Young Stand Monitoring in the Williams Lake TSA: Plot Establishment Report

A Technical Report

Ministry of Forests, Lands, and Natural Resource Operations

Forest Analysis and Inventory Branch

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EXECUTIVE SUMMARY

Seventy-nine ground plots were established in the Williams Lake Timber Supply Area (TSA) to monitor young stands. One plot was subsequently dropped. The target population was 15 to 50 year old stands which represent approximately 370,000 ha within a vegetated land base of approximately 3,500,000ha.

Overall, the whole stem volume differences were marginally statistically significant (p = 0.047). The volume bias was relatively large (38% of ground volume) but was highly variable.

The bias associated with age and height was not statistically significant but ground SI was statistically different from the PSPL and likely contributes to the volume differences.

Table 1. The results of comparing the ground plots to the inventory and to the YSM assumptions are summarized. A prob(bias = 0) of less than 0.05 is generally considered an indication of statistically significant differences (or bias).

Attribute	N	Ground mean	Comparison	Inventory mean	Bias		
					Magnitude	% of ground mean	prob(bias = 0)
Whole stem volume (m^3/ha)	78	45.1	TIPSY	62.3	-17.3 ± 8.6	-38%	0.047
Volume attribute bias (m^3/ha)	78		TIPSY		-17.1 ± 7.3	-38%	0.021
Volume model bias (m^3/ha)	78		TIPSY		-0.1 ± 4.1	0%	0.977
Species matched age (yrs)	70	36.2	VRI	32.4	3.8 ± 2.1	11%	0.069
Species matched height (m)	68	9.0	VRI	8.2	0.8 ± 0.5	9%	0.123
Site index (m)	61	15.5	PSPL	16.8	-1.2 ± 0.5	-8%	0.009

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 is not fixed and this has implications for the comparison. This should be noted in any analyses involving young polygons.

The samples 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 10.3 ± 1.4 m^2/ha (ranging from 0 – 60.5. m^2/ha) and the average stems/ha was 796 ± 99 (ranging from 0 – 4,703). The average age of the leading species was 35 ± 3 years (ranging from 14 – 138 years) and height was 8.8 ± 0.6 m (ranging from 1.5 – 26.4 m). Fifty-one of the samples were pine-leading followed by Douglas-fir (7), spruce (6), balsam (5), cedar (3), and poplar/birch (3). Three plots did not have any live trees. There was an average of approximately 191 dead stems/ha, mostly small pine. Approximately 63% of the live stems, or an average of 1045 stems/ha, had signs of damage. Pine had the highest fraction of stems with damage (74%) and the cause of most of the damage was unknown (54%) followed by disease (21%) and insect (20%).

The results here do not indicate any major issues with the Williams Lake YSM Phase I attributes or TIPSY volumes. However, a key monitoring objective is to compare observed to forecasted growth. The samples should be remeasured, as planned in order to confirm if trends meet expectations as predicted in TSR.

A VRI analysis of the Williams Lake is documented in a separate report, available from the Ministry of Forests, Lands and Natural Resource Operations, and includes stand and stock tables for both the mature and YSM portion of the TSA at: http://www.for.gov.bc.ca/hts/vri/planning_reports/tsa_analysis.html

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1 Introduction

The British Columbia Ministry of Forests, Lands and Natural Resource Operations Forest Analysis and Inventory Branch (FAIB) 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 Williams Lake 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 Vegetation Resources Inventory (VRI) polygon attributes (e.g., age, height 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.

3 Sample Design

3.1 Population

The monitoring unit, the geographic area of interest, is the Williams Lake TSA which is located in southcentral British Columbia (Figure 1). The Williams Lake TSA has approximately 5 million hectares, approximately 57 percent of which is considered productive forest (Table 2).

Table 2. Williams Lake TSA Land Base (taken from Nona Phillips Forestry Consulting 2013).

Land Classification	Area (ha)	% of TSA
Total TSA Area	**4,933,664**	**100.0%**
Net-downs	**844,545**	**17.1%**
Military Reserve	6	0.0%
Parks	588,926	11.9%
Private	231,605	4.7%
Indian Reserve	24,008	0.5%
Net Area	**4,089,119**	**82.9%**
Non-Vegetated	582,017	11.8%
Vegetated	3,507,102	71.1%
Non-Treed	682,644	13.8%
Treed	2,824,458	57.2%

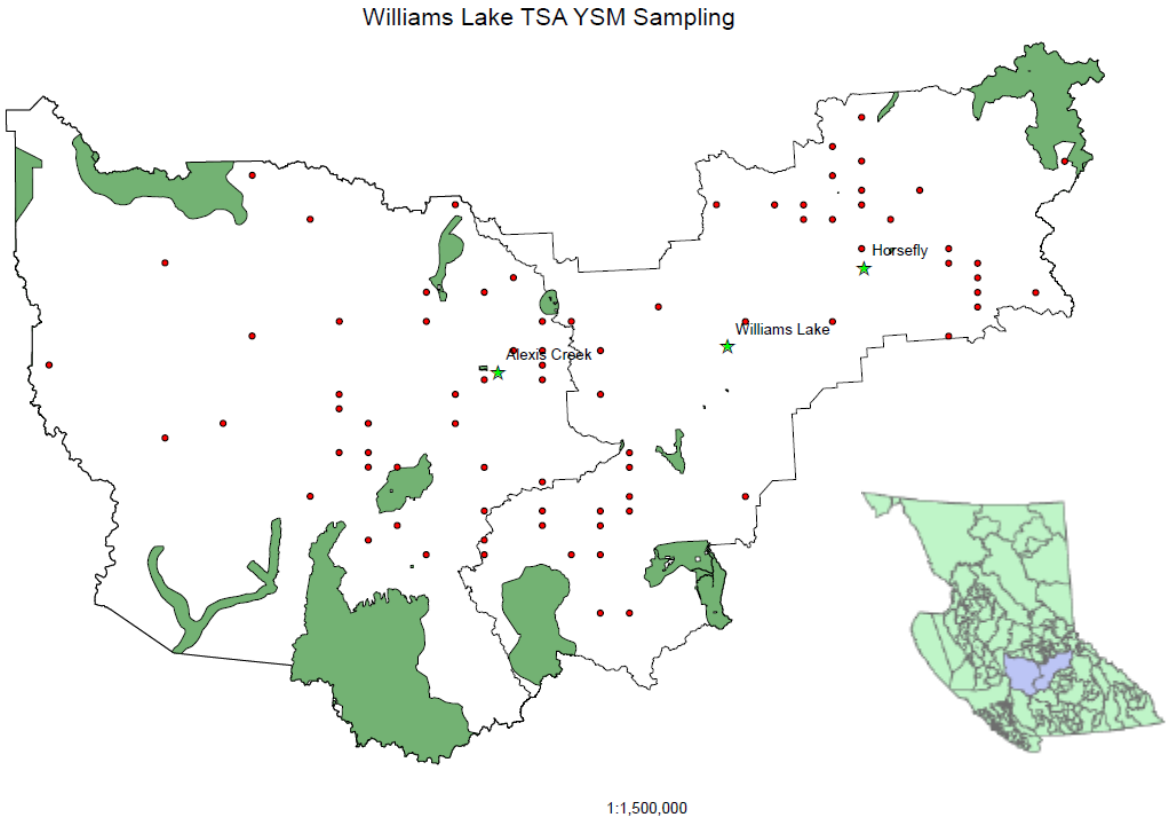

Figure 1. The location of the Williams Lake TSA and the YSM samples (from FAIB).

3.2 Target Population

The YSM target population is composed of 15- to 50-year-old young stands within the Williams Lake TSA (Table 2). The population was not restricted to vegetated treed polygons. It includes all stands in the age range (including silvicultural openings with CC < 10%). The ground sampling plan is described in Nona Phillips Forestry Consulting (2013).

Table 3. Williams Lake TSA YSM population is summarized by leading species. From Nona Phillips Forestry Consulting (2013).

Inventory Leading Species	Area (ha)	% of YSM population
Pine (PL)	242,218	66%
Douglas-Fir (FD)	47,500	13%
Spruce (SX)	43,063	12%
Aspen (AT)	19,009	5%
Balsam (BL)	8,696	2%
Cedar (CW)	5,396	1%
Birch (EP)	2,260	1%
Hemlock (HW)	1,238	0%
Larch (LW)	2	0%
Total	369,382	100%

3.3 Sample Selection

The YSM target population was not stratified prior to sample selection. The sampling design was a systematic sample on a fixed grid. Five grids were tested and, based on FAIB direction, the 5 x 10 km grid was selected, yielding 79 samples with no alternates. The samples were numbered from 200 – 278 (see Appendix A). As noted in section 4.2, sample 273 was subsequently dropped.

3.4 Plot Design & Establishment

Seventy-nine plots were established from April – September 2013 following the plot design and establishment CMI protocol[1]. 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.

There were no substitutions or movements of plots. Sample 227 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 retained and paired with the inventory data from the intended sample plan polygon.

The sampling intensity, the proportion of the area samples, was approximately 0.00085% based on 79 0.04 ha samples and a population size of 369,382 ha.

4 Data Compilation

4.1 Ground plot attributes

The tree level file was used to compile most attributes (volume, BA, etc.). The attributes are defined in Table 4 and summarized in Table 8.

Table 4. Definitions of attributes extracted from the VRI/CMI compiler at plot establishment (Source of definitions: Churlish, 2003)[2].

Attribute	Utilization	Compiler Name	Variable Description
Height	7.5 cm	Ht_txo	Mean Total height for T, X and O trees by species.
Age	7.5 cm	Aget_txo	Mean Total Age for T, X and O trees by species.
Site index	7.5 cm		The average SI by species. The SI for each suitable SI tree is computed using SiteTools and the average computed by species.
Species comp.	4.0 cm	Spb_cpct	Species composition by Basal Area.
Basal area	7.5 cm	Ba_ha	Basal area/ha (live trees).
Stems/ha	7.5 cm	Stems_ha	Number of stems/ha (live trees).
Gross volume	7.5 cm	Vha_wsv	Whole stem volume/ha (live trees).
Net volume	12.5 cm	Vha_nwb	Net stem volume/ha (live trees): Gross stem volume less cruiser-called decay volume and volume of waste, breakage, top and stump.
Mortality	7.5 cm	Vha_wsvd	Whole stem volume/ha (dead trees).

[1] http://archive.ilmb.gov.bc.ca/risc/pubs/teveg/nficmp2012/CMI%20Procedures_ver1_2012_Final.pdf
[2] G. Churlish. 2003. Data dictionary for the vegetation resources inventory and national forest inventory timber data (summary files).

4.2 Ground plot data screening

Samples 202, 228, 236, 250 and 258 were boundary plots and sampled using the walkthrough method (Ducey et al. 2004) and compiled accordingly.

The data were screened to detect any errors and departures from the intended YSM population. Sample 273 was part of the YSM population at the time of the sample plan (with a projected age of 33 in 2011). A more recent update with the RESULTS (Reporting Silviculture Updates and Land status Tracking System) layer places the sample in a polygon with an age of 7. The corresponding ground data (4 pine trees with Dbh < 4cm and one deciduous tree with Dbh = 20 cm) are consistent with a very young plot. The RESULTS-revised Phase I label for the sample does not meet the YSM population definition and sample 273 was dropped from further analysis.

There were a number of trees sampled for age, height and site index that were very young. These were reviewed by FAIB staff and trees with a breast height age < 5 years were not used in the site index calculations.

There were a number of plots with zero volume. Samples 211, 213, 214, 224, 241, 244, 259 and 269 had live trees but none with Dbh ≥ 7.5cm. Sample 258 had only dead trees. Samples 212 and 270 had no trees.

Plots with large, old trees and high volumes were also examined in more detail. The summaries are based on all live, measured trees.

Seven plots have a mean age (AT_M_TLS) greater than 60 (Table 5). These ages may represent residual trees after selective disturbance. All were retained in the analysis.

Table 5. The samples with a ground mean age greater than 60 are given (Dbh ≥ 7.5 cm).

Sample	HT_MNALL (m)	HT_M_TLS (m)	AT_M_TLS (years)	Basal area (m^2/ha)	Tree/ha	Whole stem volume (m^3/ha)
0225	10.4	19.4	91	27.8	1276	156
0226	12.7	19.7	138	3.2	50	23
0230	11.5	17.7	71	37.7	1451	253
0236	9.5	14.8	82	34.1	2327	191
0243	12.3	13.8	85	19.3	2477	114
0245	11.8	14.5	78	20.3	1576	109
0257	12.0	14.7	65	15.2	625	78

Sample 278 the highest ground basal area (60.5 m^2/ha) and volume (356 m^3/ha). Eight trees were sampled for age. One had a total age of 51.5, another had a total age of 50.5 and the rest had a total age less than 50. Despite the high volume the plot is part of the YSM population.

Sample 265 appears to have a layer of larger aspen (Dbh = 18.5 – 242.4 cm) over a layer of smaller pine (Dbh < 15 cm). Each layer contributes approximately the same amount of basal area (Dbh ≥ 4.0 cm).

Seven samples had more than 50 m^3/ha of dead whole stem volume (Dbh ≥ 7.5 cm) (see Appendix B). These were samples 201 (86 m^3/ha of dead volume), 215 (71 m^3/ha of dead volume), 226 (105 m^3/ha of dead volume), 234 (85^3/ha of dead volume), 235 (60 m^3/ha of dead volume), 277 (71 m^3/ha of dead volume), and 278 (103 m^3/ha of dead volume).

4.3 Ground sampling year and projection year

The ground sampling occurred from April 30, 2013 to October 7, 2013. The projection date for the Phase I data was January 1, 2013. For ground measurements after June 30, the age was increased by 1.

4.4 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 assessment had a breast height age ≥ 5 years, a total age, a height, and the height and site index suitability flags = Y. 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. The suitable SI trees were then processed by SiteTools using the sindex33.dll using breast height age and total height. The SiteTools growth intercept estimate was used, if available. Otherwise the SiteTools site index estimate was used.

4.5 Phase I (Inventory) data

Inventory information for recently disturbed polygons generally comes from the RESULTS (Reporting Silviculture Updates and Land status Tracking System) layer. These polygons are processed by VDYP7 to project them to the year of ground sampling. For stands less than 7 m tall, VDYP 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 211 in Appendix B which has a PROJ_HEIGHT_1 = 0.1 m and 7,439 trees/ha. The utilization limit is based on Dbh, implying that trees must be at least 1.3 m tall so the height for sample 211 does 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.

The Phase I (Inventory) SI was taken from the provincial site productivity layer (PSPL). The PSPL provides SI for up to 22 species. The intersection of the provincial site productivity layer and the ground plots was provided by the FAIB. Of the 78 YSM ground plots, three did not have any trees to determine and leading species and two were AT leading and there was not an associated AT site index estimate in the site productivity layer.

4.6 Height and Age matching

The height and age data matching followed the FAIB (2011) VRI procedures. The ground plot data were matched with the corresponding VRI Phase I data for the polygon. The ground plot heights and 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 6.

Table 6. 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

4.7 Stratification

The samples were stratified by BEC, leading species and leading species age (Table 7).

Table 7. The strata used to summarize the results are defined.

Stratification	Strata	Definition
BEC	ICH	ICH
	IDF	IDF
	Other	ESSF, MS, SBS
	SBPS	SBPS
Leading species (Phase I inventory)	Other	AT, BL, CW, FD, SE, SXW, SW
	Pine	PLI
Age (Phase I Inventory)	Young	ages 15-30
	Older	ages 31-50

5 Stand structure and health

The ground data are summarized in Table 8.

Table 8. The Williams Lake 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. All are given at the 7.5cm utilization.

Attribute	N	Statistic (n = 78)				
		Mean	Minimum	Maximum	SE	SE%
Basal area (m^2/ha)	78	10.3	0.0	60.5	1.4	13%
Trees per hectare (stems/ha)	78	796	0	4703	99	12%
Gross volume live (m^3/ha)	78	53.9	0.0	355.5	8.1	15%
Gross volume dead (m^3/ha)	78	10.5	0.0	105.1	2.8	27%
Volume net of decay, waste & breakage (m^3/ha)	78	32.3	0.0	229.4	5.5	17%
Leading species age (years)	77	35	14	138	2.6	7%
Leading species height (m)	75	8.8	1.5	26.4	0.6	7%

The average number of dead trees was 191 trees/ha. 75% of the dead trees have a Dbh < 12.5cm and 70% are pine.

Table 9. 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.

Species		Dbh Class (cm)							
Group		5	10	15	20	25	30+	Total	Fraction
AT	Poplar	3	2	1	1		0	6	3%
BL	Balsam	15	5	1			0	22	11%
CW	Cedar	3		0			2	5	3%
FD	Douglas-fir	4	6	3	1	2	0	17	9%
PL	Pine	55	48	24	6	2	0	135	70%
SX	Spruce	1	2	1		1	0	5	3%
XC	Unknown conifer			0	0	1	1	2	1%
Total		81	63	30	9	5	4	191	
Fraction		42%	33%	16%	5%	3%	2%	100%	

Approximately 63% of the trees show signs of damage (Table 10 and Figure 2). The cause of most of the damage is unknown (54%) followed by insect and disease (41%). Pine has the largest fraction of trees with damage (74%).

Table 10. Live trees per hectare are given by species and primary damage agent. The data are graphed in Figure 2a.

	Damage Agent							Total damage (% of species
sp0	Abiotic	Animal	Disease	Unknown	Insect	Treatment	None	TPH with damage)
AT	0	2	3	36			69	41 (37%)
BL	8		0	52	32		88	92 (51%)
CW		2		28			57	30 (34%)
EP				6			16	6 (28%)
FD	3		1	46	1	1	48	52 (52%)
HW				23			42	23 (36%)
PL	16	11	218	310	81		228	636 (74%)
S	2		2	62	99		75	165 (69%)
	3%	1%	21%	54%	20%	0%		1045 (63%)

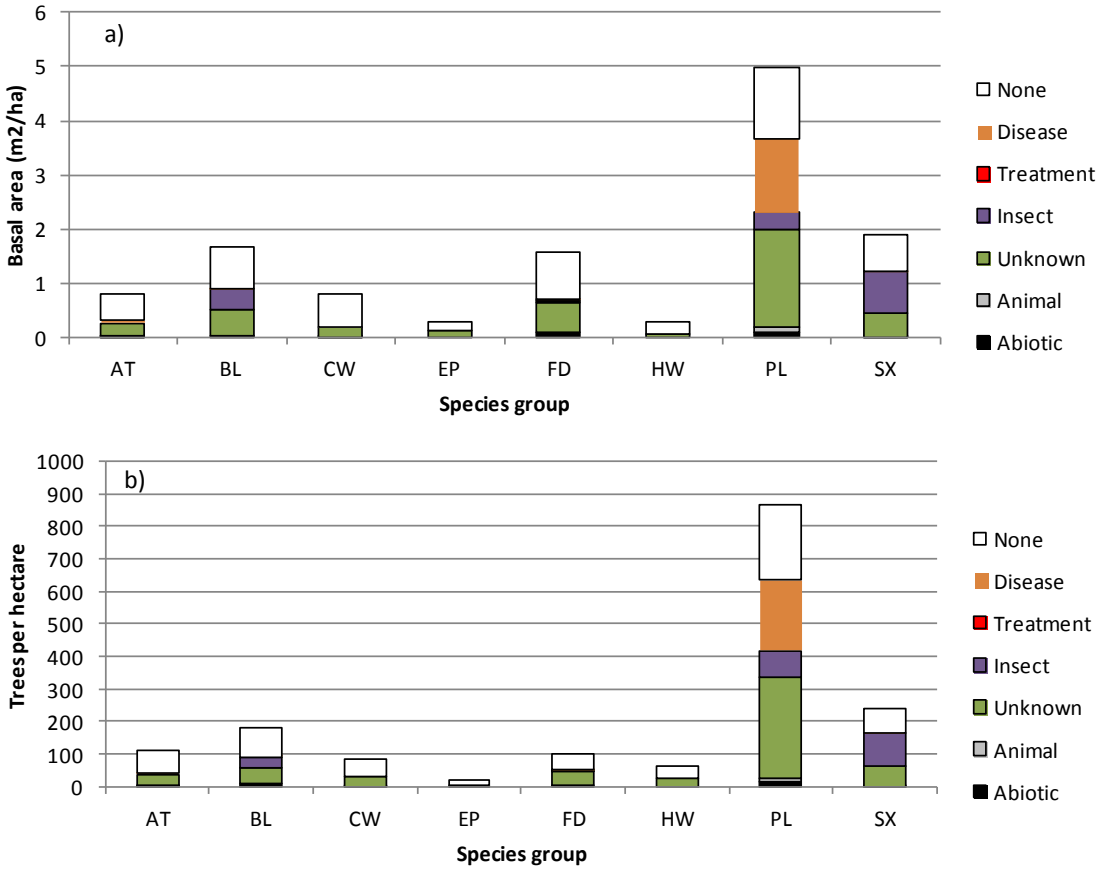

Figure 2. The basal area (a) and stems/ha (b) affected by each primary damage agent is given by species for live trees.

6 Ground vs. Inventory

6.1 Stand Age and Height

A total of 70 plots had acceptable age matches, 68 had acceptable height pairs while 61 had acceptable SI pairs (Table 11). Six out of the 20 plots that were a case 2 match (ground leading species = Phase I second species) did not have an age and height associated with the second species. For Site index, two of the case 1 matches did not have a Ground SI. Of the case 2 matches, two did not have a ground SI, two did not have a ground leading species, two were AT leading and the site productivity layer did not include an AT SI for that plot and one was EP and EP does not appear in the site productivity layer.

Table 11. The results of the age, height and SI matching are given.

Case	Number of plots	Age pairs	Height pairs	SI pairs
1	50	50	48	48
2	20	13	14	13
3	6	6	5	0
4	1	1	1	0
5	1	0	0	0
All	78	70	68	61

The leading species height and age are compared in Table 12 and Figure 3 and the species- or case-matched height and age are given in Table 13. Overall, the age differences are just over 10% while the height differences are just below 10%. Although the age differences are statistically significant (Table 12), most are close and the significant result is heavily influenced by sample 226 (Figure 3). Sample 226 has only two live trees with Dbh ≥ 7.5 cm, and both are large (Dbh > 30 cm) and old (total age 95.5 and 180.5).

The stratification (and population definition) is based on the Phase I (VRI) age so it is possible for the average ground age to be 51.5 for the age 31-50 year age class.

Table 12. The leading species ground plot and VRI Polygon ages and heights are compared. Statistically significant differences (prob(bias = 0) < 0.05) are shaded.

	Age (years)					Height (m)				
Strata	N	Ground	VRI	Bias	prob(bias = 0)	N	Ground	VRI	Bias	prob(bias = 0)
ICH	14	47.6	37.2	10.3 ± 4.5	0.038	13	13.8	14.2	-0.4 ± 0.8	0.611
IDF	16	45.7	32.8	12.9 ± 6.8	0.080	16	8.4	8.4	0 ± 1.2	0.998
Other	17	30.3	29.8	0.5 ± 2.1	0.809	18	9.2	7.8	1.4 ± 0.8	0.095
SBPS	30	27.2	27.6	-0.4 ± 1.4	0.806	28	6.2	5.1	1.2 ± 0.6	0.065
Other	24	44.6	33.5	11.1 ± 5.1	0.041	24	11.9	11.3	0.6 ± 0.8	0.479
Pine	53	31.3	29.7	1.5 ± 1.3	0.229	51	7.2	6.5	0.8 ± 0.5	0.116
Age 15-30	42	22.0	22.6	-0.6 ± 0.8	0.455	41	5.4	5.2	0.2 ± 0.4	0.559
Age 31-50	35	51.5	40.8	10.7 ± 3.8	0.007	34	12.7	11.4	1.3 ± 0.8	0.111
All	77	35.4	30.9	4.5 ± 1.9	0.018	75	8.7	8.0	0.7 ± 0.4	0.093

Table 13. The case-matched ground plot and VRI Polygon ages and heights are compared. Statistically significant differences (prob(bias = 0) < 0.05) are shaded.

	Age (years)					Height (m)				
Strata	N	Ground	VRI	Bias	prob(bias = 0)	N	Ground	VRI	Bias	prob(bias = 0)
ICH	14	47.6	37.7	9.8 ± 4.5	0.048	13	13.8	14.7	-1.0 ± 0.6	0.153
IDF	16	45.7	33.9	11.7 ± 6.9	0.112	16	8.4	8.7	-0.3 ± 1.2	0.831
Other	15	31.4	32.4	-1.0 ± 3.5	0.776	16	9.4	6.7	2.7 ± 1.2	0.040
SBPS	25	26.7	28.4	-1.7 ± 0.8	0.053	23	6.3	5.2	1.1 ± 0.7	0.113
Other	21	47.8	36.4	11.4 ± 6.1	0.079	21	12.4	11.2	1.2 ± 1.2	0.315
Pine	49	31.2	30.7	0.6 ± 1.2	0.615	47	7.4	6.8	0.6 ± 0.5	0.252
Age 15-30	37	22.6	23.2	-0.6 ± 0.9	0.533	36	5.7	5.6	0.1 ± 0.4	0.818
Age 31-50	33	51.5	42.7	8.8 ± 4.1	0.041	32	12.6	11.1	1.5 ± 0.9	0.114
All	70	36.2	32.4	3.8 ± 2.1	0.069	68	9.0	8.2	0.8 ± 0.5	0.123

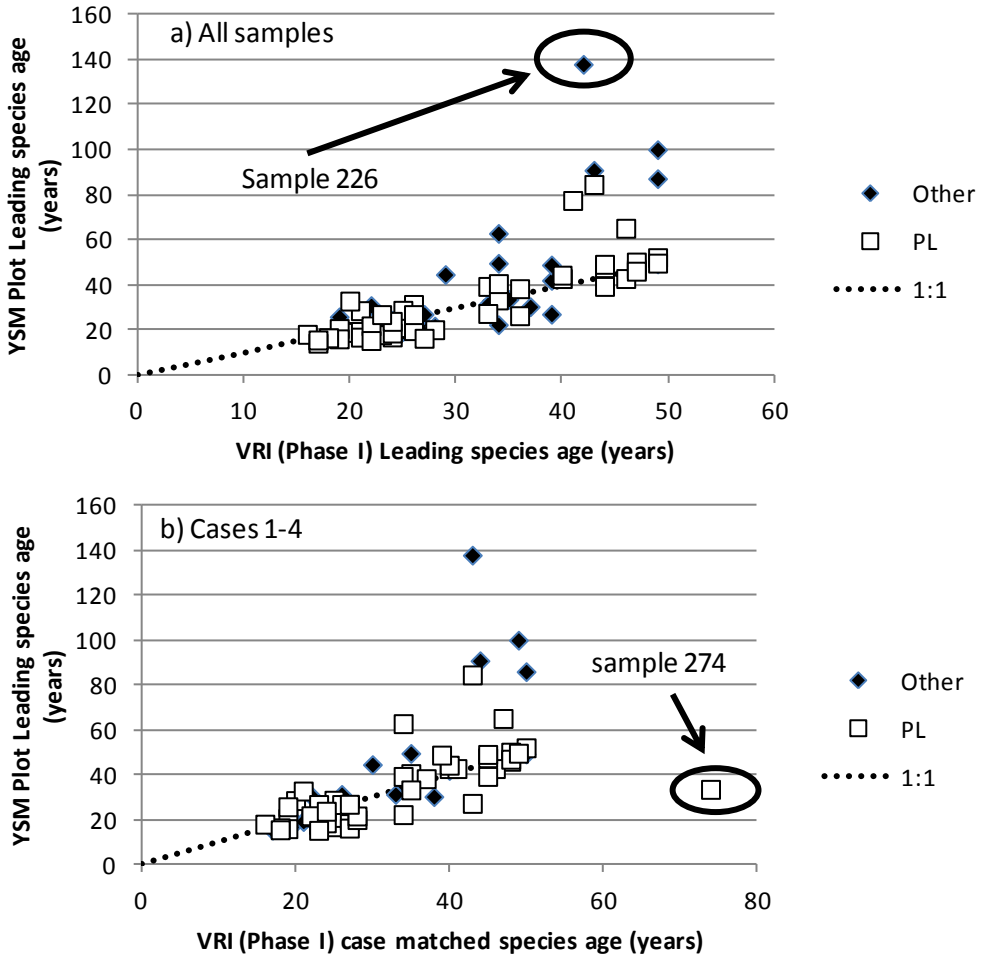

Figure 3. The VRI inventory (Phase I) and ground (YSM) leading species ages are compared (a) and the case-matched ages are compared (b). For sample 274, the inventory leading species age is 35 and the second species age is 74. The second species matches the ground leading species.

The relationship between ground and inventory height was more variable (Figure 4) but overall the bias is not statistically significant (0). As noted in section 4.5, the Phase I heights are not projected until the polygons reach a minimum height threshold and this may be responsible for the slight underestimation of height in the VRI (Phase I).

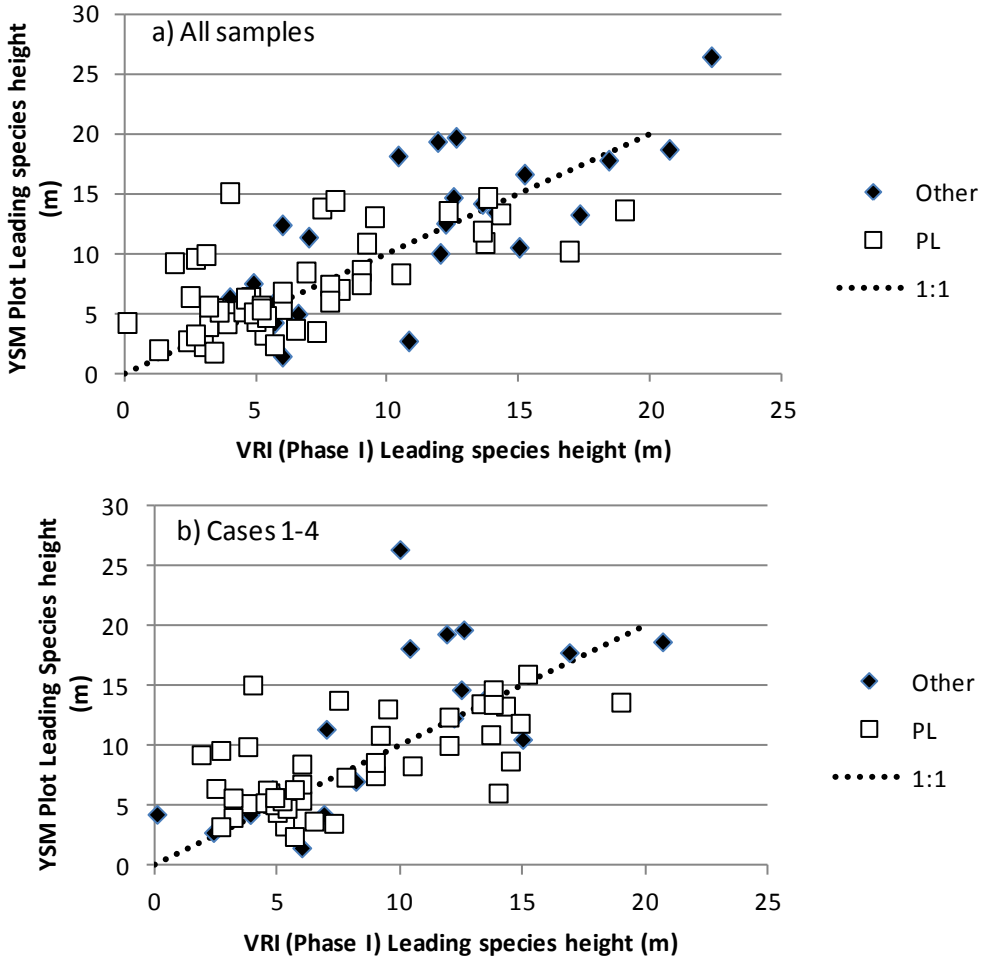

Figure 4. The VRI inventory (Phase I) and ground (YSM) leading species heights are compared (a) and the case-matched heights are compared (b).

6.2 Site index

The Phase I (inventory) site index (SI) is taken from the provincial site productivity layer (PSPL[3]). The PSPL SI values are taken from the PSPL tile with the largest overlap with the ground plot. The sample size for the PSPL SI is greater than the VRI inventory SI because of the species matching – the PSPL has more

[3] http://www.for.gov.bc.ca/hts/siteprod/download/FLNR_Provincial_Site_Productivity_Layer.pdf

species and more matches. As noted in the PSPL documentation[4], 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 PSPL estimates in the Williams Lake TSA are approved, indicating they passed a third party accuracy assessment based on published standards and procedures.

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 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 Williams Lake 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 flexibility in grouping points for weighting and averaging.

There was considerable variation in SI (Figure 5a) and evidence of statistically significant differences in SI (Table 14). There appears to be a trend of increasing differences as the ground leading species age increases (Figure 5b). The oldest ground sampled tree in the YSM population came from sample 226 and had a breast height age of 167 and an associated SI of 11.0. The other SI tree on the plot had a breast height age of 84 and an associated SI of 13.2m. The only other sample with a SI tree with a breast height age > 100 was sample 230. There were two cedar SI trees (cedar was the leading species). One tree had a breast height age of 114 and associated SI of 8.5m while the other tree had a breast height age of 63 and associated SI of 15.7m. The inclusion of older trees in the ground sample may be contributing to the differences in SI between the ground and PSPL.

A greater overestimation of SI by the site productivity layer was observed in the volume audit population where the SI of site productivity layer was 17.5 m vs. a ground SI of 13.7 m. The volume audit population has been recently inventoried and the Phase I inventory SI computed from the photo interpretation estimates of age and height did not have statistically significant bias.

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

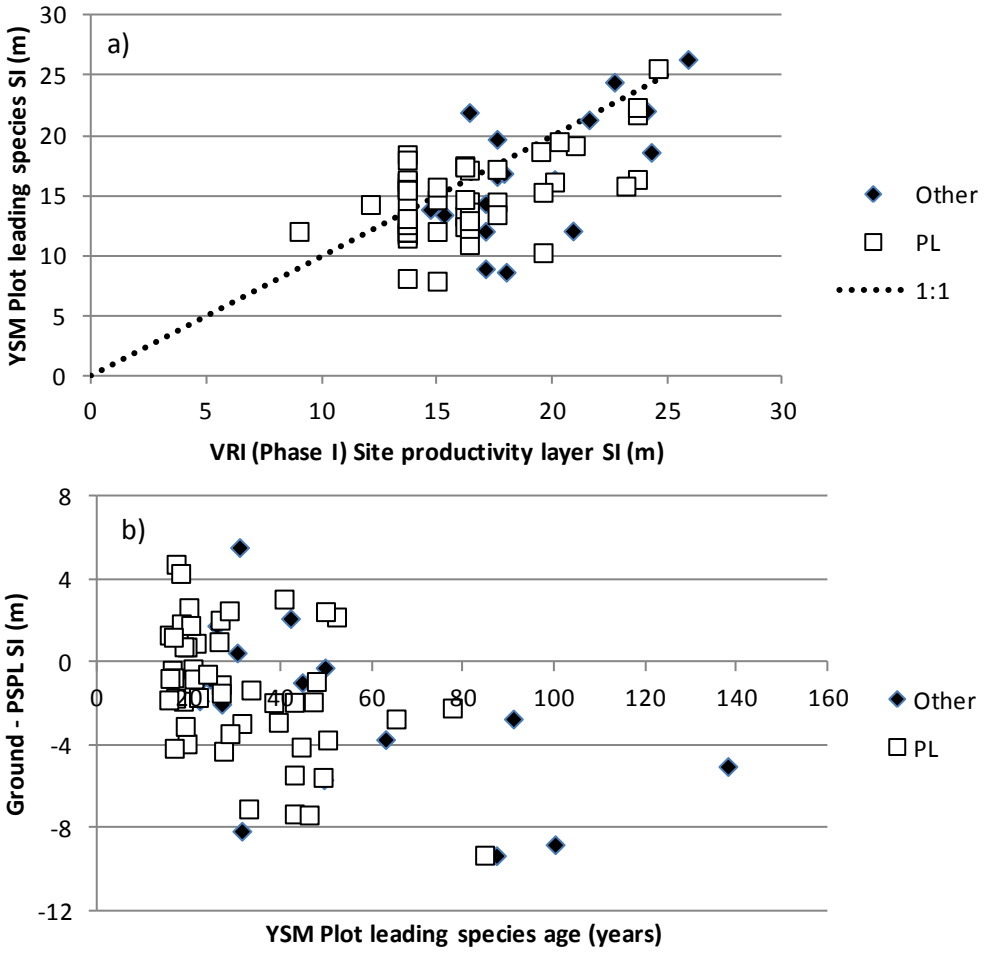

Figure 5. The inventory SI (from the PSPL) and ground leading species SIs are compared (a) and the differences plotted against the ground age (b). The site productivity layer SI corresponds to the ground leading species.

Table 14. The ground plot and VRI Polygon SI are compared. Statistically significant differences (prob(bias = 0) < 0.05) are shaded.

		SI (m)			
Strata	N	Ground	VRI (PSPL)	Bias	prob(bias = 0)
ICH	9	19.7	21.5	-1.8 ± 1.6	0.288
IDF	14	12.6	16.3	-3.7 ± 1.1	0.005
Other	14	16.6	17.5	-0.9 ± 0.7	0.255
SBPS	24	15	14.9	0.2 ± 0.5	0.735
Other	16	16.9	18.4	-1.5 ± 1.2	0.229
Pine	45	15.1	16.2	-1.2 ± 0.5	0.019
Age 15-30	36	15.5	16.2	-0.6 ± 0.6	0.275
Age 31-50	25	15.6	17.7	-2.1 ± 0.8	0.010
All	61	15.5	16.8	-1.2 ± 0.5	0.009

6.3 Leading Species

Forty-nine (63%) of the plots had the same inventory and ground leading species.

Table 15. 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	AT	BL	CW	EP	FD	PL	SX
None						3	
AT						2	
BL		1					4
CW		1	2				
EP					1		
FD					4	3	
PL	6				1	42	2
SX	1		1			3	1

6.4 Basal area and trees/ha

As noted in section 4.5, the original source of the Phase I Inventory trees/ha (TPH) and basal area (BA) is 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 VDYP 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.

The ground and Phase I (Inventory) basal area (BA) and trees per hectare (TPH) are compared in Table 16. The average Phase I TPH is 2875 stems/ha and the BA is 8.0 m^2/ha which corresponds to a quadratic mean Dbh of 6.0 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 associated with the 15 - 30 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.

Table 16. The ground plot and VRI Polygon basal area are compared. Statistically significant differences (prob(bias = 0) < 0.05) are shaded.

		Trees/ha				BA (m^2/ha)			
Strata	N	Ground	Inventory	Bias	prob(bias = 0)	Ground	Inventory	Bias	prob(bias = 0)
ICH	14	1431	1574	-142 ± 177	0.436	22.2	23.8	-1.6 ± 3.0	0.595
IDF	16	583	2177	-1594 ± 780	0.059	6.9	7.1	-0.2 ± 1.9	0.930
Other	18	1162	2402	-1240 ± 659	0.077	14.8	7.5	7.3 ± 2.6	0.012
SBPS	30	393	4137	-3744 ± 946	0.000	3.9	1.5	2.4 ± 0.9	0.009
Other	25	1101	1899	-798 ± 300	0.014	18.1	17.1	1.0 ± 2.2	0.662
Pine	53	652	3335	-2683 ± 632	0.000	6.7	3.8	2.9 ± 1	0.008
Age 15-30	42	358	4328	-3970 ± 701	0.000	3.6	2.1	1.5 ± 0.8	0.059
Age 31-50	36	1306	1179	128 ± 186	0.497	18.1	14.9	3.2 ± 2.0	0.116
All	78	796	2875	-2079 ± 450	0.000	10.3	8.0	2.3 ± 1.0	0.025

7 Ground vs. TIPSY Volumes

7.1 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.

The data were examined for potential residual or veteran trees. Each plot was examined to identify trees that appeared to be part of a residual or veteran cohort. These tended to be older, larger trees. The decision rules in Table 17 were used to remove the identified veteran trees. These trees were removed only for the TIPSY comparisons (section 7).

Section 4.2 noted some additional issues, particularly the presence of significant dead volume on some plots.

Table 17. The decision rules to remove veteran trees are listed. These trees identified as "veterans" are only removed for the TIPSY comparisons (section 7).

samp_no	Veteran?
All	IF age_bh > 70
208	IF species FD and Dbh ≥ 32.5 cm
230	IF species BL and Dbh ≥ 22.5 cm
	IF species CW and Dbh ≥ 32.5 cm
236	IF species CW and Dbh ≥ 7.5 cm
	IF other species and Dbh ≥ 17.5 cm
239	IF species BL and Dbh ≥ 22.5 cm
	IF species CW and Dbh ≥ 42.5 cm
245	IF species deciduous and Dbh ≥ 12.5 cm
251	IF species PL and Dbh ≥ 17.5 cm
265	IF deciduous and Dbh ≥ 22.5 cm
273	IF deciduous and Dbh ≥ 17.5 cm

The ground volumes were compared to the TIPSY predictions in section 7.3.

7.2 Analysis Units

FAIB provided the analysis unit definitions (Table 18).

Table 18. The analysis unit (AU) definitions and assumptions are given. OAF1 = 15% and OAF2 = 5%.

Analysis unit	Pre-harvest leading species	Site index range	Regen method	Regen %	Regen delay (years)	Expected species composition	Well-spaced density	Area-weighted PSPL SI
Fd (poor)	Fd	7.0 – 12.0	Plant	50%	2	Pl/FD/Decid/Sx 52/28/14/6	1026	14.7
			Natural	50%	2	Pl/FD/Decid/Sx 52/28/14/6	1026	14.7
Fd (good/medium)	Fd	>12.0	Plant	90%	3	Pl/FD/Decid/Sx/BL 42/24/17/15/3	1139	19.8
			Natural	10%	3	Pl/FD/Decid/Sx/BL 42/24/17/15/3	1139	19.8
Cw, Hw (poor)	Cw, Hw	7.0 – 12.0	Plant	100%	2	Sx/Pl/Fd/Cw/He/Bl/Dec 41/23/9/9/6/6/6	1152	20.5
Cw, Hw (good/medium)	Cw, Hw	>12.0	Plant	100%	1	Sx/Pl/Fc/Cw/Decid/Hw/Bl 51/18/18/8/3/2/1	1481	22.1
Sx, Bl (poor)	Sx, Bl	7.0 – 12.0	Plant	100%	2	Sx/Pl/Bl/decid/Fd 53/32/9/4/1	1173	16.0
Sx, Bl (good/medium)	Sx, Bl	>12.0	Plant	100%	2	Sx/Pl/Bl/decid/Fd 49/28/9/8/6	1255	18.4
Pl (poor)	Pl	7.0 – 12.0	Plant	30%	4	Pl/Decid/Fd/Sx 87/10/1/1	1001	14.8
	Pl	7.0 – 12.0	Natural	70%	4	Pl/Decid/Fd/Sx 87/10/1/1	1001	14.8
Pl (good/medium)	Pl	>12.0	Plant	85%	2	Pl/Decid/Sx/Fd/Bl 67/17/10/8/3	1133	19.3
	Pl	>12.0	Natural	15%	2	Pl/Decid/Sx/Fd/Bl 67/17/10/8/3	1133	19.3

7.3 Predicted (Projected) Yield Estimates

For each sample plot, ground measured volumes were compared against two separate sets of TIPSY 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 Dbh ≥ 12.5.

VOL1: Ground based plot volume. The data were screened and residual or veteran trees removed (Table 17). VOL1 is identical to the ground compiled volume except for the removal of veteran trees. Net volume is vol_ntwb * l_nvaf.

VOL2: TIPSY estimated volumes using ground plot inputs. The ground plot inputs include site index and species composition. For each species, the average site index was computed as described in section 4.4. If SI was not available for the leading species, it was taken from the site productivity layer. There were

three samples with no ground trees. They all were in Phase I pine polygons and the leading species was assumed to be pine. 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.

If there was a record of harvesting in the polygon and the species was a conifer and not balsam, the regeneration method was assumed to be planting and with a planting density of 1,400 stems/ha. Otherwise the regeneration method was assumed to be natural with an initial density of 5,000 stems/ha.

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. And the heights should match since the ground compiler and TIPSY use the same SI (SiteTool) 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. Based on comparisons by FAIB staff, the following substitutions were made. For samples with a secondary deciduous component, the deciduous component was replaced with SX and the corresponding deciduous site index reduced to 90% of the original SI.

VOL3: TIPSY estimated volumes using the PSPL site index estimates and VRI Phase I based species mix. 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 secondary deciduous component, the deciduous component was replaced with SX and the corresponding deciduous site index reduced to 90% of the original SI.

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 12.5cm. Note there were no AU curves for hardwood leading plots. Severn plots had hardwood leading species in Phase I.

The bias was defined a follows.

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

7.4 Total bias - Ground compiler vs. TIPSY Volume

The ground volume (VOL1) versus using the TIPSY volume from Phase I species composition and the PSPL SI (VOL3) are not particularly close (Figure 6).

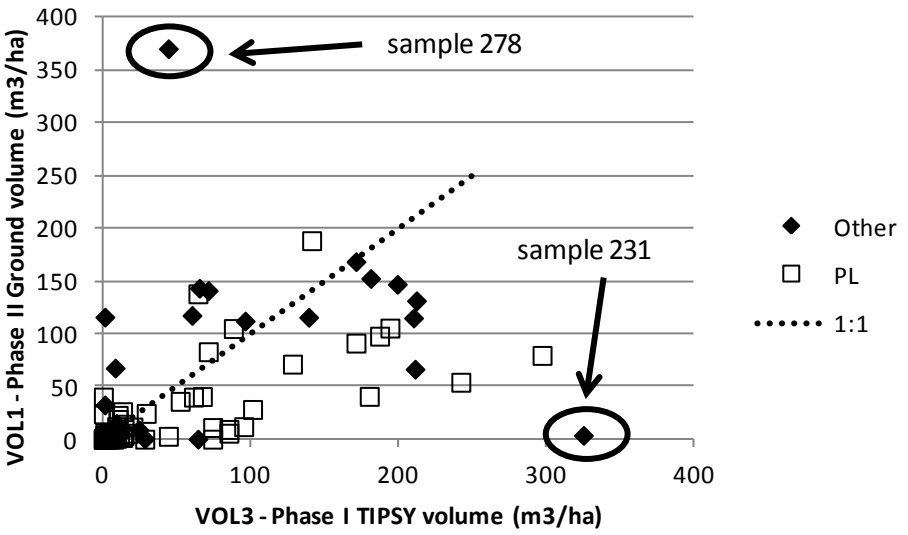

Figure 6. The ground volume is plotted against the TIPSY VOL3 predictions. Volumes are whole stem volume at the 7.5 cm utilization level.

The ground attributes for sample 231 were 150 trees/ha with a top height of 8.5 m while the Phase I inventory had 1395 trees/ha with a top height of 22.4 m. The volume differences for sample 278 in Figure 6 are due largely to age differences (ground age of 48.5 compared to an inventory age of 34).

7.5 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 7). This is an indication of the model-related volume bias. The largest difference is associated with sample 278. The leading species for both the ground and the Phase I inventory is FD. The ground SI was 21.3 m and age was 48.5 while the Phase I inventory (PSPL) SI was 23.2 m and the age was 34.

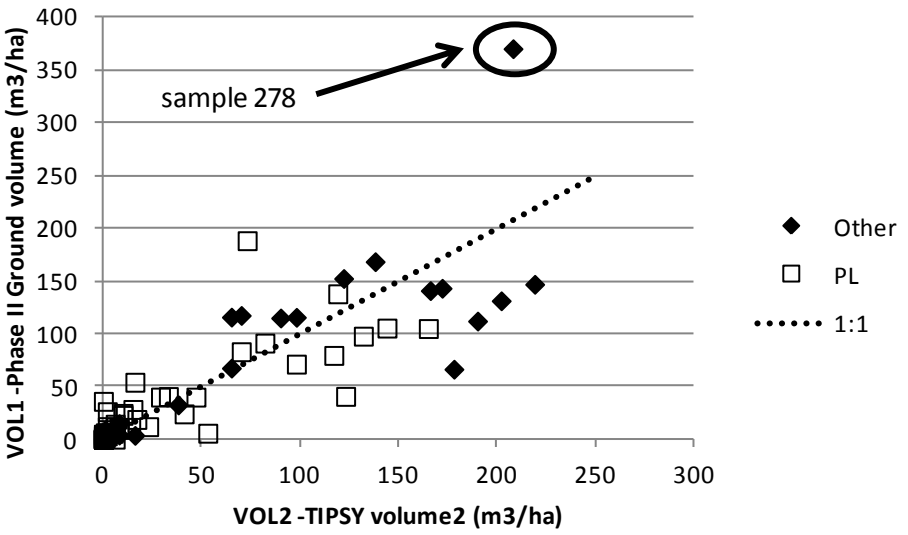

Figure 7. The ground volume is plotted against VOL2. Volumes are whole stem volume at the 7.5 cm utilization level.

7.6 Bias analysis

The results of TIPSY whole stem volume comparisons are given in Table 19 by BEC zones, Phase I leading species and age strata. The overall total bias is -17.3 m^3/ha ± 8.6 (one standard error). Most of this bias is due to attribute rather than model bias. Overall the model bias is very low.

Table 19. Overall TIPSY whole stem volume projections comparison. The utilization level is 7.5 cm. Statistically significant differences are shaded.

Strata	N	(m^3/ha)			Bias			prob(bias = 0)		
		VOL1	VOL2	VOL3	Total	Model	Attribute	Total	Model	Attribute
ICH	14	96.5	118.7	150.7	-54.2 ± 25.0	-22.2 ± 12.2	-32.0 ± 24.4	0.048	0.090	0.210
IDF	16	25.7	32.0	53.5	-27.8 ± 10.0	-6.3 ± 5.7	-21.5 ± 11.2	0.014	0.292	0.075
Other	18	66.3	43.5	58.1	8.2 ± 26.1	22.7 ± 10.2	-14.6 ± 20.0	0.758	0.038	0.475
SBPS	30	14.2	14.5	23.0	-8.7 ± 4.9	-0.3 ± 3.4	-8.4 ± 5.4	0.083	0.931	0.129
Other	25	81.5	82.2	85.2	-3.8 ± 21.9	-0.7 ± 10.4	-3.1 ± 17.7	0.864	0.947	0.863
Pine	53	27.9	27.8	51.5	-23.6 ± 7.3	0.2 ± 3.6	-23.8 ± 6.7	0.002	0.966	0.001
Age 15-30	42	13.5	8.7	8.7	4.7 ± 3.8	4.8 ± 1.8	0.0 ± 2.9	0.214	0.011	0.990
Age 31-50	36	82.0	87.8	124.9	-42.9 ± 17.2	-5.8 ± 8.6	-37.1 ± 14.8	0.017	0.502	0.017
Total	78	45.1	45.2	62.3	-17.3 ± 8.6	-0.1 ± 4.1	-17.1 ± 7.3	0.047	0.977	0.021

The volumes net of decay, waste and breakage are given in Table 20. The ground volumes are much smaller and the model bias is greater. 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 20. Overall TIPSY volumes net of decay waste and breakage comparison. The utilization level is 12.5 cm. Statistically significant differences are shaded.

Strata	N	(m^3/ha)			Bias			prob(bias = 0)		
		VOL1	VOL2	VOL3	Total	Model	Attribute	Total	Model	Attribute
ICH	15	55.6	78.3	113.5	-57.9 ± 23.2	-22.7 ± 9.9	-35.2 ± 21.2	0.026	0.037	0.120
IDF	16	11.1	19.2	31.3	-20.2 ± 9.7	-8.1 ± 6.5	-12.1 ± 9.2	0.055	0.232	0.212
Other	19	33.0	24.1	34.4	-1.4 ± 18.9	9.0 ± 4.9	-10.4 ± 16.1	0.943	0.085	0.527
SBPS	28	5.4	6.6	8.6	-3.2 ± 2.5	-1.2 ± 1.9	-2.1 ± 3.4	0.204	0.541	0.551
Other	25	49.9	53.4	55.5	-5.7 ± 15.8	-3.5 ± 7.2	-2.2 ± 14.3	0.723	0.633	0.882
Pine	53	10.3	14.9	32.3	-22.0 ± 7.2	-4.6 ± 2.6	-17.4 ± 5.9	0.004	0.085	0.005
Age 15-30	42	5.8	3.4	2.3	3.6 ± 2.1	2.5 ± 1.3	1.1 ± 1.4	0.093	0.068	0.437
Age 31-50	36	42.9	55.1	83.4	-40.5 ± 14.2	-12.1 ± 5.9	-28.4 ± 12.7	0.007	0.046	0.032
Total	78	23.0	27.2	39.7	-16.8 ± 7	-4.3 ± 2.9	-12.5 ± 6.1	0.020	0.146	0.044

The ground and Phase I (Inventory) basal area (BA) and trees per hectare (TPH) were compared (Table 21). Ten of the samples had no live trees and an additional 5 plots had stems/ha ≤ 100 stems/ha. The inclusion of these plots lowers the average ground BA and TPH.

Table 21. The ground plot and TIPSY-generated trees/ha and basal area are compared. Statistically significant differences (prob(bias = 0) < 0.05) are shaded.

		Trees/ha				BA (m^2/ha)			
Strata	N	Ground	TIPSY	Bias	prob(bias = 0)	Ground	TIPSY	Bias	prob(bias = 0)
ICH	14	1326	1111	215 ± 170	0.226	18.6	21.9	-3.4 ± 3.6	0.365
IDF	16	563	801	-238 ± 145	0.122	5.8	9.8	-4.0 ± 1.9	0.055
Other	18	1041	747	294 ± 250	0.255	12.9	7.8	5.1 ± 3.8	0.193
SBPS	30	372	574	-202 ± 100	0.053	3.5	3.8	-0.3 ± 0.9	0.726
Other	25	1017	852	165 ± 181	0.371	15.3	11.4	3.9 ± 3.0	0.207
Pine	53	635	725	-90 ± 93	0.336	6.3	8.6	-2.3 ± 1.2	0.051
Age 15-30	42	357	303	54 ± 73	0.462	3.6	1.9	1.7 ± 0.9	0.060
Age 31-50	36	1224	1305	-81 ± 167	0.632	15.7	18.3	-2.7 ± 2.6	0.307
All	78	758	766	-8 ± 86	0.924	9.2	9.5	-0.3 ± 1.3	0.800

7.7 Ground vs. AU volumes

The ground volumes (VOL1) were compared to the Analysis Unit (AU) TIPSY volumes (VOL4) (Figure 8). The AU curves were obtained from FAIB and are TIPSY-generated volumes at the 12.5 cm utilization level by 5 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.

Volumes for all ages were obtained by linear interpolation. Each sample was then assigned to an AU based on the Phase I leading species and site productivity layer SI. VOL4 is the volume from the AU yield curve corresponding to PROJ_AGE_1.

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

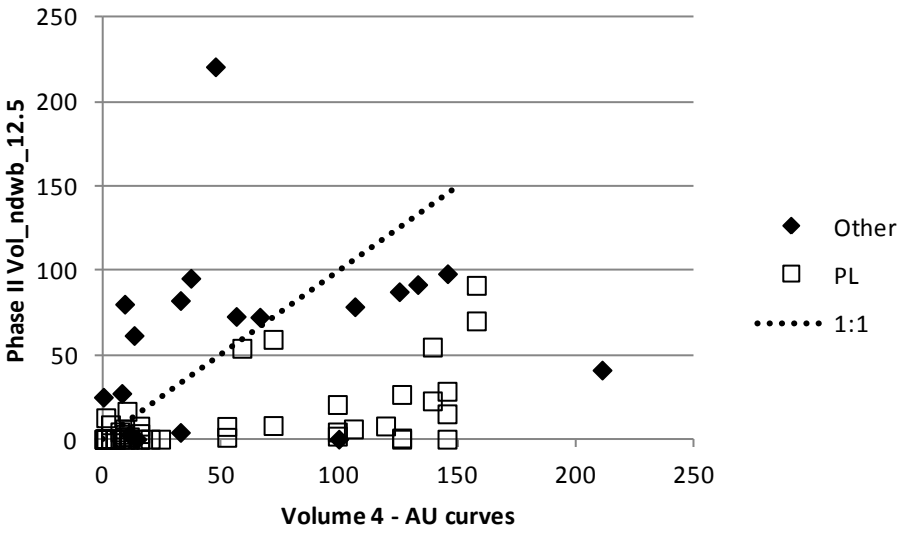

Figure 8. The ground volume is plotted against VOL4. Volumes are net of decay, waste and breakage at the 12.5 cm utilization level.

The AU volumes are summarized in Table 22 along with the Phase II ground volumes and VOL3. In general, the AU volumes are statistically larger than the ground volumes, particularly for pine-leading polygons. The AU volumes and VOL3 are closer. The volumes compared here are merchantable volumes net of decay, waste and breakage at the 12.5 cm utilization level. The AU volumes and VOL3 are closer. The differences between ground (VOL1) and AU volume observed here may have the same cause – attribute error. The average pine-leading PSPL SI was 17.7m (Table 14) compared to an AU average SI of 19.3 m (Table 18). The relatively small ground sample may not adequately reflect the population.

Table 22. Average volume, net of decay waste and breakage, is given by strata (Dbh ≥ 12.5cm). . Statistically significant differences (prob(bias = 0) < 0.05) are shaded.

		Volume (m^3/ha) (Dbh ≥ 12.5cm)			Ground vs. AU volume	
Strata	N	Ground (VOL1)	AU curves (VOL4)	VOL3	Bias	prob(bias = 0)
ICH	14	55.6	82.2	113.5	-26.6 ± 16.9	0.138
IDF	13	13.6	60.0	38.3	-46.4 ± 12.4	0.003
Other	16	30.7	32.0	18.9	-1.2 ± 14.5	0.934
SBPS	28	5.8	40.5	9.3	-34.7 ± 10.0	0.002
Other	18	63.4	63.8	58.6	-0.4 ± 17.2	0.981
Pine	53	10.3	46.4	32.3	-36.2 ± 6.5	0.000
Age 15-30	38	6.4	7.1	2.5	-0.6 ± 2.8	0.822
Age 31-50	33	43.6	101.2	80.9	-57.6 ± 12.1	0.000
All	71	23.7	50.8	38.9	-27.1 ± 6.7	0.000

8 Discussion

The analysis has a number of complications. Twelve of the 78 samples did not have any live trees with Dbh ≥ 7.5 cm. These are young samples and many of the trees may be smaller than the Dbh threshold. 43 samples had a Phase I height < 7 m and potentially have not had VRI attributes such as basal area and volume updated by VDYP7.

Overall, the total volume bias is moderately statistically significant, largely due to attribute bias.

The bias associated with age and height was not statistically significant but SI was overestimated by the PSPL and likely contributes to the overestimate of volume.

Table 23. The results of comparing the ground plots to the inventory and to the YSM assumptions are summarized. A prob(bias = 0) of less than 0.05 is generally considered an indication of statistically significant differences (or bias).

Attribute	N	Ground mean	Comparison	Inventory mean	Bias		
					Magnitude	% of ground mean	prob(bias = 0)
Whole stem volume (m^3/ha)	78	45.1	TIPSY	62.3	-17.3 ± 8.6	-38%	0.047
Volume attribute bias (m^3/ha)	78		TIPSY		-17.1 ± 7.3	-38%	0.021
Volume model bias (m^3/ha)	78		TIPSY		-0.1 ± 4.1	0%	0.977
Species matched age (yrs)	70	36.2	VRI	32.4	3.8 ± 2.1	11%	0.069
Species matched height (m)	68	9.0	VRI	8.2	0.8 ± 0.5	9%	0.123
Site index (m)	61	15.5	PSPL	16.8	-1.2 ± 0.5	-8%	0.009

9 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 do not indicate any major issues with the Williams Lake YSM Phase I attributes or TIPSY volumes. However, a key monitoring objective is to compare observed to forecasted growth. The samples should be remeasured, as planned.

10 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.

FAIB. 2012. A framework for implementing young stand growth monitoring in British Columbia – A discussion paper. Version 2.1. Dated January 6, 2012. 37p.

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. 2012a. Williams Lake Timber Supply Area – TSA 20 Vegetation Resources Inventory Project Implementation Plan for Volume Audit Sampling, Young Stand Monitoring and Net Volume Adjustment Factor Sampling.

Nona Phillips Forestry Consulting. 2012b. Williams Lake TSA VRI Sample Selection Report.

11 Appendix A – List of Sample Locations & Weights

The sample weights were equal for all plots (plot weight = 1).

Table 24. The sample locations are given.

Sample	Map ID	Polygon ID	Northing	Easting
0200	093A063	76573	5836633	607637
0201	093A052	65008	5817496	586773
0202	093B034	01000	5801787	485922
0202	093B034	01000	5801787	485922
0203	093A026	42999	5794893	645907
0204	093C010	48857	5764338	424236
0205	093B003	00403	5762644	464223
0206	092N090	00575	5744345	423396
0207	092O087	47737	5740096	523344
0208	092O067	76201	5720110	522488
0209	093C013	00014	5778519	324668
0210	093C046	00347	5811856	366133
0211	092N096	00766	5751857	363620
0212	092N097	00404	5756015	383825
0213	093C030	54103	5789330	425293
0214	092N100	01004	5759335	424028
0215	092O071	00026	5738503	443176
0216	092O061	00490	5718514	442328
0217	093B053	00539	5827634	466983
0218	092O093	13616	5752647	463799
0219	093B014	01748	5776787	484857
0220	093B026	94229	5785934	505277
0221	092O056	87069	5705977	501863
0222	092O077	74774	5735099	523131
0223	092O067	08597	5725108	522702
0224	092O037	05284	5685137	520992
0225	093B020	83958	5783361	565263
0226	092O070	58501	5723386	562679
0227	093A052	37722	5822487	586989
0228	093A084	65463	5851636	608285
0228	093A084	65463	5851636	608285
0229	093A053	70538	5826635	607208
0230	093A053	57703	5821628	606989
0231	093A033	78801	5806626	606340
0232	093A055	10718	5825762	627207
0233	093A036	85411	5799899	646123
0234	093A026	49979	5789894	645688
0235	093A016	27099	5784896	645472
0236	093A028	99920	5789019	665690
0236	093A028	99920	5789019	665690
0237	093A069	46509	5833595	677652
0238	093C059	01407	5824753	416771
0239	093A043	44654	5817058	596778

Sample	Map ID	Polygon ID	Northing	Easting
0240	093A044	54741	5816193	616776
0241	093C028	00540	5785597	395087
0242	093A015	40949	5775329	635033
0243	092O097	59274	5760510	514208
0244	092O081	00243	5743920	433390
0245	092O064	00251	5722240	472526
0246	092O065	16112	5721388	492510
0247	092O066	85920	5720533	512497
0248	093C078	43479	5840599	397401
0249	092N079	00075	5729774	412773
0250	092O091	33057	5753912	433813
0250	092O091	33057	5753912	433813
0251	092O071	00007	5738922	433173
0252	092O051	00425	5713937	432126
0253	093B032	30251	5798057	455707
0254	093B022	03987	5788061	455289
0255	092O052	00774	5708094	451898
0256	093B034	00136	5797211	475709
0257	093B004	00231	5767215	474429
0258	092O074	95758	5737234	473159
0258	092O074	95758	5737234	473159
0259	092O053	29971	5712245	472098
0260	092O053	00174	5707251	471886
0261	093B025	14025	5786362	495281
0262	093B015	00418	5776363	494856
0263	093B005	15330	5771365	494641
0264	093B005	00322	5766365	494428
0265	092O075	81435	5731385	492934
0266	092O065	72993	5716393	492296
0267	093B017	78390	5775509	514848
0268	092O056	42947	5715541	512283
0269	092O056	66973	5705547	511854
0270	092O036	00776	5685562	511002
0271	093B028	91427	5789651	535486
0272	093B060	97699	5823785	556986
0273	093A051	77856	5822929	576986
0274	093A073	69424	5842067	597849
0275	093A063	83521	5832061	597420
0276	093A012	23849	5782065	595260
0277	093A036	78700	5805326	636340
0278	093A035	15834	5800326	636121

12 Appendix B – Plot Data Summaries

Table 25. The Plot data summaries are given.

	Phase II								Phase I							Site	Prod	Layer				
	BA 7.5	TPH 7.5	WSV 7.5	Vol ndwb 125	Spp1	HT1	Age1	SI1	WSV dead	BA 12.5	TPH 12.5	Vol 12.5	Dead Vol	Spp1	HT1	Age1	SX	HW	BL	CW	PL	FD	AT
200	14.9	1651	54	8	PL	8.5	26.5	22.3	0	1.0	1928	0	0	PL	6.9	36	26.4	18.3		19.4	18.4	24.6	
201	7.3	575	41	21	PL	13.3	43.8	16.4	86	18.5	1110	61	1	PL	14.3	40	20.8			20	16.4	23.7	
202	6.5	751	26	13	PL	5.5	19.5	16.2	0		3456	0	0	PL	3.4	20	18.4					20.1	
203	23.0	1351	115	72	FD	14.2	30.3	26.2	3	31.7	2448	64	0	FD	13.6	37	24.1	19.2		20.7	18	21	
204	1.6	325	4	0	PL	5.2	21.8	14.7	0		25851	0	0	PL	3.9	22	17.9					13.7	
205	0.4	50	1	0	PL	4.3	18.9	14.6	0		6623	0	0	PL	3.9	22	17.3					16.4	
206	10.6	776	40	23	PL	8.6	42.5	11.8	0	6.1	631	6	0	PL	9	46	17.9					13.7	
207	0.4	25	1	1	AT			19.4	1	5.0	500	0	0	AT	6	23	.					19.4	
208	4.0	400	12	2	PL	8.8	45.0	12.3	4	20.1	1419	58	9	PLI	16.9	40	16.9					16.4	
209	25.6	1376	138	91	PL	13.1	51.8	14.3	2	4.9	516	4	0	PL	9.5	49				10		12.1	
210	10.4	1176	40	8	PL	9.3	39.3	13.3	1			0	0	PL	1.9	33	16.9					16.2	
211	0.0	0	0	0	PL	4.3	19.1	14.5	0		7439	0	0	PL	0.1	20	18.4			17.5		17.6	
212	0.0	0	0	0	PL				0		3208	0	0	PLI	1.3	21	17.9					13.7	
213	0.0	0	0	0	PL				0		8817	0	0	PLI	2.7	16	17.9					13.7	
214	0.0	0	0	0	PL				0		7745	0	0	PL	3.2	19	16.7					15	
215	1.1	150	6	0	PL	9.6	47.2		71			0	0	PL	2.7	47	17.9					13.7	
216	17.8	1626	83	27	PL	10.8	47.5	12.8	0	14.1	1270	36	0	PL	13.7	44	17.9					13.7	
217	1.3	175	4	0	AT	6.0	19.5	17.3	0		2944	0	0	AT	5.7	25	17.3					15	
218	0.2	25	0	0	AT	4.5	19.5	14.5	0		6305	0	0	AT	5.3	23	16.7					14.7	
219	1.5	175	3	0	AT	5.0	22.5	13.8	0	5.0	2364	0	0	AT	6.6	24	17.4					16.4	
220	2.2	250	6	1	PL	6.1	18.5	18.4	0	3.0	1800	0	0	PL	4.7	24	17.9					13.7	
221	0.6	125	2	0	PL	5.3	20.8	15.5	0	5.0	8676	0	0	PLI	4.5	28	17.9					13.7	
222	0.2	25	0	0	AT	3.7	29.5	8.9	2	13.8	1876	8	0	AT	10.8	33	18.6					19.3	
223	4.6	600	11	1	PL	6.3	30.5	12.7	0	3.0	5492	0	0	PLI	4.6	25	17.2					16.4	
224	0.0	0	0	0	PL				0		4806	0	0	PL	5.3	19	18.4					17.6	
225	21.1	1201	112	79	FD	17.0	90.5	14.3	0	20.6	954	56	0	FD	11.9	43	19.1					19.6	
226	0.0	0	0	0	FD		95.5	13.2	105	14.0	1152	25	0	FDI	12.6	42	19.1					19.6	

	Phase II								Phase I							Site	Prod	Layer				
	BA 7.5	TPH 7.5	WSV 7.5	Vol ndwb 125	Spp1	HT1	Age1	SI1	WSV dead	BA 12.5	TPH 12.5	Vol 12.5	Dead Vol	Spp1	HT1	Age1	SX	HW	BL	CW	PL	FD	AT
227	27.6	1976	116	73	SX			20.0	4	15.9	1940	21	0	SX	14.1	39	20.8			20	16.4	23.7	
228	2.4	275	9	4	SX	5.7	22.5	20.5	2	1.0	800	0	0	SE	4.9	34				9		17.3	
229	6.9	275	32	25	SX	10.1	26.0	24.6	33	10.0	800	0	0	SX	12	19	22.7	19.9		21.3	17.6	22.5	
230	21.5	1276	131	92	BL	15.8	60.8	16.4	2	34.8	1255	192	0	BL	20.7	49	22.9	18.6		20.9	17.4	21	
231	1.1	150	4	1	AT			20.5	17	14.4	560	61	0	AC	22.3	44	20.5	.		21.1		21.1	
232	24.6	1501	117	80	SX	12.4	26.9	22.0	0	5.0	2300	0	0	SX	6	27	24.1	18		19.7	18	21	
233	7.9	776	24	6	PL	7.1	20.5	18.7	0	3.3	419	1	0	PL	8.2	24				12		19.5	
234	18.9	1551	105	59	PL	15.9	33.8	22.8	85	13.5	477	13	17	PL	12.3	36	20.8			20	16.4	23.7	
235	17.8	1151	91	54	PL	11.9	34.0	22.5	60	18.9	1348	42	5	PL	13.6	34	20.8			20	16.4	23.7	
236	11.7	801	66	41	CW			24.0	32	19.7	1456	65	0	CW	12.2	49	24	19.9		21.3	18	21.1	
237	26.6	1576	141	87	CW	14.7	42.5	19.7	4	46.8	1896	138	0	CW	12.5	39	22.7	19.9		21.3	17.6	22.5	
238	6.0	700	19	3	PL	7.5	26.3	15.8	0	5.4	347	2	2	PL	9	26	17.9					13.7	
239	24.7	1776	143	82	SX	16.0	62.8	15.9	8	39.1	2879	104	0	SX	15.2	34	20.1			20.5	16.7	24	
240	23.5	1326	147	98	FD	18.1	47.0	21.8	7	33.8	1535	137	0	FD	18.4	49	22.7	19.9		21.3	17.6	22.5	
241	0.0	0	0	0	PL				0		8040	0	0	PLI	5.7	22	17.9					13.7	
242	26.5	1976	116	61	BL	11.4	44.8	16.6	0	5.0	850	0	0	BL	7	29				17.6		17.1	
243	17.3	2352	98	8	PL		85.1	10.7	44	2.9	378	2	0	PL	7.5	43	19.1					19.6	
244	0.0	0	0	0	PL	6.5	49.7	8.2	0			0	0	PL	2.5	44	17.9					13.7	
245	7.9	926	36	6	PL		76.5		11	3.8	463	3	0	PL	8	41	17.9					13.7	
246	2.2	300	6	0	PL	5.7	28.5	12.4	0		2157	0	0	PLI	5.2	26	17.9					13.7	
247	4.9	525	15	3	SX	6.4	21.2	16.9	0	3.0	1900	0	0	SW	4	28	17.9					13.7	
248	0.9	150	2	0	PL	3.7	37.2	7.3	0		5954	0	0	PLI	6.5	20	9.8					15	
249	10.7	1001	40	17	PL	8.4	40.5	12.0	1	8.4	849	11	0	PL	10.5	34	.					9	
250	0.2	25	1	0	PL	3.1	16.5	13.0	0		5231	0	0	PL	5	18	17.9					13.7	
251	3.6	575	11	1	PL			13.7	0			0	0	PL	3	44	17.9					13.7	
252	38.5	4703	188	28	PL	10.9	50.5	12.5	6	5.1	550	5	0	PL	9.2	47	16.9			15.8		16.2	
253	6.7	675	24	9	PL	8.1	24.0	18.0	0	1.0	1198	0	0	PL	3.1	21	17.9					13.7	
254	1.4	150	6	3	PL	5.7	18.8	17.2	0		784	0	0	PLI	3.2	24	17.1					16.4	
255	18.3	1101	105	70	PL	15.1	52.0	16.1	22			0	0	PL	4	49	17.9					13.7	
256	1.7	325	3	0	PL			15.0	0		6153	0	0	PL	4.6	25	15.1					15	
257	13.6	600	71	55	PL	13.6	67.5	13.6	0	13.2	961	36	1	PL	13.8	46	17.9					16.4	

	Phase II								Phase I							Site	Prod	Layer				
	BA 7.5	TPH 7.5	WSV 7.5	Vol ndwb 125	Spp1	HT1	Age1	SI1	WSV dead	BA 12.5	TPH 12.5	Vol 12.5	Dead Vol	Spp1	HT1	Age1	SX	HW	BL	CW	PL	FD	AT
258	0.0	0	0	0	PL				47		4037	0	0	PLI	3.4	17	15.5					14.7	
259	0.0	0	0	0	PL				0		2243	0	0	PL	2.4	17	16.9			15.8		16.2	
260	2.3	325	6	0	PL	5.2	19.1	16.0	9		1127	0	0	PL	3.6	21	12			12		15	
261	1.0	100	3	0	PL	5.1	15.5	19.2	0		6224	0	0	PLI	4.9	22	18.1					21	
262	5.0	776	12	0	PL	5.4	19.0	16.3	0		2222	0	0	PL	4.8	26	17.9					13.7	
263	2.2	325	5	0	FD	4.3	20.5	13.4	0	0.0	477	0	0	FD	5.7	27	16.8					16.4	
264	8.4	1251	28	4	PL	7.4	40.2	10.9	12	3.9	89	0	2	PL	7.8	40	17.3					16.4	
265	4.4	325	14	8	PL		95.5	14.2	2		10475	0	0	PL	4.8	26	16.9					15	
266	1.9	325	5	0	PL	4.8	22.8	13.2	0		7520	0	0	PLI	5.4	24	17.9					13.7	
267	1.1	175	3	0	PL	5.5	17.5	17.9	0	4.0	1915	0	0	PL	6	23	17.9					13.7	
268	7.5	951	23	4	PL	6.8	27.0	14.7	0	7.0	2881	0	0	PLI	6	23	16.9			17.3		16.2	
269	0.0	0	0	0	PL				0	4.0	4433	0	0	PLI	7.3	27	16.9			17.8		16.2	
270	0.0	0	0	0	PL	3.5	17.5	13.5	0		4067	0	0	PL	3	18	18.4			16		17.6	
271	3.3	525	9	1	PL	6.1	27.5	15.2	6	3.6	439	2	0	PL	7.8	33	19.1					19.6	
272	26.4	1676	168	104	AT	13.3	27.2	23.0	0	29.1	1494	106	0	AT	17.3	39	21			18.4		21.8	
274	29.2	1801	152	95	SX	13.5	33.3	23.0	0	25.4	2013	63	0	SX	14.1	35				19.5		19.8	
275	15.0	1451	67	27	CW	10.6	31.5	22.0	0	20.0	800	0	0	CW	15	22	20.8			20	16.4	23.7	
276	1.9	375	5	0	PL	5.4	16.0	19.5	0	0.0	1200	0	0	PLI	5.2	17	21.6					20.3	
277	14.3	1651	79	15	PL	13.7	47.2	15.8	71	25.2	1787	105	0	PL	19	47	19.5	18.2		20.3	15.9	23.2	
278	60.5	3753	370	221	FD	18.2	48.5	21.3	103	34.7	5967	0	0	FDI	10.4	34	19.5	16.7		20.3	15.9	23.2	