	Vol 12.5	Dead Vol	Spp1	HT1	Age1	SX	BL	PL	AT
247	Spruce	2.2	275	6	0	SX	6.2	22	21.4	0	1735	0	0	SX	2.6	21	22	20.9	21.6	21.2
249	Spruce	25.2	1426	126	0	S	11.6	28	25.2	20	1799	29	0	SX	11	30	19.4	16.1	20.6	19.5
250	Spruce	18.2	1526	68	0	S	9.1	25	24.3	0	4633	0	0	SX	2.6	19	0	0	0	0
251	Spruce	13	450	55	7	SX	10.5	34	20.3	12.1	1118	19	0	SX	11.7	34	0	0	0	0
252	Spruce	40	1776	296	48	BL	19.5	63	19	6	4550	0	0	SXW	7.3	42	22	19.7	21.3	21
255	Spruce	20.4	1426	85	0	S	10.7	29	23.7	20	5500	0	0	SX	8	27	0	0	0	0
256	Spruce	22.7	2201	105	0	AT	14.9	19	31	0	3224	0	0	SX	1.9	20	19.1	16.3	20.5	19.7
257	Spruce	33.8	876	179	1	FD	15.8	41	21.7	6	2350	0	0	SXW	5	32	22.3	18.9	20.5	21.8
259	Spruce	25.7	1851	123	0	SX	13.1	38	21.8	10.8	928	29	0	SX	12	38	0	0	0	0
260	Spruce	18.7	1001	77	0	SX	10.4	29	23.6	0	1250	0	0	SXW	2.5	23	21.8	23	22.5	21.1
261	Spruce	30.8	1676	204	0	SW	16.7	41	24.2	8	3631	0	0	SW	6.9	38	0	0	0	0
262	Spruce	22.2	976	100	0	SX	12.5	35	22.7	5.1	662	4	0	SX	9.2	39	0	21	21	19.7
263	Spruce	13.1	1126	50	0	SX	9.5	30	21.4	0	1300	0	0	SX	4.3	26	21.8	19.7	21.5	21.3
264	Spruce	24.9	1876	121	0	PL	12.2	28	21.1	2	2125	0	0	SW	3.6	27	19.1	17.7	21.2	20.9
265	Spruce	18	851	132	0	EP	19.9	35	26	20	1907	0	0	SW	5.6	34	18.9	17.3	15.6	13.2
266	Spruce	4.2	600	20	1	AT	12.8	26	21.7	0	3100	0	0	SX	4.3	26	18.7	15.7	20.6	16.8
267	Spruce	5.8	650	29	41	PL	12.3	32	19.6	0	1400	0	0	SX	6.5	30	21.8	20.7	22	20.2
273	Spruce	6.1	150	37	24	BL	9.8	35	19	0	1720	0	0	SW	2.1	21	17.7	16.9	20.2	18.4

13 Appendix B – Plot Data Summaries

Table 31. The AU assumptions associated with each sample are given. All are the curve type "ex_ngd_std_FG".

		Ground		Analysis Unit VOL2 (ground leading species)				Analysis Unit VOL3 (Phase I leading species)					
BEC	Sample	Leading species	Age	Label	AU	TPH	Regen		Label	AU	Util (cm)	TPH	Regen
SBS	64			SBS_	.	5000	N	PLI	SBS_P	34	12.5	1200	P
SBS	81	SX	29	SBS_S	92	3800	N	SX	SBS_S	92	17.5	3800	N
ESSF	111	SE	23	ESSF_S	74	3100	N	SX	ESSF_S	74	17.5	3100	N
SBS	200	PL		SBS_P	91	5700	N	PLI	SBS_P	34	12.5	1200	P
SBS	201	PL	23	SBS_P	91	5700	N	PLI	SBS_P	91	12.5	5700	N
ESSF	202	PL	24	ESSF_P	73	5000	N	PLI	ESSF_P	73	12.5	5000	N
ESSF	204	SX	30	ESSF_S	74	3100	N	SX	ESSF_S	74	17.5	3100	N
ESSF	205	PL	21	ESSF_P	73	5000	N	SX	ESSF_S	74	17.5	3100	N
SBS	206	PL	32	SBS_P	91	5700	N	SX	SBS_S	92	17.5	3800	N
ESSF	207	SX	18	ESSF_S	74	3100	N	SX	ESSF_S	74	17.5	3100	N
SBS	208	S	25	SBS_S	92	3800	N	PLI	SBS_P	91	12.5	5700	N
SBS	210	PL	32	SBS_P	91	5700	N	PLI	SBS_P	91	12.5	5700	N
SBPS	211			SBPS_	.	5000	N	PL	SBPS_P	27	12.5	1300	P
SBS	212	PL	23	SBS_P	91	5700	N	PLI	SBS_P	91	12.5	5700	N
SBS	214	PL	25	SBS_P	91	5700	N	SX	SBS_S	92	17.5	3800	N
SBS	215	SW	35	SBS_S	92	3800	N	SW	SBS_S	92	17.5	3800	N
SBS	216	SW	26	SBS_S	92	3800	N	SW	SBS_S	92	17.5	3800	N
SBS	219	PL	29	SBS_P	91	5700	N	AT	SBS_A	.	17.5	5000	N
SBS	220	SW	123	SBS_S	92	3800	N	SW	SBS_S	92	17.5	3800	N
ESSF	221	PL	26	ESSF_P	73	5000	N	SW	ESSF_S	74	17.5	3100	N
SBS	222	BL	84	SBS_B	86	3600	N	BL	SBS_B	86	17.5	3600	N
SBS	223	SX	36	SBS_S	92	3800	N	SX	SBS_S	92	17.5	3800	N
ICH	224	SX	24	ICH_S	81	4200	N	EP	ICH_E	.	17.5	5000	N
ICH	225	SW	27	ICH_S	81	4200	N	SW	ICH_S	81	17.5	4200	N
SBS	226	AT	37	SBS_A	.	5000	N	AT	SBS_A	.	17.5	5000	N
ESSF	227	PL	15	ESSF_P	73	5000	N	PLI	ESSF_P	73	12.5	5000	N
SBS	228	PL	22	SBS_P	91	5700	N	PLI	SBS_P	91	12.5	5700	N
SBS	229	PL	27	SBS_P	91	5700	N	PLI	SBS_P	91	12.5	5700	N
SBS	230	PL	34	SBS_P	91	5700	N	SW	SBS_S	92	17.5	3800	N
SBS	231	SX		SBS_S	92	3800	N	SX	SBS_S	35	17.5	1300	P
ICH	232	AT	39	ICH_A	.	5000	N	PL	ICH_P	80	12.5	2900	N
SBS	233	SX	49	SBS_S	92	3800	N	SX	SBS_S	92	17.5	3800	N
SBS	234	PL	19	SBS_P	91	5700	N	PLI	SBS_P	91	12.5	5700	N
SBS	235	PL	25	SBS_P	91	5700	N	SX	SBS_S	92	17.5	3800	N
SBS	237	BL	75	SBS_B	86	3600	N	SX	SBS_S	92	17.5	3800	N
SBS	239	BL	44	SBS_B	86	3600	N	BL	SBS_B	86	17.5	3600	N
SBS	240	PL	23	SBS_P	91	5700	N	PLI	SBS_P	91	12.5	5700	N
SBS	241	S	44	SBS_S	92	3800	N	S	SBS_S	92	17.5	3800	N
SBS	242	PL	33	SBS_P	91	5700	N	PLI	SBS_P	91	12.5	5700	N
SBS	243	PL	27	SBS_P	91	5700	N	PLI	SBS_P	91	12.5	5700	N
SBS	244	PL	27	SBS_P	91	5700	N	SXW	SBS_S	92	17.5	3800	N
SBS	245	AT	26	SBS_A	.	5000	N	PL	SBS_P	91	12.5	5700	N

		Ground		Analysis Unit VOL2 (ground leading species)				Analysis Unit VOL3 (Phase I leading species)					
BEC	Sample	Leading species	Age	Label	AU	TPH	Regen		Label	AU	Util (cm)	TPH	Regen
SBS	246	PL	31	SBS_P	91	5700	N	PLI	SBS_P	91	12.5	5700	N
SBS	247	SX	22	SBS_S	92	3800	N	SX	SBS_S	92	17.5	3800	N
SBS	248	PL	25	SBS_P	91	5700	N	AT	SBS_A	.	17.5	5000	N
SBS	249	S	28	SBS_S	92	3800	N	SX	SBS_S	92	17.5	3800	N
SBS	250	S	25	SBS_S	92	3800	N	SX	SBS_S	92	17.5	3800	N
SBS	251	SX	34	SBS_S	92	3800	N	SX	SBS_S	92	17.5	3800	N
SBS	252	BL	63	SBS_B	86	3600	N	SXW	SBS_S	92	17.5	3800	N
SBS	253	PL	29	SBS_P	91	5700	N	PLI	SBS_P	91	12.5	5700	N
SBS	254	PL	29	SBS_P	91	5700	N	PLI	SBS_P	91	12.5	5700	N
SBS	255	S	29	SBS_S	92	3800	N	SX	SBS_S	92	17.5	3800	N
SBS	256	AT	19	SBS_A	.	5000	N	SX	SBS_S	92	17.5	3800	N
SBS	257	FD	41	SBS_F	89	4700	N	SXW	SBS_S	92	17.5	3800	N
SBS	258	PL	38	SBS_P	91	5700	N	PLI	SBS_P	91	12.5	5700	N
SBS	259	SX	38	SBS_S	92	3800	N	SX	SBS_S	92	17.5	3800	N
SBS	260	SX	29	SBS_S	92	3800	N	SXW	SBS_S	92	17.5	3800	N
SBS	261	SW	41	SBS_S	92	3800	N	SW	SBS_S	92	17.5	3800	N
SBS	262	SX	35	SBS_S	92	3800	N	SX	SBS_S	92	17.5	3800	N
SBS	263	SX	30	SBS_S	92	3800	N	SX	SBS_S	92	17.5	3800	N
SBS	264	PL	28	SBS_P	91	5700	N	SW	SBS_S	92	17.5	3800	N
SBS	265	EP	35	SBS_E	.	5000	N	SW	SBS_S	92	17.5	3800	N
SBS	266	AT	26	SBS_A	.	5000	N	SX	SBS_S	92	17.5	3800	N
SBS	267	PL	32	SBS_P	91	5700	N	SX	SBS_S	92	17.5	3800	N
SBS	268	SX	30	SBS_S	92	3800	N	AT	SBS_A	.	17.5	5000	N
SBS	269	PL	21	SBS_P	91	5700	N	PLI	SBS_P	91	12.5	5700	N
SBS	272	PL	32	SBS_P	91	5700	N	BL	SBS_B	86	17.5	3600	N
SBS	273	BL	35	SBS_B	86	3600	N	SW	SBS_S	92	17.5	3800	N
SBS	381	SX	33	SBS_S	92	3800	N	FDI	SBS_F	89	12.5	4700	N
SBS	436	SX	43	SBS_S	92	3800	N	BL	SBS_B	86	17.5	3600	N
SBS	561	PL	16	SBS_P	91	5700	N	PLI	SBS_P	91	12.5	5700	N
SBS	908	SX	21	SBS_S	92	3800	N	SX	SBS_S	92	17.5	3800	N
SBS	925	BL		SBS_B	86	3600	N	PLI	SBS_P	34	12.5	1200	P
SBS	8711	BL	154	SBS_B	86	3600	N	PLI	SBS_P	91	12.5	5700	N