Young Stand Monitoring in Lakes & Morice TSAs: Plot Establishment Report

A Technical Report

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EXECUTIVE SUMMARY

This report presents results of Young Stands Monitoring (YSM) in the Lakes and Morice Timber Supply Areas (TSAs). The YSM population consists of 15-50 year old polygons covering approximately 10% of the TSAs. Fifty-eight monitoring field plots were established in 2017, 29 in each TSA. As part of an earlier YSM pilot study, 47 change monitoring plots were established and remeasured in the Morice TSA.

The YSM population is dominated by pine followed by spruce with minor amounts of aspen/cottonwood and balsam. The highest volumes are found in the aspen/cottonwood stratum.

The Phase I inventory attributes, including species composition and site index, are used to assign polygons to an analysis unit and project yields. Errors in these attributes will affect the accuracy of the yield projections.

The ground basal area is approximately 10% higher than the inventory estimates for both TSAs (Table 1) but the difference is not statistically significant. The lower inventory BA may be due in part to some polygons with short trees. VDYP7 does not project BA until the projected height is approximately 7m.

The species matched ground age was 12% higher than the inventory estimates in the Lakes TSA and 6% higher in the Morice TSA. The largest differences were found in the aspen/cottonwood polygons in the Lakes TSA. The species matched ground heights were 9% taller than the inventory heights in the Lakes and were 23% higher in the Morice TSA with the largest differences in the aspen/cottonwood and spruce strata and the younger ages.

The ground estimates of Site Index (SI) are 8% higher than the PSPL estimates in the Lakes TSA and 18% in the Morice TSA, an unexpected result. The range, by species, of the PSPL SI is quite narrow compared to the ground estimates.

Twenty-six of 29 (90%) of the samples had the same inventory and ground leading species in the Lakes TSA, a very high agreement. The agreement is 55% in the Morice TSA. These agreements rise to 93% and 72% respectively if close matches are considered acceptable.

Table 1. The results of comparing the ground plots to the inventory are summarized. A p-value < 0.05 is generally considered an indication of statistically significant differences (or bias). Statistically significant biases are shaded. All attributes are at the 7.5 cm utilization level.

TSA	Attribute	N	Estimate	Ground mean	Inventory mean	Bias		
						Magnitude	p-value	% of ground mean
Lakes	Basal area (m^2/ha)	29	VRI	18.4	16.3	2.0	0.356	11%
	Density (trees/ha)	29	VRI	1192	2566	-1374	0	-115%
	Species matched age (years)	29	VRI	32.2	28.4	3.8	0.07	12%
	Species matched height (m)	29	VRI	11.6	10.5	1.1	0.000	9%
	Site index (m)	26	PSPL	20	18.4	1.6	0.003	8%
	Whole stem volume (m^3/ha)	29	TIPSY	106.4	50	56.4	0.001	53%
	Volume model bias (m^3/ha)		TIPSY			32.8	0.003	31%
	Volume attribute bias (m^3/ha)		TIPSY			23.6	0.028	22%
Morice	Basal area (m^2/ha)	29	VRI	18	16.4	1.6	0.278	9%
	Density (trees/ha)	29	VRI	1144	2284	-1140	0.0	-100%
	Species matched age (years)	29	VRI	32.3	30.2	2.0	0.129	6%
	Species matched height (m)	29	VRI	12	9.2	2.8	0	23%
	Site index (m)	15	PSPL	21.8	18	3.8	0.001	18%
	Whole stem volume (m^3/ha)	29	TIPSY	98.7	48.7	50.0	0	51%
	Volume model bias (m^3/ha)		TIPSY			18.5	0.134	19%
	Volume attribute bias (m^3/ha)		TIPSY			31.5	0.014	32%

Inventory estimates of volume were generated using TIPSY and the inventory species composition, the PSPL SI and an assumed initial density. The ground volume is approximately double the TIPSY estimates for both TSAs.

The 47 monitoring plots in the Morice TSA were summarized (Table 2). The change in whole stem volume is approximately 7 m^3/ha/yr and is relatively constant across strata with the exception of the balsam strata which has an average rate of change of 3 m^3/ha/yr.

Table 2. The average at time 0 and time 1 and the annual difference (± standard error) are given by attribute (Dbh ≥ 4.0 cm). The annual differences are statistically significant except for TPH.

Attribute	N	Time 0	Time 1	annual difference ± s.e.	p-value
Height (m)	47	11.3	13.4	0.42 ± 0.02	0
Age (years)	47	30.2	34.9	0.91 ± 0.03	0
SI (m) – all	47	20.4	21.6	-1.6 ± 0.33	0
SI (m) – only if SI Time 2 ≠ .	27	20.3	21.6	0.24 ± 0.05	0
BA (m^2/ha)	47	20	24.3	0.83 ± 0.07	0
TPH (trees/ha)	47	1964	1939	-5.4 ± 7.2	0.46
WSV (m^3/ha)	47	102.3	140.1	7.36 ± 0.51	0
Netvol (m^3/ha)	47	57.2	90.4	6.47 ± 0.46	0

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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. This monitoring program helps to identify opportunities to improve the accuracy of timber supply forecasting for a management unit.

2 Objective

The objective of the YSM program (Omule 2013) is:

> To check the accuracy of the growth and yield predictions (assumptions) of key timber attributes of young stands used in Timber Supply Review (TSR) in a management unit, based on an independent random sample of monitoring plots. The TSR assumptions include stand gross and net volume (gross volume less cruiser-called decay and waste), site index, total age, and species composition, and succession.

The monitoring plots used here are on a grid. They are not a random sample but are an unbiased sample.

This report summarizes YSM for the Lakes and Morice TSAs. 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 I 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. Compare observed change to forecasts from growth and yield models for the young stand population once remeasurements are available.

3 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. This includes all land types across BC, including young stands.
- For the YSM population, the monitoring plot grid is intensified and sampling occurs at the intersection of young stands on a 5 x 10 km grid.

The ground sample in the Lakes and Morice TSAs includes both sampling components. This report is focused on the intensive young stand sample.

3.1 Population

The monitoring unit, the geographic area of interest, includes the Lakes and Morice TSAs (Figure 1 and Figure 2).

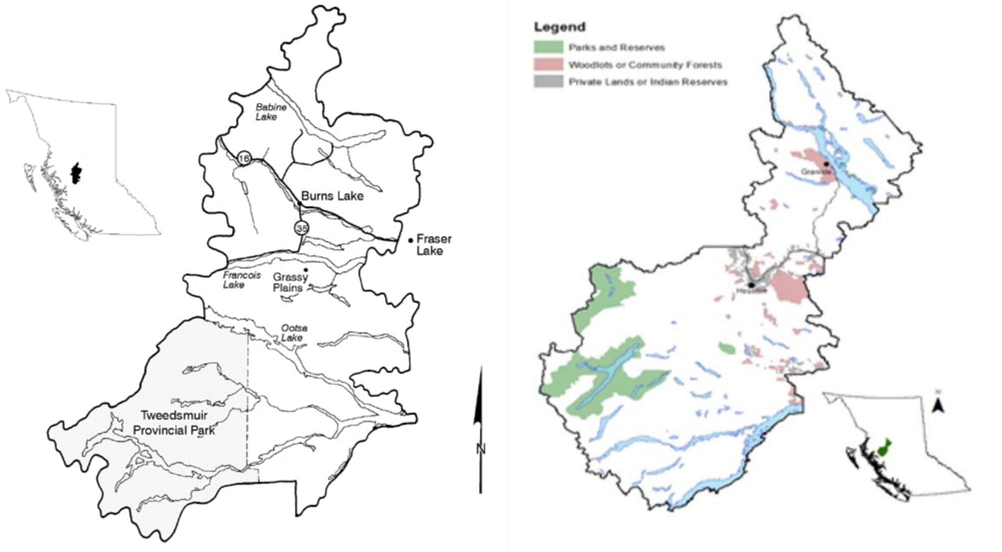


Figure 1. The locations of the Lakes (left) and Morice (right) TSAs are given.

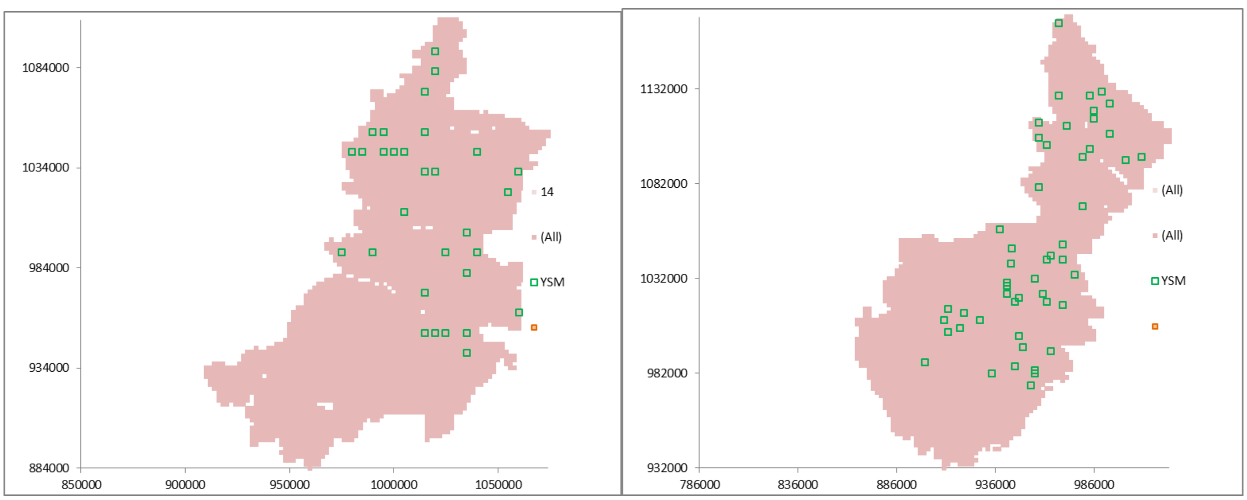


Figure 2. The locations of the Lakes and Morice TSA YSM samples (from FAIB).

The following descriptions are from the Allowable Annual Cut Rationale for Lakes[1] and Morice[2].

The Morice TSA is situated on the western edge of British Columbia's (BC) central interior plateau and covers approximately 1.5 million hectares. The TSA extends from the most northerly tip of Babine Lake in

[1] https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/stewardship/forest-analysis-inventory/tsr-annual-allowable-cut/lakes_tsa_rationale.pdf
[2] https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/stewardship/forest-analysis-inventory/tsr-annual-allowable-cut/morice_tsa_rationale.pdf

the north to Ootsa and Whitesail Lakes in the south. The Morice TSA is administered by the Nadina Natural Resource District in Burns Lake.

Eight First Nations have traditional territories that overlap the Morice TSA: Yekooche First Nation, Cheslatta Carrier Nation, Lake Babine Nation, Moricetown Band, Office of the Wet'suwet'en, Nee Tahi Buhn Band, Skin Tyee Nation and Wet'suwet'en First Nation.

The TSA has a gentle, rolling landscape in the north and east that becomes more mountainous in the southwest. The overall climate, which includes cool summers and cold winters, reflects the transition between coastal and interior conditions. This climate supports forests that are dominated by lodgepole pine, hybrid spruce, and subalpine fir (balsam). Minor amounts of trembling aspen, amabilis fir, western hemlock and mountain hemlock also occur in the TSA.

About 935 000 hectares or 62 percent of the Morice TSA land base is considered productive Crown forest land. After all other resource requirements have been accounted for, about 649 000 hectares, or 43 percent of the total TSA area, are considered available for timber harvesting. The boundary of the TSA includes: several protected areas and parks; private land, Indian Reserves, and area-based tenures, such as community forests, and woodlots. These areas do not contribute to the TSA timber supply.

The Lakes TSA covers about 1.1 million hectares of land in north-central British Columbia (Figure 1), ranging from Tweedsmuir Provincial Park in the south to the Tildelsy watershed in the north. The TSA contains the headwaters of important tributaries of both the Skeena and Fraser watersheds as well as numerous lakes, which include some of the largest freshwater bodies in British Columbia. Currently, 523 909 hectares or about 47 percent of the total TSA land base is considered to be suitable and available for timber harvesting, this area is referred to as the timber harvesting land base (THLB). The forest and range resources of the TSA are administered by the Nadina District office located in Burns Lake.

Pine-leading stands dominate the Lakes TSA, representing about 74 percent of stands in the THLB, while spruce, balsam and fir stands occupy the remainder of the area. The preponderance of mature pine stands was a significant factor contributing to the recent mountain pine beetle (MPB) epidemic. The infestation is believed to have begun slowly in the mid-1990s. By the year 2000, the beetle-affected pine volume was 900 000 cubic metres. By 2009, approximately 90 percent of the pine trees available for harvesting were dead. It is currently assumed that MPB-killed pine remains a potential source of wood fibre as long as the trees remain standing, which is about 15 years in the Lakes TSA. It is estimated that by 2019, almost all of the beetle-killed pine stands will have been dead for more than 15 years

Approximately 10% of the area within the TSAs is part of the YSM population (Table 3).

Table 3. A summary of the land base (from FAIB).

TSA	TSA area (ha)	YSM area (age 15 – 50) (ha)
Lakes	1,500,000	144,695
Morice	1,501,703	170,451

3.2 Target Population

The YSM target population is composed of 15- to 50-year-old young stands, based on the Phase I inventory, within the Lakes and Morice TSAs. The population was not restricted to vegetated treed polygons. It includes all stands in the age range (including silvicultural openings with crown closure <

10%). Three plots from the YSM pilot departed slightly from the target population definition either at the second measurement or both measurements but were used anyway (Table 4).

Two samples, 020Y-4304-YO1 and 020Y-6209-YO1, were noted by FAIB as not part of the YSM and were removed.

Table 4. YSM pilot plots included in the change analysis but not part of the strict YSM definition are given.

Samples	Proj_Age_adj	Description
0201-0056-MO1	51	Used for change analysis
0201-0056-YR1	56	Used for change analysis
0201-0075-MO1	51	Used for change analysis
0201-0075-YR1	56	Used for change analysis
0201-0100-MO1	47	Used for change analysis
0201-0100-YR1	52	Used for change analysis

3.3 Sample Selection

The YSM ground sample data come from three data sources – CMI ground plots and two YSM programs (Table 5). The current YSM program was established in 2017 covering the Lakes and Morice TSAs. There was also a YSM pilot program established in 2012 in Morice only. The pilot program was remeasured in 2017 to estimate change components. One sample from the YSM pilot was incorporated into the current YSM program (sample 77).

Table 5. The data sources are defined. All are circular, 0.04 ha fixed area plots.

Source	Data Source	Description	Use
CMI	Change monitoring inventory	Established on the 20 x 20 km NFI grid.	Establishment
YSM	Young Stand Monitoring	Established on a 5 x 10 km grid superimposed on the 20 x 20 km grid, and within the YSM population. Established in 2017 in Lakes and Morice	Establishment
YSM pilot	Young Stand Monitoring Pilot	Established on a 2 x 2 km grid in the YSM population. Established in 2012 in Morice and remeasured in 2017	Change

The compiled ground attributes for the YSM samples are given in Appendix B. There were no substitutions or movements of plots. Table 6 gives the sample sizes.

Table 6. The YSM sample sizes are given.

				Year			
Use	TSA	Proj_id	grid	Established	remeasured	N	Comment
Establishment	Lakes	CMI5	20 x 20 km	2001	2017	1	2017 only
		0142	20 x 20 km	2017		2	
		014Y	5 x 10 km	2017		26	
	Morice	020Y	5 x 10 km	2017		24	
		0202	20 x 20 km	2017		3	
		CMI5	20 x 20 km	2001	2017	1	2017 only
		0201	2 x 2 km	2011/2012	2017	1	2017 only, sample 77 falls on 20km grid
Change	Morice	0201	2 x 2 km	2011/2012	2017	47	YSM Pilot

3.4 Plot Design & Establishment

The ground samples are circular fixed-area (0.04 ha) permanent sample plots. Plot establishment and measurement followed provincial YSM standards and procedures[3]. The 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; a 100 m^2 (5.64 m radius) for trees with DBH ≥ 4.0 cm and Dbh < 9.0 cm; and a 19.6 m^2 (2.50 m radius) plot for all trees taller than 0.1 m and DBH < 4.0 cm. The sample plots are centered at the grid intersection points.

The walkthrough method (as specified in the CMI ground sampling standards) was assessed for all YSM ground samples in proximity to a potential out-of-population polygon boundary.

The sampling intensity for the establishment analysis, the proportion of the area sampled, was approximately 0.02% based on each 0.04 ha plot representing 5,000 (based on the 5 x 10 km grid).

4 Data Compilation

The attributes in Table 7 were taken or compiled from the FAIB files.

Table 7. The field names for the attributes are given.

Attribute	Utilization	Ground file	VDYP7 file
Age of leading species	N/A	AGET_TXO	PRJ_TOTAL_AGE
Height of leading species	N/A	HT_TXO	PRJ_DOM_HT
SI of leading species	N/A	See section 4.4	PRJ_SITE_INDEX
Basal area	7.5 cm	BA_HA	PRJ_BA
Trees per hectare	7.5 cm	STEMS_HA	PRJ_TPH
Lorey height	N/A	HT_LOREY	PRJ_LOREY_HT
Whole stem volume	7.5 cm	VHT_WSV	PRJ_WSV
Merchantable volume Dwb	12.5 cm	VHT_NWB	PRJ_VOL_DWB

For the ground measurements, Lorey height is calculated as the basal area weighted mean height for all live, standing, full measure trees, including broken top trees. Lorey height does not have a utilization level, it includes all trees that meet the criteria regardless of DBH.

Some additional screening of SI trees was undertaken (section 4.4) so the ground site index was calculated in a similar manner to SI_M_TXO, but based on fewer trees.

4.1 Ground plot attributes

The compiled summaries were used for most attributes (volume, BA, etc.). The attributes are defined in the data dictionary[4] and summarized in Table 14.

[3] BC Ministry of Forests, Lands and Resource Management Operations. June 2015. Change Monitoring Inventory BC. Change Monitoring procedures for provincial reporting. Ver. 2.2. https://www.for.gov.bc.ca/hts/vri/standards/RISC/2015/cmi_ground_sampling_procedures_2015.pdf.

[4] Data Dictionary for Vegetation Resrouces Inventory and National Forest Inventory Timber Data. Ministry of Sustatinable Resource Management. By Gitte Churlish. Dec. 2003. 8p.

4.2 Ground plot data screening

There were 6 walkthrough plots, four establishment plots (014Y-5396-YO1, 014Y-5673-YO1, 020Y-6761-YO1, 020Y-8050-YO1) and two growth plots (0201-0075-MO1 and 0201-0091-MO1 and their remeasurements).

Seven samples had non primary layers (Table 8). These layers were not projected.

Table 8. The non primary layers are summarized (Dbh ≥ 7.5 cm).

clstr_id	vdyp7 layer cd	Species 1	Pct 1	CC %	Basal area (m^2/ha)	Tree/ha
0201-0056-MO1	V	B	100	1	0.5	14
0201-0062-YR1	D	PLI	100	.	10.0	550
020Y-7315-YO1	D	PLI	100	.	1.5	104
0201-0064-YR1	D	PL	100	1	1.0	124
014Y-8792-YO1	R	AT	100	5	4.8	230
0201-0069-YR1	D	PLI	100	.	3.0	30
014Y-7571-YO1	D	PLI	100	.	7.0	600

Trees with a breast height age < 10 years or with breast height age > 120 are not considered suitable site index trees and were not used for SI estimation. No trees had a non-blank ST_FL field (used to identify standing or fallen trees – usually these are dead trees).

Residual trees are identified in the field. 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 and veteran trees were included in the establishment analysis to compared age, height, site index, leading species, basal area and trees/ha. For the comparison of ground vs. TIPSY volume, the residual trees were removed. Veteran trees were not considered suitable SI trees.

The samples were examined for evidence of multi-cohort conditions. Multi-cohort conditions may or may not indicate a departure from the YSM population. TIPSY was not developed for multi-cohort condition and the volume predictions may have more bias. The screening included examining plots that met the following conditions.

1. A residual or veteran layer is identified in the inventory.
2. Residual or veteran trees identified on the ground.
3. More than 25 years between the inventory age of the leading species and the second species.
4. More than 5 m between the inventory height of the leading and second species.
5. More than 25 years between the ground and inventory age.

Four plots were treated as multi-cohort (Table 9).

Table 9. The four plots treated as multi-cohort are given. Three plots appear twice.

clstr_id	Location	Use	Cause to suspect multi-cohort	action
014Y-8792-YO1	Lakes	Estab	residual layer	multi-cohort
			Abs(Phase1 -Phase2 age) > 25	multi-cohort
020Y-9504-YO1	Morice	Estab	13 residual trees	multi-cohort
014Y-5396-YO1	Lakes	Estab	abs(ht1 - ht2) > 5	multi-cohort
			Abs(age 1 - age 2) > 25	multi-cohort
014Y-7821-YO1	Lakes	Estab	Abs(age 1 - age 2) > 25	multi-cohort
			Abs(Phase1 -Phase2 age) > 25	multi-cohort

Plots with large, old trees and high volumes were also examined in more detail. The summaries are based on all live, measured trees. Six plots (two with remeasurements) have trees with ground total ages for the leading species greater than 50 (Table 10). These ages may represent residual trees after selective disturbance. All samples were retained.

Table 10. The plots where the leading species total age (ground measurement) is greater than 50 years.

clstr_id	Species	AGEB_TXO	HT_TXO	N_AG_TXO	Species (4.0 cm)	Multi-cohort
014Y-7821-YO1	At	73.8	19.2	4	At 66 Sx 34	Yes
014Y-8792-YO1	At	70.6	18.3	5	At 98 Sx 02	Yes
0201-0056-MO1	Bl	62.5	10.0	4	Bl 96 Hm 02 Pa 02	No
0201-0056-YR1	Bl	64.2	11.1	4	Bl 97 Hm 03	No
0201-0100-MO1	Pl	54.9	17.9	4	Pl 100	No
0201-0100-YR1	Pl	58.1	19.1	5	Pl 100	No
020Y-6208-YO1	Bl	52.7	11.0	4	Bl 81 Pl 14 Sx 04 At 01	No
020Y-7815-YO1	Bl	67.2	12.9	4	Bl 69 Pl 23 Sx 08	No

Eighteen samples had ground basal area greater than 30 m^2/ha, six of which only exceeded 30 m^2/ha at the second measurement (Table 11). All were included in the analysis.

Table 11. The plots where the ground basal area is greater than 30 m^2/ha. All attributes are at the 7.5 cm utilization level.

clstr_id	Basal area (m^2/ha)	Tree/ha	Whole stem volume (m^3/ha)	Dead volume (m^3/ha)	Measurement	Multi- cohort
014Y-6496-YO1	33.1	1226	173	0.0	0	No
014Y-7048-YO1	36.5	2552	224	0.0	0	No
014Y-7572-YO1	36.7	3577	244	20.3	0	No
014Y-7580-YO1	35.0	1651	219	0.0	0	No
014Y-7821-YO1	53.1	1201	424	20.6	0	Yes
0201-0052-MO1	34.0	3227	166	0.0	0	No
0201-0052-YR1	37.7	3027	205	0.0	1	No
0201-0055-YR1	33.8	2802	178	0.0	1	No
0201-0058-YR1	31.7	2927	161	3.2	1	No
0201-0059-YR1	33.7	2502	171	0.0	1	No
0201-0061-MO1	31.0	1401	157	0.9	0	No
0201-0061-YR1	35.2	1401	196	0.9	1	No
0201-0064-MO1	32.3	1276	179	0.0	0	No
0201-0064-YR1	41.0	1376	257	0.0	1	No
0201-0081-YR1	30.8	1301	170	0.8	1	No

clstr_id	Basal area (m^2/ha)	Tree/ha	Whole stem volume (m^3/ha)	Dead volume (m^3/ha)	Measurement	Multi- cohort
0201-0086-YR1	31.4	1826	182	0.0	1	No
0201-0091-MO1	35.3	2126	211	0.0	0	No
0201-0091-YR1	32.2	1501	217	1.6	1	No
0201-0098-YR1	35.4	1951	217	0.0	1	No
0201-0100-MO1	67.9	5954	547	14.4	0	No
0201-0100-YR1	68.2	5429	578	26.7	1	No
020Y-6491-YO1	40.3	2076	245	0.0	0	No
020Y-8790-YO1	49.8	2477	359	3.5	0	No

4.3 Ground sampling year and projection year

Ground sampling occurred throughout the growing season. The measurement year for measurements prior to June 30 were assumed to be the calendar year and the measurement year for measurements after June 30 were assumed to correspond to the subsequent calendar year. The Phase I data were projected to the ground measurement year for the purpose of Objective 2: assessing the accuracy of some Phase 1 Vegetation Resources Inventory (VRI) polygon attributes for young stands.

4.4 Ground SI and years to breast height

Age and height were measured on sample trees on the ground plots. The trees used in site index assessment had a breast height or total age, a height, and the age, 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 SIBEC standard (BC Ministry of Forests and Range, Research Branch 2009) of excluding trees with breast height age < 10 or > 120 was used here.

4.5 Phase I (Photo Interpreted Inventory) data

The average reference year for the Phase I inventory information is 2011. 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 clstr_id = 0142-8701-MO1 which, in the original inventory file, had a PROJ_HEIGHT_1 = 3.7 m and 4,703 trees/ha and basal area = 1.0 m^2/ha, implying the quadratic mean DBH is 1.6 cm (below any of the common utilization limits). For some young stands, the Phase I inventory utilization limit is not known.

The Phase I data were projected to the year of ground sampling. Twenty-three establishment samples were too short to project basal area and trees/ha. Seventeen change samples were too short at the time of establishment and four samples were too short at the time of remeasurements. For these measurements, basal area and trees/ha were copied from the input file. Volumes were set to zero. Ages and heights were projected.

The height of the second species is not projected by VDYP7. The height and age of the second species was projected by preparing a VDYP7 input file with the second species attributes (species, age and height) as the primary species attributes and projecting the height and age.

Five polygons had a dead layer, one had a veteran layer and one had a residual layer (Table 8).

4.6 Provincial Site Productivity Layer

The provincial site productivity layer (PSPL[5]), version 6.0, provides an alternative source of site index estimates, which is particularly useful for the YSM population. The PSPL is the prime source of SI information used in Timber Supply Review (TSR) for existing managed stands. 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[6], 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 for the Morice TSA was completed by Timberline Natural Resource Group and the accuracy of the PEM was assessed by Bio-Geo Dynamics Limited, as reported in *Morice TSA Level 4 Predictive Ecosystem Mapping (PEM) Accuracy Assessment: 2008 – 2009 Revision Report.* According to the report, the Morice TSA PEM meets the minimum accuracy assessment standard of 65 percent only by using some site series clumping. However, following a review of the PEM and accuracy assessment, provincial experts confirm that the PEM is "of sufficient quality for use in a SIBEC-based timber supply analysis." (Morice TSA TSR Data Package).

The PSPL does not include SI for AC so the SI estimate for AT was used for AC.

4.7 Height and Age matching

The height and age data matching followed the FAIB (2011) VRI procedures with exceptions for the spruces. The ground plot data were matched with the corresponding VRI Phase I photo interpreted inventory data for the polygon. The ground plot heights and ages were based on the average values for the T, L, S, X and O trees by 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 spruces were classified as SB, SE, SS or SW (including SX and SXW). The five possible matching cases are given in Table 12.

Table 12. 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
3	VRI polygon leading species and the ground leading species are both coniferous or both deciduous.
4	VRI polygon second species and the ground leading species are both coniferous or both deciduous.
5	No match

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

4.8 Stratification

The samples were stratified by TSA and leading species, leading species, and leading species age (Table 13). The stratification was based on the Phase I data for age and leading species. Note the small sample sizes for some strata.

Table 13. The strata used to summarize the results are defined. All strata include the multi-cohort samples (Table 9) except for "All – single" which omits them.

Analysis	TSA	Stratification	Strata	Definition	N	Include multicohort
Establishment	Lakes	Leading species (Phase I inventory)	A	AT	4	Yes
			B	BL	0	Yes
			P	PL, PLI	25	Yes
			S	S, SE, SX	3	Yes
			All - multi	Includes multicohort	29	Yes
			All - single	Excludes multicohort	26	No
	Morice	Leading species (Phase I inventory)	A	AT	3	Yes
			B	BL	3	Yes
			P	PL, PLI	17	Yes
			S	S, SE, SX	6	Yes
			All - multi	Includes multicohort	29	Yes
			All - single	Excludes multicohort	28	No
	Lakes & Morice	Age (Phase I Inventory)	Young	ages ≤ 30	35	Yes
			Older	ages > 30	23	Yes
		Leading species (Phase I inventory)	A	AT	7	Yes
			B	BL	3	Yes
			P	PL, PLI	41	Yes
			S	S, SE, SX	7	Yes
Change	Morice	Leading species (Phase I inventory)	B	BL	2	No
			P	PL, PLI	30	No
			S	S, SE, SX	15	No
		Age (Phase I Inventory)	Young	ages 15-30	28	No
			Older	ages 31-50	19	No

5 Establishment stand structure and health

The Lakes and Morice TSAs are adjacent to one another and have some similarities as well as some important differences. The TSA rationales for both TSAs indicate the pine mortality in both TSAs is about 90%. The Morice TSA has a single major license holder, CanFor, while the Lakes TSA has a number of license holders.

The YSM inventory information can from silvicultural surveys (RESULTS), from photo interpretation (Photo) or a combination (Both). In Morice, more of the Phase I information comes from photo interpretation and less from a combination than in Lakes.

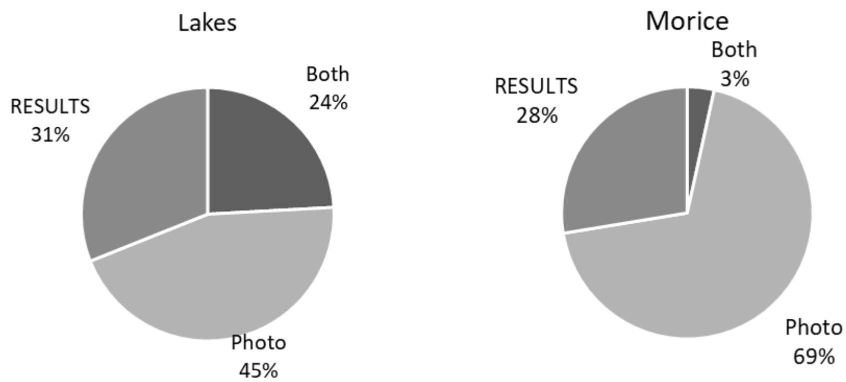


Figure 3. The source of the Phase I information for the establishment samples is given by source – silvicultural survey (RESULTS), photo interpretation (Photo) or a combination (Both).

The ground data are summarized in Table 14. The ground data are compiled from 0.04 ha fixed area plots. The ranges and standard errors associated with small plots are considerably higher than what is expected for larger polygons. The averages are similar for both TSAs.

Table 14. The Lakes and Morice TSAs 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.

	Util	N	Statistic				
Attribute	(cm)		Mean	Minimum	Maximum	SE	SE%
Lakes							
Basal area (m^2/ha)	4.0	29	20	0.2	53.7	2.4	12%
Trees per hectare (stems/ha)	4.0	29	1813	25	6479	249	14%
Gross volume live (m^3/ha)	4.0	29	112	1	426	17	16%
Basal area (m^2/ha)	7.5	29	18.4	0.2	53.1	2.4	13%
Trees per hectare (stems/ha)	7.5	29	1192	25	3577	144	12%
Gross volume live (m^3/ha)	7.5	29	106	1	424	17	16%
Gross volume dead (m^3/ha)	7.5	29	3	0	21	1	38%
Volume net of decay, waste & breakage (m^3/ha)	7.5	29	59	0	273	11	19%
Dead trees per hectare (stems/ha)	7.5	29	45	0	475	19	42%
Leading species age (years)	NA	29	32.2	15.2	73.8	2.5	8%
Leading species height (m)	NA	29	11.6	5.1	19.2	0.6	6%
Morice							
Basal area (m^2/ha)	4	29	19.6	2.7	50	2.2	11%
Trees per hectare (stems/ha)	4	29	1744	250	5829	220	13%
Gross volume live (m^3/ha)	4	29	106	7	360	15	14%
Basal area (m^2/ha)	7.5	29	18	1	49.8	2.2	12%
Trees per hectare (stems/ha)	7.5	29	1144	50	3127	132	12%
Gross volume live (m^3/ha)	7.5	29	101	3	359	15	15%
Gross volume dead (m^3/ha)	7.5	29	1	0	23	1	60%
Volume net of decay, waste & breakage (m^3/ha)	7.5	29	53	0	178	10	18%
Dead trees per hectare (stems/ha)	7.5	29	24	0	225	10	42%
Leading species age (years)	NA	29	32.3	15.7	67.2	2	6%
Leading species height (m)	NA	29	12	4.5	27.3	0.8	7%

The species composition in the YSM population is dominated by pine and spruce (Figure 4 and Figure 5), with the Lakes TSA having more pine while the Morice TSA has more spruce and balsam.

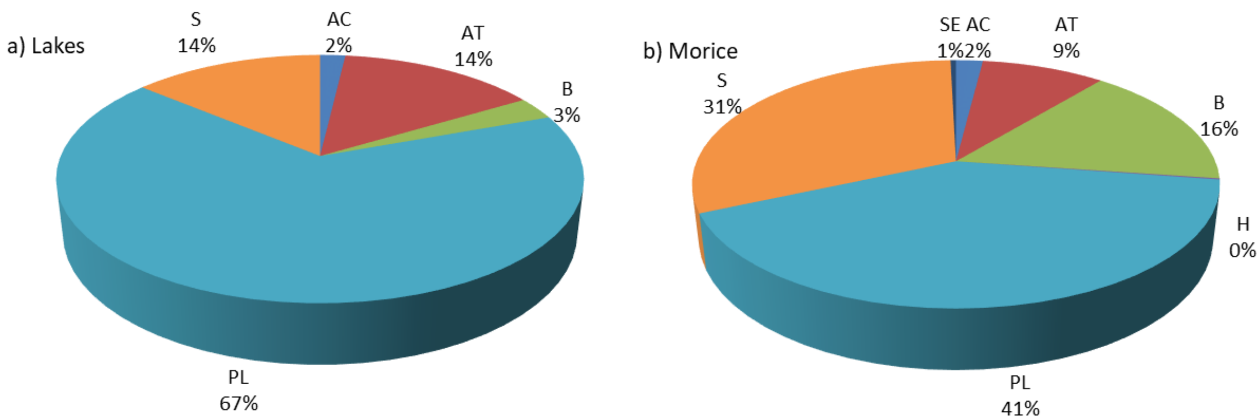


Figure 4. The percentage of live basal area is given by species based on the ground measurements for the establishment plots.

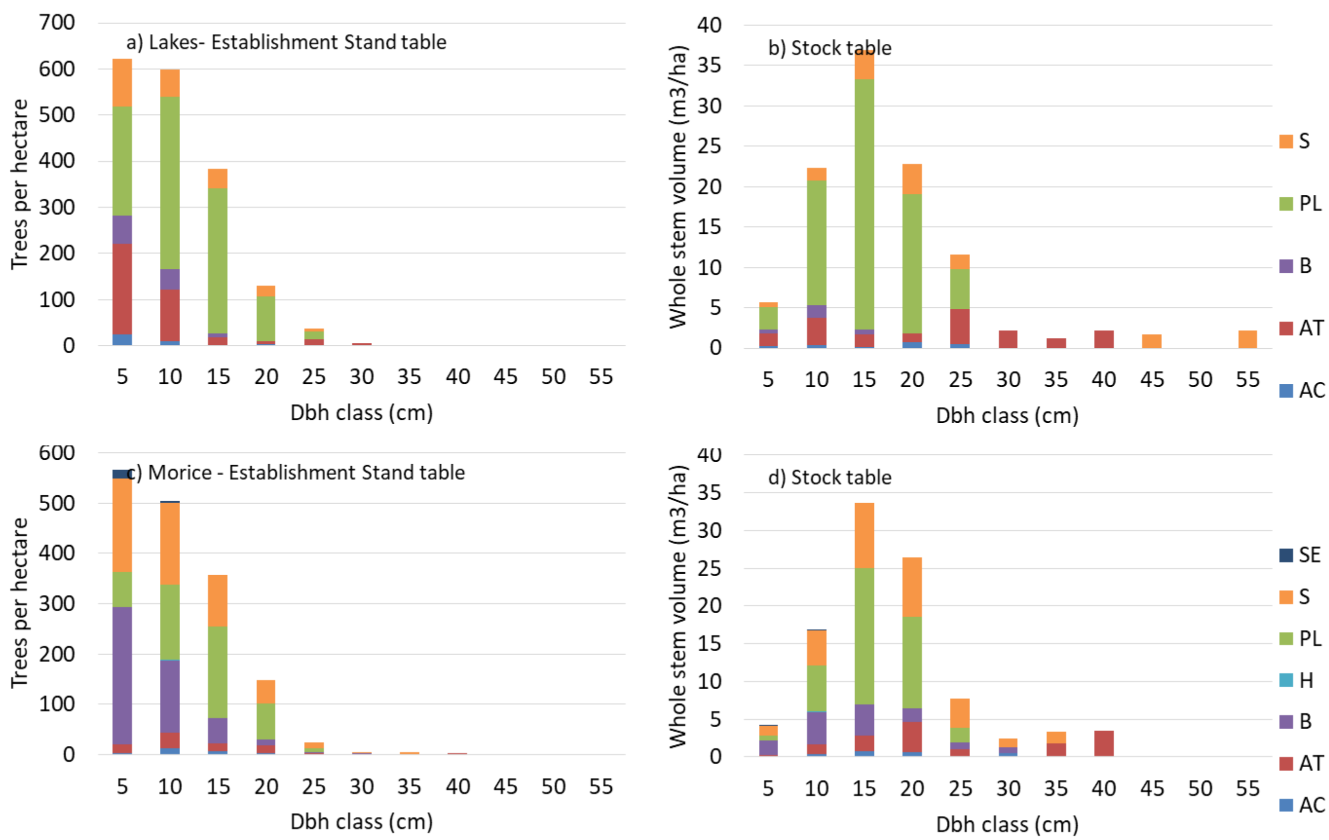


Figure 5. The stand and stock tables based on the ground measurements are given for the establishment plots.

The average number of dead trees (DBH ≥ 4.0 cm) is higher in the Lakes TSA (Table 15), mainly due to more dead pine in the Lakes TSA. Over half the dead trees have a DBH < 7.5.

Table 15. 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. For establishment plots only.

	Species		DBH	Class	(cm)					
Location	Group	5	10	15	20	25	30	35	Total	Percent
Lakes	AT	28	4	1	1	1			35	30%
	B								0	0%
	PL	45	26	8	1		2		81	70%
	S		1						1	1%
	Total	72	31	9	2	1	2	0	116	
	Percent	62%	27%	7%	1%	1%	1%	0%		
Morice	AC	3	3						7	13%
	AT	17	3						21	40%
	B		3	4	1		1		9	17%
	PL		8						8	15%
	S	7	1						8	15%
	Total	28	18	4	1	0	1	0	52	
	Percent	53%	35%	8%	2%	0%	2%	0%		

Visible damage is recorded in the ground plots. There is a relatively high incidence of unknown damage agent in the Lakes and Morice TSAs. Damage agent is coded as 'unknown' 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. The level of severity, however, may vary and there may or may not be a significant impact on volume or change. The damage severity is not recorded when the damage agent is unknown. 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.

Approximately 65% of the live trees in the Lakes TSA and 45% in the Morice TSA show signs of damage (Figure 6). The higher incidence of damage in the Lakes TSA appears to be associated with the greater occurrence of pine. The cause of most of the damage is unknown, form-related. If the Unknown damage is excluded, 80% of the trees are damage-free. Again, at this time, there is no assessment of damage severity when the cause is unknown. If the damage severity is low, it may be negligible.

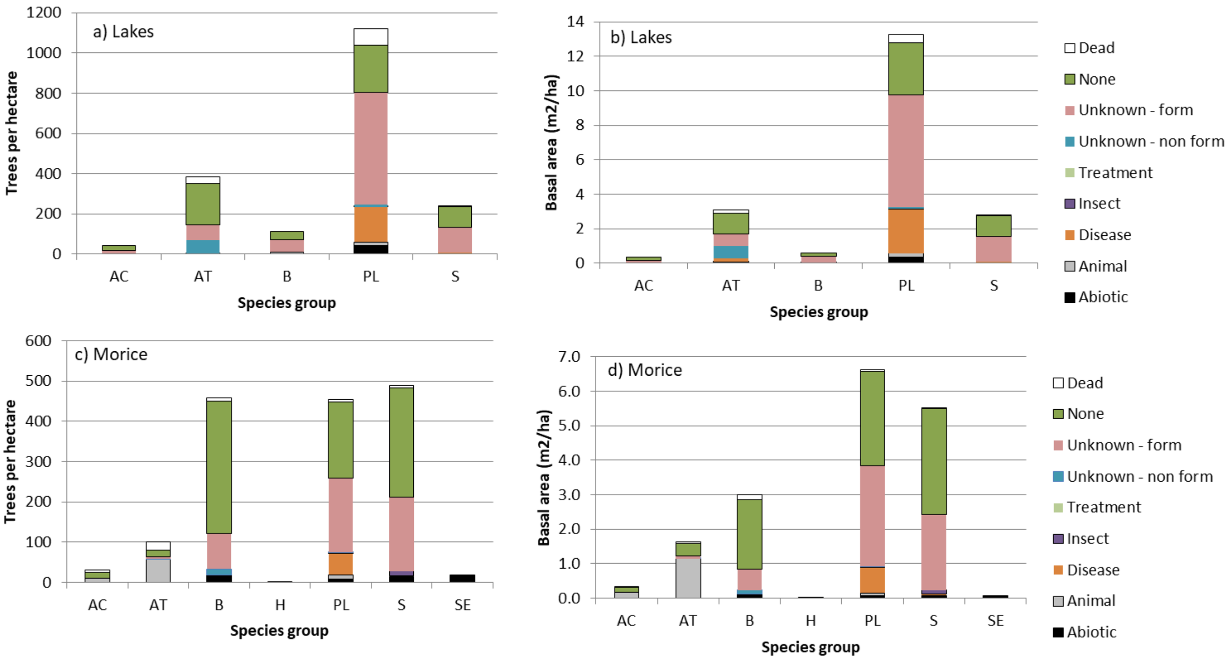


Figure 6. The trees/ha and basal area affected by each primary damage agent is given by TSA and species for live and dead trees, DBH ≥ 4.0 cm. Establishment plots only.

6 Ground vs. Inventory

6.1 Stand Age and Height

The leading species age, height and SI are compared. Most of the samples had case 1 matches (Table 16). There are some differences between the VRI and ground definitions of age and height. The ground total age is based on the breast height age and calculations of years to breast height. The photo age is an estimate of total age. The ground age is based on the trees sampled to estimate top height for a given species. The photo interpretation or leading and second species height is the average height, weighted by basal area, of the dominant, codominant and high intermediate trees for the leading and second species of each tree layer identified (FAIB 2014).

Table 16. The number of measurements are given by species matching case and use (establishment vs. change).

	Establishment		Change	Morice
Case	Lakes	Morice	Time 0	Time 1
1	26	16	38	38
2	1	7	7	7
3	1	4	1	1
4		1		
5	1	1	1	1
All	29	29	47	47

The leading species height and age are compared in Table 17 and Figure 7 and the species- or case-matched height and age are given in Table 18. Overall, the ground age is approximately 10% higher than the VRI age. Age differences are slightly greater for the 15 – 30 year age range and considerably higher for the A species stratum. Overall, by TSA, the age differences are not statistically significant for the single-cohort sample.

Overall, the ground height is approximately 20% higher than the inventory height. The height differences are statistically significant for the young age class but not for the older age class. Overall, the height differences are not statistically significant in Lakes but are in Morice.

Table 17. The leading species ground plot and VRI Polygon ages and heights are compared. The mean bias is followed by the standard error. Statistically significant differences are shaded.

	Phase I		Age (years)				Height (m)			
	Strata	N	Ground	VRI	Bias	p-value[7]	Ground	VRI	Bias	p-value
Lakes	A	4	55.4	31.8	23.6 ± 10.3	0.106	13.6	15	-1.3 ± 3.3	0.72
	P	24	28.4	27.8	0.6 ± 0.6	0.307	11.2	9.9	1.3 ± 0.4	0.007
	S	1	30.7	30			12	7		
	All - multi	29	32.2	28.4	3.8 ± 2	0.07	11.6	10.5	1.1 ± 0.6	0.078
	All - single	26	29.7	28.5	1.2 ± 0.9	0.187	11.2	10.3	0.9 ± 0.6	0.11
Morice	A	3	37.8	37.7	0.2 ± 4.8	0.978	19.6	14.8	4.7 ± 2.3	0.172
	B	3	31.6	28	3.6 ± 3.3	0.388	8.9	5.5	3.4 ± 0.7	0.034
	P	17	33.8	31	2.8 ± 1.9	0.156	12.1	10.6	1.5 ± 0.6	0.024
	S	6	25.5	25.5	0 ± 2.2	0.994	9.7	4.4	5.4 ± 0.8	0.001
	All - multi	29	32.3	30.2	2 ± 1.3	0.129	12	9.2	2.8 ± 0.5	0
	All - single	28	31.7	29.8	1.9 ± 1.3	0.163	12	9	3 ± 0.5	0
Lakes & Morice	A	7	47.8	34.3	13.6 ± 7.5	0.12	16.2	14.9	1.3 ± 2.3	0.604
	B	3	31.6	28	3.6 ± 3.3	0.388	8.9	5.5	3.4 ± 0.7	0.034
	P	41	30.6	29.1	1.5 ± 0.9	0.084	11.6	10.2	1.4 ± 0.4	0
	S	7	26.2	26.1	0.1 ± 1.8	0.963	10.1	4.8	5.3 ± 0.7	0
Lakes & Morice	Young	35	27.5	24.6	2.9 ± 1.3	0.03	10.6	7.8	2.8 ± 0.5	0
	Older	23	39.4	36.5	2.8 ± 2.3	0.231	13.7	13	0.7 ± 0.7	0.343
	All	58	32.2	29.3	2.9 ± 1.2	0.018	11.8	9.9	1.9 ± 0.4	0

The case-matched age differences are slightly larger and height differences are slightly smaller (Table 18).

[7] 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.

Table 18. The case-matched ground plot and VRI Polygon ages and heights are compared. Statistically significant differences are shaded.

	Phase I		Age (years)				Height (m)			
	Strata	N	Ground	VRI	Bias	p-value	Ground	VRI	Bias	p-value
Lakes	A	4	55.4	31.5	23.9 ± 10.3	0.103	13.6	12.9	0.8 ± 3.2	0.828
	P	24	28.9	28.2	0.7 ± 0.6	0.248	11.2	10.1	1.2 ± 0.4	0.015
	S	1	30.7	30			12	7		
	All - multi	29	32.8	28.8	4 ± 2.1	0.065	11.6	10.4	1.3 ± 0.6	0.033
	All - single	26	30.3	28.9	1.4 ± 0.9	0.163	11.2	10.1	1.1 ± 0.5	0.04
Morice	A	3	37.8	36.3	1.5 ± 5.9	0.825	19.6	14.2	5.4 ± 2.2	0.136
	B	3	31.6	29	2.6 ± 2.1	0.349	8.9	7.1	1.8 ± 1	0.213
	P	17	33.8	30.8	3 ± 1.9	0.137	12.1	10.6	1.5 ± 0.6	0.029
	S	6	27.4	27.8	-0.4 ± 1.2	0.776	9.4	5.9	3.4 ± 1.7	0.108
	All - multi	29	32.9	30.7	2.2 ± 1.3	0.107	12.1	9.8	2.3 ± 0.6	0
	All - single	28	32.3	30.4	2 ± 1.3	0.155	12.1	9.5	2.5 ± 0.5	0
Lakes & Morice	A	7	47.8	33.6	14.3 ± 7.4	0.104	16.2	13.5	2.7 ± 2.1	0.242
	B	3	31.6	29	2.6 ± 2.1	0.349	8.9	7.1	1.8 ± 1	0.213
	P	41	31	29.3	1.7 ± 0.9	0.066	11.6	10.3	1.3 ± 0.4	0.001
	S	7	28	28.2	-0.2 ± 1	0.865	9.8	6.1	3.7 ± 1.4	0.044
Lakes & Morice	Young	35	28.2	24.9	3.3 ± 1.4	0.02	10.6	8	2.6 ± 0.4	0
	Older	23	39.4	36.6	2.8 ± 2.3	0.243	13.7	13.1	0.6 ± 0.7	0.419
	All	58	32.8	29.7	3.1 ± 1.2	0.014	11.8	10.1	1.8 ± 0.4	0

The relationship between ground and inventory age was strong with a few exceptions (Figure 7).

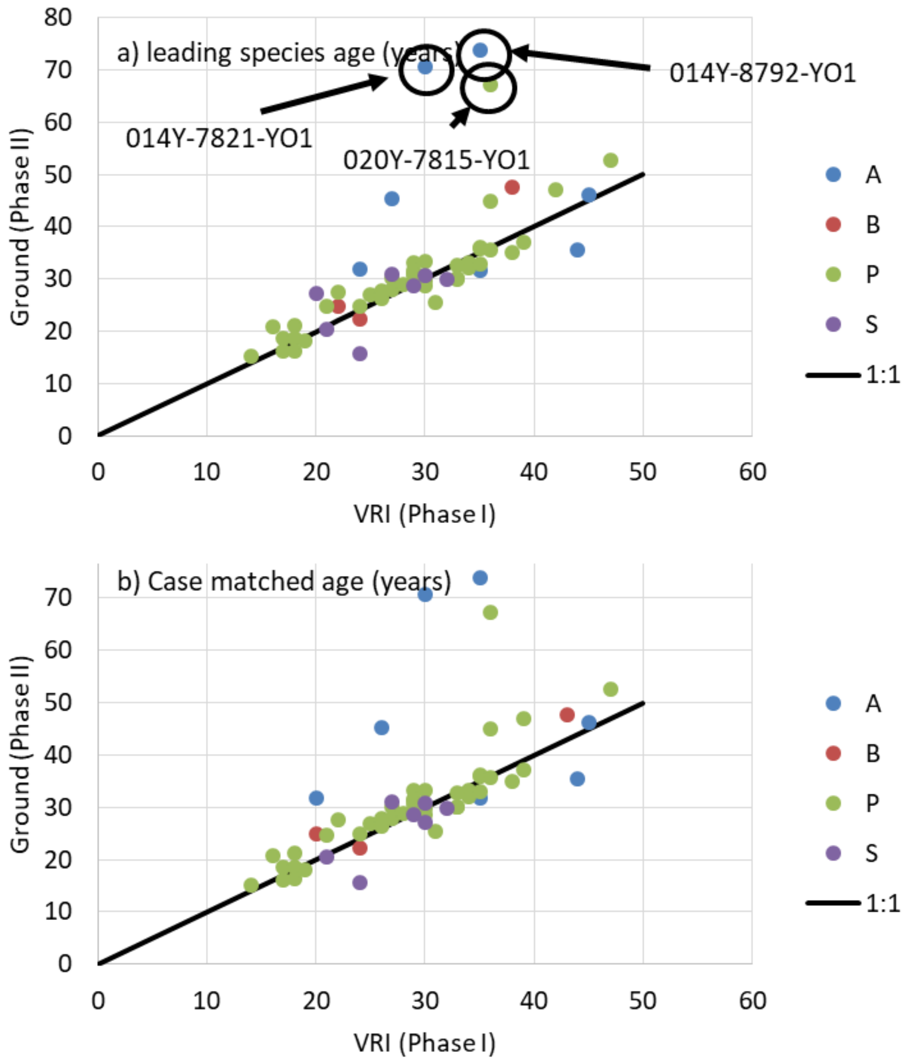


Figure 7. The VRI inventory (Phase I) and ground (Phase II) leading species ages are compared (a) and the case-matched ages are compared (b).

The relationship between ground and inventory height was relatively strong (Figure 8) with some evidence of underestimation in the inventory (Table 18). The Phase I age is used in TSR but the Phase I height is not used directly. Phase I age and height are used in the estimation of VRI SI. Another estimate of SI is available from the PSPL. The Phase I inventory is updated to the year of ground sampling using the Phase I age and SI (either from the VRI or the PSPL). If the SI is biased, it will have an impact on the projected height. The comparison here indicates the projected Phase I inventory underpredicts height. The Phase I height indirectly affects TSR projections as height and age are used to estimate SI.

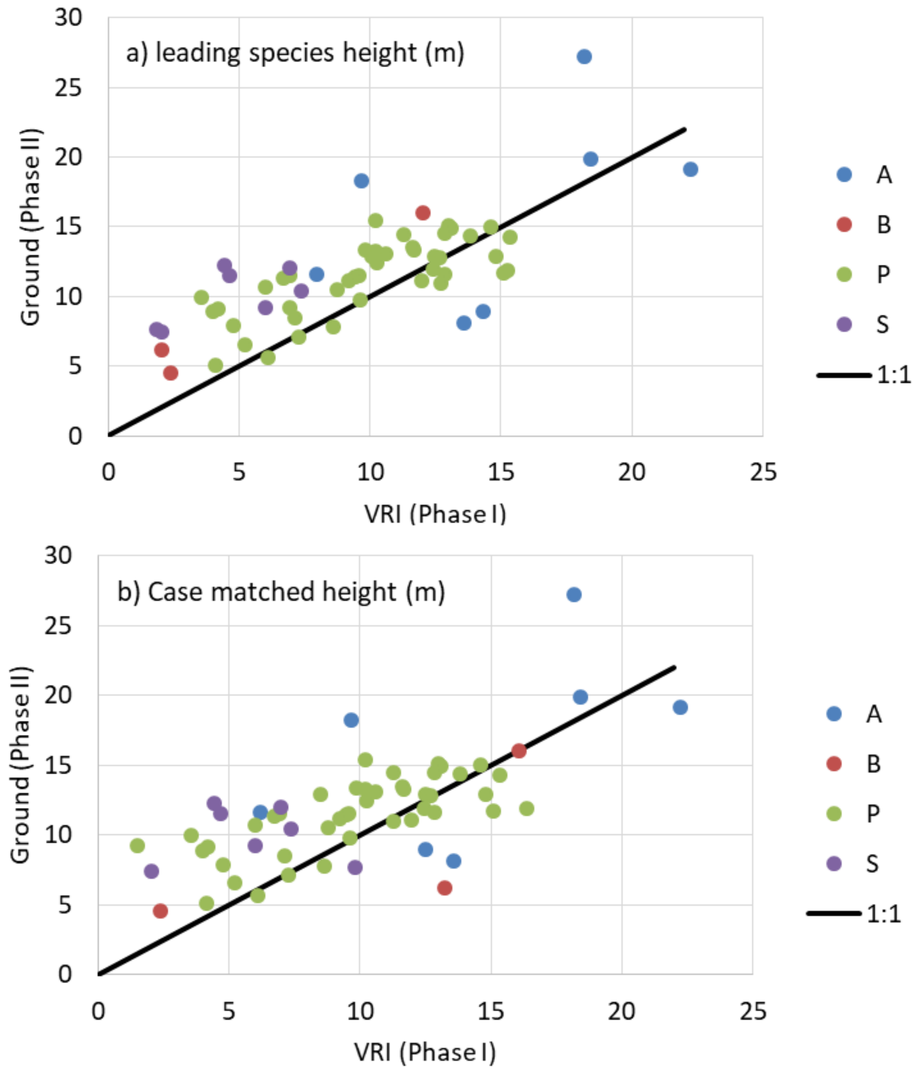


Figure 8. The VRI inventory (Phase I) and ground (Phase II) leading species heights are compared (a) and the case-matched heights are compared (b).

6.2 Site index

The ground, VRI and PSPL SI are compared in Figure 9 and Table 19. The sample size for the PSPL SI (n = 41) is greater than the VRI inventory SI (n = 38) because of species matching – the PSPL has more species and more matches. The VRI SI is based on the estimated average age and height of the dominant, codominant and high intermediate trees of the leading species. The ground SI is based on the average SI of the trees of the leading species sampled for SI.

Some of the polygons have been fertilized. Fertilization is expected to increase tree height and diameter. It is expected fertilized stands will have a higher site index than the PSPL, relative to unfertilized stands. Fertilization is applied to stands expected to benefit from the treatment. As a result of this targeted selection of stands for treatment, the average ground SI of fertilized stands compared to unfertilized stands should not be interpreted as a treatment effect.

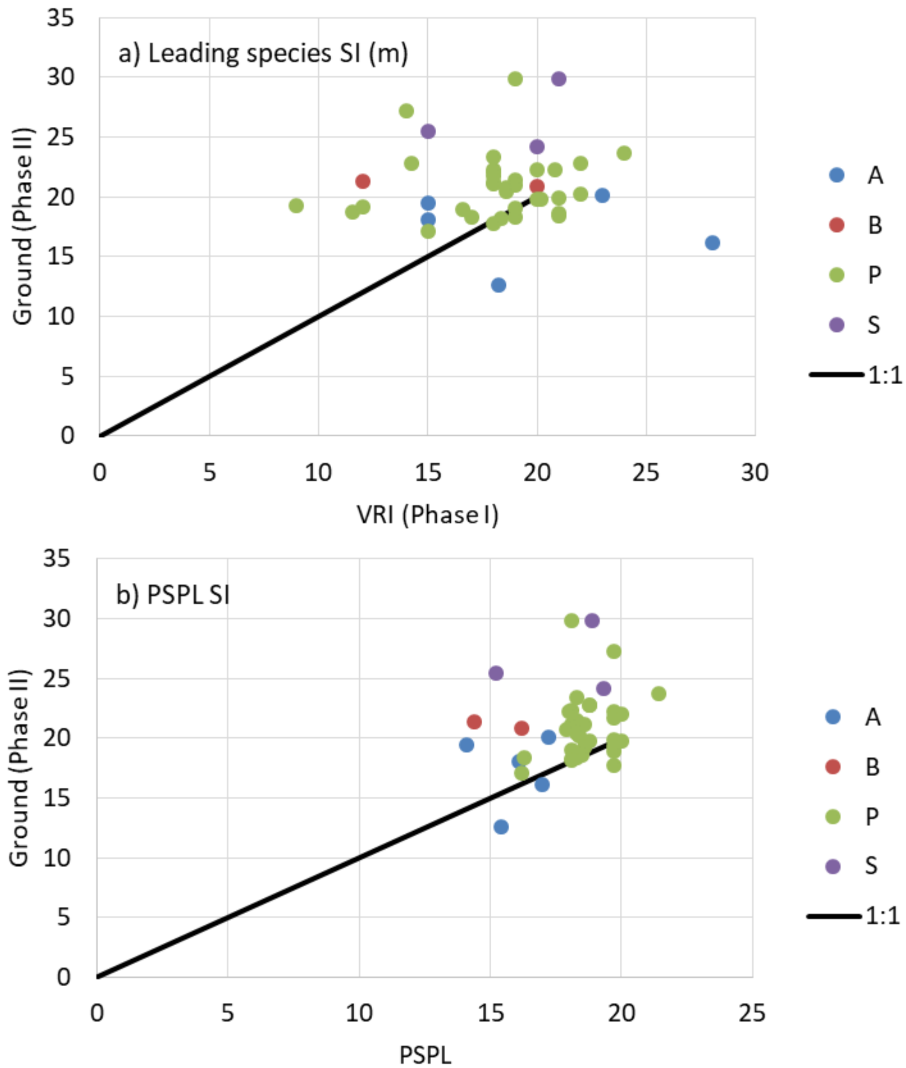


Figure 9. The ground SI and inventory SI (from Phase I) (a) and ground SI and PSPL SI (b) are compared. The Phase I and PSPL SI correspond to the ground leading species.

Both the Ground and VRI SI showed greater range than the PSPL (Figure 9). The PSPL SI range is particularly narrow by species. There is a tendency for the PSPL to underestimate SI (Table 19), particularly for the S strata and the younger strata. Overall, the ground SI was 10% greater than the PSPL SI. Usually the PSPL estimates of SI are higher than the ground or inventory estimates because the PSPL represents potential SI. SI estimates for young trees are sensitive to small errors in age and height. The ground SI is higher than the VRI SI as well but the differences are smaller and generally not statistically significant.

Table 19. The ground plot SI is compared to the PSPL SI for the ground leading species and to the VRI SI for case 1 and 2 matches.

	Phase I		Leading	Species	SI (m)			Case 1	& 2	SI (m)	
	Strata	N	Ground	PSPL	Bias	p-value	N	Ground	VRI	Bias	p-value
Lakes	A	4	16.7	16.7	0 ± 1.1	0.976	4	16.7	20.9	-4.2 ± 3.12	0.271
	P	21	20.4	18.7	1.7 ± 0.5	0.003	20	20.1	18.5	1.59 ± 0.6	0.016
	S	1	24.2	19.3			1	24.2	20		
	All - multi	26	20	18.4	1.6 ± 0.5	0.003	25	19.7	18.9	0.77 ± 0.79	0.342
	All - single	23	20.2	18.6	1.6 ± 0.5	0.005	22	19.9	18.7	1.13 ± 0.67	0.105
Morice	A	1	19.5	18.8			0				
	B	2	21.1	16.9	4.2 ± 2.5	0.345	2	21.1	22.3	-1.17 ± 1.9	0.648
	P	10	21	18.5	2.5 ± 0.5	0.001	9	21.2	18.5	2.65 ± 1.1	0.042
	S	2	27.7	16.2	11.5 ± 1.2	0.065	0				
	All - multi	15	21.8	18	3.8 ± 0.9	0.001	11	21.1	19.2	1.96 ± 1.04	0.088
	All - single	15	21.8	18	3.8 ± 0.9	0.001	11	21.1	19.2	1.96 ± 1.04	0.088
Lakes & Morice	A	5	17.3	17.1	0.2 ± 0.9	0.861	4	16.7	20.9	-4.2 ± 3.12	0.271
	B	2	21.1	16.9	4.2 ± 2.5	0.345	2	21.1	22.3	-1.17 ± 1.9	0.648
	P	31	20.6	18.6	2 ± 0.4	0	29	20.4	18.5	1.92 ± 0.53	0.001
	S	3	26.5	17.2	9.3 ± 2.3	0.056	1	24.2	20		
Lakes & Morice	Young	25	21.6	18.4	3.2 ± 0.7	0	21	20.8	19	1.81 ± 0.66	0.012
	Older	16	19.2	18	1.2 ± 0.5	0.02	15	19.2	19	0.18 ± 1.2	0.884
	All	41	20.7	18.2	2.4 ± 0.5	0	36	20.1	19	1.13 ± 0.63	0.083

The previous comparison looked at the SI for the ground leading species. Some of the ground samples have SI estimates for additional species. The PSPL was compared to all species with ground SI estimates. As with the leading species comparison, the ground SIs are generally higher than the PSPL SI (Table 20).

Table 20. The ground and PSPL SI are compared by ground species group (lead, second or third).

	Phase I		SI (m)			
	Strata	N	Ground	PSPL	Bias	p-value
Lakes	A	8	18.2	17.5	0.73 ± 0.76	0.372
	P	28	20.3	18.5	1.84 ± 0.61	0.005
	S	2	22.7	19.2	3.54 ± 1.37	0.235
	All - multi	38	20	18.3	1.69 ± 0.48	0.001
	All - single	34	20.3	18.4	1.81 ± 0.53	0.002
Morice	A	2	20.8	18.9	1.94 ± 1.26	0.365
	B	4	20.7	16.1	4.59 ± 1.14	0.028
	P	14	21.8	18.3	3.46 ± 1.22	0.014
	S	3	26.6	17.1	9.53 ± 2.04	0.043
	All - multi	23	22.1	17.8	4.32 ± 0.91	0
	All - single	23	22.1	17.8	4.32 ± 0.91	0
Lakes & Morice	A	7	22.2	16.4	5.8 ± 2.81	0.084
	B	4	19.3	15.6	3.69 ± 0.87	0.024
	P	34	20.1	18.7	1.37 ± 0.36	0.001
	S	16	22.1	18.3	3.85 ± 0.94	0.001
Lakes & Morice	Young	36	22.1	18.3	3.8 ± 0.7	0
	Older	25	19	18	1.08 ± 0.44	0.022
	All	61	20.8	18.1	2.68 ± 0.48	0

6.3 Leading Species

In the Lakes TSA, 90% (26 of 29) had the same inventory and ground leading species, a very high agreement. In the Morice TSA, the agreement was 55% (16 out of 29). If S and SE are considered matches, the agreement for Morice rises to 62%.

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

Location	Ground Plot Leading Species	VRI polygon leading species AT	B	PL	S	SE	Total	% Agreement
Lakes	AC	3		1			4	75%
	B						0	0%
	PL			22			22	100%
	S	1		1	1		3	33%
	SE						0	0%
	Total	4	0	24	1	0	29	90%
	% agreement	75%	0%	92%	100%	0%		73%
Morice	AC	2			1		3	67%
	B			2			2	0%
	PL	1		12		1	14	86%
	S		2	3	2	1	8	25%
	SE		1		1		2	0%
	Total	3	3	17	4	2	29	
	% agreement	67%	0%	71%	50%	0%		55%

Seven samples had 10% or less difference between the leading and second species in terms of species composition on the ground or in the inventory (Table 22 – one sample appears twice). If the leading and second species in the inventory composition were switched when the difference ≤ 10%, four additional samples would have become case 1 matches. The overall effect would be to increase the agreement for Lakes from 90% to 93% and Morice from 55% to 66% (if S ≠ SE) or 72% (if S = SE).

Table 22. The samples with 10% 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.

Clstr_id	Ground Spp 1	Spp 2	Spp 3	Spp 4	Pct 1	Pct 2	Pct 3	Pct 4	VRI Spp 1	Spp 2	Spp 3	Spp 4	Pct 1	Pct 2	Pct 3	Pct 4	Case	Approx Case
020Y-6767-YO1	Sx	Bl			53	47	.	.	BL	SX	PLI		60	30	10	.	2	1
014Y-5673-YO1	Sx	Pl			55	45	.	.	PLI	AT	SX		70	20	10	.	3	1
020Y-9498-YO1	At	Sx			52	48	.	.	AT	SX	BL	PLI	50	20	20	10	1	1
020Y-6491-YO1	Sx	Bl	Pl	Ac	48	47	4	1	BL	SX	PLI		50	40	10	.	2	1
014Y-8061-YO1	Ac	Pl			96	4	.	.	PLI	BL	SX		50	40	10	.	5	5
020Y-6491-YO1	Sx	Bl	Pl	Ac	48	47	4	1	BL	SX	PLI		50	40	10	.	2	1
0202-3641-MO1	Pl	At	Bl	Sx	55	19	18	8	PLI	SX	BL	AT	45	40	10	5	1	1
020Y-9504-YO1	Sx	Bl	Pl	At	69	22	8	1	PLI	SX	AC		40	35	25	.	2	1

6.4 Basal area and trees/ha

Phase I Inventory trees/ha (TPH) and basal area (BA) are compared to the YSM ground data in order to assess the accuracy of these Phase I polygon attributes for young stands. Note that the Phase I TPH and

BA are not used in TSR. As noted in section 4.5, 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 projections represent trees with DBH ≥ 7.5 cm in the projection year. However, BA and TPH are only projected 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 lower utilization limit.

The ground and Phase I (Inventory) BA and TPH are compared in Table 23. Twenty-two establishment samples (8 in Lakes and 14 in Morice and 56) were not projected by VDYP7 and the BA and TPH were copied over from the input file and likely have a lower utilization limit. The effect of differing utilization levels and lack of updating BA and TPH is expected to be greater for younger samples. This is confirmed by the larger relative biases for BA associated with the 15 - 30 year age class (compared to the 31 – 50 year age class) and, to a lesser extent, by TPH. Overall, the differences are not statistically significant for BA and are statistically significant for TPH.

Table 23. The ground plot and VRI Polygon BA and TPH are compared.

	Phase I		BA (m^2/ha)				Trees/ha			
	Strata	N	Ground	VRI	Bias	p-value	Ground	VRI	Bias	p-value
Lakes	A	4	24.1	23.9	0.2 ± 8.8	0.981	1326	1494	-169 ± 662	0.815
	P	24	16.8	15.5	1.2 ± 2	0.536	1168	2799	-1630 ± 381	0
	S	1	33.1	5			1226	1280		
	All - multi	29	18.4	16.3	2 ± 2.2	0.356	1192	2566	-1374 ± 341	0
	All - single	26	17.3	16.3	1 ± 2.3	0.654	1186	2735	-1549 ± 358	0
Morice	A	3	35.1	25.7	9.3 ± 7.5	0.34	1785	1153	631 ± 536	0.36
	B	3	14.2	12.8	1.4 ± 2.3	0.597	809	4259	-3450 ± 1012	0.076
	P	17	18.1	19.1	-1 ± 1.7	0.566	1208	2381	-1172 ± 312	0.002
	S	6	11.3	6.2	5.2 ± 2.2	0.068	809	1588	-779 ± 320	0.059
	All - multi	29	18	16.4	1.6 ± 1.4	0.278	1144	2284	-1140 ± 280	0
	All - single	28	18	16.3	1.7 ± 1.5	0.249	1150	2289	-1140 ± 290	0.001
Lakes & Morice	A	7	28.8	24.7	4.1 ± 5.8	0.503	1522	1348	174 ± 438	0.705
	B	3	14.2	12.8	1.4 ± 2.3	0.597	809	4259	-3450 ± 1012	0.076
	P	41	17.3	17	0.3 ± 1.4	0.818	1185	2625	-1440 ± 257	0
	S	7	14.4	6	8.4 ± 3.8	0.067	868	1544	-675 ± 289	0.058
Lakes & Morice	Young	35	14.2	11.4	2.8 ± 1.9	0.143	968	2609	-1641 ± 332	0
	Older	23	24.3	24	0.2 ± 1.5	0.873	1473	2146	-673 ± 171	0.001
	All	58	18.2	16.4	1.8 ± 1.3	0.165	1168	2425	-1257 ± 219	0

7 Ground vs. TIPSY Volumes

The current volumes associated with young stands are generally less important than the growth curves, which estimate yields at maturity. Growth curves are generated by analysis units (AUs) for TSR. The volumes evaluated here are the static volumes from the establishment plots. The growth model TIPSY was used to generate growth projections for the samples. TIPSY projects growth, given assumptions of initial stand conditions.

Residual trees have been omitted from the volume analysis.

7.1 Analysis Unit yield curves

The Lakes TSA analysis unit (AU) definitions and yield curves were used. AU curves were not available for the Morice TSA so the AU definitions in Table 24 were used to assign the samples to AUs and to generate TIPSY yield curves.

Table 24. The Morice analysis unit criteria and TIPSY assumptions are given. For all AU curves, the regen delay = 2 years, OAF1 = 0.85, OAF2 = 0.95 and genetic gain = 0.

	Criteria		TIPSY Input						
AU	Species composition	Site index	Spp1	Spp2	Pct1	Pct2	SI	Regen method	Density
PL-pure	PL 65%+	SI ≥ 17.5	PL		100		20	Plant	1500
PL-pure	PL 65%+	12.5 ≤ SI < 17.5	PL		100		15	Plant	1500
PL-pure	PL 65%+	SI < 12.5	PL		100		10	Plant	1500
PL-mixed	PL leading, PL < 65%	SI ≥ 17.5	PL	Sx	50	50	20	Natural	5000
PL-mixed	PL leading, PL < 65%	12.5 ≤ SI < 17.5	PL	Sx	50	50	15	Natural	5000
PL-mixed	PL leading, PL < 65%	SI < 12.5	PL	Sx	50	50	10	Natural	5000
S-pure	S 65%+	SI ≥ 17.5	Sx		100		20	Plant	1500
S-pure	S 65%+	12.5 ≤ SI < 17.5	Sx		100		15	Plant	1500
S-pure	S 65%+	SI < 12.5	Sx		100		10	Plant	1500
S-mixed	S leading, S < 65%	SI ≥ 17.5	Sx	Pl	50	50	20	Natural	5000
S-mixed	S leading, S < 65%	12.5 ≤ SI < 17.5	Sx	Pl	50	50	15	Natural	5000
S-mixed	S leading, S < 65%	SI < 12.5	Sx	Pl	50	50	10	Natural	5000
AT	AT leading	All	AT		100		15	Natural	5000
BL	AT leading	All	AT		100		15	Natural	5000

7.2 Predicted (Projected) Yield Estimates

For each sample, 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. The net volume utilization level is 12.5 cm for pine and 17.5 cm for all other species.

<u>VOL1</u>: Ground based plot volume. VOL1 is identical to the ground compiled volume except for the removal of residual trees (if applicable).

<u>VOL2</u>: 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 were not known. Stands with a leading species of P or S were assumed to be planted with 1,500 stems/ha. All other stands were assumed to be natural origin with an initial density of 5,000 stems/ha. No TIPSY curves are available for AC so it was mapped to AT. Regeneration delay was set to two years. For spruce stands < 31 years old, the genetic gain was set to 17%. Genetic gain was set to zero for all other samples.

For each species, the average site index was computed as described in section 4.4. SI was always available for the leading species.

TIPSY does not model mixed stands but outputs the weighted average of pure species stand where the weights reflect the species composition. Pure species curves were generated for up to the top four species on the ground plots. For each species, the yield curve was generated assuming 100% species composition and the ground SI for that species. The ground SI was not always available for species other than the leading species. Where possible, the SI for additional species was generated using SiteTools and the SI for the leading species and the SiteTools SI conversion equations. If that was not possible, the PSPL SI was used. A mixed species, composite yield curve was generated by the weighted average pure species yield curves with weights equal to the species composition fraction. Height, BA, TPH and volume were taken as the species composition weighted average of the curves. The species-weighted average height is consistent with TIPSY output for multiple species runs which is the weighted top height by 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. And 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. For mixed species stands, the species-weighted average height from the TIPSY curves was matched to the species-weighted average height from the ground sample.

<u>VOL3</u>: TIPSY estimated volumes using the PSPL site index estimates and the VRI Phase I species composition. The regeneration assumptions in Table 24 were used for VOL3. 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 (corresponding to the age of ground sampling).

<u>VOL4</u>: The AU volumes are described in section 7.1. These volumes correspond to a utilization of 12.5 cm for pine and 17.5 cm for all other. VOL4 is the volume from the AU yield curve corresponding to PROJ_AGE_1 (adjusted to the year of ground sampling).

The bias was defined a follows.

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

7.3 Bias analysis

The ground volumes (VOL1) are approximately double the TIPSY volumes based on the Phase I species composition and the PSPL SI (VOL3) (Figure 10). The samples are from the YSM population and the volume estimates are sensitive to changes in SI, species composition, age and height.

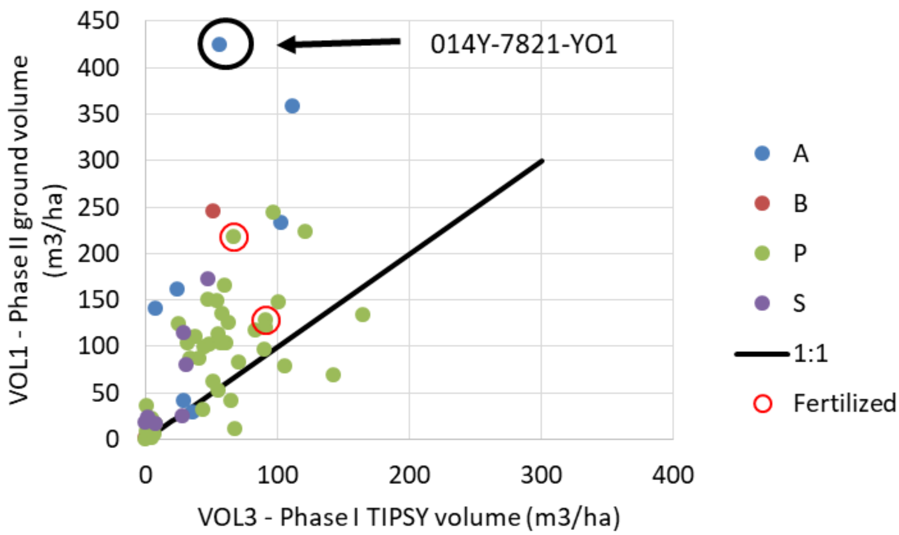


Figure 10. The ground volume is plotted against the TIPSY VOL3 predictions. This is an estimate of total bias. Volumes are whole stem volume at the 7.5 cm utilization level. Fertilization is discussed in section 6.2.

The ground volumes (VOL1) were compared to the TIPSY volumes using the ground species composition and site index (VOL2) (Figure 11). This is an estimate of model bias but also includes bias resulting from the assumption of initial stand density and stand origin. The model bias is approximately half of the total bias (Table 25)

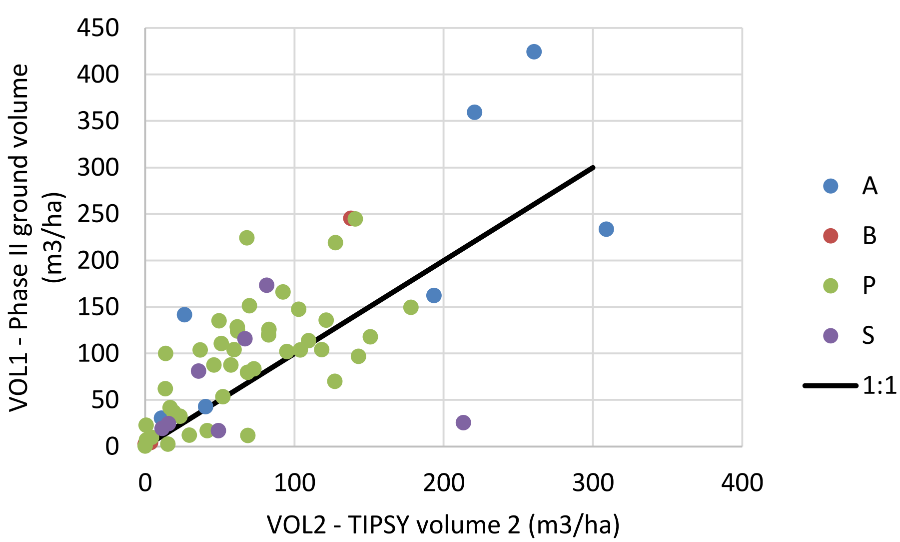


Figure 11. The ground volume is plotted against VOL2. Volumes are whole stem volume at the 7.5 cm utilization level.

VOL2 was compared to VOL3 to estimate the attribute bias (Figure 12). The model bias and attribute bias have similar magnitude but the relationship between VOL2 and VOL3 is not as strong (Figure 12).

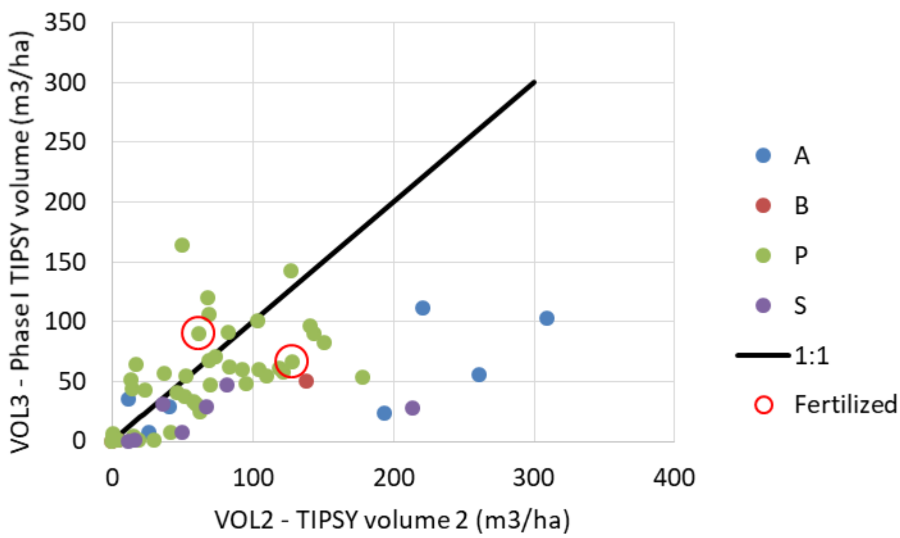


Figure 12. The VOL3 is plotted against VOL2. This is an estimate of attribute bias. Volumes are whole stem volume at the 7.5 cm utilization level.

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 (based on the previous TSR) 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. The results of TIPSY whole stem volume comparisons are given in Table 25.

Table 25. Ground and TIPSY whole stem volumes are compared. The utilization level is 7.5 cm. Statistically significant biases are shaded. The samples sizes for the A, B and S strata are small and the results should be viewed with caution.

	Phase I	N	(m3/ha)			Bias			p-value		
	Strata		VOL1	VOL2	VOL3	Total	Model	Attribute	Total	Model	Attribute
Lakes	A	4	164.9	126.5	36.0	128.9	38.4	90.5	0.231	0.439	0.21
	P	24	93.9	64.5	52.5	41.4	29.4	12.0	0.001	0.008	0.083
	S	1	173.3	81.6	47.1	126.2	91.7	34.5			
	All - multi	29	106.4	73.6	50.0	56.4	32.8	23.6	0.001	0.003	0.028
	All - single	26	104.9	73.6	49.7	55.2	31.3	23.9	0.003	0.01	0.045
Morice	A	3	244.8	185.5	73.8	171.0	59.3	111.7	0.047	0.474	0.175
	B	3	84.0	47.2	17.3	66.7	36.8	29.9	0.407	0.407	0.406
	P	17	93.7	72.7	61.4	32.3	21.0	11.3	0.015	0.055	0.39
	S	6	47.1	65.4	16.0	31.1	-18.3	49.4	0.066	0.633	0.137
	All - multi	29	98.7	80.2	48.7	50.0	18.5	31.5	0	0.134	0.014
	All - single	28	98.1	80.7	49.4	48.6	17.4	31.2	0.001	0.17	0.019

	Phase I	N	(m3/ha)			Bias			p-value		
	Strata		VOL1	VOL2	VOL3	Total	Model	Attribute	Total	Model	Attribute
Lakes &	A	7	199.1	151.8	52.2	146.9	47.3	99.6	0.024	0.221	0.036
Morice	B	3	84.0	47.2	17.3	66.7	36.8	29.9	0.407	0.407	0.406
	P	41	93.8	67.9	56.2	37.6	25.9	11.7	0	0.001	0.078
	S	7	65.2	67.7	20.4	44.7	-2.6	47.3	0.044	0.942	0.093
Lakes &	Young	35	75.6	62.8	28.3	47.3	12.9	34.4	0	0.152	0
Morice	Older	23	143.5	98.4	81.4	62.1	45.0	17.1	0.01	0.003	0.298
	All	58	102.5	76.9	49.4	53.2	25.6	27.6	0	0.002	0.001

The attribute portion of the total bias is greater for the younger samples than the older samples (34 vs. 17 m^3/ha), similar to the larger SI bias associated with the younger samples compared to the older samples (3.2 vs 1.2 m). The ground SI is approximately 12% higher than the PSPL SI and the ground BA is approximately 10% higher than the VRI estimate which may account for the volume attribute bias of approximately 27%.

The volumes net of decay, waste and breakage are given in Table 26. 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 for pine and 17.5 cm for all other species.

	Phase I	N	(m3/ha)			Bias			p-value		
	Strata		VOL1	VOL2	VOL3	Total	Model	Attribute	Total	Model	Attribute
Lakes	A	4	82.1	47.3	1.8	80.3	34.7	45.6	0.301	0.386	0.236
	P	24	53.2	43.6	34.0	19.2	9.6	9.6	0.018	0.171	0.11
	S	1	119.6	25.6	7.5	112.1	94.0	18.1			
	All - multi	29	59.5	43.5	28.6	30.9	16.0	14.8	0.01	0.047	0.03
	All - single	26	57.3	42.8	28.4	28.9	14.5	14.4	0.026	0.1	0.056
Morice	A	3	134.7	148.2	16.6	118.1	-13.5	131.6	0.052	0.725	0.165
	B	3	49.7	20.9	5.6	44.1	28.8	15.3	0.423	0.423	0.423
	P	17	50.3	45.6	40.1	10.2	4.7	5.5	0.432	0.589	0.691
	S	6	14.3	32.6	1.0	13.3	-18.3	31.6	0.135	0.576	0.311
	All - multi	29	51.5	51.0	26.0	25.5	0.5	25.0	0.024	0.952	0.067
	All - single	28	51.6	52.2	26.9	24.7	-0.7	25.4	0.034	0.944	0.072
Lakes &	A	7	104.6	90.6	8.1	96.5	14.1	82.4	0.04	0.584	0.048
Morice	B	3	49.7	20.9	5.6	44.1	28.8	15.3	0.423	0.423	0.423
	P	41	52.0	44.4	36.5	15.5	7.6	7.9	0.028	0.157	0.231
	S	7	29.4	31.6	2.0	27.4	-2.3	29.7	0.126	0.943	0.258
Lakes &	Young	35	41.0	36.4	12.8	28.1	4.5	23.6	0	0.541	0.001
Morice	Older	23	77.6	63.6	49.4	28.3	14.0	14.3	0.126	0.179	0.373
	All	58	55.5	47.2	27.3	28.2	8.3	19.9	0.001	0.169	0.008

7.4 Ground vs. AU volumes

The Lakes AU volumes were taken from the file tipsy_to_woodstock_5_year_period, the "tipsy" tab. The MAI from that tab was multiplied by age to get VOL4. The Morice AU volumes were based on the AU assignments and corresponding AU assumptions (Table 24) and TIPSY. There is a great deal of variation in the bias and overall the AU volume bias is not statistically significant.

Table 27. The ground and inventory volumes are compared to the AU volumes.

	Phase I	N	(m3/ha)			Bias	p-value
	Strata		VOL1	VOL4	VOL3	VOL1 – VOL4	
Lakes	A						
	P	24	53.2	76.1	34.0	-22.8 ± 7.9	0.008
	S	1	119.6	103.2	7.5	16.4	.
	All - multi	25	55.9	77.2	32.9	-21.3 ± 7.8	0.011
	All - single	22	52.8	76.4	33.2	-23.6 ± 8.7	0.013
Morice	A	3	134.7	6.3	16.6	128.3 ± 32.2	0.058
	B	3	49.7	0.0	5.6	49.7 ± 49.7	0.423
	P	17	50.3	44.7	40.1	5.6 ± 16.9	0.746
	S	6	14.3	1.0	1.0	13.3 ± 7.5	0.134
	All - multi	29	51.5	27.1	26.0	24.4 ± 13.2	0.074
	All - single	28	51.6	28.0	26.9	23.6 ± 13.6	0.095
Lakes & Morice	A	3	134.7	6.3	16.6	128.3 ± 32.2	0.058
	B	3	49.7	0.0	5.6	49.7 ± 49.7	0.423
	P	41	52.0	63.1	36.5	-11.1 ± 8.6	0.203
	S	7	29.4	15.6	2.0	13.8 ± 6.3	0.072
Lakes & Morice	Young	33	41.8	37.6	13.5	4.2 ± 8.4	0.620
	Older	21	71.9	70.1	53.9	1.8 ± 17.7	0.919
	All	54	53.5	50.3	29.2	3.3 ± 8.5	0.701

8 Change

This section focuses on the remeasured plots from the YSM pilot study in the Morice TSA and YSM objective 5 (see section 2) to compare observed change to forecasts from growth and yield models. The analysis follows the change estimation section of the Merrit TSA YSM analysis[8]. For trees present and tagged at plot establishment, the components of change used the tree factor at time of measurement. Some trees were tagged on the small tree plot at establishment (4.0 cm ≥ Dbh < 9.0 cm and had a tree factor = 100 stems /ha) and at remeasurement were tagged on the large tree plot (Dbh ≥ 9.0 cm and had a tree factor = 25 stems/ha). The components of change used the tree factor = 100 stems/ha. Ingress did not have a tree factor at the time of plot establishment and was assigned the tree factor at the time of remeasurement.

The components of change are defined in Table 28.

[8] Merritt Timber Supply Area Ground Sample Data Analysis Young Stand Analysis. Prepared by Associated Strategic Consulting Experts, March 31, 2015. 54p.

Table 28. The components of change are described.

Abbreviation	Component	Description
S	Survivor	Tree that is live at both measurements with Dbh ≥ 4.0 cm at both measurements. Estimated from both the small and large tree plots.
M	Mortality	Tree that is live at first measurement and Dbh ≥ 4.0 cm and dead at second measurement Tree that is live at first measurement and Dbh ≥ 4.0 cm and missing at second measurement (assumed dead and fallen or cut) Estimated from both the small and large tree plots.
I	Ingress	Tree that is not tallied at first measurement and is live with Dbh ≥ 4.0 cm at second measurement Estimated from the small tree plot only.
D	Dead	Dead at first measurement and dead at second measurement Missing at first measurement and dead at second measurement (ingress that died) Dead at first measurement and missing at second measurement (assumed dead and fallen) Estimated from both the small and large tree plots.

Let $\hat{Y}_0$ be the estimate of the attribute of interest at time 0. The net change can be estimated as

$$\hat{\Delta}_Y = \hat{Y}_1 - \hat{Y}_0$$

Change may also be estimated, using the notation in Table 28, as

$$\tilde{\Delta}_Y = \hat{S} + \hat{M} + \hat{I}$$

For a single fixed area plot $\hat{\Delta}_Y = \tilde{\Delta}_Y$. For variable radius plots or nested plots where trees have different selection probabilities (as is the case here), the two estimates of change are not equivalent. That is, $\hat{\Delta}_Y \neq \tilde{\Delta}_Y$. The two estimates are unbiased so the difference between the two estimates has an expected value of zero (Gregoire 1993).

The net annual change of the main attributes are given in Table 29. Two SI comparisons are given. “SI (m) – all” includes all samples – if a SI estimate was not available at time 1, it was set to the SI estimate at time 0. “SI (m) – only if SI Time 2 ≠ .” only includes samples with separate estimates of SI at time 0 and time 1.

Table 29. The average at time 0 and time 1 and the annual difference (± standard error) are given by attribute (Dbh ≥ 4.0 cm). The annual differences are statistically significant except for TPH.

Attribute	N	Time 0	Time 1	annual difference ± s.e.	p-value
Height (m)	47	11.3	13.4	0.42 ± 0.02	0
Age (years)	47	30.2	34.9	0.91 ± 0.03	0
SI (m) – all	47	20.4	21.6	-1.6 ± 0.33	0
SI (m) – only if SI Time 2 ≠ .	27	20.3	21.6	0.24 ± 0.05	0
BA (m^2/ha)	47	20	24.3	0.83 ± 0.07	0
TPH (trees/ha)	47	1964	1939	-5.4 ± 7.2	0.46
WSV (m^3/ha)	47	102.3	140.1	7.36 ± 0.51	0
Netvol (m^3/ha)	47	57.2	90.4	6.47 ± 0.46	0

The plot-level changes in trees/ha are given in Figure 13.

One issue associated with sampling is that the same trees are not necessarily sampled for age at remeasurement. Sample 67 has an average leading species age of 62.5 at establishment and 64.2 at remeasurement (5 years later). Similarly the height trees may not be the same. As a consequence, the site index estimate may change from measurement to measurement. A reference breast height age = 50 years is used for SI estimation. The SI estimates should become more precise the closer a site tree is to that reference age. For young trees, a small error in age or height has a larger impact on the SI estimate that for older, taller trees. Another issue is that some trees shrink between measurements, leading to a negative survivor "growth". For example, sample 51, tree 471 has Dbh = 15.9 cm and plot establishment and Dbh = 11.8 cm at first remeasurement.

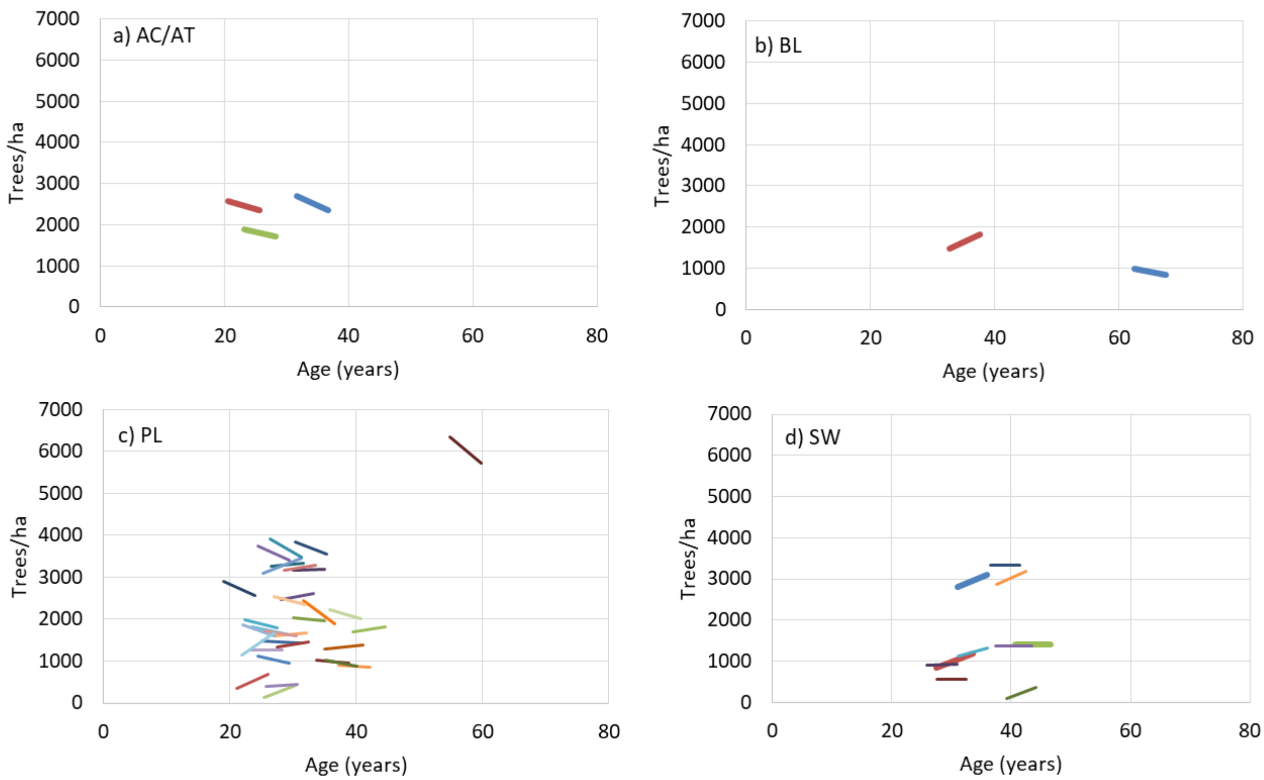


Figure 13. The change in trees/ha is given by ground leading species. The age at the end of the trajectory is the age at establishment + the measurement interval.

The change in whole stem volume is relatively constant across strata (Figure 14 and Table 30) except for the BL strata (n = 2).

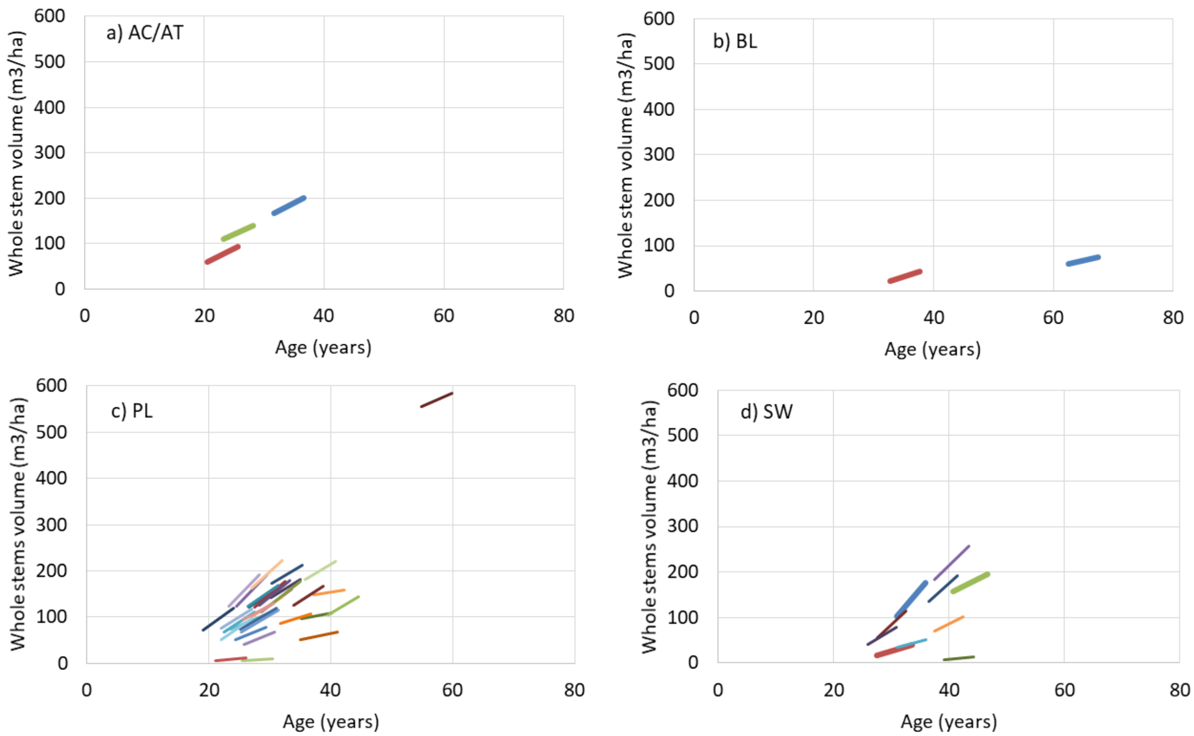


Figure 14. The change in whole stem volume (Dbh ≥ 4.0 cm) is given by ground leading species. The age at the end of the trajectory is the age at establishment + the measurement interval.

For BA and volume, most of the change is due to survivor growth with minor changes due to ingress and mortality (Table 30). For density, the biggest change was due to mortality followed by ingress.

Table 30. The average ground attributes at time 0 and time 1 and the change components are given (Dbh ≥ 4.0 cm).

Attribute	Strata	N	Interval (years)	Average time 0	time1	Change (m^2/ha/yr) dead	survivor	ingress	mortality
BA (m^2/ha)	A	3	5.0	19.2	22.0	0.1	0.9	0.0	-0.6
	BL	2	5.0	11.6	15.1	0.4	0.7	0.1	-0.1
	PL	32	5.1	21.5	25.5	0.3	1.0	0.0	-0.1
	SW	10	5.3	17.2	23.1	0.0	1.0	0.0	0.0
	All	47	5.1	20.0	24.3	0.2	1.0	0.0	-0.1
Density (trees/ha)	A	3	5.0	2385	2143	11	0	27	-105
	BL	2	5.0	1226	1338	3	0	30	-23
	PL	32	5.1	2106	2041	0	0	15	-18
	SW	10	5.3	1531	1671	0	0	21	-2
	All	47	5.1	1964	1939	0	0	18	-20
Whole Stem Volume (m^3/ha)	A	3	5.0	111.9	143.9	0.5	8.0	0.1	-2.9
	BL	2	5.0	41.3	58.6	3.3	3.4	0.1	-0.4
	PL	32	5.1	112.2	150.6	1.6	8.5	0.1	-0.6
	SW	10	5.3	80.0	121.5	0.0	7.6	0.1	0.0

			Interval	Average		Change (m^2/ha/yr)			
Attribute	Strata	N	(years)	time 0	time1	dead	survivor	ingress	mortality
	All	47	5.1	102.3	140.1	1.3	8.1	0.1	-0.6
Net	A	3	5.0	23.3	53.7		7.2		-0.6
Merchantable	BL	2	5.0	21.1	28.0	3.1	2.6		
Volume	PL	32	5.1	51.8	84.2	1.2	7.0		-0.2
(m^3/ha)	SW	10	5.3	28.9	61.1	0.0	6.5		
	All	47	5.1	43.8	75.0	0.9	6.7		-0.2

A difficulty associated in projecting growth occurs with species mixtures. At establishment, the species composition associated with sample 67 is At50Pl50. At remeasurement, the species composition is Pl65At35, a change in leading species. Sample 67 was the only one that changed leading species between measurements.

9 Discussion

The YSM population is dominated by pine followed by spruce with minor amounts of aspen/cottonwood, balsam and hemlock. The highest volumes are found in the aspen/cottonwood stratum followed by the spruce stratum. The ground average basal area is approximately 10% higher than the inventory estimates (Table 31). The bias is greatest in the younger age class (age 15 - 30). The bias in the older age class (age 31 – 50) is relatively smaller and not statistically significant. The lower inventory BA may be due in part to some polygons with short trees. VDYP7 does not project BA and volume until the projected height is approximately 7m.

Table 31. 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	Estimate	Ground mean	Inventory mean	Bias: Magnitude	Bias: p-value	Bias: % of ground mean
Lakes	Basal area (m^2/ha)	29	VRI	18.4	16.3	2.0	0.356	11%
	Density (tree/ha)	29	VRI	1192	2566	-1374	0	-115%
	Species matched age (years)	29	VRI	32.2	28.4	3.8	0.07	12%
	Species matched height (m)	29	VRI	11.6	10.5	1.1	0.000	9%
	Site index (m)	26	PSPL	20	18.4	1.6	0.003	8%
	Whole stem volume (m^3/ha)	29	TIPSY	106.4	50	56.4	0.001	53%
	Volume model bias (m^3/ha)		TIPSY			32.8	0.003	31%
	Volume attribute bias (m^3/ha)		TIPSY			23.6	0.028	22%
Morice	Basal area (m^2/ha)	29	VRI	18	16.4	1.6	0.278	9%
	Density (tree/ha)	29	VRI	1144	2284	-1140	0.0	-100%
	Species matched age (years)	29	VRI	32.3	30.2	2.0	0.129	6%
	Species matched height (m)	29	VRI	12	9.2	2.8	0	23%
	Site index (m)	15	PSPL	21.8	18	3.8	0.001	18%
	Whole stem volume (m^3/ha)	29	TIPSY	98.7	48.7	50.0	0	51%
	Volume model bias (m^3/ha)		TIPSY			18.5	0.134	19%
	Volume attribute bias (m^3/ha)		TIPSY			31.5	0.014	32%

The ground estimates of SI are 12% higher than the PSPL estimates. The PSPL is the potential SI and expected to be higher than the actual SI so the higher ground SI estimates are unexpected. The range, by species, of the PSPL SI is quite narrow compared to the ground estimates. The PSPL estimates are based on SIBEC Site series so the amplitude in the PSPL will always be less than any set of ground observations.

Approximately 65% of the live trees in the YSM portion of the Lakes TSA and 45% in the Morice TSA show signs of damage. The cause of most of the damage is unknown, non form-related. At this time there is no assessment of damage severity when the cause is unknown. With such a high level of unknown damage, it may be informative to assess the damage severity.

There are differences between the TSAs. Approximately 67% of the BA in YSM portion of the Lakes TSA is pine followed by deciduous (16%) and spruce (14%) while 41% of the BA in Morice is pine followed by spruce (31%) and balsam (16%). In the Lakes TSA, 90% of the samples have the same inventory and ground leading species compared to 55% in Morice. This rises to 93% and 72% if close matches are included and all spruces are considered matches. In Lakes, 45% of the VRI information for the YSM samples comes exclusively from photo interpretation compared to 69% in Morice. These differences between the TSAs should be kept in mind when interpreting the combined results.

The ground volumes were compared to those generated by TIPSY. The ground volumes were approximately double the TIPSY volumes with the bias distributed relatively evenly between attribute and model bias.

The growth of the 47 monitoring plots in Morice were examined. Generally, projection models assume a constant SI, species composition and that age will increment with time. The trees measured for height and age at plot establishment are not necessarily remeasured so the difference in ages is not necessarily the same as the remeasurement interval. And the dominant height at remeasurement may be shorter than the height at establishment. As a result, the SI estimates may change over time. The average net change in whole stem volume is 7 m^3/ha/year, ranging from 3 m^3/ha/year for the B stratum to 7 – 8 m^3/ha/year for the remaining strata. The change in net volume was 6.5 m^3/ha/year.

The analysis has a number of complications. The samples sizes are small for the deciduous, balsam and spruce strata. There are differences between TSAs that limit interpreting the combined results. The samples are young and the trees are small. Small errors in age (e.g., due to missing the pith) and height can have relatively large effects on SI. The compilations and projections are sensitive to the utilization standard.

10 List of References

BC Ministry of Forests and Range, Research Branch. 2009. SIBEC: Sampling and data standards. Version 5.3, revised September 2009. 8p + app.

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. Morice Timber Supply Area – TSA 20: Vegetation Resources Inventory Project implementation plan for volume audit sampling, young stand monitoring and net volume adjustment factor sampling. March 2012. 14p + app.

FAIB. 2014. Vegetation Resources Inventory – Photo Interpretation Procedures. Version 3.0. Ministry of Forests, Lands and Natural Resource Operations. 21p + app.

Gregoire, T.G. 1993. Estimation of forest growth from successive surveys. Forest Ecology and Management 56:267 – 278.

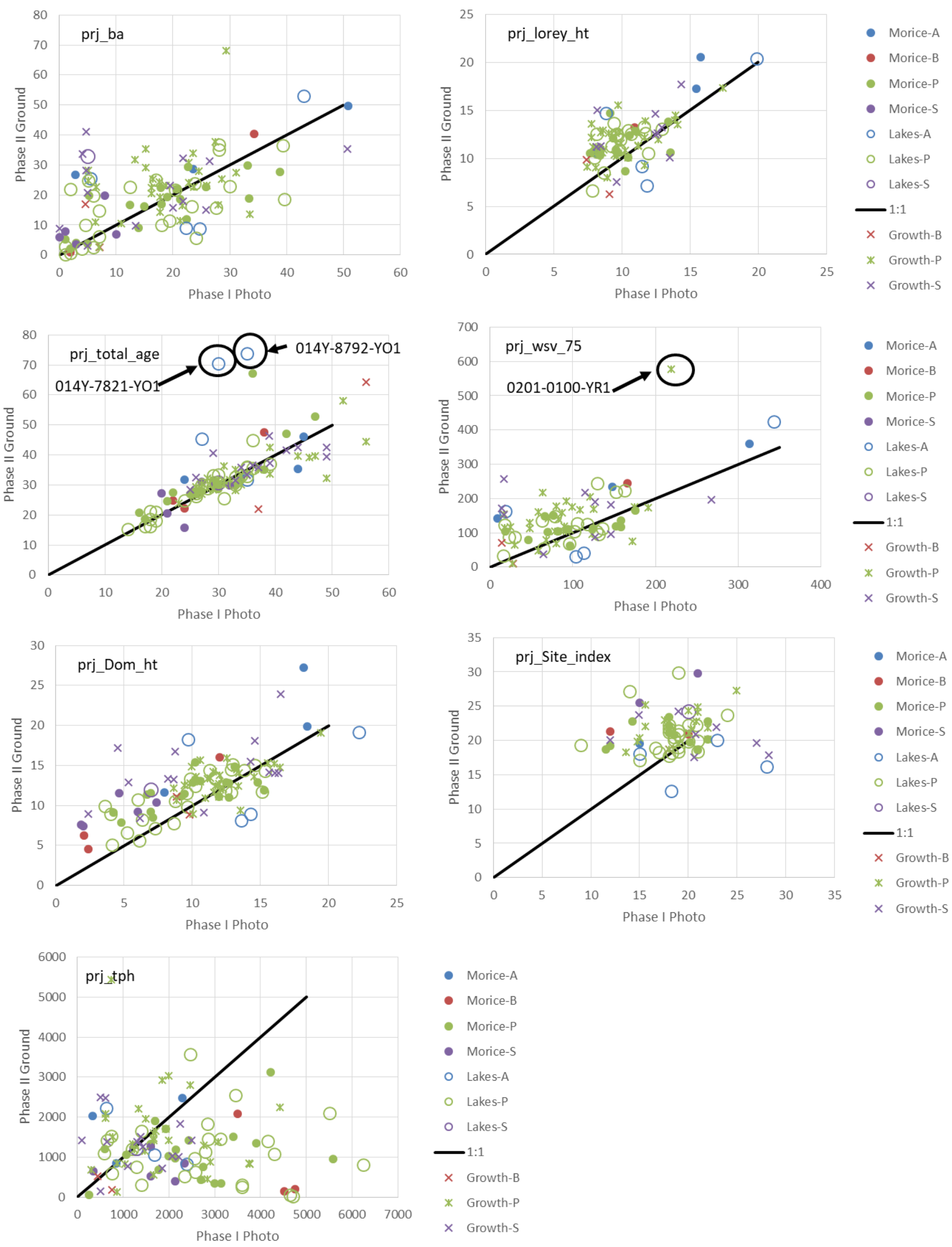
MFLNRO. 2011. The Lakes and Morice TSAs Timber Supply Review – Data Package 2011. 87p. + app.

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.

Omule, A., 2013. A framework for implementing young stand monitoring in British Columbia: a discussion paper.

11 Appendix A – Data Screens

Figure 15. The Phase II ground measurements are plotted against the Phase I Photo estimates. The ground data for the change plots is the second measurement.



12 Appendix B – Plot Data Summaries

Table 32. The Plot data summaries are given.

			Phase II								Phase I							PSPL					
use	strata	clstr_id	BA 7.5	TPH 7.5	WSV 7.5	WSV D 7.5	Spp	HT	Age	SI	BA 7.5	TPH 7.5	WSV 7.5	Dead Vol 12.5	Spp	HT	Age	At	BL	PL	SB	SE	SX
Estab	P	0142-8691-MO1	10.0	1101	32	0	Pl	7.8	25.5	17.1	4.6	580	16		PLI	8.6	31.0		14.7	16.2		14.8	14.8
Estab	P	0142-8701-MO1	0.2	25	1	0	Pl	5.1	15.2		1.0	4703	0		PLI	4.1	14.0	16.9	17.3	19.7	10.9		18.2
Estab	P	014Y-5127-YO1	21.8	1451	104	0	Pl	11.7	32.9	18.4	20.3	3124	129		PLI	15.1	35.0		14.8	16.3		14.7	14.7
Estab	P	014Y-5396-YO1	2.8	300	10	0	Pl	6.6	16.2	21.2	1.0	1400	0		PLI	5.2	17.0	16.6	15.8	18.1	10.6		18.9
Estab	P	014Y-5397-YO1	25.2	1826	148	0	Pl	13.3	30.0	21.7	16.9	2843	78		PLI	11.7	33.0	16.9	16.2	19.7	11.0		18.2
Estab	P	014Y-5398-YO1	21.8	2101	100	1	Pl	9.9	26.4	19.3	2.0	5500	0		PLI	3.6	26.0	16.9	16.4	19.7	10.8		18.2
Estab	P	014Y-5673-YO1	0.7	50	2	0	Sx	8.9	21.2	27.2	2.0	4650	0		PLI	4.0	18.0	17.0	17.5	19.7	11.0		18.2
Estab	P	014Y-5939-YO1	6.1	801	23	0	Pl	7.1	18.7	19.9	7.0	6240	0		PLI	7.3	18.0	16.9	16.4	19.7	11.1		18.2
Estab	P	014Y-6220-YO1	19.8	1526	88	0	Pl	9.8	27.8	18.3	6.0	731	23		PLI	9.6	26.0	17.8	15.7	18.3			19.6
Estab	S	014Y-6496-YO1	33.1	1226	173	0	Sx	12.0	30.7	24.2	5.0	1280	0		SX	7.0	30.0	18.0	17.3	19.0	10.8		19.3
Estab	A	014Y-6503-YO1	9.0	1051	30	0	At	8.1	31.7	12.6	22.3	1677	104		AT	13.6	35.0	15.4	16.7	18.6	11.3		18.2
Estab	P	014Y-6506-YO1	23.0	1126	126	0	Pl	11.9	32.7	19.0	30.1	2794	117		PLI	12.4	33.0	18.7	15.8	18.1			18.9
Estab	P	014Y-6785-YO1	22.7	1201	136	0	Pl	14.4	30.1	23.7	12.4	1189	63		PLI	13.8	27.0	20.9	18.8	21.4	11.6		20.3
Estab	P	014Y-7048-YO1	36.5	2552	224	0	Pl	13.5	35.6	18.9	39.4	3449	163		PLI	11.6	36.0	17.0	16.3	19.7			18.2
Estab	P	014Y-7571-YO1	11.5	751	70	12	Pl	14.3	37.1	19.8	19.3	1285	96	10	PLI	15.3	39.0	17.3	16.8	20.0	11.1		18.5
Estab	P	014Y-7572-YO1	36.7	3577	244	20	Pl	15.1	45.0	18.2	28.1	2457	130		PLI	13.0	36.0	16.2	15.8	18.1			18.9
Estab	P	014Y-7580-YO1	35.0	1651	219	0	Pl	15.0	33.2	22.3	28.1	1400	152		PLI	14.6	34.0	17.0	15.8	18.1			18.9
Estab	P	014Y-7817-YO1	10.1	525	54	1	Pl	11.5	33.2	18.3	18.0	2334	64		PLI	9.6	29.0	17.5	15.8	18.1	10.8		18.9
Estab	P	014Y-7818-YO1	18.6	1401	114	4	Pl	13.4	28.9	22.3	39.7	4151	136		PLI	9.8	28.0	16.9	16.9	19.7	11.3		18.2
Estab	A	014Y-7819-YO1	8.8	826	43	0	Sx	9.0	45.3	20.1	24.6	2386	113		AT	14.3	27.0	17.2	16.7	19.6	11.4		18.3
Estab	P	014Y-7820-YO1	2.0	300	7	0	Pl	5.6	18.1	17.8	4.0	3600	0		PLI	6.1	19.0	16.9	16.8	19.7	11.5		18.2
Estab	A	014Y-7821-YO1	53.1	1201	424	21	At	19.2	73.8	16.2	43.1	1282	343		AT	22.2	35.0	17.0	17.1	19.7	11.6		18.2
Estab	P	014Y-7826-YO1	14.9	600	88	0	Pl	12.4	27.3	22.2	7.0	758	29		PLI	10.2	26.0	17.2	15.5	18.0	10.8		19.1
Estab	P	014Y-8061-YO1	2.6	250	12	0	Ac	10.7	16.3	29.8	6.0	3600	0		PLI	6.0	18.0		15.8	18.1	10.5		18.9
Estab	P	014Y-8065-YO1	23.8	1451	128	12	Pl	11.6	35.8		23.8	2863	105		PLI	12.8	35.0	17.8	16.2	18.4			19.2
Estab	P	014Y-8548-YO1	16.3	1076	104	9	Pl	14.4	33.4	21.4	23.3	4303	102		PLI	11.3	30.0	16.1	16.1	18.3	11.4		18.9
Estab	A	014Y-8792-YO1	25.5	2226	162	1	At	18.3	70.6	18.1	5.5	634	19		AT	9.7	30.0	16.1	16.7	18.8	10.9		19.5
Estab	P	014Y-9028-YO1	24.8	1426	124	0	Pl	10.5	24.9	20.9	5.1	652	17		PLI	8.8	24.0	18.0	15.8	18.1	10.7		18.9
Estab	P	CMI5-0232-FR1	15.8	976	97	2	Pl	14.5	36.2	20.5	27.6	2563	131		PLI	12.8	35.0	16.2	16.1	18.3	10.6		18.9
Estab	P	0201-0077-MR1	22.0	1701	111	0	Pl	11.1	27.4	20.2	20.6	1934	94		PLI	12.0	26.0	17.2	16.2	18.4			19.2

			Phase II								Phase I							PSPL					
use	strata	clstr_id	BA 7.5	TPH 7.5	WSV 7.5	WSV D 7.5	Spp	HT	Age	SI	BA 7.5	TPH 7.5	WSV 7.5	Dead Vol 12.5	Spp	HT	Age	At	BL	PL	SB	SE	SX
Estab	P	0202-1156-MO1	2.2	50	12	0	Pl	11.4	30.2		2.0	250	0		PLI	6.7	33.0	15.5	15.4	17.9	10.9		18.8
Estab	P	0202-3641-MO1	11.8	751	62	0	Pl	12.9	32.1	20.7	22.4	2745	97		PLI	12.5	34.0	19.0	15.4	17.9	10.8		18.8
Estab	P	0202-6761-MO1	4.1	350	16	0	Sx	9.2	24.7		3.0	3000	0		PLI	7.0	21.0	17.0	16.1	18.3	10.6		18.9
Estab	P	020Y-6208-YO1	29.8	3127	135	0	Bl	11.0	52.7		33.2	4214	158		PLI	12.7	47.0	18.3	15.8	18.1	10.5		18.9
Estab	P	020Y-6485-YO1	29.3	1351	151	0	Pl	11.5	28.0	21.1	22.6	3902	77		PLI	9.4	27.0	17.4	16.5	18.6			19.0
Estab	S	020Y-6490-YO1	7.0	525	25	0	Se	9.2	30.9		10.0	1600	0		SX	6.0	27.0		16.9	18.8			19.0
Estab	B	020Y-6491-YO1	40.3	2076	245	0	Sx	16.0	47.6	20.9	34.3	3506	166		BL	12.0	38.0	17.0	16.2	18.4	10.6		19.2
Estab	B	020Y-6765-YO1	1.0	150	3	0	Se	4.5	22.3		2.0	4525	0		BL	2.4	24.0		14.4	16.5		14.2	14.2
Estab	P	020Y-6766-YO1	16.7	675	80	0	Sx	12.9	35.1	22.8	12.4	1775	46		PLI	10.1	38.0	17.8	16.9	18.8	11.0		19.0
Estab	B	020Y-6767-YO1	1.3	200	4	0	Sx	6.2	24.9	21.4	2.0	4747	0		BL	2.0	22.0		14.4	16.8		14.6	14.6
Estab	P	020Y-7314-YO1	17.0	1326	102	0	Pl	13.2	30.6	23.4	18.0	1596	70		PLI	10.2	29.0	18.0	16.1	18.3	11.0		18.9
Estab	P	020Y-7315-YO1	16.3	1026	83	3	Pl	11.6	32.6	18.7	15.0	2000	0	6	PLI	6.9	34.0	14.4	16.1	18.3			18.9
Estab	S	020Y-7563-YO1	7.8	650	24	0	Pl	7.6	27.2		1.0	350	0		SE	1.8	20.0		14.4	16.5		14.2	14.2
Estab	S	020Y-7811-YO1	3.5	400	17	0	Ac	11.5	15.7	29.8	3.0	2133	0		SX	4.7	24.0	17.2	16.1	18.3	11.1		18.9
Estab	P	020Y-7815-YO1	22.7	1901	120	0	Bl	12.9	67.2	19.8	25.8	1688	153		PLI	14.8	36.0	17.8	17.0	18.8	10.9		19.3
Estab	A	020Y-7816-YO1	26.7	2026	141	0	Pl	11.6	31.9	19.5	2.8	329	9		AT	8.0	24.0	14.1	16.9	18.8			19.0
Estab	S	020Y-8050-YO1	6.0	851	19	0	S	7.4	20.5	25.5	0.0	2343	0		SE	2.0	21.0		14.7	16.6		15.2	15.2
Estab	P	020Y-8051-YO1	18.8	1176	118	4	Pl	14.9	28.7		33.4	2144	158		PLI	13.1	30.0	17.1		20.1			18.8
Estab	P	020Y-8058-YO1	19.2	1501	104	2	Pl	13.1	29.8	22.1	19.0	3413	82		PLI	10.6	30.0	17.3	17.1	20.0	11.7		18.5
Estab	A	020Y-8790-YO1	49.8	2477	359	3	At	19.9	46.1		50.9	2289	314		AT	18.4	45.0	16.3	15.8	18.2	11.6		18.9
Estab	P	020Y-9024-YO1	9.1	951	37	0	Pl	8.5	18.7	22.8	14.0	5580	0		PLI	7.1	17.0	18.6	16.9	18.8	11.3		19.0
Estab	P	020Y-9268-YO1	22.4	1051	149	4	Pl	15.4	31.3		17.8	1069	66		PLI	10.2	29.0	16.0	16.1	18.3	11.0		18.9
Estab	S	020Y-9495-YO1	19.7	1251	81	0	Sx	10.4	29.8		8.0	1600	0		SX	7.4	32.0	16.7	16.1	18.3	11.4		18.9
Estab	A	020Y-9498-YO1	28.7	851	234	0	At	27.3	35.5		23.6	841	148		AT	18.2	44.0	18.1	16.5	18.6	11.1		19.0
Estab	P	020Y-9499-YO1	27.6	1426	166	0	Pl	12.8	31.6	18.6	38.8	2427	175		PLI	12.7	29.0	18.8	16.5	18.5	11.1		19.0
Estab	P	020Y-9504-YO1	18.6	976	113	23	Sx	11.9	47.0		21.2	2129	124		PLI	15.3	42.0	16.4	16.9	18.9	11.1		
Estab	S	020Y-9743-YO1	23.9	1176	116	0	Sx	12.3	28.7		15.0	1500	0		SX	4.4	29.0	18.8	16.1	18.3	11.2		18.9
Estab	P	CMI5-0435-FR1	19.9	1201	104	0	Pl	11.2	27.0		5.2	603	19		PLI	9.2	25.0	16.1	16.2	18.2			
Growth	P	0201-0051-MO1	23.9	901	147	4	Pl	13.5	37.2	18.9	14.2	837	61		PLI	11.7	34.0	16.2	16.1	18.3	11.0		18.9
Growth	P	0201-0051-YR1	24.4	851	159	8	Pl	14.5	42.5		17.5	859	87		PLI	13.3	39.0	16.2	16.1	18.3	11.0		18.9
Growth	P	0201-0052-MO1	34.0	3227	166	0	Pl	10.8	30.3	18.5	22.1	1944	83		PLI	10.7	32.0	16.7	16.1	18.4			18.9
Growth	P	0201-0052-YR1	37.7	3027	205	0	Pl	12.1	35.2		27.4	1991	121		PLI	12.3	37.0	16.7	16.1	18.4			18.9
Growth	P	0201-0053-MO1	19.1	926	125	0	Pl	13.1	33.8	19.8	21.1	3798	86		PLI	11.3	41.0	16.6	17.0	18.8			19.3

			Phase II								Phase I							PSPL					
use	strata	clstr_id	BA 7.5	TPH 7.5	WSV 7.5	WSV D 7.5	Spp	HT	Age	SI	BA 7.5	TPH 7.5	WSV 7.5	Dead Vol 12.5	Spp	HT	Age	At	BL	PL	SB	SE	SX
Growth	P	0201-0053-YR1	22.5	851	166	0	Pl	15.9	39.1		23.7	3755	109		PLI	12.5	46.0	16.6	17.0	18.8			19.3
Growth	P	0201-0054-MO1	24.0	1026	96	0	Pl	9.6	35.2	15.0	20.8	2974	78		PLI	10.5	42.0		14.8	16.3		14.7	14.7
Growth	P	0201-0054-YR1	24.2	876	109	9	Pl	11.6	39.6		22.8	2906	96		PLI	11.6	47.0		14.8	16.3		14.7	14.7
Growth	P	0201-0055-MO1	28.2	2477	136	0	Pl	10.9	30.1	18.7	16.4	2008	45		PLI	9.8	28.0		16.1	18.3			18.9
Growth	P	0201-0055-YR1	33.8	2802	178	0	Pl	12.4	35.1		23.5	2469	80		PLI	11.7	33.0		16.1	18.3			18.9
Growth	B	0201-0056-MO1	13.7	425	54	33	Bl	10.0	62.5	11.0	2.7	303	8		B	7.7	51.0		14.9	15.8		13.8	13.8
Growth	B	0201-0056-YR1	16.9	525	72	33	Bl	11.1	64.2		4.6	438	14		B	8.8	56.0		14.9	15.8		13.8	13.8
Growth	P	0201-0058-MO1	25.5	2652	115	3	Pl	10.2	26.6	19.6	9.3	1258	32		PLI	10.1	27.0	17.9	16.1	18.3	10.7		18.9
Growth	P	0201-0058-YR1	31.7	2927	161	3	Pl	12.0	31.7	19.5	13.3	1855	58		PLI	12.1	32.0	17.9	16.1	18.3	10.7		18.9
Growth	S	0201-0059-MO1	22.0	2001	95	0	Sx	10.4	31.0	22.0	25.0	2200	0		SX	6.1	29.0	18.1	15.8	18.1	11.0		18.9
Growth	S	0201-0059-YR1	33.7	2502	171	0	Sx	13.4	35.9	24.2	4.0	508	14		SX	8.2	34.0	18.1	15.8	18.1	11.0		18.9
Growth	S	0201-0060-MO1	3.8	450	13	0	Sx	6.8	27.5	18.9	0.0	1100	0		SX	1.5	20.0	17.6	16.1	18.3	11.1		18.9
Growth	S	0201-0060-YR1	8.8	776	35	0	Sx	8.9	32.5	20.1	0.0	1100	0		SX	2.4	26.0	17.6	16.1	18.3	11.1		18.9
Growth	S	0201-0061-MO1	31.0	1401	158	1	Sx	13.0	40.7	20.1	36.5	2473	154		SX	12.8	33.0	18.1	16.5	18.5	11.0		19.0
Growth	S	0201-0061-YR1	35.2	1401	196	1	Sx	14.0	46.3	19.6	50.7	2510	268		SX	16.4	39.0	18.1	16.5	18.5	11.0		19.0
Growth	P	0201-0062-MO1	8.4	500	46	8	Pl	11.9	35.1	17.8	5.2	325	20	26	PLI	10.5	38.0	16.9	16.1	18.4	11.4		18.9
Growth	P	0201-0062-YR1	11.0	675	64	9	Pl	13.8	39.8	19.9	6.4	296	30	26	PLI	12.0	44.0	16.9	16.1	18.4	11.4		18.9
Growth	P	0201-0063-MO1	14.8	1701	59	0	Pl	8.9	25.3	18.5	20.7	4404	55		PLI	8.6	25.0	16.9	16.9	18.8	10.8		19.0
Growth	P	0201-0063-YR1	23.1	2252	105	1	Pl	10.9	30.0	18.7	25.9	4418	89		PLI	11.0	31.0	16.9	16.9	18.8	10.8		19.0
Growth	S	0201-0064-MO1	32.3	1276	182	0	Sx	14.7	37.5	23.8	0.0	3963	0	1	S	6.8	38.0	17.5	16.5	18.5	11.0		19.0
Growth	S	0201-0064-YR1	41.0	1376	257	0	Sx	16.7	42.5	23.7	4.7	644	16	1	S	8.7	44.0	17.5	16.5	18.5	11.0		19.0
Growth	P	0201-0065-MO1	7.6	725	31	1	Sx	8.2	31.0	18.8	7.4	821	33		PL	11.3	26.0	16.5	15.8	18.2	11.4		18.9
Growth	P	0201-0065-YR1	10.3	826	47	1	Sx	9.4	36.4		10.9	1041	58		PL	13.5	31.0	16.5	15.8	18.2	11.4		18.9
Growth	S	0201-0066-MO1	22.4	2277	105	0	Pl	11.2	28.6	19.8	20.0	2400	0		SX	6.5	30.0	18.3	16.3	20.6	10.9		19.2
Growth	S	0201-0066-YR1	28.2	2477	154	7	Pl	13.3	33.5		4.7	617	17		SX	8.6	35.0	18.3	16.3	20.6	10.9		19.2
Growth	P	0201-0067-MO1	10.2	1176	47	1	At	9.1	20.6	19.5	15.0	2700	0		PLI	7.8	23.0	18.7	17.3	20.8	11.7		19.4
Growth	P	0201-0067-YR1	14.3	1301	79	2	Pl	12.8	29.0	22.9	17.7	2763	68		PLI	9.8	28.0	18.7	17.3	20.8	11.7		19.4
Growth	P	0201-0068-MO1	1.9	125	6	166	Pl	7.4	25.4	16.1	5.0	700	0		PLI	7.9	22.0		14.4	16.5		14.2	14.2
Growth	P	0201-0068-YR1	2.6	125	10	166	Pl	9.0	30.4		7.0	862	27		PLI	10.1	27.0		14.4	16.5		14.2	14.2
Growth	P	0201-0069-MO1	8.0	400	42	0	Pl	11.6	25.7	21.9	5.0	1100	0		PLI	7.7	29.0	16.6	16.3	18.4	11.2		19.0
Growth	P	0201-0069-YR1	11.5	450	68	0	Pl	13.6	30.1	22.0	21.3	2839	80	14	PLI	10.3	34.0	16.6	16.3	18.4	11.2		19.0
Growth	P	0201-0070-MO1	14.4	1726	74	0	Pl	10.6	23.5	21.8	20.0	1999	0		PLI	8.0	27.0	16.9	17.4	19.7			18.2
Growth	P	0201-0070-YR1	16.4	1426	105	6	Pl	14.9	28.1	25.2	21.7	1999	79		PLI	9.9	33.0	16.9	17.4	19.7			18.2

			Phase II								Phase I							PSPL					
use	strata	clstr_id	BA 7.5	TPH 7.5	WSV 7.5	WSV D 7.5	Spp	HT	Age	SI	BA 7.5	TPH 7.5	WSV 7.5	Dead Vol 12.5	Spp	HT	Age	At	BL	PL	SB	SE	SX
Growth	P	0201-0071-MO1	18.9	1401	99	1	Pl	11.8	27.1	21.3	7.8	908	22		PLI	9.3	24.0	18.9	16.3	20.9	11.0		19.4
Growth	P	0201-0071-YR1	23.2	1476	143	8	Pl	14.3	31.7	24.3	18.7	1660	70		PLI	11.6	29.0	18.9	16.3	20.9	11.0		19.4
Growth	P	0201-0072-MO1	14.3	1376	72	0	Pl	11.8	25.1	22.5	11.4	1300	43		PLI	10.4	24.0	15.3	16.5	18.5	11.5		19.0
Growth	P	0201-0072-YR1	19.4	1426	119	5	Pl	14.7	30.0	24.9	17.7	1671	90		PLI	13.1	30.0	15.3	16.5	18.5	11.5		19.0
Growth	P	0201-0073-MO1	10.7	826	49	0	Pl	10.2	24.4	20.7	29.3	3855	120		PLI	11.0	24.0	16.9	17.1	19.7	11.5		18.2
Growth	P	0201-0073-YR1	13.5	826	75	4	Pl	12.4	28.6	21.9	33.6	3765	173		PLI	13.4	29.0	16.9	17.1	19.7	11.5		18.2
Growth	B	0201-0074-MO1	1.5	150	5	0	Pl	6.1	21.0	16.7	3.0	376	10		BL	7.9	32.0	16.7	15.8	18.1	10.7		18.9
Growth	B	0201-0074-YR1	2.5	175	10	0	Pl	8.9	21.9	18.7	7.1	746	28		BL	9.8	37.0	16.7	15.8	18.1	10.7		18.9
Growth	P	0201-0075-MO1	21.5	1301	104	58	PL	12.2	39.6	16.6	15.0	1199	69		PLI	12.5	51.0		14.5	16.6		14.4	14.4
Growth	P	0201-0075-YR1	25.2	1326	141	46	Pl	14.1	44.4	18.3	16.4	1206	82		PLI	13.4	56.0		14.5	16.6		14.4	14.4
Growth	P	0201-0076-MO1	20.8	2151	108	0	Pl	11.2	24.5	22.1	23.0	1313	0		PLI	8.9	21.0	16.8	17.3	19.4	11.5		18.0
Growth	P	0201-0076-YR1	27.9	2201	176	2	Pl	13.4	29.5	24.1	24.5	1331	100		PLI	11.3	26.0	16.8	17.3	19.4	11.5		18.0
Growth	P	0201-0077-MO1	15.5	1576	64	0	Pl	8.8	22.4	20.0	7.6	886	24		PLI	9.4	21.0	17.2	16.2	18.4			19.2
Growth	P	0201-0077-MR1	22.0	1701	111	0	Pl	11.1	27.4	20.2	20.6	1934	94		PLI	12.0	26.0	17.2	16.2	18.4			19.2
Growth	S	0201-0078-MO1	22.8	1701	160	5	Ac	21.4	31.7	29.8	13.9	1242	74		SX	13.2	31.0	17.4	17.0	19.9	11.4		18.5
Growth	S	0201-0078-YR1	23.1	1251	190	19	Ac	23.9	36.7		19.6	1424	127		SX	16.5	36.0	17.4	17.0	19.9	11.4		18.5
Growth	P	0201-0079-MO1	20.6	1126	121	1	Pl	12.3	27.5	21.7	26.2	1508	146		PLI	14.7	44.0	17.8	15.4	17.9	11.4		18.8
Growth	P	0201-0079-YR1	25.3	1151	175	0	Pl	15.3	32.3	23.0	28.6	1474	175		PLI	16.0	49.0	17.8	15.4	17.9	11.4		18.8
Growth	P	0201-0080-MO1	22.8	1701	123	1	Pl	13.0	30.0	21.3	26.8	1697	145		PLI	14.6	34.0	17.0	16.9	20.0	11.1		18.6
Growth	P	0201-0080-YR1	27.6	1651	174	0	Pl	14.8	33.8	22.7	31.1	1714	192		PLI	16.4	39.0	17.0	16.9	20.0	11.1		18.6
Growth	P	0201-0081-MO1	25.7	1376	119	0	Pl	11.5	28.2	20.4	18.8	1227	88		PLI	12.6	30.0		15.0	16.5		14.7	14.7
Growth	P	0201-0081-YR1	30.8	1301	170	1	Pl	13.6	33.2	21.7	22.8	1238	125		PLI	14.5	35.0		15.0	16.5		14.7	14.7
Growth	S	0201-0082-MO1	13.3	1176	59	0	S	12.4	37.5	20.9	17.3	1216	89		SX	13.6	44.0		16.5	18.5			19.0
Growth	S	0201-0082-YR1	17.9	1376	88	0	S	14.1	42.6	20.9	21.8	1298	127		SX	15.7	49.0		16.5	18.5			19.0
Growth	S	0201-0083-MO1	5.6	776	18	0	Bl	7.8	32.7	17.2	9.0	1599	0		SE	8.5	34.0		15.1	17.0		15.6	15.6
Growth	S	0201-0083-YR1	9.7	1026	37	0	Bl	9.1	37.2	17.6	13.5	2070	64		SE	10.8	39.0		15.1	17.0		15.6	15.6
Growth	P	0201-0084-MO1	24.5	2402	113	0	Pl	10.1	26.4	19.5	15.0	2400	0		PLI	7.0	26.0	17.2	15.8	18.1			18.9
Growth	P	0201-0084-YR1	28.1	1976	156	0	Pl	12.2	31.3	20.4	5.1	614	17		PLI	8.6	31.0	17.2	15.8	18.1			18.9
Growth	S	0201-0085-MO1	13.2	1151	74	2	Pl	11.6	31.6	18.9	17.0	1716	78		SX	12.9	32.0	17.6	15.8	18.1	10.8		18.9
Growth	S	0201-0085-YR1	15.0	1001	96	2	Pl	14.1	35.9	17.9	25.9	2218	146		SX	16.1	37.0	17.6	15.8	18.1	10.8		18.9
Growth	S	0201-0086-MO1	24.1	1626	122	0	Sx	13.6	36.5	23.0	19.2	1912	90		SX	11.8	37.0	18.2	16.1	18.4	10.8		18.9
Growth	S	0201-0086-YR1	31.4	1826	182	0	Sx	15.5	41.6	22.0	26.4	2238	146		SX	14.3	42.0	18.2	16.1	18.4	10.8		18.9
Growth	P	0201-0088-MO1	17.0	1751	74	0	Pl	9.7	22.0	21.6	6.0	4880	0		PLI	7.4	22.0	17.3	16.5	18.5	11.0		19.0

			Phase II								Phase I							PSPL					
use	strata	clstr_id	BA 7.5	TPH 7.5	WSV 7.5	WSV D 7.5	Spp	HT	Age	SI	BA 7.5	TPH 7.5	WSV 7.5	Dead Vol 12.5	Spp	HT	Age	At	BL	PL	SB	SE	SX
Growth	P	0201-0088-YR1	22.6	1501	117	0	Pl	12.5	27.1		6.4	769	24		PLI	9.4	27.0	17.3	16.5	18.5	11.0		19.0
Growth	S	0201-0089-MO1	12.2	550	55	0	S	12.5	27.5	26.9	10.0	700	0		SX	4.6	25.0	19.3	16.1	18.3	11.2		18.9
Growth	P	0201-0089-YR1	20.5	550	114	0	Sx	15.7	31.8		16.2	1668	48		PLI	10.6	30.0	19.3	16.1	18.3	11.2		18.9
Growth	P	0201-0090-MO1	18.6	1626	93	0	Pl	11.0	25.6	21.0	12.0	1400	0		PLI	8.6	25.0	18.9	16.1	18.3	11.1		18.9
Growth	P	0201-0090-YR1	22.5	1601	129	2	Pl	13.0	30.6		16.2	1668	48		PLI	10.6	30.0	18.9	16.1	18.3	11.1		18.9
Growth	S	0201-0091-MO1	30.1	1726	179	0	PL	13.0	35.8	21.7	16.3	1213	76		SX	12.6	44.0	16.6	16.5	18.5	11.1		19.0
Growth	S	0201-0091-YR1	32.2	1501	217	2	Pl	18.1	39.3		21.8	1376	114		SX	14.6	49.0	16.6	16.5	18.5	11.1		19.0
Growth	S	0201-0092-MO1	17.3	1476	105	0	At	16.2	23.2	28.5	5.0	100	0		SX	2.8	20.0	18.7	15.8	18.1	11.1		18.9
Growth	S	0201-0092-YR1	20.8	1426	134	4	At	17.2	28.3		5.0	100	0		SX	4.6	25.0	18.7	15.8	18.1	11.1		18.9
Growth	S	0201-0093-MO1	1.8	100	6	0	S	8.0	39.2	15.4	5.0	500	0		SX	4.2	24.0	17.5	16.1	18.4	11.0		18.9
Growth	S	0201-0093-YR1	3.0	150	12	0	Sx	8.4	40.7		5.0	500	0		SX	6.1	29.0	17.5	16.1	18.4	11.0		18.9
Growth	P	0201-0094-MO1	22.6	1176	122	0	Pl	11.8	23.2	23.6	10.0	949	49		PLI	12.8	24.0	17.0	15.8	18.1	11.3		18.9
Growth	P	0201-0094-YR1	29.1	1176	192	0	Pl	15.3	28.3	27.3	15.2	1241	92		PLI	15.6	29.0	17.0	15.8	18.1	11.3		18.9
Growth	P	0201-0095-MO1	10.6	1051	50	0	Pl	9.9	22.0	21.9	8.0	971	25		PLI	9.4	21.0	18.1	16.1	18.4	11.5		18.9
Growth	P	0201-0095-YR1	16.8	1376	97	0	Pl	12.7	26.6		28.0	3080	123		PLI	12.0	26.0	18.1	16.1	18.4	11.5		18.9
Growth	S	0201-0096-MO1	9.6	600	38	0	S	9.8	25.9	24.4	20.0	1850	0		SX	3.9	28.0	18.3	16.1	18.3	11.3		18.9
Growth	S	0201-0096-YR1	15.7	725	77	0	Sx	12.9	31.6		20.0	1850	0		SX	5.3	33.0	18.3	16.1	18.3	11.3		18.9
Growth	P	0201-0098-MO1	29.8	2051	155	0	Pl	11.0	27.0	20.3	13.0	1400	0		PLI	8.8	23.0	16.8	16.1	18.3	10.7		18.9
Growth	P	0201-0098-YR1	35.4	1951	217	0	Pl	13.4	32.1		15.2	1492	64		PLI	11.1	28.0	16.8	16.1	18.3	10.7		18.9
Growth	P	0201-0099-MO1	17.4	1976	65	0	Pl	8.2	19.0	21.5	4.0	3182	0		PLI	6.4	18.0	18.4	16.1	18.3	11.0		18.9
Growth	P	0201-0099-YR1	24.7	2076	115	0	Pl	10.6	23.9		5.1	611	18		PLI	8.8	23.0	18.4	16.1	18.3	11.0		18.9
Growth	P	0201-0100-MO1	67.9	5954	547	14	Pl	17.9	54.9	18.4	27.5	772	191		PLI	18.2	47.0		16.5	18.6			19.0
Growth	P	0201-0100-YR1	68.2	5429	578	27	Pl	19.1	58.1	21.1	29.4	734	219		PLI	19.4	52.0		16.5	18.6			19.0
Growth	S	0201-0096-YR1	15.7	725	77	0	Sx	12.9	31.6		20.0	1850	0		SX	5.3	33.0	18.3	16.1	18.3	11.3		18.9

13 Appendix C – Plot Data Summaries

Table 33. The volume predictions associated with each sample are given.

		Ground				VOL2				VOL3				
Sample	Use	Leading species	Leading species age	SI	WSV (m^3/ha)	BA (m^2/ha)	TPH	Top height (m)	WSV (m^3/ha)	Phase pp	BA (m^2/ha)	TPH	Top height (m)	WSV (m^3/ha)
014Y-8061-YO1	Estab	Ac	16.3	29.8	12	3.2	866	10.4	30	PLI	0.2	84	5.8	2
020Y-7811-YO1	Estab	Ac	15.7	29.8	17	6.0	976	12.8	49	SX	1.1	326	7.3	7
014Y-6503-YO1	Estab	At	31.7	12.6	30	1.1	365	7.6	11	AT	4.6	975	10.8	36
014Y-7821-YO1	Estab	At	73.8	16.2	424	35.5	1458	19.8	261	AT	6.7	1270	12.0	56
014Y-8792-YO1	Estab	At	70.6	18.1	162	21.7	1758	17.9	194	AT	3.0	711	9.9	24
020Y-8790-YO1	Estab	At	46.1		359	9.2	302	0.0	221	AT	17.0	1444	14.1	111
020Y-9498-YO1	Estab	At	35.5	33.5	234	32.1	1061	26.2	309	AT	14.1	1477	15.5	103
020Y-6208-YO1	Estab	Bl	52.7	14.2	135	8.3	1143	9.9	50	PLI	29.5	1055	16.1	164
020Y-7815-YO1	Estab	Bl	67.2	19.8	120	14.7	1259	10.6	83	PLI	20.3	981	13.4	91
0142-8691-MO1	Estab	Pl	25.5	17.1	32	6.3	673	8.6	23	PLI	12.0	908	9.8	43
0142-8701-MO1	Estab	Pl	15.2	19.8	1	0.0	19	4.9	0	PLI	0.0	2	4.4	0
014Y-5127-YO1	Estab	Pl	32.9	18.4	104	10.4	791	9.8	37	PLI	15.1	895	11.1	57
014Y-5396-YO1	Estab	Pl	16.2	21.2	10	0.9	267	6.2	4	PLI	0.1	55	5.3	1
014Y-5397-YO1	Estab	Pl	30.0	21.7	148	23.1	1035	13.1	103	PLI	22.4	1041	13.0	101
014Y-5398-YO1	Estab	Pl	26.4	19.3	100	3.6	549	7.6	14	PLI	12.2	896	10.1	44
014Y-5939-YO1	Estab	Pl	18.7	19.9	23	0.1	56	5.4	1	PLI	1.0	248	6.3	4
014Y-6220-YO1	Estab	Pl	27.8	18.3	88	12.8	982	9.7	46	PLI	10.9	937	9.3	40
014Y-6506-YO1	Estab	Pl	32.7	19.0	126	20.4	1042	12.1	83	PLI	15.7	946	11.8	62
014Y-6785-YO1	Estab	Pl	30.1	23.7	136	24.2	1004	15.0	122	PLI	14.6	813	12.0	58
014Y-7048-YO1	Estab	Pl	35.6	18.9	224	17.0	911	12.0	68	PLI	25.3	1026	14.1	120
014Y-7571-YO1	Estab	Pl	37.1	19.8	70	23.8	986	16.5	127	PLI	27.4	1038	15.4	142
014Y-7572-YO1	Estab	Pl	45.0	18.2	244	27.7	1040	14.8	141	PLI	22.2	1035	12.8	97
014Y-7580-YO1	Estab	Pl	33.2	22.3	219	25.8	1028	14.4	128	PLI	15.8	999	12.2	66
014Y-7817-YO1	Estab	Pl	33.2	18.3	54	14.5	950	10.5	52	PLI	15.1	1030	10.3	55
014Y-7818-YO1	Estab	Pl	28.9	22.3	114	23.9	1040	13.5	110	PLI	14.3	917	11.0	55

		Ground				VOL2				VOL3				
Sample	Use	Leading species	Leading species age	SI	WSV (m^3/ha)	BA (m^2/ha)	TPH	Top height (m)	WSV (m^3/ha)	Phase pp	BA (m^2/ha)	TPH	Top height (m)	WSV (m^3/ha)
014Y-7820-YO1	Estab	Pl	18.1	17.8	7	0.1	45	5.2	1	PLI	1.5	309	6.8	7
014Y-7826-YO1	Estab	Pl	27.3	22.2	88	14.9	939	11.0	57	PLI	8.9	849	9.1	34
014Y-8065-YO1	Estab	Pl	35.8	16.7	128	16.3	964	11.1	62	PLI	20.9	1030	12.7	90
014Y-8548-YO1	Estab	Pl	33.4	21.4	104	19.7	1230	12.9	118	PLI	16.0	985	10.9	61
014Y-9028-YO1	Estab	Pl	24.9	20.9	124	16.5	1039	10.7	62	PLI	6.4	761	8.3	25
0201-0077-MR1	Estab	Pl	27.4	20.2	111	14.3	973	10.3	51	PLI	10.0	881	9.3	38
0202-1156-MO1	Estab	Pl	30.2	18.8	12	17.9	1039	11.2	69	PLI	16.7	1005	11.7	68
0202-3641-MO1	Estab	Pl	32.1	20.7	62	3.7	487	8.1	14	PLI	12.6	832	12.0	51
020Y-6485-YO1	Estab	Pl	28.0	21.1	151	18.2	1041	11.3	70	PLI	13.3	989	9.9	47
020Y-7314-YO1	Estab	Pl	30.6	23.4	102	21.6	1023	12.8	95	PLI	12.4	963	10.5	49
020Y-7315-YO1	Estab	Pl	32.6	18.7	83	18.6	1040	11.5	73	PLI	16.9	993	12.3	71
020Y-7563-YO1	Estab	Pl	27.2	15.2	24	4.4	590	7.9	16	SE	0.3	96	2.6	2
020Y-7816-YO1	Estab	Pl	31.9	19.5	141	7.1	651	9.1	26	AT	1.1	204	6.6	7
020Y-8051-YO1	Estab	Pl	28.7	24.3	118	29.2	1040	15.0	151	PLI	20.4	1043	12.1	83
020Y-8058-YO1	Estab	Pl	29.8	22.1	104	22.6	1043	13.4	104	PLI	13.7	952	12.0	60
020Y-9024-YO1	Estab	Pl	18.7	22.8	37	5.2	713	7.9	19	PLI	0.1	63	5.5	1
020Y-9268-YO1	Estab	Pl	31.3		149	14.7	321	0.0	178	PLI	14.7	986	10.5	54
020Y-9499-YO1	Estab	Pl	31.6	18.6	166	21.8	1038	12.5	92	PLI	16.2	1036	10.6	60
CMI5-0232-FR1	Estab	Pl	36.2	20.5	97	28.1	1036	14.6	143	PLI	21.0	1029	12.7	90
CMI5-0435-FR1	Estab	Pl	27.0	20.3	104	15.8	998	10.8	60	PLI	8.1	832	8.8	31
020Y-8050-YO1	Estab	S	20.5	25.5	19	2.5	407	8.6	12	SE	0.0	0	2.9	0
020Y-6490-YO1	Estab	Se		19.0	25	27.2	746	16.1	213	SX	6.9	733	9.0	28
020Y-6765-YO1	Estab	Se	22.3	20.5	3	0.0	0	4.2	0	BL	0.0	0	2.7	0
014Y-5673-YO1	Estab	Sx	21.2	27.2	2	3.7	463	9.4	15	PLI	0.9	250	6.3	4
014Y-6496-YO1	Estab	Sx	30.7	24.2	173	19.2	1124	12.5	82	SX	11.3	994	10.5	47
014Y-7819-YO1	Estab	Sx	45.3	20.1	43	6.9	859	8.8	41	AT	5.0	709	9.6	29
0202-6761-MO1	Estab	Sx	24.7	25.4	17	9.2	898	9.3	42	PLI	1.7	309	7.2	7
020Y-6491-YO1	Estab	Sx	47.6	20.9	245	21.3	1431	15.8	138	BL	9.9	839	8.0	51
020Y-6766-YO1	Estab	Sx	35.1	22.8	80	15.7	1090	11.7	69	PLI	22.2	1000	14.1	106
020Y-6767-YO1	Estab	Sx	24.9	21.4	4	0.5	161	7.2	4	BL	0.0	56	2.3	1

		Ground				VOL2				VOL3				
Sample	Use	Leading species	Leading species age	SI	WSV (m^3/ha)	BA (m^2/ha)	TPH	Top height (m)	WSV (m^3/ha)	Phase pp	BA (m^2/ha)	TPH	Top height (m)	WSV (m^3/ha)
020Y-9495-YO1	Estab	Sx	29.8	22.8	81	8.7	927	10.0	36	SX	6.8	849	9.5	31
020Y-9504-YO1	Estab	Sx	47.0	16.0	42	3.7	495	8.3	17	PLI	12.1	413	15.4	64
020Y-9743-YO1	Estab	Sx	28.7	26.4	116	15.6	1092	11.9	67	SX	6.7	774	9.5	29
0201-0078-MO1	Growth	Ac	31.7	29.8	160	21.6	1545	18.7	181	SX	11.3	789	8.9	48
0201-0078-YR1	Growth	Ac	36.7	29.3	195	22.9	1427	20.0	193	SX	17.6	995	10.9	82
0201-0067-MO1	Growth	At	20.6	19.5	47	6.8	849	9.4	36	PLI	10.5	871	9.7	40
0201-0092-MO1	Growth	At	23.2	28.5	105	14.2	1652	15.4	120	SX	0.1	57	5.5	1
0201-0092-YR1	Growth	At	28.3	25.6	134	15.8	1659	15.7	123	SX	2.0	478	7.7	12
0201-0056-MO1	Growth	Bl	62.5	11.0	58	4.4	1116	9.9	34	B	6.0	1130	11.0	46
0201-0056-YR1	Growth	Bl	64.2	11.4	73	7.2	1354	11.0	55	B	9.9	1335	12.5	73
0201-0083-MO1	Growth	Bl	32.7	17.2	18	1.2	374	6.3	11	SE	0.6	192	7.0	4
0201-0083-YR1	Growth	Bl	37.2	17.6	37	3.9	738	8.0	25	SE	2.9	562	8.7	15
0201-0075-MO1	Growth	PL	39.6	16.6	104	19.5	1029	12.0	79	PLI	23.8	1566	15.1	157
0201-0091-MO1	Growth	PL	35.8	21.7	178	14.8	918	13.1	69	SX	15.6	1237	14.6	90
0201-0051-MO1	Growth	Pl	37.2	18.9	147	24.9	1037	13.5	114	PLI	17.9	939	12.3	75
0201-0051-YR1	Growth	Pl	42.5	17.8	159	27.5	1033	14.4	137	PLI	22.8	995	14.0	109
0201-0052-MO1	Growth	Pl	30.3	18.5	168	11.4	840	9.8	41	PLI	18.2	989	11.7	72
0201-0052-YR1	Growth	Pl	35.2	17.6	207	15.4	909	11.1	58	PLI	23.5	1007	13.4	107
0201-0053-MO1	Growth	Pl	33.8	19.8	125	21.9	1036	12.7	94	PLI	26.7	1029	15.0	139
0201-0053-YR1	Growth	Pl	39.1	20.4	166	30.8	1034	15.6	166	PLI	30.2	1068	16.4	174
0201-0054-MO1	Growth	Pl	35.2	15.0	96	11.1	935	9.4	41	PLI	21.3	989	13.1	97
0201-0054-YR1	Growth	Pl	39.6	15.5	109	18.0	1013	11.5	70	PLI	25.0	1030	14.4	125
0201-0055-MO1	Growth	Pl	30.1	18.7	136	11.9	861	9.9	42	PLI	10.4	724	10.1	37
0201-0055-YR1	Growth	Pl	35.1	18.0	178	16.0	910	11.4	61	PLI	14.0	754	12.0	57
0201-0058-MO1	Growth	Pl	26.6	19.6	115	14.2	802	11.3	54	PLI	11.0	891	9.7	40
0201-0058-YR1	Growth	Pl	31.7	19.5	161	16.7	860	12.9	74	PLI	16.5	1004	11.6	67
0201-0062-MO1	Growth	Pl	35.1	17.8	46	11.0	845	9.8	39	PLI	23.3	1011	13.7	109
0201-0062-YR1	Growth	Pl	39.8	19.9	64	12.8	872	10.7	47	PLI	28.4	1040	15.5	152
0201-0063-MO1	Growth	Pl	25.3	18.5	59	6.0	676	8.6	22	PLI	5.4	539	9.2	21
0201-0063-YR1	Growth	Pl	30.0	18.7	105	11.2	765	10.7	41	PLI	11.3	752	11.6	45

		Ground				VOL2				VOL3				
Sample	Use	Leading species	Leading species age	SI	WSV (m^3/ha)	BA (m^2/ha)	TPH	Top height (m)	WSV (m^3/ha)	Phase pp	BA (m^2/ha)	TPH	Top height (m)	WSV (m^3/ha)
0201-0066-MO1	Growth	Pl	28.6	19.8	105	15.1	993	11.5	59	SX	13.7	1031	10.5	61
0201-0066-YR1	Growth	Pl	33.5	19.3	154	21.9	1058	12.7	101	SX	17.5	1103	11.2	88
0201-0067-YR1	Growth	Pl	29.0	22.9	83	5.5	590	8.6	20	PLI	17.0	1005	12.0	71
0201-0068-MO1	Growth	Pl	25.4	16.1	6	3.7	645	7.3	15	PLI	2.3	489	6.7	10
0201-0068-YR1	Growth	Pl	30.4	15.6	10	6.7	759	8.4	25	PLI	8.1	865	8.6	31
0201-0069-MO1	Growth	Pl	25.7	21.9	42	15.6	987	10.8	59	PLI	13.9	979	10.5	53
0201-0069-YR1	Growth	Pl	30.1	22.0	68	21.4	1011	12.8	94	PLI	21.4	1040	12.4	89
0201-0070-MO1	Growth	Pl	23.5	21.8	74	16.7	1039	10.8	62	PLI	15.2	1013	10.6	57
0201-0070-YR1	Growth	Pl	28.1	25.2	105	29.5	1040	15.1	154	PLI	22.4	1041	13.0	101
0201-0071-MO1	Growth	Pl	27.1	21.3	99	19.8	1040	11.9	78	PLI	11.6	864	10.2	44
0201-0071-YR1	Growth	Pl	31.7	24.3	143	25.8	1037	13.9	122	PLI	17.4	985	12.5	77
0201-0072-MO1	Growth	Pl	25.1	22.5	72	19.2	1044	11.7	76	PLI	7.5	825	8.6	29
0201-0072-YR1	Growth	Pl	30.0	24.9	119	28.9	1040	14.9	149	PLI	16.6	1013	11.0	63
0201-0073-MO1	Growth	Pl	24.4	20.7	49	11.9	926	9.6	43	PLI	9.8	865	9.2	36
0201-0073-YR1	Growth	Pl	28.6	21.9	77	16.8	987	11.3	65	PLI	16.9	994	11.4	66
0201-0074-MO1	Growth	Pl	21.0	16.7	5	0.3	124	5.7	2	BL	5.4	479	5.7	24
0201-0074-YR1	Growth	Pl	21.9	18.7	10	4.1	585	7.8	16	BL	9.0	749	7.4	46
0201-0075-YR1	Growth	Pl	44.4	18.3	141	25.1	1033	13.7	116	PLI	27.9	1553	16.2	184
0201-0076-MO1	Growth	Pl	24.5	22.1	108	11.8	878	9.9	42	PLI	4.8	723	7.7	19
0201-0076-YR1	Growth	Pl	29.5	24.1	176	15.5	884	11.6	60	PLI	14.3	1027	9.9	50
0201-0077-MO1	Growth	Pl	22.4	20.0	64	7.2	813	8.4	27	PLI	3.1	546	7.2	12
0201-0077-MR1	Growth	Pl	27.4	20.2	111	14.3	973	10.3	51	PLI	10.0	881	9.3	38
0201-0079-MO1	Growth	Pl	27.5	21.7	121	20.7	1044	12.2	84	PLI	27.6	1090	15.1	149
0201-0079-YR1	Growth	Pl	32.3	23.0	175	28.9	1038	14.9	150	PLI	31.0	1093	16.4	180
0201-0080-MO1	Growth	Pl	30.0	21.3	124	21.0	1049	12.8	92	PLI	19.8	1019	13.6	94
0201-0080-YR1	Growth	Pl	33.8	22.7	174	27.3	1051	15.2	142	PLI	25.1	1075	15.4	134
0201-0081-MO1	Growth	Pl	28.2	20.4	119	13.7	913	10.4	50	PLI	11.5	892	9.7	41
0201-0081-YR1	Growth	Pl	33.2	21.7	170	18.1	949	12.2	73	PLI	16.3	955	11.3	64
0201-0084-MO1	Growth	Pl	26.4	19.5	113	11.3	1033	11.7	51	PLI	9.7	880	9.2	36
0201-0084-YR1	Growth	Pl	31.3	20.4	156	16.3	1190	13.4	91	PLI	16.3	1016	11.1	63

		Ground				VOL2				VOL3				
Sample	Use	Leading species	Leading species age	SI	WSV (m^3/ha)	BA (m^2/ha)	TPH	Top height (m)	WSV (m^3/ha)	Phase pp	BA (m^2/ha)	TPH	Top height (m)	WSV (m^3/ha)
0201-0085-MO1	Growth	Pl	31.6	18.9	74	13.2	984	10.1	48	SX	9.3	748	9.5	37
0201-0085-YR1	Growth	Pl	35.9	17.9	96	19.5	1063	12.4	85	SX	15.3	951	11.6	68
0201-0088-MO1	Growth	Pl	22.0	21.6	74	11.7	925	9.6	43	PLI	3.9	585	7.7	15
0201-0088-YR1	Growth	Pl	27.1	22.2	117	16.8	953	11.5	66	PLI	11.1	830	9.8	40
0201-0090-MO1	Growth	Pl	25.6	21.0	93	14.9	1083	11.2	65	PLI	4.4	476	8.9	18
0201-0090-YR1	Growth	Pl	30.6	20.7	129	19.1	1024	12.8	86	PLI	9.1	694	10.9	36
0201-0091-YR1	Growth	Pl	39.3	22.7	215	23.4	1071	16.0	125	SX	20.9	1398	16.4	129
0201-0094-MO1	Growth	Pl	23.2	23.6	122	19.5	1038	11.8	77	PLI	4.4	520	8.3	17
0201-0094-YR1	Growth	Pl	28.3	27.3	192	30.2	1036	15.4	161	PLI	9.9	726	10.3	36
0201-0095-MO1	Growth	Pl	22.0	21.9	50	13.1	983	9.8	47	PLI	3.1	544	7.2	12
0201-0095-YR1	Growth	Pl	26.6	22.7	97	18.7	1012	11.8	74	PLI	9.9	870	9.3	37
0201-0098-MO1	Growth	Pl	27.0	20.3	155	16.7	1039	10.8	63	PLI	6.0	797	8.0	22
0201-0098-YR1	Growth	Pl	32.1	20.4	217	24.7	1039	13.4	113	PLI	14.8	1034	10.1	53
0201-0099-MO1	Growth	Pl	19.0	21.5	65	5.7	785	8.0	21	PLI	0.3	112	5.8	2
0201-0099-YR1	Growth	Pl	23.9	21.7	115	16.5	1039	10.7	62	PLI	3.7	485	8.0	13
0201-0100-MO1	Growth	Pl	54.9	18.4	547	33.4	1527	18.0	230	PLI	33.0	1029	16.5	187
0201-0100-YR1	Growth	Pl	58.1	21.1	578	36.3	1459	19.1	258	PLI	31.2	1551	17.2	213
0201-0082-MO1	Growth	S	37.5	20.9	59	15.4	822	14.5	78	SX	23.3	1150	14.6	125
0201-0082-YR1	Growth	S	42.6	20.9	88	17.5	1272	14.1	97	SX	27.7	1226	16.4	164
0201-0089-MO1	Growth	S	27.5	26.9	55	17.4	1128	12.2	75	SX	4.7	684	7.7	22
0201-0093-MO1	Growth	S	39.2	15.4	4	2.2	487	8.0	11	SX	1.0	302	7.3	7
0201-0096-MO1	Growth	S	25.9	24.4	38	5.7	733	9.4	24	SX	4.5	639	9.1	21
0201-0059-MO1	Growth	Sx	31.0	22.0	95	9.1	738	11.3	39	SX	5.1	553	9.5	23
0201-0059-YR1	Growth	Sx	35.9	24.2	171	17.0	1103	14.5	90	SX	7.5	664	10.3	35
0201-0060-MO1	Growth	Sx	27.5	18.9	13	1.5	405	6.4	13	SX	0.7	165	5.5	3
0201-0060-YR1	Growth	Sx	32.5	20.1	35	3.8	599	7.4	25	SX	5.4	673	8.2	22
0201-0061-MO1	Growth	Sx	40.7	20.1	158	18.0	1125	12.2	79	SX	12.3	991	10.2	51
0201-0061-YR1	Growth	Sx	46.3	19.6	196	21.1	1128	13.1	98	SX	21.3	1119	12.7	98
0201-0064-MO1	Growth	Sx	37.5	23.8	182	17.4	1103	12.2	80	S	20.3	1115	12.3	92
0201-0064-YR1	Growth	Sx	42.5	23.7	257	13.8	1013	11.1	65	S	27.1	1127	14.6	140

		Ground				VOL2				VOL3				
Sample	Use	Leading species	Leading species age	SI	WSV (m^3/ha)	BA (m^2/ha)	TPH	Top height (m)	WSV (m^3/ha)	Phase pp	BA (m^2/ha)	TPH	Top height (m)	WSV (m^3/ha)
0201-0065-MO1	Growth	Sx	31.0	18.8	31	1.8	435	6.2	15	PL	9.8	873	9.2	37
0201-0065-YR1	Growth	Sx	36.4	19.7	47	6.3	759	8.1	35	PL	16.6	1004	11.2	63
0201-0086-MO1	Growth	Sx	36.5	23.0	122	12.5	1032	11.2	55	SX	14.9	952	11.6	66
0201-0086-YR1	Growth	Sx	41.6	22.0	182	20.1	1152	12.7	98	SX	20.2	1091	13.5	101
0201-0089-YR1	Growth	Sx	31.8	28.5	114	27.6	1150	15.3	147	PLI	9.1	694	10.9	36
0201-0093-YR1	Growth	Sx	40.7	14.3	8	2.8	545	8.3	14	SX	5.5	755	9.5	26
0201-0096-YR1	Growth	Sx	31.6	25.0	77	14.9	1090	11.8	64	SX	7.2	801	9.9	31