100 Mile House TSA

Documentation of

Vegetation Resources Inventory Analysis – Volume Audit (Mature)

Prepared For:
Forest Analysis and Inventory Branch
Ministry of Forests, Lands and Natural Resource Operations

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Executive Summary

The objective of this project was to assess the accuracy of the Phase I inventory of the 100 Mile House TSA by completing a VRI statistical analysis of selected Phase I inventory attributes in the target population of interest. The target population is the vegetated treed portion of the landbase older than 50 years, excluding parks and private land. The analysis is based on current standards.

Based on the results of sampling in 2015, additional sampling was recommended and completed in 2016. The analysis using the entire dataset is compared to the analysis using the preliminary sample.

Overall, the ground samples had a lower average age, height, basal area and volume than the Phase I inventory (Table 1). The site index (SI) differences between the ground and Phase I inventory were very small while the PSPL estimates of SI were approximately 20% higher than the ground sample.

Table 1. The sample size (N), mean, ratio of means (Phase II Ground/Phase I Inventory) and sampling error of the ratio expressed as a percent of the ratio (SE of ratio (%)) are given by attribute for the volume audit (mature) portion of the 100 Mile House TSA. The ratios that differ from 1.0 by more than 10% are shaded. The results using the entire dataset (Current – includes samples from 2015 & 2016) are compared to the results using the samples measured up to 2015 (2015). The Phase I data come from the primary layer only.

		Current	2015	% change
Attribute	Statistic	Volume Audit	Volume Audit	(Current – 2015)/ 2015
Leading	N	133	73	82%
species	Mean Phase II Ground	115	123.5	-7%
age	Mean Phase I inventory	135	141.2	-4%
(years)	Ratio (Phase II/Phase I)	0.85	0.875	-3%
	SE of Ratio (%)	(7.7%)	(9.9%)	-22%
Leading	N	132	72	83%
species	Mean Phase II Ground	21.2	22.8	-7%
height	Mean Phase I inventory	24.5	24.8	-1%
(m)	Ratio (Phase II/Phase I)	0.868	0.92	-6%
	SE of Ratio (%)	(4.6%)	(5%)	-8%
Basal area	N	134	74	81%
(m^2/ha)	Mean Phase II Ground	23.3	23.6	-1%
7.5 cm+	Mean Phase I inventory	25.6	26.2	-2%
Primary	Ratio (Phase II/Phase I)	0.911	0.902	1%
Layer	SE of Ratio (%)	(9.5%)	(13.1%)	-27%
Trees/ha	N	134	74	81%
7.5 cm+	Mean Phase II Ground	790	778.8	1%
Primary	Mean Phase I inventory	502	488.8	3%
Layer	Ratio (Phase II/Phase I)	1.575	1.593	-1%
	SE of Ratio (%)	(13.3%)	(17.9%)	-26%
Lorey	N	134	74	81%
height	Mean Phase II Ground	18.7	18.8	0%
(m)	Mean Phase I inventory	21.5	21.6	-1%
Primary	Ratio (Phase II/Phase I)	0.869	0.869	0%
Layer	SE of Ratio (%)	(4.8%)	(5.8%)	-17%
Volume	N	134	74	81%
Net dwb	Mean Phase II Ground	147.8	151.5	-2%
(m^3/ha)	Mean Phase I inventory	172.9	182.3	-5%
12.5 cm+	Ratio (Phase II/Phase I)	0.855	0.831	3%
Primary L	SE of Ratio (%)	(11.4%)	(15.5%)	-26%
Leading	N	119	61	95%

Attribute	Statistic	Current Volume Audit	2015 Volume Audit	% change (Current – 2015)/ 2015
species	Mean Phase II Ground	15.4	16.1	-4%
Site index	Mean Phase I inventory	15.2	15.1	1%
(m)	Ratio (Phase II/Phase I)	1.012	1.066	-5%
	SE of Ratio (%)	(4.8%)	(6.2%)	-23%
Leading	N	119	61	95%
species	Mean Phase II Ground	15.4	16.1	-4%
Site index	Mean PSPL	18.0	18.0	0%
(m)	Ratio (Phase II/PSPL)	0.854	0.893	-4%
	SE of Ratio (%)	(4.9%)	(6.9%)	-29%

Overall, the Phase II volume (Dbh ≥ 12.5 cm, net of decay, waste and breakage) was 148 m^3/ha compared to a Phase I volume of 173 m^3/ha. The differences were greatest for the Other (n = 14) and pine (n = 17) strata while the ratio of Phase II/Phase I volume was within 10% of the desired ratio of 1.0 or the Fd (n = 68) and S&B (n = 35) strata. The overestimation of Phase I volume appears to be associated with an overestimate of the live pine volume (Phase I live pine volume = 23 m^3/ha compared to Phase II live pine volume = 2 m^3/ha) and an underestimate of the dead pine volume (Phase I dead pine volume = 20 m^3/ha compared to Phase II dead pine volume = 35 m^3/ha). This is particularly acute for the pine stratum. The Phase I photo acquisition occurred after the main mountain pine beetle epidemic. The inventory used film photography. Current projects use digital photography and include infrared bands that should improve the estimation of dead volume. The Ministry will be investigating when inventories should be adjusted and how they should be adjusted and will be developing appropriate guidelines.

The Phase I and Phase II estimates of SI were quite a bit lower than the PSPL estimates. The average total age of the ground leading species is 115 years, based on an average of 4.4 trees/sample with an average range of 58 years and standard error of 12 years. The age range is quite large, indicating the polygons may not be even-aged, making SI assessment challenging. The PSPL SI is an estimate of the potential SI. The ground SI may be lower than the potential due to disturbance (e.g., MPB), early height suppression, regeneration delay and other factors.

The additional 60 samples measured in 2016 resulted in modest changes in the attribute averages and small changes in the ratios. The biggest impact of the additional samples was the reduction of the sampling error by about 25%. The sampling error associated with the volume ratio is 11.4%, still greater than the target maximum sampling error of 10% but significantly lower than the 2015 sampling error of 15.5%.

Overall, the agreement between Phase I and Phase II leading species was 60%. The agreement by Phase I strata was 85% for Fd (n = 68), 14% for other (n = 14), 29% for pine (n = 17) and 49% for S&B (n = 35).

In 2016, height sampling on the ground plots was expanded to include height samples on the auxiliary plots. Based on 47 ground samples, the ratio between the Phase II ground leading species height (based on T, L, S, X, O trees), and the Phase I leading species height is 0.823 compared to a ratio of Phase II ground leading species height based on all trees of 0.849 ± 8%. This is a minor improvement in the averages. The additional heights are expected to lead to more accurate estimates of stem volume, particularly for mixed species, complex stands.

Acknowledgements

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1. Scope and Objectives

This report documents the statistical analysis of the Vegetation Resources Inventory (VRI) for the 100 Mile House Timber Supply Area (TSA).

The main objective of the project is to perform a VDYP7-based VRI analysis for the 100 Mile House TSA, based on current standards (FAIB 2011) for the Volume Audit (mature) population.

A preliminary volume audit sampling was completed in 2015 and a report drafted in March 2016. The results indicated potential issues with the inventory. Additional ground samples were collected in 2016 to confirm the results.

2. Background

2.1 Description of the Target Population Area

The description of the target population is taken from Nona Phillips Forestry Consulting (2014) available from the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO). The 100 Mile House TSA covers about 1.2 million ha and is located in the south-central interior of British Columbia (Figure 1). Approximately 53,000 ha are in provincial parks and 115,000 ha in private land. The 100 Mile House TSA is administered from the Ministry of Forests, Lands and Natural Resource Operations' office in 100 Mile House. The TSA boundary coincides with the 100 Mile House Forest District Boundary, which is part of the Cariboo Region. It is bounded by the Williams Lake TSA to the north and northwest, the Fraser River to the west, Kamloops TSA to the south, and the Cariboo Mountains and Wells Gray Provincial Park and TFL 18 to the east.

The 100 Mile House TSA has varied topography. It consists primarily of undulating plateaus with the Fraser River valley forming much of the western boundary and includes the lowest elevations in the TSA. The southwestern part includes areas of higher relief, the largely calcareous Marble and Pavilion ranges. Along the north eastern edge of the TSA the area rises steeply to form the Quesnel Highlands and the most westerly portions of the Cariboo Mountains.

The southwestern part of the TSA along the Fraser River has a hot, dry climate, while the Cariboo Mountains to the northeast produce a wet climate. There are eighteen biogeoclimatic subzones/variants in the TSA with the single largest unit being Interior Douglas-fir dry cool variant 3 (IDFdk3). The previous inventory showed lodgepole pine as the dominant tree species in the TSA at 49%, and that 60% of the pine volume in the TSA was over 80 years old. This was prior to the Mountain Pine Beetle (MPB) epidemic of the last decade. This mature pine was particularly susceptible to MPB.

The population of interest is the vegetated treed (VT) landbase that is greater than 50 years old, excluding parks and private land. VT is defined as forested polygons having a crown closure greater than 10%. The population of interest covers approximately 800,000 ha.

2.2 State of the Inventory

During the 2008/09 fiscal year, a VRI Strategic Inventory Planning exercise (VSIP) was undertaken co-operatively between the local stakeholders and the Ministry staff. This work was funded under the Forest Investment Account (FIA) and followed Ministry Standards. A business case concluded that it was timely to undertake a new VRI for the 100 Mile House TSA including both Phase I and Phase II activities. Timing the photography to reflect the land base following the MPB epidemic was recognized as important.

As a follow-up to the Strategic Planning process, a Project Implementation Plan was prepared to outline the Phase I photo acquisition and photo interpretation. Conventional film photography was flown in 2010 and 2011. The Phase I project was delivered to the Ministry in early 2014. This was a pre-digital, non-infrared acquisition and some issues with identification of dead stems were noted. Newer photo acquisitions are digital and include infrared bands and are expected to result in improved estimates of dead trees.

The inventory files used for this project's sample selection reflect harvest and reforestation updates current to 2016.

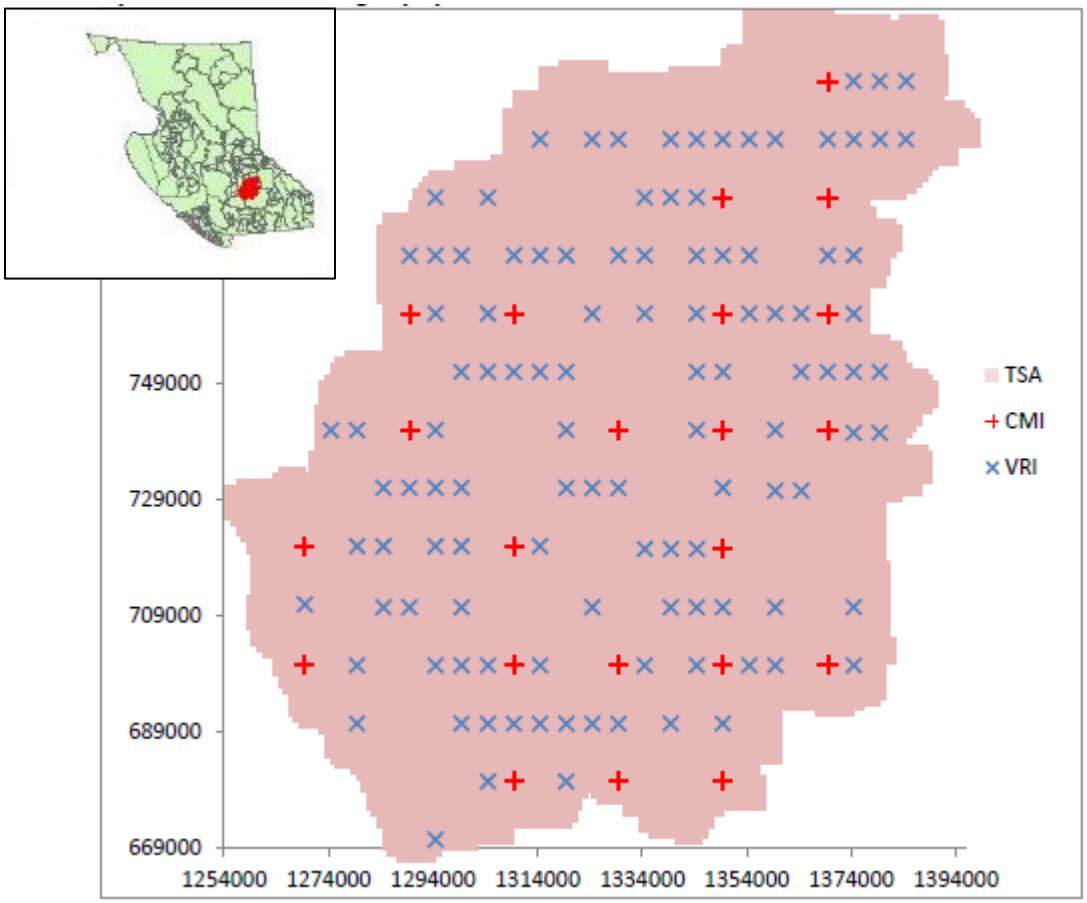

Figure 1. The location of the ground samples and the 100 Mile House TSA (from FAIB).

3. Data Sources

3.1 Phase I photo-interpreted inventory data

The VRI input files

- DMH_VEG_COMP_VDYP7_INPUT_LAYER_TBL.csv
- DMH_VEG_COMP_VDYP7_INPUT_POLY_TBL.csv

were provided and projected to the year of ground sampling using VDYP7 Console version 7.14b. VDYP7 allows for layer processing. There are some samples with more than two layers. VDYP7 outputs layer 1, 2 and D. It projects the primary layer.

Ten polygons had two projected layers (Table 2). Only the primary layer is used here unless otherwise noted.

Table 2. The samples with two projected layers are given. CD = VDYP7_LAYER_CD, Lyr = LAYER.

	Primary							Secondary						
clstr_id	CD	Lyr	Species	Age	Ht	BA	TPH	CD	Lyr	Species	Age	Ht	BA	TPH

	Primary							Secondary						
clstr_id	CD	Lyr	Species	Age	Ht	BA	TPH	CD	Lyr	Species	Age	Ht	BA	TPH
0231-0064-QO1	P	2	PLI	53	14.6	10.6	456	V	1	FDI	183	24.0	5.0	25
0231-0084-QO1	P	2	FDI	106	18.4	23.3	594	R	1	FDI	217	25.2	10.0	49
0231-0086-QO1	P	2	PLI	64	8.5	0.9	97	R	1	FDI	184	25.2	12.3	262
0231-0092-QO1	P	1	AT	123	26.2	5.0	89	Y	2	PLI	33	7.8	1.0	300
0231-0093-QO1	P	2	FDI	79	27.9	44.7	1084	V	1	FDI	262	32.0	1.0	5
0231-0109-QO1	P	1	FDI	204	27.2	14.9	148	Y	2	FDI	54	17.1	10.5	482
0231-0260-QO1	P	2	FDI	93	15.5	20.4	1395	R	1	FDI	366	27.2	15.0	16
0231-0329-QO1	P	2	EP	56	15.1	26.6	722	R	1	FDI	146	27.5	5.1	49
0231-0338-QO1	P	2	FD	81	15.9	19.0	631	R	1	FD	251	26.2	5.0	45
CAR1-8206-MO1	P	2	FDI	82	14.3	10.2	894	R	1	FDI	182	23.1	5.0	75

Twenty polygons had layers that were not projected. The non-projected layers include Phase I estimates of BA and TPH but not volume.

For all polygons, the species composition, leading species age, leading species height and leading species site index were taken from the primary layer. VDYP7 does not project the height and age for the second species. In a separate run, the second species and its associated height and age were put as the primary species and projected. This was used to obtain the projected height, age and site index of the second species.

Generally, the Phase I inventory forest descriptions come originally from photo interpretation, updated to the year of ground sampling. Volumes are estimated using VDYP7. Outputs from VDYP7 have a utilization level specified by the user – usually 7.5 cm for most attributes and 12.5 cm for volume.

Inventory information for recently disturbed polygons generally comes from the RESULTS (Reporting Silviculture Updates and Land status Tracking System) layer. These are also 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. None of the samples had an inventory height < 8 m.

3.2 Phase II Ground sample data

The ground sample data come from two data sources – Volume Audit (VA) ground samples and Change Monitoring Inventory (CMI) samples. The compiled ground sample attributes are given in Appendix B.

Ground samples with a measurement date prior to July 1 were considered to be part of the previous measurement year. Ground sampling occurred in the measurement years 2012 through 2016.

Fallen trees were included in the ground tallies. These are not included in the compiler summaries. Residual trees are included in the summaries.

3.2.1 CMI & NFI samples

The National Forest Inventory (NFI) 20 km grid is the basis for sample selection. All points on the grid are either ground sampled or photo sampled. Photo samples are established at the grid points in non-forest areas and unsafe locations. The photo vs. ground sample decision is based on reviewing imagery for the area before the project begins.

Only ground samples are used here. There were 24 CMI sample plots (including 5 NFI plots) in the VA population. Ground samples consist of 11.28 m fixed radius plots. Specifics about the CMI sampling can be found in the CMI Ground Sampling manual.

3.2.2 VA samples

Samples were selected using a 10 x 10 km grid superimposed on the 20 x 20 km NFI grid. There are 121 total grid points in the TSA of which 76 are in the VT population. Of these 76 points, 23 were sampled in

the 2013 field season as part of the CMI and NFI programs (see previous section). 53 samples were established in the 2015 field season and are referred to as VA samples. One plot was subsequently dropped.

In 2016, the grid was intensified to 10 x 5 km and an additional 61 field plots were established.

The majority of VA field plots consist of a cluster of 5 variable radius plots. The main plot is established with 4 auxiliary plots centered 50 m from the main plot centre at cardinal directions. Specifics about the ground sampling can be found in the VRI Ground Sampling manual. In 2016 the sampling protocol was modified to include height measurements on auxiliary plots. A small number of plots were fixed area and follow the CMI protocol.

3.3 Phase II Sample Selection Pre-Stratification and Weights

A mixture of fixed area and variable radius plots is used here. All samples are located on a grid and do not need to be weighted by selection probability. The variation associated with the ground estimates may vary with plot type. The variance of volume (net of decay, waste and breakage, Dbh ≥ 125 cm) for the 26 fixed area plots is about double that of the 108 variable radius plots (Figure 2).

The following weights were used, where s_V^2 is an estimate of the variance associated with merchantable volume for variable radius plots and s_F^2 is an estimate of the variance associated with fixed area plots.

$$\theta_V = \frac{1/s_V^2}{1/s_V^2 + 1/s_F^2} = \frac{1/8681}{1/8681 + 1/20915} = 0.29331$$

$$\theta_F = 1 - \theta_V = 0.70669$$

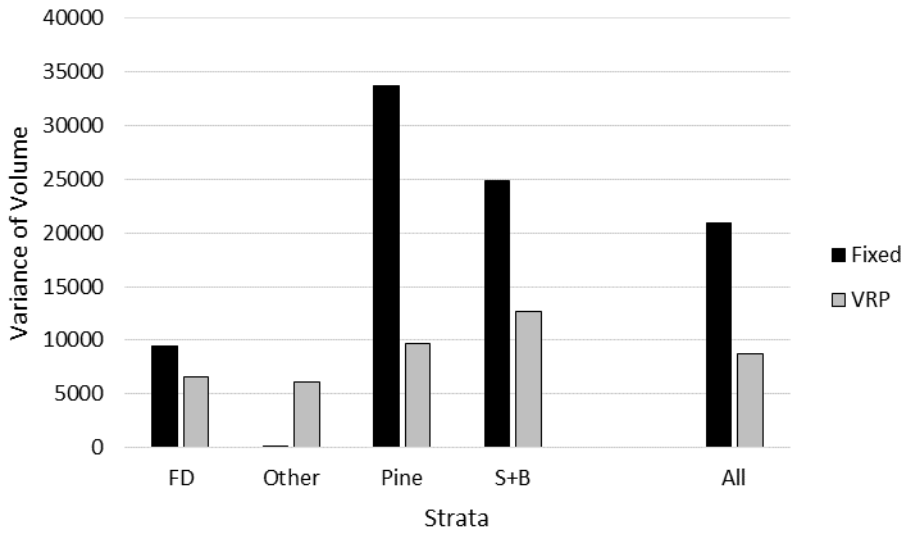

Figure 2. The variance of volume is given by strata and plot type (Fixed area vs. Variable radius).

3.4 Mountain Pine Beetle (MPB) and the Phase I Inventory D layer

Mountain Pine Beetle has killed most of the lodgepole pine in B.C. In the 100 Mile House district, the main years of attack were 2004-2006[1]. The Phase I photo acquisition occurred after the MPB epidemic occurred.

The photo interpretation was completed before the database was modified to include dead layers. Snags (dead, standing stems) were photo interpreted. The snag estimate was then used to construct a D layer. The ratio of dead stems (snags)/live stems per hectare was computed. This ratio was multiplied by the live basal area to estimate a dead basal area. The species composition of the D layer was set at PL 100 and height and age taken from the live pine attributes.

The D layer was only estimated if the dead fraction was ≥ 10% and the projected age was ≥ 30.

Further information on the adjustment of the inventory for MPB can be found at https://www.for.gov.bc.ca/hts/vridata/download/MPB_Changes_to_VEG_2015.pdf.

4. METHODS

4.1 Overview of VRI Sample Data Analysis

The purpose of the VRI sample data analysis is to evaluate the accuracy of the Phase I photo-interpreted inventory data using the Phase II ground sample data as the basis for the comparison. The analysis includes the following steps.

1 Project the inventory attributes using VDYP7 in accordance with the most recent Ministry standards and procedures.
2 Identify any outliers and data issues with the Phase I and Phase II data files supplied by the Ministry.
3 Identify analysis strata in consultation with Ministry staff.
4 Calculate sample selection probability weights.
5 Compute ratio of means and related statistics for each stratum and overall for the attributes of interest. These ratios of means form the basis of the inventory assessment. The sampling errors for these ratios can be used to assess the risk and uncertainty associated with the sampling process.
6 Produce an analysis of the comparison of leading species.
7 Provide separate tables, graphs and ratios for all key attributes.

There are seven timber attributes that are considered in the current VRI ground sample data analysis:

- Age of the leading species,
- Height of the leading species,
- Basal area at 7.5+ cm DBH utilization,
- Trees per hectare at 7.5+ cm DBH utilization,
- Lorey height (LH) at 7.5+ cm DBH utilization,
- Volume net top, stump (CU), decay, waste and breakage at 12.5+ cm DBH utilization, and
- Site index.

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. For variable radius plots, this is equivalent to HT_MEAN1. It does not have a utilization level (it includes all trees that meet the criteria, regardless of Dbh).

[1] Walton, A. 2013. Provincial-level projection of the current mountain pine beetle outbreak: Update of the infestation projection based on the provincial aerial overview surveys of forest health conducted from 1999 through 2012 and the BCMPB Model (year10). 13p.

Table 3. The field names for the attributes are given. All are at the 7.5 cm utilization level except for merchantable volume which is at the 12.5 cm utilization level and Lorey height, which does not have a utilization level.

Attribute	Ground file	VDYP7 file
Age of leading species	AGET_TXO	PRJ_TOTAL_AGE
Height of leading species	HT_TXO	PRJ_DOM_HT
SI of leading species	See section 4.5	PRJ_SITE_INDEX
Basal area	Ba_ha	RPJ_BA
Trees per hectare	Stems_ha	VRI_LIVE_STEMS_PER_HA
Lorey height	calculated	PRJ_LOREY_HT
Whole stem volume	Vht_wsv	PRJ_WSV
Merchantable volume Dwb	Vht_nwb	PRJ_VOL_DWB

4.2 Combining Live Phase I Inventory layers

The Phase I inventory polygon estimates may include multiple layers (e.g., Table). The layers were combined as follows. Only live projected layers are included (Table 2).

BA = sum of BA in live, projected layers
TPH = sum of TPH in live, projected layers
Volume = sum of volume in live, projected layers
Lorey height = basal area weighted Lorey height of the live, projected layers
Leading species = leading species from the primary layer
Age of leading (secondary) species = age of leading (secondary) species in the primary layer
Height of leading (secondary) species = height of leading (secondary) species in the primary layer
Strata = taken from the leading species in the primary layer

4.3 Data issues related to the statistical adjustment

Scatterplots comparing the Phase I and Phase II attributes were examined for potential outliers (Figure 9). Large differences between the ground sample and photo-based estimates were noted for a number of samples.

4.4 Height and Age data matching

Two height and age comparisons were undertaken – leading species and species matched. For the leading species comparison, the ground leading species age and height were compared to the Inventory leading species and height, regardless of whether the leading species were the same. For the species matched comparison, the MFLRNO data matching procedures (FAIB 2011) were followed to determine the appropriate Phase I and II heights and ages for the comparison ratios.

The objective of the species matching was to choose an inventory height and age (i.e. for either the leading or second species) so that the ground and inventory species "matched". If a leading species match could not be made at the sp0 (Table 22) level, conifer-to-conifer (or deciduous-to-deciduous) matches were allowed. However, conifer-deciduous matches were not considered acceptable. Appendix E provides the details for the height and age data matching.

The ground heights and ages used in the analysis were based on the average values for the T, L, S, X & O[2] trees by species.

In addition to comparing the leading species, the ground secondary species was compared to Phase I, using similar methods.

4.5 Site Index from the Phase II Samples

The Phase II site index (SI) value for each sample was computed as the arithmetic average site index (SI) of the T, L, S, X and O trees on the "trees_h" file that were suitable height and age trees by species. Overmature trees are generally not suitable for estimating site index as they may not always have been dominant/codominant trees and may have experienced suppression at young ages. This leads to lower SI estimates associated with older trees (Figure 3). Trees with breast height age > 120 were not used for site index estimates. Likewise, very young trees may have unreliable SI estimates. The trees used for SI estimates meet the age criteria (10 ≤ age_bh ≤ 120), are acceptable height trees (suit_ht = Y) and are acceptable age trees (suit_tr = Y). Residual trees are included if they meet the criteria. Seven SI trees had age_bh < 10 and 189 had age_bh > 120 and were not used in SI calculations.

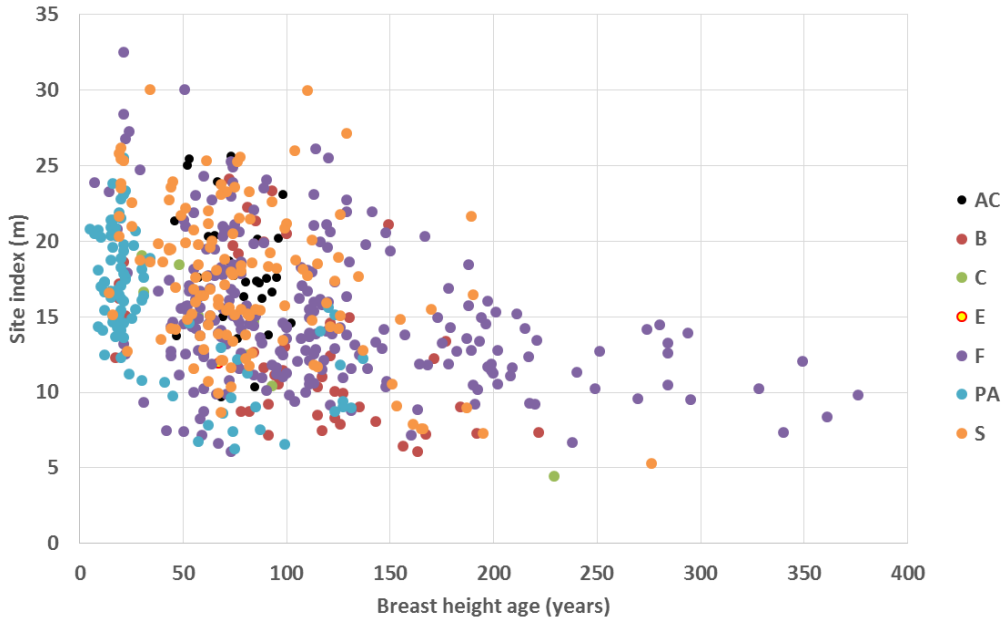

Figure 3. The trees with site estimates in the ground sample are given. There is a tendency for older trees to have lower site index estimates. Trees with a breast height age > 120 and breast height age < 10 were removed from the site index calculations.

[2]The T or "top height" tree is the tree of largest DBH in the central plot of the cluster, regardless of species. The L or "leading species" tree is the tree of largest DBH on any plot in the plot cluster. If a suitable (age or height) leading species sample tree is not found in any plot in the cluster, a "replacement" tree is selected. An "O" tree is the closest suitable (for height and age) tree of the leading species within 5.64m of the plot center. An "X" tree is the closest suitable tree of the leading species further than 5.64m but closer than 25m to plot centre. For further details, refer to the MFLNRO document "VRI Ground Sampling Procedures Version 4.8, May 2008, Amendment # 1: Modifications to the Leading Species Site Tree Selection Procedures", April, 2009.

Different trees may be used for calculation of leading species height, age and SI. In addition, the average of the SI of individual trees does not necessarily equal the SI calculated from average age and height. VDYP7 ignores the input SI and calculates the SI from the average height and age.

The samples in Table 4 do not have Phase II heights or ages for the leading species or the trees are too old for use in estimating site index.

Table 4. The samples without Phase II heights or ages for the leading species are summarized. Also noted are samples where the trees are too old for site index estimates.

Clstr_id	VRI lead	Ground Spp comp 4.0 cm	Comment
0231-0025-QO1	FDI	Fd 100	All sample trees have age_bh > 120
0231-0026-QO1	FDI	Fd 79 Sx 21	All sample trees have age_bh > 120
0231-0027-QO1	FDI	Fd 100	All sample trees have age_bh > 120
0231-0044-QO1	FDI	Fd 100	All sample trees have age_bh > 120
0231-0076-QO1	FDI	Fd 87 Pl 13	All sample trees have age_bh > 120
0231-0109-QO1	FDI	Fd 100	All sample trees have age_bh > 120
0231-0117-QO1	FDI	Fd 100	All sample trees have age_bh > 120
0231-0201-QO1	FDI	S 73 Bl 18 Fd 09	All sample trees have age_bh > 120
CAR1-3816-MO1	FDI	Cw 63 Bl 15 S 08 Fd 08 Ep 06	All height tree have suit_ht="N", all sample trees have age_bh > 120
0231-0087-QO1	PLI	At 50 Pl 47 Fd 03	Only pine sampled
CAR1-8211-MO1	PLI	Pl 58 Fd 39 S 03	All sample trees have age_bh > 120
0231-0005-QO1	SE	Bl 88 Se 12	All sample trees have age_bh > 120
0231-0332-QO1	SX	Fd 32 S 28 At 24 Bl 12 Ac 04	All sample trees have age_bh > 120
CAR1-0681-MO1	SX	S 100	All sample trees have age_bh > 120
CAR1-0701-MO1	SX	S 76 Bl 24	All sample trees have age_bh > 120

4.6 Site Index from the VRI Phase I polygons

As with age and height, site index (SI) was compared at the leading species level and species matched. The only difference is that for the species matched site index comparison, only Case 1 (samples where the Phase II and Phase I leading species were the same) and case 2 (Phase II leading species and Phase I secondary species were the same and there was a height and age available for the Phase I secondary species) were included. No other cases were considered acceptable matches for the ground plots.

4.7 Site index from Provincial Site productivity layer

The provincial site productivity layer (PSPL[3]) provides an alternative source of site index estimates, particularly for younger polygons. This layer provides site index estimates for up to 22 species. Three samples did not have PSPL estimates for the Phase I leading species so SiteTools 4.0 Beta was used to convert available SI estimates. 0231-0213-QO0 had AT as the leading species. The SX SI of 20 m was converted to an AT SI of 20.3 m. 0231-0346-QO1 had FD as the leading species and PL as the second species. The PL SI of 20.5 m was converted to an FD SI of 19.9 m. CAR-1331-MO1 had AT leading. The SX SI of 19.2 m was converted to an AT SI of 19.3 m.

4.8 Comparison with previous analysis

A previous VRI analysis of the 100 Mile House TSA was based on samples up to and including samples measured in 2015. Additional samples were established in 2016.

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

5. RESULTS AND DISCUSSION

The compilations from the Phase II ground sample are assumed to be accurate but are a small sample from a large population. The Phase I inventory is a complete assessment of the population of interest but has unknown accuracy and precision. The Phase II samples are considered unbiased but may have large sampling error due to the relatively small sample size. The Phase I polygon-based attributes have unknown bias. By comparing the Phase I inventory and Phase II ground samples, the bias of the Phase I estimates can be quantified. For quantitative attributes, unbiased population estimates with relatively small sampling error can be obtained.

The bias associated with the Phase I inventory is examined here for quantitative attributes and the agreement between the Phase I inventory and Phase II ground sample is examined for qualitative attributes.

5.1 Attribute bias

Attribute bias is the difference between the Inventory Phase I photo estimated attributes and the ground Phase II attributes measured to known precision on the ground. Attributes bias can be assessed as the ratio of the weighted mean Phase II ground sample attribute to the corresponding weighted mean Phase I inventory attribute, for example leading species height as estimated in Phase I and the corresponding ground measurements. The ratios were computed for the attributes identified in Section 4.1 as well as some additional attributes of interest. The stratification for the Volume Audit population is based on Phase I inventory leading species from the primary layer. The means are given in Table 5 and the ratios in Table 6.

Overall the Phase I estimates of age, height, basal area and volume are greater than the Phase II sample.

Table 5. Sample-estimated weighted means for the Phase I inventory and Phase II ground sample for key inventory attributes, for the volume audit strata of the 100 Mile House TSA. The shading indicates the subsample of plots that were measured in 2016 and include additional height measurements (see section 5.2). The Phase I primary layer is used.

Attribute		Strata					2015
		Fd	Other	Pine	S&B	All	All
N	Phase I Sample	68	14	17	35	134	75
Area (ha)	Phase I Population	412,832	69,409	128,704	198,367	809,312	809,312
Leading Species Age	N	68	14	16	35	133	73
(years)	Phase II Ground	132	68	100	107	115	124
	Phase I Sample	145	112	112	136	135	141
Leading Species	N	67	12	15	35	129	71
Matched Age	Phase II Ground	133	68	101	107	116	125
(years)	Phase I Sample	146	117	109	133	136	140
Second Species	N	53	13	12	28	106	59
Matched Age	Phase II Ground	132	67	99	107	114	122
(years)	Phase I Sample	138	115	109	138	132	134
Leading Species Height	N	67	14	16	35	132	72
(m)	Phase II Ground	21.4	19.1	20.1	22.2	21.2	22.8
	Phase I Sample	24.8	25.4	22.0	24.5	24.5	24.8
Leading Species Height	N	24	5	5	13	47	
2016 – TLSXO	Phase II TLSXO	20.5	18.1	22.4	18.8	20.0	
Subsample	Phase I Sample	24.9	25.2	23.8	22.0	24.0	
Leading Species Height	N	24	5	5	13	47	
2016 – All	Phase II All	21.3	19.0	22.5	19.3	20.6	
Subsample	Phase I Sample	24.9	25.2	23.8	22.0	24.0	
Leading Species	N	66	12	15	35	128	70

Attribute		Strata					2015
		Fd	Other	Pine	S&B	All	All
Matched Height (m)	Phase II Ground	21.3	18.9	19.8	22.2	21.2	22.7
	Phase I Sample	24.8	26.3	22.0	24.1	24.5	24.6
Second Species	N	52	13	12	28	105	58
Matched Height (m)	Phase II Ground	21.6	18.7	20.5	22.6	21.4	23.3
	Phase I Sample	23.9	26.1	23.4	24.5	24.3	24.5
Species Matched Height	N	24	4	5	13	46	
2016 – TLSXO	Phase II TLSXO	20.5	16.7	22.4	18.8	19.9	
Subsample	Phase I Sample	24.8	27.2	24.5	21.9	24.2	
Species Matched Height	N	24	4	5	13	46	
2016 – All	Phase II All	21.3	17.9	22.5	19.3	20.5	
Subsample	Phase I Sample	24.8	27.2	24.5	21.9	24.2	
Basal area	N	68	14	17	35	134	74
(m^2/ha)	Phase II Ground	24.2	20.6	15.4	26.2	23.3	23.6
7.5 cm+	Phase I Sample	24.1	27.8	23.7	28.4	25.6	26.2
Trees/ha	N	68	14	17	35	134	74
7.5 cm+	Phase II Ground	841	722	582	808	790	779
	Phase I Sample	469	457	581	549	502	489
Lorey Height	N	68	14	17	35	134	74
(m)	Phase II Ground	18.4	18.0	17.9	19.9	18.7	18.8
	Phase I Sample	21.4	23.3	19.6	21.6	21.5	21.6
Volume net	N	68	14	17	35	134	74
Dwb (m^3/ha)	Phase II Ground	141.0	126.3	109.3	186.1	147.8	151.5
12.5 cm+	Phase I Sample	153.5	173.9	186.3	204.5	172.9	182.3
Leading Species	N	59	14	15	31	119	61
Site index (m)	Phase II Ground	14.7	17.8	15.1	15.6	15.4	16.1
	Phase I Sample	15.1	17.5	16.3	13.9	15.2	15.1
Species Matched	N	55	7	7	23	92	47
Site index (m)	Phase II Ground	14.4	17.1	13.8	15.4	14.8	15.3
	Phase I Sample	14.6	15.9	14.7	13.8	14.5	14.5
Site index	N	59	14	15	31	119	61
(m)	Phase II Ground	14.7	17.8	15.1	15.6	15.4	16.1
Site prod	PSPL	18.0	17.6	18.4	18.0	18.0	18.0

Table 6. Ratio of means comparisons (and sampling error % at a 95% confidence level[4]) are given for the attributes in Table 5, for the target populations in the 100 Mile House TSA. The ratios are based on the Phase I primary layer. The ratios that differ from 1.0 by more than 10% are shaded.

	Strata					2015
Attribute	Fd	Other	Pine	S&B	All	All
Leading Species	0.911	0.608	0.894	0.789	0.85	0.875
Age (years)	(11.1%)	(17.3%)	(18.3%)	(13.2%)	(7.7%)	(9.9%)
Leading Species matched	0.908	0.582	0.927	0.805	0.855	0.89
Age (years)	(11.1%)	(16.1%)	(19.2%)	(13.8%)	(7.9%)	(10.1%)
Second Species matched	0.954	0.585	0.902	0.773	0.859	0.91
Age (years)	(11.4%)	(15.2%)	(23.1%)	(17.6%)	(8.7%)	(9.6%)

[4] The mean ± the sampling error gives 95% confidence interval for the mean, given a number of assumptions are met. For small sample sizes, the assumptions are less likely to be met.

Attribute	Strata				All	2015 All
	Fd	Other	Pine	S&B		
Leading Species	0.865	0.753	0.912	0.907	0.868	0.92
Height (m)	(5.9%)	(17.5%)	(15%)	(8.3%)	(4.6%)	(5%)
Leading Species Height	0.825	0.72	0.94	0.851	0.832	0.92
2016 – TLSXO	(10.6%)	(33.8%)	(34.3%)	(15.8%)	(9%)	(5%)
Leading Species Height	0.865	0.753	0.912	0.907	0.868	0.924
2016 – All	(5.9%)	(17.5%)	(15%)	(8.3%)	(4.6%)	(5%)
Leading Species matched	0.86	0.719	0.899	0.921	0.866	0.952
Height (m)	(5.9%)	(16.9%)	(14.8%)	(8%)	(4.5%)	(5.8%)
Second Species matched	0.901	0.719	0.875	0.923	0.88	0.92
Height (m)	(7%)	(16%)	(19.6%)	(8.6%)	(5.3%)	(5%)
Species Matched Height	0.826	0.613	0.915	0.855	0.823	
2016 – TLSXO	(10.6%)	(11.9%)	(30.3%)	(15.8%)	(8.5%)	
Species Matched Height	0.856	0.657	0.917	0.88	0.849	
2016 – All	(9.5%)	(15%)	(27.7%)	(17%)	(8%)	
Basal area	1.001	0.741	0.651	0.924	0.911	0.902
(m^2/ha) 7.5 cm+	(13%)	(23.3%)	(30.1%)	(17.8%)	(9.5%)	(13.1%)
Trees/ha	1.795	1.581	1	1.47	1.575	1.593
7.5 cm+	(20.2%)	(30.1%)	(32.6%)	(23.3%)	(13.3%)	(17.9%)
Lorey Height	0.856	0.771	0.914	0.919	0.869	0.869
(m)	(6%)	(14.9%)	(16.1%)	(9.2%)	(4.8%)	(5.8%)
Volume net Dwb	0.919	0.727	0.587	0.91	0.855	0.831
(m^3/ha) 12.5 cm+	(13.8%)	(27.7%)	(42.4%)	(23%)	(11.4%)	(15.5%)
Leading Species	0.976	1.017	0.929	1.123	1.012	1.066
Site index (m)	(6.5%)	(11.2%)	(13.2%)	(10.5%)	(4.8%)	(6.2%)
Species matched	0.98	1.076	0.937	1.11	1.018	1.054
Site index (m)	(6.5%)	(14.1%)	(22.6%)	(9.8%)	(5.1%)	(6.1%)
Site index (m)	0.816	1.013	0.821	0.87	0.854	0.893
PSPL	(6.5%)	(8.1%)	(17.3%)	(9.6%)	(4.9%)	(6.9%)

Several attributes are affected by the projected, non-primary layer in the Phase I summary and the combined projected layer estimates are given in Table 7 and Table 8.

Table 7. Sample-estimated weighted means for the Phase I inventory and Phase II ground sample for key inventory attributes, for the volume audit strata of the 100 Mile House TSA. The Phase I attributes include all live projected layers.

Attribute		Strata				All	2015 All
		Fd	Other	Pine	S&B		
Basal area	N	68	14	17	35	134	74
(m^2/ha)	Phase II Ground	24.2	20.6	15.4	26.2	23.3	23.6
7.5 cm+	Phase I Sample	24.8	28.3	24.5	28.4	26.1	26.8
Trees/ha	N	68	14	17	35	134	74
7.5 cm+	Phase II Ground	841	722	582	808	790	779
	Phase I Sample	479	484	591	549	511	506
Lorey Height	N	68	14	17	35	134	74
(m)	Phase II Ground	18.4	18.0	17.9	19.9	18.7	18.8
	Phase I Sample	21.6	23.2	20.2	21.6	21.6	21.7
Volume net	N	68	14	17	35	134	74
Dwb (m^3/ha)	Phase II Ground	141.0	126.3	109.3	186.1	147.8	151.5
12.5 cm+	Phase I Sample	156.9	176.7	190.5	204.5	175.5	185.1

Table 8. Ratio of means comparisons (and sampling error % at a 95% confidence level) are given for the attributes in Table 7Table 5, for the target populations in the 100 Mile House TSA. The ratios are based on the Phase I live projected layers. The ratios that differ from 1.0 by more than 10% are shaded.

	Strata					2015
Attribute	Fd	Other	Pine	S&B	All	All
Basal area (m^2/ha) 7.5 cm+	0.973 (12.8%)	0.729 (22.4%)	0.631 (30.2%)	0.924 (17.8%)	0.894 (9.4%)	0.883 (12.9%)
Trees/ha 7.5 cm+	1.756 (20.3%)	1.492 (28.3%)	0.984 (32.6%)	1.47 (23.3%)	1.546 (13.3%)	1.541 (17.9%)
Lorey Height (m)	0.85 (5.9%)	0.776 (14%)	0.889 (16.8%)	0.919 (9.2%)	0.864 (4.7%)	0.866 (5.9%)
Volume net Dwb (m^3/ha) 12.5 cm+	0.898 (13.2%)	0.715 (26.6%)	0.574 (42.4%)	0.91 (23%)	0.842 (11.2%)	0.818 (15.2%)

5.2 Value of the additional height measurements

Prior to 2016, heights were only sampled on the integrated plot centre (IPC) of the ground plots. In 2016, the height sample was expanded to include trees on the auxiliary plots and all heights were measured. This increased height sample should improve the estimates of leading species height as well as volume. To look at the differences, the plots measured in 2016 were further examined. The leading species average height based only on the IPC heights was compared to the leading species average height based on all the plots. The analysis includes trees measured for height that are of the ground leading species, are live, do not have a broken top and have a crown class of "D" or "C".

If only the IPC heights are used, 13 of the 60 plots do not have any heights measured on the leading species compared to 0 out of 60 when heights on auxiliary plots are included.

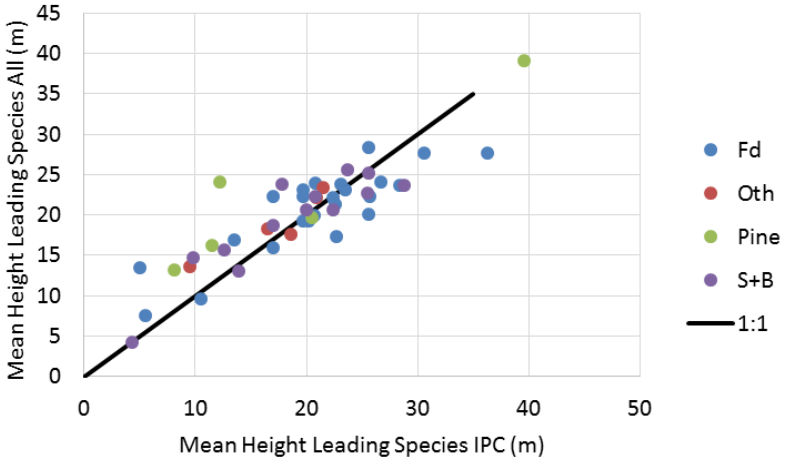

Figure 4. The mean height from the IPC is compared to the mean height for all plots for the leading species. Based 47 plots measured in 2016 that have heights measured on the leading species on the IPC.

For the 47 samples with IPC heights, the average number of height trees for the leading species was 9.8 (All plots) compared to 2.3 (IPC only) with an average leading species height of 20.6 m (All plots) and 19.9 m (IPC only).

Of the 47 samples, the difference between the All plots average height and the IPC average height was less than 1m for 28% of the plots (Table 9) and approximately half were within the 95% confidence interval for the mean height using all plots.

Table 9. The number of samples where the differences between the IPC height and all plot heights for the leading species is given by criteria. The total number of samples with both heights is 47. "SE" is the sampling error associated with the mean height for the sample based on all plots. The last criteria evaluates whether the IPC height estimate is within the approximate 95% confidence interval of the All height estimate.

Criteria diff = abs(IPC– All height)	Number of plots	% of plots
diff < 1	13	28%
diff < 2	23	49%
diff < 5	38	81%
diff < 10	46	98%
diff < 15	47	100%
diff < 2*SE	23	49%

In general, the ratio of IPC heights to all heights was within 10% of 1.0 (Table 10).

Table 10. The average heights of All the height trees is compared to the average of the IPC height trees are given along with the ratio of means comparisons (and sampling error % at a 95% confidence level. The ratios that differ from 1.0 by more than 10% are shaded.

		Strata				
Attribute		Fd	Other	Pine	S&B	All
Leading Species	N	24	5	5	13	47
Height (m)	Phase II All	21.3	19.0	22.5	19.3	20.6
	Phase II IPC	21.6	17.4	18.4	18.6	19.9
	ratio	0.984	1.093	1.223	1.037	1.032
	Sampling error	(7.1%)	(8.9%)	(25.5%)	(8.6%)	(5.5%)

The impact of the additional heights on the leading species height is relatively modest. The additional height measurements allow using tree-based taper equations to estimate volume rather than fitting volume/basal area regression equations. Taper equation-based estimates of volume should be more accurate. The impact of the additional height measurements is likely to improve the volume estimates, particularly for mixed species stands with a range of heights.

5.3 Model-Related and Attribute-Related Components of Volume Bias

The difference between the mean Phase I inventory volume and the mean Phase II ground sample volume is an estimate of the total volume bias. Residual trees are included.

The Phase I inventory estimates of volume for a polygon are generated by VDYP7. Generally, photo interpreted estimates of species composition, age, height, basal area and trees/ha are input into VDYP7. The remaining attributes required for VDYP7 (e.g., BEC zone, stockability, etc.) are taken from the Phase I inventory. These are projected to the year of ground sampling and various volumes estimated. There are two potential sources of bias that contribute to the volume bias.

1 Attribute-related volume bias: This is the bias associated with providing VDYP7 with incorrect input attributes (i.e. species composition, height, age, basal area, trees/ha) as well as errors associated with projecting these attributes to the year of ground sampling. In addition, the bias includes sampling error – comparing the Phase I polygon to the Phase II sample plot.

2 Model-related volume bias: This is the bias associated with predicting volume from projected species composition, height, age, basal area, trees/ha using the VDYP7 yield model. Depending on the volume, it can include errors in estimation of decay, waste and breakage.

Estimates of the relative contribution of each of these bias components to the total inventory volume bias can be obtained by estimating a new volume using the attributes from the ground sample as inputs to the VDYP7 yield model. The model-related bias is evaluated by comparing this third volume to the ground volume. The total bias minus model bias is considered attribute bias.

VOL A – Phase II ground volume – assumed to be correct.

VOL B – Phase I inventory – uses the photo interpreted attributes, projected to the year of ground sampling, using VDYP7. It includes errors in original attributes, projection errors, and volume estimation errors.

VOL C – VDYP7 volume using the ground attributes. It includes only VDYP7 volume estimation errors.

Total bias = VOL A – VOL B

Model bias = VOL A – VOL C. Includes VDYP7 volume estimation errors but not errors in input attributes.

Attribute bias = VOL C - VOL B. Does not include VDYP7 volume estimation errors but includes errors in original attributes, errors in attribute projection and sampling errors. Note that if age and height are supplied, VDYP7 ignores the input SI.

Two samples (0231-0087-QO1 and CAR1-3816-MO1) did not have heights for the leading species (Table 4) and were not projected by VDYP7.

The attribute volume bias is -44.3 m^3/ha, or about one quarter of the ground volume (Figure 5 and Table 11). The model bias is 18.5 m^3/ha.

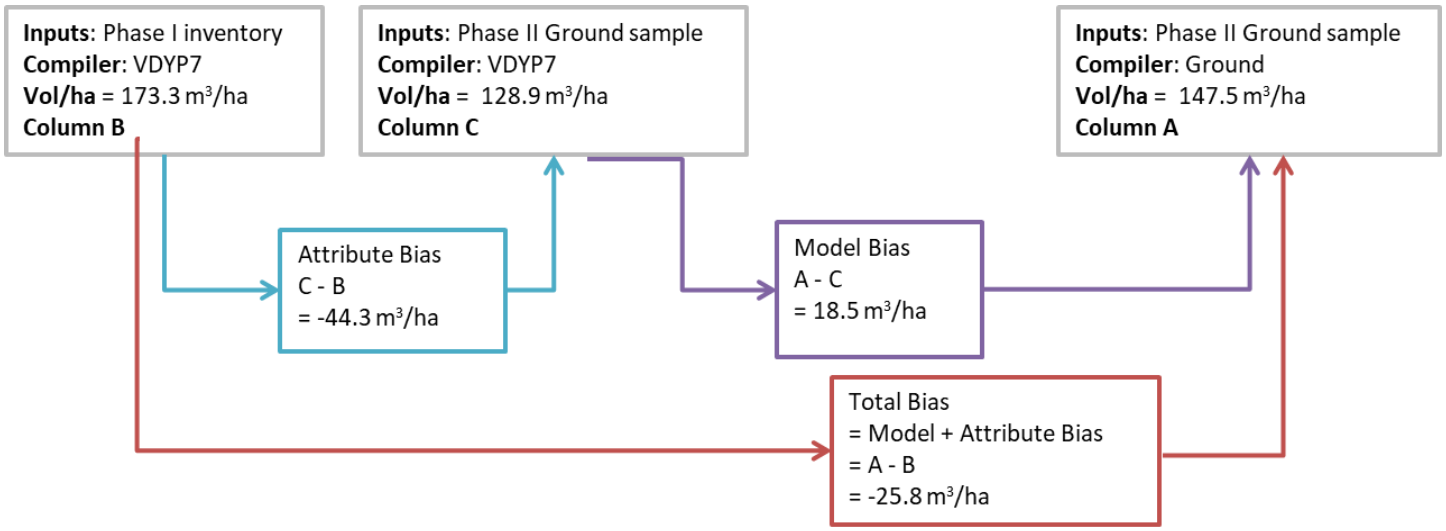

Figure 5. The relationship between the model and attribute components of total volume bias for the mature target population in the 100 Mile House TSA (from Table 11). A negative bias indicates Phase I overestimation whereas a positive bias indicates underestimation. The Phase I primary layer is used.

The mean model bias is smaller than the mean attribute bias. The range in model bias is considerably smaller than the range in attribute bias (Figure 6).

Attribute bias is largest in the other and pine strata. In the pine stratum, this may be related to an underestimate of pine mortality. If the live and dead volumes are combined, the Phase II ground volume is 182.6 m^3/ha compared to a Phase I average volume of 192.9 m^3/ha (Table 17).

The changes in average volume from 2015 to the expanded sample are modest (Table 11 versus Table 13). The major benefit from the increased sample size is a reduction in the sampling error associated with the volume estimates (Table 12 versus Table 14).

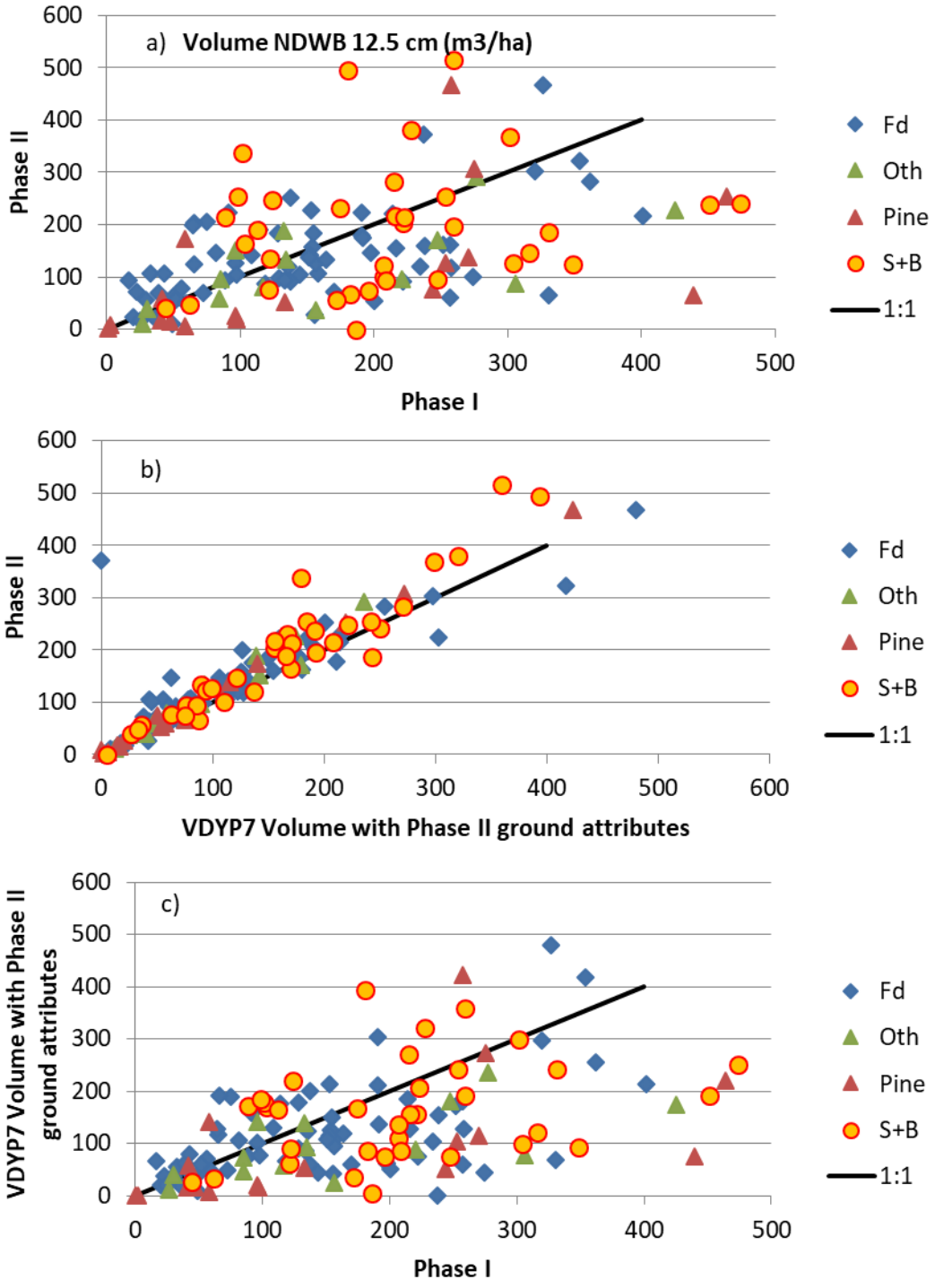

Figure 6. The top graph illustrates the total volume error (Phase I vs. Phase II volume). Total volume error = attribute-related volume error + model-related volume error. The middle graph illustrates model-related volume error (VDYP7 volume using Phase II inputs vs. Phase II volume). The model-related volume error is small indicating the VDYP7 volume estimates are similar to those from the ground compiler. The bottom graph illustrates the attribute-related volume error (Phase I volume vs. VDYP7 volume using Phase II inputs). The attribute-related volume error dominates the total volume error

indicating that most of the differences in volume between Phase I and Phase II are due to differences in the input values to VDYP7.

Table 11. Volumes for model-related and attribute-related bias comparison.

			Weighted mean Live Volume (m^3/ha) net Dwb at 12.5cm DBH						Dead Volume	
			Phase II Ground	VDYP7 Phase I Inventory	VDYP7 volume with Phase II attributes as input	Model-related volume bias	Attribute-related volume bias	Total volume bias	Phase II Ground	Phase I Inventory
Layers	Stratum	N	A	B	C	A-C	C-B	A-B		
Primary	Fd	67	139.4	152.9	125.7	13.7	-27.2	-13.5	31.9	17.0
	Other	14	126.3	173.9	105.0	21.3	-68.9	-47.5	30.5	14.3
	Pine	16	112.5	192.2	98.6	13.9	-93.5	-79.6	87.9	32.3
	S+B	35	186.1	204.5	157.6	28.5	-46.8	-18.4	82.0	23.7
	Total	132	147.5	173.3	128.9	18.5	-44.3	-25.8	51.3	20.2
All Live projected	Fd	67	139.4	156.4	125.7	13.7	-30.7	-17.0	31.9	17.0
	Other	14	126.3	176.7	105.0	21.3	-71.7	-50.3	30.5	14.3
	Pine	16	112.5	196.5	98.6	13.9	-97.8	-83.9	87.9	32.3
	S+B	35	186.1	204.5	157.6	28.5	-46.8	-18.4	82.0	23.7
	Total	132	147.5	175.9	128.9	18.5	-46.9	-28.4	51.3	20.2

Table 12. Ratios of mean volumes (12.5cm+ DBH net Dwb) representing total, model and attribute bias, with associated sampling error (expressed as a % of the mean bias) at a 95% confidence level.

			Total bias: Ground/Inventory	Model bias: Ground/VDYP7 (ground attributes)	Attribute bias: VDYP7 (Ground attributes)/ Inventory
Layers	Stratum	N	(Table 11 A/B)	(Table 11 A/C)	(Table 11 C/B)
Primary	Fd	67	0.912 (±6.4%)	1.109 (±3.3%)	0.822 (±6.1%)
	Other	14	0.727 (±10.3%)	1.203 (±4.5%)	0.604 (±8.5%)
	Pine	16	0.586 (±12.9%)	1.141 (±2.4%)	0.513 (±11.2%)
	S+B	35	0.91 (±10.7%)	1.181 (±4.4%)	0.771 (±7.9%)
	Total	132	0.851 (±5%)	1.144 (±2.3%)	0.744 (±4.2%)
All Live projected	Fd	67	0.891 (±6%)	1.109 (±3.3%)	0.804 (±5.8%)
	Other	14	0.715 (±9.7%)	1.203 (±4.5%)	0.594 (±8%)
	Pine	16	0.573 (±12.6%)	1.141 (±2.4%)	0.502 (±11%)
	S+B	35	0.91 (±10.7%)	1.181 (±4.4%)	0.771 (±7.9%)
	Total	132	0.839 (±4.8%)	1.144 (±2.3%)	0.733 (±4.1%)

Table 13. Volumes for model-related and attribute-related bias comparison **from 2015**. The Phase I estimates include only the primary layer.

		Weighted mean Live Volume (m^3/ha) net Dwb at 12.5cm DBH						Dead Volume	
		Phase II Ground	VDYP7 Phase I Inventory	VDYP7 volume with Phase II attributes as input	Model-related volume bias	Attribute-related volume bias	Total volume bias	Phase II Ground	Phase I Inventory
Stratum	N	A	B	C	A-C	C-B	A-B		

		Weighted mean Live Volume (m^3/ha) net Dwb at 12.5cm DBH						Dead Volume	
		Phase II Ground	VDYP7 Phase I Inventory	VDYP7 volume with Phase II attributes as input	Model-related volume bias	Attribute-related volume bias	Total volume bias	Phase II Ground	Phase I Inventory
Stratum	N	A	B	C	A-C	C-B	A-B		
Fd	37	148.1	165.1	144.3	3.8	-20.8	-17.0	30.3	13.0
Other	6	83.5	136.2	79.0	4.6	-57.2	-52.6	23.8	38.0
Pine	10	71.9	163.9	67.2	4.6	-96.6	-92.0	78.5	34.2
S+B	19	214.0	243.6	200.2	13.8	-43.5	-29.6	75.2	27.2
Total	72	151.0	183.2	144.4	6.6	-38.8	-32.2	47.3	21.3

Table 14. Ratios of mean volumes (12.5cm+ DBH net Dwb) representing total, model and attribute bias, with associated sampling error (expressed as a % of the mean bias) at a 95% confidence level **from 2015**. The Phase I estimates include only the primary layer.

		Total bias: Ground/Inventory	Model bias: Ground/VDYP7 (ground attributes)	Attribute bias: VDYP7 (Ground attributes)/ Inventory
Stratum	N	(Table 13 A/B)	(Table 13 A/C)	(Table 13 C/B)
Fd	37	0.897 (±9.3%)	1.026 (±3.8%)	0.874 (±9.2%)
Other	6	0.613 (±10%)	1.058 (±6.4%)	0.58 (±10%)
Pine	10	0.439 (±19.2%)	1.069 (±4.2%)	0.41 (±16.9%)
S+B	19	0.878 (±11.3%)	1.069 (±3.7%)	0.822 (±9.3%)
Total	72	0.824 (±6.6%)	1.046 (±2.5%)	0.788 (±6.1%)

The model-related bias is less than half the attribute-related bias. It is also much more consistent (Figure 6b) than the attribute-related bias (Figure 6c).

5.4 Phase I Layers

The VRI can include several live layers including primary, residual, veteran and young layers as well as potentially including a dead layer. The analysis in sections 5.1 and 5.3 only included the primary layer or the projected live layers. The total BA in live, non-projected layers is 242 m^2/ha. If this was included, it would increase the Phase I sample average BA by approximately 1.8 m^2/ha or about 7%. The additional layers are primarily in FD leading polygons (n = 19), based on the Phase I leading species, and one AT leading sample.

5.5 Leading species comparison

Table 15 summarizes the agreement between the leading species in the Phase I inventory and the leading species from the Phase II ground sample compilation for the sampled polygons. Of the 134 samples, 81 (60%) were correctly classified.

Table 15. The Phase II ground vs. Phase I inventory leading species cross-tabulation for the target population in the 100 Mile House TSA. The shaded cells are correct classifications. The overall correct classification rate is 60%.

Phase I Inventory	Phase II Ground Leading Species @ 4cm DBH utilization							%
leading spp	A	B	C	F	P	S	Total	Agreement
A	2				2	1	8	13	15%
B		4	1				1	6	67%

Phase I Inventory leading spp	Phase II Ground Leading Species @ 4cm DBH utilization A	B	C	F	P	S	Total	% Agreement
C				1			1	
F	1		2	57	1	7	68	84%
P	2	1		5	5	4	17	29%
S	2	7	1	6		13	29	45%
Total	7	12	4	71	7	33	134	
% agreement	29%	33%	0%	80%	71%	39%		60%

The agreement by Phase I strata is 84% for Fd (n = 68), 14% for other (n = 14), 29% for pine (n = 17) and 49% for S&B (n = 35).

The leading species is important for stratification and for inventory projection. However, for some polygons the choice of leading species is somewhat arbitrary and varies with utilization level. For instance, for clstr_id = 0231-0050-Q01, the species composition at the 4.0 cm utilization level is BL39 FD30 SE31 while at the 7.5cm utilization level the species composition is SE35 FD35 BL30.

Two additional comparisons were undertaken to evaluate the reasonableness of the species estimates. The first comparison used the rule that if the leading and secondary species differ by 10% or less, either can be considered the leading species; this is a standard that is used in photo interpretation audits. The second comparison used a 20% threshold. For sample CAR1-1336-MO1, the ground species composition is S 41 Fd 34 At 22 Pl 03 while the Phase I species composition is Fd 65 Sx 35. This sample would not be considered a leading species match. Using the first reasonableness criteria (10%), the ground leading species could be either S or Fd (their species percentages are ≤ 10% of each other).

Using 10% reasonable criteria, 69% of the volume audit samples are close in terms of leading species (Table 16). This rises to 74% when the criteria is reasonableness criteria is raised to 20%. The biggest improvement is for the S+B stratum.

Table 16. A comparison of leading species using two reasonableness criteria. The 10% rule is that if the leading and second species are within 10% of each other, either can be considered the leading species. The 20% rule is similar but uses a 20% threshold.

	N			%	
Strata	All	10% rule	20% rule	10% rule	20% rule
Fd	68	59	59	87%	87%
Other	14	4	5	29%	36%
Pine	17	6	10	35%	59%
S+B	35	23	25	66%	71%
Total	134	92	99	69%	74%

5.6 Analysis of Dead Pine

As noted in section 3.4, MPB has killed most of the mature lodgepole pine in B.C. In the 100 Mile House district, the main years of attack were 2004 – 2006. Most of the Phase I aerial photography was acquired after MPB occurred. All the ground sampling occurred after the main MPB attack.

In the Phase I inventory, the live pine volume is relatively minor except in the Pine strata (Table 17). In the Phase II ground sample, pine is minor in all strata. The rest of the discussion focuses on the Pine strata (n = 17). In the pine strata, the inventory significantly overestimates the live pine volume compared to the ground sample. The ground sampling occurred in the 2012 – 2016 field seasons, more than 6 years after the peak of the MPB attack. The ground plot summaries only include standing trees. Some of the pine are likely on the ground and not included in the estimate of dead volume.

Table 17. The average volume (m^3/ha net dwb at 12.5 cm+ Dbh), by stratum as well as dead pine volume expressed as a percent of total pine volume and total live volume + dead pine.

		Live All Species A		Live Pine B		Dead Pine C		Pine mortality as % of pine C/(B + C)		Pine mortality as % of live all + dead pine c/(A + C)	
Strata	N	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II
Fd	68	153.5	141.0	6.7	1.6	16.9	24.8	71%	94%	10%	15%
Oth	14	173.9	126.3	12.1	0.4	14.3	20.5	54%	98%	8%	14%
Pine	17	186.3	109.3	130.6	9.1	31.3	71.3	19%	89%	14%	39%
S+B	35	204.5	186.1	13.7	1.5	23.7	44.2	63%	97%	10%	19%
Total	134	172.9	147.8	23.2	2.3	20.0	34.8	46%	94%	10%	19%

A similar summary is given for trees/ha in Table 18.

Table 18. The average trees per hectare (at 7.5 cm+ Dbh), by stratum as well as dead pine trees/ha expressed as a percent of total pine trees/ha and total live trees/ha + dead pine.

		Live All Species A		Live Pine B		Dead Pine C		Pine mortality as % of pine C/(B + C)		Pine mortality as % of live all + dead pine c/(A + C)	
Strata	N	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II
Fd	68	469	841	28	78	42	123	60%	61%	8%	13%
Oth	14	457	722	19	82	72	50	79%	38%	14%	6%
Pine	17	581	582	395	145	226	370	36%	72%	28%	39%
S+B	35	549	808	38	17	79	151	68%	90%	13%	16%
Total	134	502	790	71	70	76	150	52%	68%	13%	16%

If the live and dead volumes are combined, the Phase I and Phase II estimates of volume become 192.9 m^3/ha and 182.6 m^3/ha respectively, much closer than the live volume only. It is possible that some of the pine have died since the photo acquisition. It is also possible the pine mortality was underestimated. The most recent version of the VRI has been adjusted for MPB dead pine using the methodology described in https://www.for.gov.bc.ca/hts/vridata/download/MPB_Changes_to_VEG_2015.pdf

Essentially this adjustment process involves creation of a D layer and assignment of dead volume in accordance with polygons containing 10% or greater pine mortality that are 30 years an older (projected age at year of disturbance). The 100-Mile House adjustment subsequently shows an approximate 2 million m3 downward adjustment in dead volume from previous estimates in the VRI. Initial results from an analysis 100 Mile House show the VRI estimates a greater total volume and a greater proportion of live volume than in the Harvest Billing System (HBS) or the Electronic Commerce Appraisal System (ECAS) for the 100 Mile House TSA for the harvest from 2011 - 2015[5].

5.7 Size class distributions

The ground sample trees were used to examine the size class distributions for the live and dead trees.

The live trees are primarily Douglas-fir and spruce (Figure 7).

[5] Harvest Performance Analysis Report: Procedures and initial results 100 Mile House Timber Supply Area 2011-2015. Prepared by Iaian McDougall, B.C. Ministry of Forests, Lands and Natural Resource Operations. Aug 29, 2016. 9p.

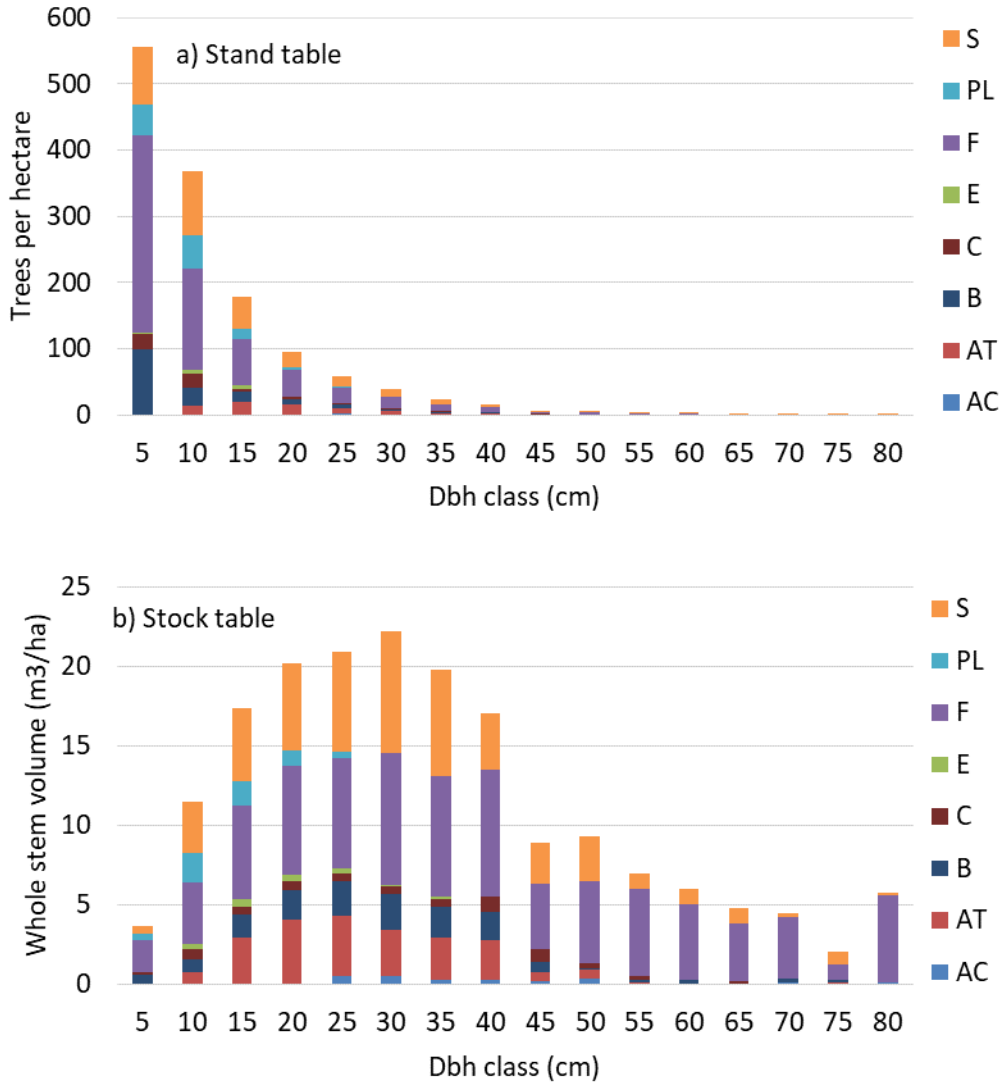

Figure 7. The number of trees (a) and volume (b) are summarized by species and Dbh class for live trees with Dbh ≥ 4.0 cm.

The dead trees are largely pine (Figure 8).

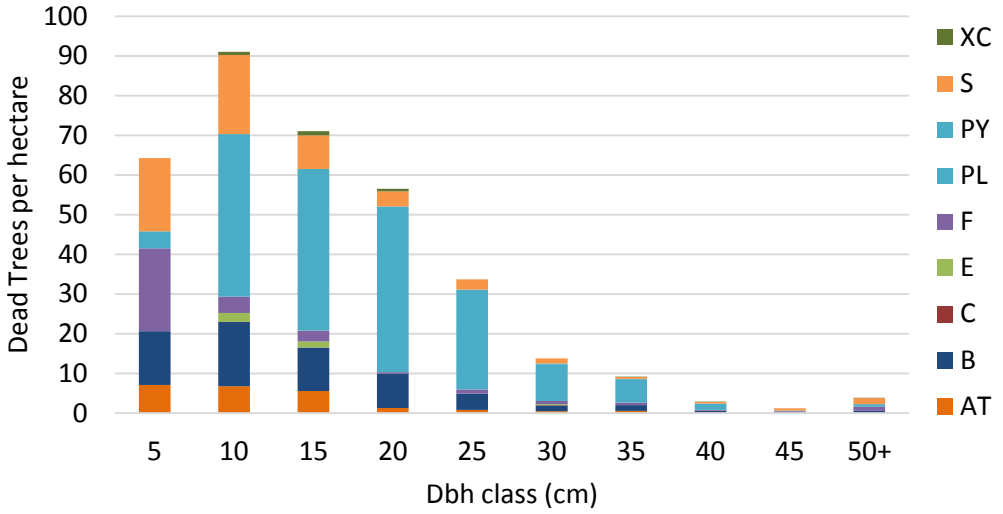

Figure 8. The number of dead trees is given by species and Dbh class for trees with Dbh ≥ 4.0 cm.

5.8 Limitations of the approach

Utilization limit– The original photo interpreted attributes in Phase I do not have a utilization limit. In Nona Philips Forestry Consulting (2014) report (which was not used), sample 93 has BA = 0 and stems = 595 stems/ha, implying the Dbh limit is 0cm. When the Phase I attributes are run through VDYP7, the resulting attributes will all have a utilization limit.

Sample unit – The Phase I sample unit is the polygon while the Phase II sample unit is a fixed area plot (CMI or NFI) or a cluster of 5-variable radius plots (Volume audit). In highly variable polygons (polygons with small openings, rock, multi-layered stands, mixes of immature and mature, etc.), a photo-interpreter may reflect this within-polygon variability in the Phase I attribute values that are assigned. However, the Phase II plot may not be as effective in capturing such variability.

VDYP7 – VDYP7 is used to project the Phase I attributes to the year of ground sampling. For very young stands, VDYP7 uses the module VRIYoung which does not estimate the full suite of inventory attributes until the polygon meets the minimum criteria of breast height age ≥ 6 years, dominant height ≥ 6 m and basal area (7.5cm+ DBH) ≥2 m^2/ha. Hence VDYP7 may not be the most appropriate model for projecting young managed stands. In the timber supply analysis process, the table interpolation program for stand yields (TIPSY) is generally used instead of VDYP7 for estimating yields of young managed stands.

Net volume – VDYP7 and the Phase II ground compiler use different methods to reduce whole stem merchantable volume to volume net of decay, waste and breakage (DWB). Net factoring, in combination with the net volume adjustment factor (NVAF), is used in the ground compiler and is generally considered more accurate and precise. VDYP7 was developed from TSP and PSP data and net volumes were estimated using BEC-based loss factors. Any net volume estimation bias associated with the BEC-based loss factors is built into the VDYP7 model.

Sample sizes – The sample sizes for the pine and other are small, resulting in estimates with high standard errors.

Target population - THLB – The target population for the volume audit (mature) stratum was the vegetated treed portion of the land base. The Timber Harvesting Land Base (THLB) is a subset of this area. If the THLB differs substantially from the larger population (e.g., more productive, less pine), the results may not be appropriate for the THLB.

6. Conclusions and recommendations

The inventory estimates of age, height and basal area are higher than the ground sample averages. The Phase I estimates of height are 15% higher and basal area are 10% higher than the ground sample measurements leading to a Phase I estimate of volume that is 17% higher than the ground sample. The differences are larger for the other and pine strata. Partitioning the volume bias into model and attribute bias confirms the bulk of the volume bias is due to attribute bias.

Overall, the Phase II volume (Dbh ≥ 12.5 cm, net of decay, waste and breakage) was 148 m^3/ha compared to a Phase I volume of 173 m^3/ha. The differences were greatest for the Other (n = 14) and pine (n = 17) strata while the ratio of Phase II/Phase I volume was within the 1.0 ± 10% for the Fd (n = 68) and S&B (n = 35) strata. The overestimation of Phase I volume appears to be associated with an overestimate of the live pine volume (Phase I live pine volume = 23 m^3/ha compared to Phase II live pine volume = 2 m^3/ha) and an underestimate of the dead pine volume (Phase I dead pine volume = 20 m^3/ha compared to Phase II dead pine volume = 35 m^3/ha). This is particularly acute for the pine stratum. The Phase I photo acquisition occurred after the main mountain pine beetle epidemic. There may have been additional pine mortality following the main outbreak and after the photo acquisition.

The site index (SI) differences between the ground and Phase I inventory were very small while the PSPL estimates of SI were approximately 17% higher than the ground sample and the Phase I inventory. The average total age of the ground leading species is 115 years, based on an average of 4.4 trees/sample with an average range of 58 years and standard error of 12 years. The age range is quite large, indicating the polygons may not be even-aged, making SI assessment challenging.

The additional 60 samples measured in 2016 resulted in modest changes in the attribute averages and small changes in the ratios. The biggest impact of the additional samples was the reduction of the sampling error by about 25%. The sampling error associated with the volume ratio is 11.4%, still greater than the target maximum sampling error of 10% but significantly lower than the 2015 sampling error of 15.5%.

The leading species agreement for the Volume Audit population is comparable to results from other TSA (60% or 81 out of 134). The agreement by Phase I strata was 85% for Fd (n = 68), 14% for other (n = 14), 29% for pine (n = 17) and 49% for S&B (n = 35).

In 2016, height sampling on the ground plots was expanded to include height samples on the auxiliary plots. Based on 47 ground samples, the ratio between the Phase II ground leading species height (based on T, L, S, X, O trees), and the Phase I leading species height is 0.823 compared to a ratio of Phase II ground leading species height based on all trees of 0.849 ± 8%. This is a minor improvement in the averages. The additional height measurements are used in the calculations of ground volume and are expected to improve the estimates of volume, particularly in in multi-species stands with complex structures such as post-MPB stands.

This report quantifies the bias associated with the Phase I inventory attributes, relative to the Phase II ground measurements. This raises the question of when the biases are significant and what should be done when they are significant. As a result, the Ministry will be investigating when inventories should be adjusted and how they should be adjusted and will be developing appropriate guidelines. These guidelines should include consideration of the size of the bias and the strength of the relationship between Phase I and Phase II. They should also include consideration of which attributes are adjusted, where the attributes are adjusted (in the corporate database vs. derived products), at what scale the attributes are adjusted (polygon vs. population) and how the attributes are adjusted (e.g., within VDYP7). Attribute adjustment is complex when adjustment of multiple attributes is undertaken. One option is to retain all the original Phase I attributes, including the derived attribute volume, and use the estimates of volume bias to adjust the overall volume estimates, rather than the individual polygon estimates. The need for adjustment may also depend on the application. For example, the PSPL estimates of SI are very important for young stands but less important for older polygons

7. Literature cited

FAIB 2011. Vegetation Resources Inventory – VRI sample data analysis procedures and standards. Version 1, June 2011. Ministry of Forests and Range, Forest Analysis and Inventory Branch. 23p. + app.

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

Jahraus Consulting Inc. 2013. Morice TSA – Documentation of Vegetation Resources Inventory Analysis. 20p + app,

Nona Phillips Forestry Consulting. 2014. 100 Mile House Timber Supply Area – TSA 23: Vegetation resources inventory project implementation plan including volume audit sampling and air calls. April 21, 2014. 12p. + app.

8. Appendix A: Phase I inventory attributes

Table 19. The Phase I inventory projected attributes are given. The estimates correspond to the primary layer.

Clstr_id	inventory standard	BEC	Reference year	Input CC%	Polygon area (ha)	sp01	pct1	sp02	pct2	sp03	pct3	sp04	pct4	sp05	pct5	sp06	pct6	Age sp1	Height sp1	Age sp2	Height sp2	Basale area (m2/ha)	Trees/ha	Lorey height (m)	Volume NWB 12.5 (m3/ha)	Dead WSV (m^3/ha)	SI SPp1 (m)	SI spp2 (m)
0231-0005-QO1	V	ESSF	2011	60	21.1	SE	70	BL	30									223	31.1	203	27.1	35.0	449	27.1	316	0	13.4	11.4
0231-0009-QO1	V	SBS	2011	65	13.1	SX	60	FDI	25	AT	15							133	35.3	133	36.4	45.4	442	32.8	474	0	21.9	21.7
0231-0010-QO1	I	ESSF	2007	70	18.5	PLI	70	SX	30									147	26.3			49.3	1191	22.8	439	0	17.6	
0231-0011-QO1	V	ESSF	2012	60	34.6	SE	75	BL	25									172	27.1	132	19.2	30.0	700	21.4	216	0	12.6	9.6
0231-0012-QO1	V	ESSF	2011	70	16.3	SE	70	PLI	20	BL	10							113	24.5	113	22.2	35.3	688	21.1	259	0	14.7	15.6
0231-0013-QO1	V	ESSF	2010	45	9.3	SE	86	CW	14									107	28.8	179	25.8	29.2	353	24.5	228	202	18.5	9.3
0231-0014-QO1	V	ICH	2010	40	13.9	FDI	70	SX	20	AT	5	BL	5					114	28.5	114	26.7	20.4	315	24.5	156	119	18.3	16.2
0231-0019-QO1	V	ICH	2010	60	89.8	SX	40	PLI	35	BL	20	FDI	5					94	23.8	94	20.4	31.1	594	20.4	215	0	16.6	15.4
0231-0023-QO1	V	IDF	2010	15	46.5	FD	100											250	27.2	250	27.2	10.0	114	23.3	65	0	12.6	12.6
0231-0024-QO1	V	IDF	2010	50	49.8	FD	95	SX	5									230	26.2	190	23.5	30.0	468	22.1	191	0	12.5	8.0
0231-0025-QO1	V	IDF	2010	50	34.3	FDI	100											242	28.2	242	28.2	35.0	395	24.1	238	0	13.3	13.3
0231-0026-QO1	V	SBS	2010	55	121.3	FDI	95	AT	3	SX	2							139	29.5	135	28.3	48.0	307	26.6	354	0	17.2	18.2
0231-0027-QO1	V	SBS	2010	20	26.7	FDI	100											135	30.5	135	30.5	15.0	100	29.5	129	0	18.0	18.0
0231-0029-QO1	V	SBS	2010	65	17.9	FDI	70	PLI	15	AT	15							74	20.8	74	20.6	36.5	978	17.7	191	0	17.5	17.5
0231-0031-QO1	V	ICH	2010	65	12.5	AT	50	PLI	25	FDI	15	SX	10					94	24.5	94	25.4	36.0	575	23.5	248	0	18.0	19.8
0231-0039-QO1	V	SBS	2010	40	17.7	FDI	85	SX	10	AT	5							245	38.2	225	34.2	25.0	174	35.8	257	0	18.2	14.6
0231-0043-QO1	V	IDF	2010	40	27.3	SX	45	FD	30	AT	15	PL	10					230	26.3	230	25.2	30.0	445	23.4	207	0	8.0	12.0
0231-0044-QO1	V	IDF	2010	15	58.7	FDI	100											195	24.2	195	24.2	10.1	151	22.5	66	0	12.2	12.2
0231-0045-QO1	V	IDF	2010	55	57	FDI	80	AT	10	SX	10							125	23.5	125	22.4	25.8	493	20.6	153	0	14.4	14.0
0231-0048-QO1	V	SBS	2010	55	16.5	FDI	60	SX	25	AT	15							165	32.4	135	28.6	40.3	447	28.0	327	0	17.6	15.6
0231-0050-QO1	V	ESSF	2010	45	62.1	SE	60	BL	30	FDI	10							135	19.5	135	18.6	20.1	339	16.7	103	113	9.9	8.9
0231-0051-QO1	V	ESSF	2010	65	51.9	BL	65	SE	30	PLI	5							109	24.6	114	27.6	45.7	963	21.9	331	0	15.6	16.8
0231-0052-QO1	V	IDF	2010	40	135.7	FD	75	PL	25									55	11.0	40	7.0	12.3	1097	8.3	17	0	12.2	10.1
0231-0056-QO1	V	IDF	2010	50	15.1	PLI	50	SX	35	AT	15							125	22.3	115	21.8	20.3	775	19.2	133	68	15.1	12.4
0231-0060-QO1	V	SBS	2010	60	11.5	SX	90	AT	10									114	18.6	114	18.3	25.6	695	15.9	124	0	10.3	11.5
0231-0062-QO1	V	SBS	2011	50	8.9	SX	65	BL	30	PLI	5							183	29.2	153	27.2	29.9	400	25.9	253	0	12.4	14.2

Clstr_id	inventory standard	BEC	Reference year	Input CC%	Polygon area (ha)	sp01	pct1	sp02	pct2	sp03	pct3	sp04	pct4	sp05	pct5	sp06	pct6	Age sp1	Height sp1	Age sp2	Height sp2	Basale area (m2/ha)	Trees/ha	Lorey height (m)	Volume NWB 12.5 (m3/ha)	Dead WSV (m^3/ha)	SI SPp1 (m)	SI spp2 (m)
0231-0064-QO1	V	IDF	2012	50	130.9	PLI	85	FDI	15									53	14.6	53	16.9	10.6	456	13.5	47	48	15.4	18.5
0231-0065-QO1	V	IDF	2011	35	166	PLI	80	FDI	20									94	18.4	124	22.4	15.4	444	17.4	97	47	13.6	13.8
0231-0067-QO1	V	IDF	2010	60	5.8	SX	60	AT	30	FDI	10							84	23.9	94	24.5	26.4	597	22.0	182	60	18.6	18.0
0231-0068-QO1	V	IDF	2010	30	6.8	AC	50	SX	30	FDI	20							124	24.5	114	23.6	15.2	284	21.0	85	125	14.5	13.9
0231-0070-QO1	V	SBS	2011	45	6.6	SX	65	AT	25	FDI	10							103	25.5	103	26.3	30.4	490	23.6	223	0	16.7	18.8
0231-0071-QO1	V	SBS	2011	45	7.6	AT	50	FDI	30	SX	20							131	26.2	133	27.3	35.3	489	24.5	221	0	16.7	16.2
0231-0074-QO1	V	IDF	2011	55	26.5	FDI	100											94	17.5	94	17.5	21.1	451	15.3	89	0	12.7	12.7
0231-0076-QO1	V	IDF	2012	45	26.3	FDI	100											113	24.4	113	24.4	25.6	345	21.4	158	0	15.8	15.8
0231-0080-QO1	V	IDF	2012	55	71.8	FDI	60	AT	25	SX	15							122	27.2	122	25.2	50.3	836	23.3	330	0	16.9	16.4
0231-0084-QO1	V	IDF	2012	40	63.3	FDI	100											106	18.4	106	18.4	23.3	594	14.5	92	0	12.4	12.4
0231-0086-QO1	V	IDF	2011	25	10.7	PLI	80	FDI	20									64	8.5	64	8.5	0.9	97	7.2	1	4	8.1	8.6
0231-0087-QO1	I	IDF	2011	60	5.8	PLI	100											89	8.4	89	8.4	7.0	1011	7.4	3	0	6.2	6.2
0231-0091-QO1	V	IDF	2011	50	15.9	FDI	90	AT	5	SX	5							143	26.3	128	24.2	40.2	712	22.0	258	0	15.1	15.2
0231-0092-QO1	V	IDF	2011	20	18.8	AT	60	FDI	25	SX	15							123	26.2	123	28.4	5.0	89	22.0	27	61	17.2	17.5
0231-0093-QO1	V	SBS	2012	65	13.2	FDI	80	SX	15	AT	5							79	27.9	75	26.2	44.7	1084	22.9	320	0	22.2	22.5
0231-0096-QO1	V	IDF	2010	30	27.8	FDI	100											155	25.4	155	25.4	15.2	247	21.9	97	0	14.1	14.1
0231-0098-QO1	V	IDF	2010	30	29.7	FDI	70	PLI	30									65	17.1	65	13.8	10.9	647	13.4	37	38	16.0	12.7
0231-0104-QO1	I	SBPS	2009	60	15.5	PLI	70	AT	20	SX	10							130	25.3			30.1	765	23.0	253	0	17.4	
0231-0106-QO1	V	MS	2010	30	24.1	FDI	100											205	29.2	205	29.2	15.1	200	25.5	114	0	14.6	14.6
0231-0108-QO1	V	MS	2011	40	17.9	FDI	70	PLI	30									164	28.3	129	22.2	39.7	348	22.7	257	213	15.3	14.8
0231-0109-QO1	V	IDF	2011	30	29.7	FDI	100											204	27.2	204	27.2	14.9	148	20.3	82	54	13.5	13.5
0231-0110-QO1	V	IDF	2011	40	15.3	FDI	95	PY	5									204	20.1	164	17.3	15.0	274	17.6	73	0	10.0	7.1
0231-0111-QO1	V	IDF	2012	30	43.6	FDI	100											203	28.1	203	28.1	25.0	224	24.3	170	0	14.1	14.1
0231-0112-QO1	V	IDF	2011	50	606	FDI	70	SX	20	AT	10							264	32.1	184	31.3	30.0	371	29.3	252	0	14.8	14.1
0231-0113-QO1	V	IDF	2011	60	6.2	FDI	60	SX	25	AT	10	PLI	5					204	32.2	124	27.5	49.9	591	27.2	401	0	16.1	15.9
0231-0117-QO1	V	IDF	2011	30	48.6	FDI	90	PY	10									129	14.2	139	15.4	10.3	399	12.4	32	0	8.7	7.2
0231-0201-QO1	V	MS	2011	35	17.3	FDI	85	PLI	10	SX	5							185	28.3	165	26.2	30.0	350	24.1	214	0	14.6	16.9
0231-0207-QO1	V	IDF	2011	50	39.9	FDI	95	PLI	5									185	19.2	155	18.2	24.9	644	15.8	109	0	9.9	10.6
0231-0213-QO1	V	IDF	2011	55	13.7	AT	65	SX	30	FDI	5							145	30.3	145	28.5	45.1	659	27.4	306	0	19.4	14.6

Clstr_id	inventory standard	BEC	Reference year	Input CC%	Polygon area (ha)	sp01	pct1	sp02	pct2	sp03	pct3	sp04	pct4	sp05	pct5	sp06	pct6	Age sp1	Height sp1	Age sp2	Height sp2	Basale area (m2/ha)	Trees/ha	Lorey height (m)	Volume NWB 12.5 (m3/ha)	Dead WSV (m^3/ha)	SI SPp1 (m)	SI spp2 (m)
0231-0215-QO1	V	IDF	2011	15	33.5	FDI	100											145	26.4	145	26.4	5.3	52	25.3	39	0	15.1	15.1
0231-0217-QO1	V	IDF	2011	60	3.4	AT	80	FDI	10	SX	10							130	28.4	145	31.5	45.6	706	26.2	277	0	18.6	18.0
0231-0221-QO1	V	MS	2011	55	12.8	SX	60	PLI	25	BL	15							75	21.3	75	17.7	31.1	810	17.6	186	27	18.2	14.9
0231-0224-QO1	V	IDF	2010	40	21.8	FDI	85	SX	15									206	31.3	166	29.5	24.9	319	26.3	198	122	15.6	13.8
0231-0226-QO1	V	IDF	2012	55	31.2	FDI	95	SX	5									104	24.6	64	23.2	36.0	733	20.3	216	0	16.6	22.9
0231-0227-QO1	V	IDF	2010	35	45.2	FDI	100											146	28.5	146	28.5	16.1	256	26.2	129	0	16.3	16.3
0231-0229-QO1	V	IDF	2010	20	20.3	FDI	100											206	35.3	206	35.3	15.0	127	30.9	137	0	17.7	17.7
0231-0231-QO1	V	IDF	2010	40	4.4	AT	80	SX	20									136	23.4	126	21.8	25.5	518	21.2	117	0	14.2	11.3
0231-0233-QO1	V	IDF	2010	30	10.9	FDI	100											126	21.6	126	21.6	11.2	264	19.8	65	0	13.2	13.2
0231-0238-QO1	V	MS	2011	45	13.2	SX	60	FDI	20	AT	10	PLI	10					90	23.1	90	24.9	30.6	713	20.6	207	50	16.7	18.3
0231-0242-QO1	V	IDF	2011	60	9.6	SX	50.1	FDI	49.9									65	22.7	65	23.4	38.3	980	20.2	248	0	22.0	21.4
0231-0245-QO1	V	IDF	2011	50	11.3	SX	55	PLI	25	AT	20							95	22.0	95	18.5	26.6	451	19.7	172	0	15.1	13.6
0231-0249-QO1	V	IDF	2011	20	20.3	FDI	80	PLI	20									205	28.2	165	22.2	15.1	149	25.9	119	0	14.1	13.5
0231-0253-QO1	V	IDF	2011	30	88.8	FDI	90	AT	10									165	29.4	145	27.3	20.3	225	26.9	156	0	15.9	16.9
0231-0255-QO1	V	IDF	2011	30	12.2	FDI	100											165	28.3	165	28.3	20.3	176	26.3	154	0	15.3	15.3
0231-0256-QO1	V	IDF	2011	35	168.1	FDI	100											185	27.3	185	27.3	20.0	344	22.8	134	0	14.1	14.1
0231-0260-QO1	V	IDF	2012	45	14.6	FDI	95	PLI	5									93	15.5	85	10.9	20.4	1395	11.8	50	9	11.4	8.2
0231-0261-QO1	V	IDF	2012	65	73.6	FDI	100											69	16.8	69	16.8	36.7	885	13.7	136	0	15.0	15.0
0231-0266-QO1	V	SBS	2011	45	16.4	AT	80	EP	10	SX	10							105	23.5	85	21.6	26.1	432	21.7	134	0	16.2	16.9
0231-0271-QO1	V	IDF	2010	25	8.5	SX	60	PLI	30	AT	10							76	18.5	86	19.7	10.9	342	16.6	62	126	15.6	15.5
0231-0276-QO1	V	IDF	2011	60	30.7	FDI	50.1	PLI	49.9									145	26.4	135	20.3	30.6	587	21.4	222	0	15.1	12.9
0231-0278-QO1	V	IDF	2012	35	78.8	PLI	100											74	13.5	74	13.5	10.4	395	11.6	41	82	11.3	11.3
0231-0280-QO1	V	SBS	2011	40	34.4	AT	70	FDI	20	SX	10							105	22.5	95	22.8	26.0	377	21.1	133	0	15.4	16.3
0231-0286-QO1	V	SBS	2010	40	7.5	SX	50	AT	40	PLI	10							116	23.9	116	20.5	20.6	436	20.5	122	70	13.9	13.1
0231-0291-QO1	V	IDF	2011	50	32.2	SX	70	AT	30									75	16.2	75	17.7	25.5	1128	14.3	101	0	14.0	14.3
0231-0294-QO1	V	IDF	2010	39	119.2	FD	100											116	15.5	116	15.5	9.6	528	13.1	30	0	10.0	10.0
0231-0296-QO1	V	ESSF	2010	40	38.4	BL	50	SE	35	PLI	10	AT	5					126	21.7	146	28.6	25.4	621	21.2	175	49	11.8	14.9
0231-0298-QO1	V	SBS	2010	55	21.2	FDI	80	SX	10	BL	10							136	25.5	136	24.8	35.8	589	21.9	234	0	15.0	12.5
0231-0301-QO1	V	SBS	2010	50	15.2	PLI	60	AT	30	FDI	10							136	30.3	136	31.4	25.6	626	28.2	244	0	21.5	20.8

Clstr_id	inventory standard	BEC	Reference year	Input CC%	Polygon area (ha)	sp01	pct1	sp02	pct2	sp03	pct3	sp04	pct4	sp05	pct5	sp06	pct6	Age sp1	Height sp1	Age sp2	Height sp2	Basale area (m2/ha)	Trees/ha	Lorey height (m)	Volume NWB 12.5 (m3/ha)	Dead WSV (m^3/ha)	SI SPp1 (m)	SI spp2 (m)
0231-0306-QO1	V	IDF	2010	15	30.5	FDI	100											126	25.6	126	25.6	6.1	171	24.0	45	0	15.7	15.7
0231-0308-QO1	V	IDF	2010	20	24.2	FDI	100											146	26.5	146	26.5	9.9	142	20.2	56	343	15.1	15.1
0231-0310-QO1	V	SBS	2010	20	95.1	AT	80	FDI	20									96	28.7	96	27.0	11.6	172	27.7	85	0	21.5	19.1
0231-0312-QO1	V	SBS	2010	25	19.3	PLI	60	AT	20	SX	10	FDI	10					76	18.8	76	24.0	10.3	334	17.5	58	140	15.7	19.7
0231-0314-QO1	V	SBS	2010	20	1.8	FDI	40	SX	30	BL	30							206	27.3	166	24.6	10.0	173	21.1	63	165	13.5	10.1
0231-0316-QO1	V	SBS	2010	55	4.7	FDI	60	AT	20	SX	20							146	31.6	146	28.4	45.6	534	27.5	362	0	18.0	17.7
0231-0317-QO1	V	SBS	2010	50	39.2	FDI	70	AT	20	SX	5	PLI	5					76	25.4	76	24.0	22.1	500	22.6	152	0	20.8	19.7
0231-0319-QO1	V	SBS	2010	55	35.5	AT	40	SX	30	FDI	20	PLI	10					116	33.5	116	32.8	45.1	550	31.2	425	0	23.9	21.4
0231-0322-QO1	V	IDF	2010	55	76.9	FDI	50	SX	35	AT	15							66	19.4	96	23.2	27.3	339	19.1	151	78	17.8	15.9
0231-0324-QO1	V	IDF	2011	50	59.6	FD	98	AT	2									115	23.6	65	17.9	24.9	688	19.2	138	0	15.1	15.7
0231-0326-QO1	V	ICH	2012	50	43.7	BL	50.1	SX	49.9									137	16.8	106	21.9	16.6	652	17.2	88	0	7.8	13.5
0231-0329-QO1	V	IDF	2010	60	14.2	EP	60	AT	30	FDI	10							56	15.1	56	15.1	26.6	722	14.1	96	0	14.6	14.6
0231-0331-QO1	V	SBS	2010	80	30.6	FDI	70	EP	25	SX	5							76	22.3	76	17.8	42.5	1736	17.4	200	0	18.4	14.4
0231-0332-QO1	V	SBS	2010	60	32	SX	60	FDI	35	AT	5							76	26.7	76	26.5	32.0	481	24.7	259	0	22.8	21.7
0231-0335-QO1	V	IDF	2010	50	10.7	FDI	50	AT	40	SX	10							136	24.5	136	25.4	25.8	438	23.0	155	0	14.4	15.8
0231-0338-QO1	V	IDF	2010	45	19.8	FD	75	PL	25									81	15.9	81	15.7	19.0	631	13.4	75	0	12.7	12.5
0231-0342-QO1	V	SBS	2010	40	67.2	FDI	70	SX	10	BL	10	EP	10					76	26.5	76	26.7	27.0	489	22.8	192	0	21.7	22.8
0231-0344-QO1	V	SBS	2010	55	53.5	SX	60	PLI	25	BL	15							116	21.9	116	18.4	15.6	345	18.8	99	58	12.4	12.3
0231-0346-QO1	V	SBPS	2010	25	33.6	FDI	90	SX	10									91	16.8	91	11.0	12.0	249	15.2	49	0	12.4	7.9
0231-0347-QO1	V	IDF	2010	40	99.4	FD	65	AT	30	SX	5							86	17.9	46	16.6	25.7	887	14.8	96	0	13.7	18.2
0231-0348-QO1	V	ICH	2010	50	22.8	SX	90	FDI	10									266	34.2	306	37.2	34.8	297	31.2	349	0	12.9	16.7
0231-0350-QO1	V	ICH	2010	45	12	SX	50	CW	35	BL	10	FDI	5					166	28.5	206	23.5	30.6	477	23.5	209	0	12.9	7.0
0231-0353-QO1	V	ICH	2011	60	5	BL	70	SX	30									205	26.3	245	28.3	29.9	448	24.1	222	0	10.6	8.6
0231-0355-QO1	V	ESSF	2011	60	9.1	PLI	40	SE	30	BL	30							145	25.2	145	27.5	35.4	501	22.9	270	0	16.7	14.2
0231-0358-QO1	V	SBS	2010	65	15.9	PLI	80	AT	10	SX	5	FDI	5					141	31.3	141	31.4	45.0	600	28.7	464	0	22.2	20.5
0231-0359-QO1	V	SBS	2010	60	34.5	PLI	50	FDI	30	SX	15	AT	5					136	25.3	136	28.6	35.0	399	24.4	275	0	17.1	16.8
0231-0361-QO1	V	ESSF	2011	45	32.2	BL	80	SE	20									165	21.4	245	25.2	20.4	528	18.8	122	0	9.0	9.3
0231-0363-QO1	V	ESSF	2011	25	41.8	BL	100											245	18.2	245	18.2	10.0	225	14.9	44	0	4.6	4.6
CAR1-0681-MO1	V	IDF	2010	45	4.7	SX	85	FD	10	PL	5							118	20.5	118	23.3	18.5	478	18.3	112	0	11.2	14.7

Clstr_id	inventory standard	BEC	Reference year	Input CC%	Polygon area (ha)	sp01	pct1	sp02	pct2	sp03	pct3	sp04	pct4	sp05	pct5	sp06	pct6	Age sp1	Height sp1	Age sp2	Height sp2	Basale area (m2/ha)	Trees/ha	Lorey height (m)	Volume NWB 12.5 (m3/ha)	Dead WSV (m^3/ha)	SI SPp1 (m)	SI spp2 (m)
CAR1-0701-MO1	V	SBS	2010	40	57.3	SX	60	BL	20	FDI	20							243	33.1	163	27.2	20.0	249	28.4	181	174	12.7	13.5
CAR1-1316-MO1	V	BG	2010	25	10.6	FDI	100											203	18.1	203	18.1	5.0	150	16.1	20	0	9.0	9.0
CAR1-1331-MO1	V	IDF	2010	20	1.8	AT	80	PLI	10	SX	5	FDI	5					63	22.6	63	15.5	5.4	152	20.4	30	58	20.5	14.5
CAR1-1336-MO1	V	IDF	2010	20	17.3	FDI	65	SX	35									143	28.3	123	24.4	5.2	77	26.1	43	0	16.3	13.5
CAR1-1341-MO1	V	MS	2011	50	15.7	SX	70	FDI	15	PLI	10	AT	5					142	28.2	162	31.2	35.1	560	25.5	304	0	14.6	17.0
CAR1-3816-MO1	V	ICH	2010	55	31.2	FDI	70	SX	15	BL	10	EP	5					93	25.5	93	23.6	35.8	736	21.4	238	0	18.4	16.6
CAR1-3821-MO1	V	ICH	2010	60	30	SX	60	FDI	25	BL	10	AT	5					143	32.3	143	30.3	50.1	639	27.9	451	0	18.1	17.4
CAR1-4436-MO1	V	IDF	2011	25	153.3	FDI	100											202	25.1	202	25.1	25.0	175	21.9	144	0	12.5	12.5
CAR1-4446-MO1	V	IDF	2011	45	45.8	FDI	50	SX	35	PLI	15							142	28.2	137	26.2	35.0	346	24.7	274	147	16.3	13.5
CAR1-6941-MO1	V	ICH	2011	60	23.2	PLI	50	SX	35	AT	15							112	23.1	112	24.3	35.2	831	21.3	258	0	16.5	14.6
CAR1-7561-MO1	V	IDF	2010	50	16.8	AT	65	PL	20	FD	10	SX	5					118	23.2	118	20.2	28.4	535	21.4	156	0	15.1	13.6
CAR1-7571-MO1	V	IDF	2010	30	63.9	PLI	50	SX	25	AT	15	FDI	10					83	20.4	83	22.7	15.2	390	18.3	96	212	16.3	17.7
CAR1-7581-MO1	V	SBS	2011	50	12.6	SX	60	AT	25	FDI	10	BL	5					132	27.3	132	28.1	40.2	493	25.1	301	0	14.7	18.2
CAR1-8206-MO1	V	IDF	2011	45	41.1	FDI	60	PLI	40									82	14.3	82	14.2	10.2	894	11.8	23	0	11.4	11.1
CAR1-8211-MO1	V	MS	2011	35	34.6	PLI	80	SX	10	FDI	10							127	16.1	122	16.3	10.1	595	13.9	42	52	10.0	8.3
CMI1-0122-FR2	V	IDF	2010	15	7.6	FDI	90	AT	10									102	19.2	82	17.3	10.5	102	18.7	52	0	13.2	13.2
CMI1-0279-FR1	V	SBS	2010	30	49.3	PLI	50	FDI	30	BL	15	SX	5					113	19.2	93	21.4	10.1	345	17.6	59	57	13.1	15.5
CMI1-0410-FR1	V	IDF	2010	55	34.5	FDI	80	AT	15	SX	5							113	24.4	103	25.3	25.8	497	22.1	164	0	15.8	17.9
CMI1-0500-FR2	V	SBS	2010	20	79.9	FDI	50	AT	40	PLI	10							83	20.5	83	22.4	10.6	305	20.1	60	0	16.0	17.4
CMI1-0513-FR1	V	SBPS	2011	45	54.6	SX	75	AT	15	PLI	5	FDI	5					121	24.1	121	27.1	30.1	496	21.4	196	103	13.5	18.1
KMHY-0219-YO1	I	IDF	1997	12	66.3	FDI	60	PLI	40									58	13.0			10.3	881	11.9	25	0	13.6	

9. Appendix B: Phase II compiled ground attributes

Table 20. The Phase II compiled ground attributes are given.

Strata	Sample	Year	Species composition At DBH ≥ 4.0 cm	Basal area (m^2/ha) DBH ≥ 7.5 cm	Trees/ ha DBH ≥ 7.5 cm	Lorey height (m) DBH ≥ 7.5 cm	Live volume net DWB (m^3/ha) DBH ≥ 12.5 cm	Dead volume net DWB (m^3/ha) DBH ≥ 12.5 cm
S+B	0231-0005-QO1	2014	Bl 88 Se 12	14.4	89	32.5	147	159
S+B	0231-0009-QO1	2014	Fd 64 Sx 27 Ep 09	26.4	235	29.9	240	14
Pine	0231-0010-QO1	2014	Pl 100	8.4	253	22.0	66	165
S+B	0231-0011-QO1	2014	Bl 74 Se 26	30.6	786	18.6	217	64
S+B	0231-0012-QO1	2014	Fd 80 Se 15 Cw 05	28.0	375	17.9	196	81
S+B	0231-0013-QO1	2014	Sx 53 Cw 26 Fd 21	45.6	462	31.6	380	38
Fd	0231-0014-QO1	2014	Sx 100	5.4	136	18.3	27	135
S+B	0231-0019-QO1	2014	Fd 60 Bl 20 Sx 08 Ep 04 At 04 Cw 04	43.2	1562	20.5	282	53
Fd	0231-0023-QO1	2015	Fd 89 Pl 11	25.2	901	14.8	124	20
Fd	0231-0024-QO1	2015	Fd 95 Sx 05	29.4	855	19.2	178	0
Fd	0231-0025-QO1	2015	Fd 100	23.8	709	17.5	160	22
Fd	0231-0026-QO1	2015	Fd 79 Sx 21	43.2	1032	23.2	322	18
Fd	0231-0027-QO1	2015	Fd 100	28.0	466	10.7	183	47
Fd	0231-0029-QO1	2014	At 24 Ep 24 Cw 24 Fd 18 Sx 10	51.8	2793	18.5	223	28
Oth	0231-0031-QO1	2014	Sx 63 At 25 Cw 06 Ac 06	22.4	521	21.3	171	35
Fd	0231-0039-QO1	2015	Fd 85 Sx 15	21.6	282	22.7	162	0
S+B	0231-0043-QO1	2015	Sx 81 At 13 Fd 06	16.0	556	21.7	100	0
Fd	0231-0044-QO1	2015	Fd 100	32.4	1301	24.5	203	36
Fd	0231-0045-QO1	2015	Fd 90 Sx 10	40.6	1369	18.4	228	19
Fd	0231-0048-QO1	2015	Fd 59 Sx 28 At 06 Ep 07	57.6	881	29.1	467	51
S+B	0231-0050-QO1	2015	Bl 39 Fd 30 Se 31	28.0	944	15.5	164	164
S+B	0231-0051-QO1	2014	Se 43 Bl 43 Pl 07 Fd 07	25.2	904	21.5	185	73
Fd	0231-0052-QO1	2015	Fd 95 Pl 05	19.0	760	10.5	93	7
Pine	0231-0056-QO1	2015	Sx 64 Pl 27 At 09	11.0	605	16.1	53	59
S+B	0231-0060-QO1	2014	Fd 42 At 37 Sx 16 Pl 05	34.2	605	20.8	248	152
S+B	0231-0062-QO1	2014	Bl 52 Sx 48	35.0	1206	20.8	255	86
Pine	0231-0064-QO1	2015	Pl 57 Fd 43	7.0	576	13.8	15	43
Pine	0231-0065-QO1	2015	Pl 100	6.0	494	7.5	18	6
S+B	0231-0067-QO1	2014	Sx 95 Pl 05	26.6	2180	11.1	66	57
Oth	0231-0068-QO1	2014	Sx 88 At 12	15.0	655	12.1	95	17
S+B	0231-0070-QO1	2014	Sx 35 Fd 27 At 19 Ac 12 Pl 07	36.4	1627	20.7	215	66
Oth	0231-0071-QO1	2014	Sx 55 Fd 36 At 09	12.6	376	27.8	96	48
Fd	0231-0074-QO1	2015	Fd 100	25.2	1535	10.9	93	12
Fd	0231-0076-QO1	2015	Fd 87 Pl 13	13.0	246	25.9	106	16
Fd	0231-0080-QO1	2014	Fd 71 At 14 Pl 15	9.8	234	20.0	65	105
Fd	0231-0084-QO1	2015	Fd 100	40.6	1346	17.2	222	0
Pine	0231-0086-QO1	2015	Pl 100	0.8	80	7.2	2	11
Pine	0231-0087-QO1	2015	At 50 Pl 47 Fd 03	2.9	260	9.2	9	55
Fd	0231-0091-QO1	2014	Fd 73 Pl 27	19.6	836	17.2	117	1
Oth	0231-0092-QO1	2014	Pl 89 Fd 11	7.0	552	11.1	10	0
Fd	0231-0093-QO1	2014	Fd 81 Sx 15 At 04	46.8	1208	21.9	303	56
Fd	0231-0096-QO1	2015	Fd 100	17.0	448	14.9	104	16
Fd	0231-0098-QO1	2015	Pl 70 Fd 30	10.0	961	10.1	21	5
Pine	0231-0104-QO1	2014	At 65 Sx 29 Fd 06	22.4	1154	18.0	126	35

Strata	Sample	Year	Species composition At DBH ≥ 4.0 cm	Basal area (m^2/ha) DBH ≥ 7.5 cm	Trees/ ha DBH ≥ 7.5 cm	Lorey height (m) DBH ≥ 7.5 cm	Live volume net DWB (m^3/ha) DBH ≥ 12.5 cm	Dead volume net DWB (m^3/ha) DBH ≥ 12.5 cm
Fd	0231-0106-QO1	2015	Fd 100	28.0	905	27.1	191	24
Fd	0231-0108-QO1	2015	Se 67 Fd 33	12.6	523	13.4	59	116
Fd	0231-0109-QO1	2015	Fd 100	21.0	214	21.8	147	8
Fd	0231-0110-QO1	2015	Fd 100	13.0	324	13.8	70	11
Fd	0231-0111-QO1	2015	Fd 50 At 30 Pl 20	14.0	871	17.8	72	72
Fd	0231-0112-QO1	2015	Fd 80 Sx 13 At 07	28.0	1205	23.7	162	0
Fd	0231-0113-QO1	2015	Fd 64 Sx 27 At 09	29.4	677	25.1	215	21
Fd	0231-0117-QO1	2015	Fd 100	13.0	75	17.6	106	9
Fd	0231-0201-QO1	2016	S 73 Bl 18 Fd 09	23.3	360	24.6	221	180
Fd	0231-0207-QO1	2016	Fd 100	33.6	1011	16.1	142	12
Oth	0231-0213-QO1	2016	S 63 At 19 Pl 18	16.0	618	16.2	88	13
Fd	0231-0215-QO1	2016	Fd 100	19.0	882	12.6	69	0
Oth	0231-0217-QO1	2016	S 68 At 16 Ac 14 Fd 02	49.0	1874	18.4	291	52
S+B	0231-0221-QO1	2016	Bl 100	0.0	0	4.3	0	173
Fd	0231-0224-QO1	2016	Fd 87 S 07 Pl 06	25.2	1447	20.6	146	46
Fd	0231-0226-QO1	2016	Fd 94 S 06	30.6	1065	17.7	155	43
Fd	0231-0227-QO1	2016	Fd 100	15.0	123	22.3	98	1
Fd	0231-0229-QO1	2016	Fd 91 Pl 09	15.4	432	21.5	91	0
Oth	0231-0231-QO1	2016	S 77 At 23	13.0	287	17.6	80	20
Fd	0231-0233-QO1	2016	Fd 100	33.0	767	22.6	200	2
S+B	0231-0238-QO1	2016	S 78 At 22	16.2	384	23.2	121	174
S+B	0231-0242-QO1	2016	Fd 75 S 13 At 12	22.4	1082	16.4	95	86
S+B	0231-0245-QO1	2016	S 64 Fd 14 At 14 Pl 08	10.0	346	13.3	57	31
Fd	0231-0249-QO1	2016	Fd 96 Pl 04	23.0	1140	14.2	88	0
Fd	0231-0253-QO1	2016	Fd 100	19.8	537	19.9	126	14
Fd	0231-0255-QO1	2016	Fd 96 At 04	25.2	906	18.7	158	10
Fd	0231-0256-QO1	2016	Fd 89 Pl 11	14.4	110	20.4	94	0
Fd	0231-0260-QO1	2016	Fd 81 Pl 19	11.0	331	16.6	63	20
Fd	0231-0261-QO1	2016	Fd 89 At 11	30.6	916	14.0	121	5
Oth	0231-0266-QO1	2016	S 38 At 31 Ac 19 Fd 12	22.4	822	18.4	134	14
S+B	0231-0271-QO1	2016	S 80 At 13 Fd 07	11.0	573	12.4	47	30
Fd	0231-0276-QO1	2016	Fd 73 Pl 27	18.2	691	16.5	92	40
Pine	0231-0278-QO1	2016	Fd 75 Pl 25	8.0	620	12.6	17	9
Oth	0231-0280-QO1	2016	At 46 S 46 Fd 08	23.4	361	22.8	188	133
S+B	0231-0286-QO1	2016	At 55 S 45	19.8	627	20.7	134	56
S+B	0231-0291-QO1	2016	At 87 S 13	55.8	2659	18.9	338	0
Fd	0231-0294-QO1	2016	Fd 100	8.4	70	22.1	57	79
S+B	0231-0296-QO1	2016	Bl 87 At 13	25.2	616	23.0	231	234
Fd	0231-0298-QO1	2016	S 70 Bl 30	16.2	744	19.7	119	163
Pine	0231-0301-QO1	2016	S 83 Pl 08 At 09	16.8	1222	14.9	75	105
Fd	0231-0306-QO1	2016	Fd 99 S 01	16.2	1141	11.1	41	0
Fd	0231-0308-QO1	2016	Fd 82 S 12 Pl 06	18.2	656	14.6	78	5
Oth	0231-0310-QO1	2016	Fd 57 S 36 At 07	14.0	466	13.9	59	0
Pine	0231-0312-QO1	2016	S 53 Fd 40 Bl 07	25.2	885	20.8	172	211
Fd	0231-0314-QO1	2016	Fd 75 Bl 25	7.2	77	19.3	45	143
Fd	0231-0316-QO1	2016	S 52 Fd 28 At 20	45.0	1953	19.6	283	12
Fd	0231-0317-QO1	2016	Fd 100	25.2	1389	17.4	141	0

Strata	Sample	Year	Species composition At DBH ≥ 4.0 cm	Basal area (m^2/ha) DBH ≥ 7.5 cm	Trees/ ha DBH ≥ 7.5 cm	Lorey height (m) DBH ≥ 7.5 cm	Live volume net DWB (m^3/ha) DBH ≥ 12.5 cm	Dead volume net DWB (m^3/ha) DBH ≥ 12.5 cm
Oth	0231-0319-QO1	2016	S 36 Ac 32 At 23 Fd 09	30.8	664	21.9	227	43
Fd	0231-0322-QO1	2016	S 54 Fd 46	23.4	991	18.1	138	28
Fd	0231-0324-QO1	2016	Fd 53 At 38 Pl 06 S 03	55.8	2876	15.4	252	0
S+B	0231-0326-QO1	2016	Cw 67 Bl 17 S 08 Ac 08	37.8	902	18.3	213	253
Oth	0231-0329-QO1	2016	Fd 65 Cw 17 Ep 13 S 05	30.8	1680	18.2	151	0
Fd	0231-0331-QO1	2016	Cw 55 Ep 18 S 18 At 09	14.0	985	13.8	53	36
S+B	0231-0332-QO1	2016	Fd 32 S 28 At 24 Bl 12 Ac 04	45.0	507	32.3	516	143
Fd	0231-0335-QO1	2016	Fd 100	23.4	597	24.6	184	32
Fd	0231-0338-QO1	2016	Fd 74 S 21 Pl 05	34.2	1417	20.1	206	20
Fd	0231-0342-QO1	2016	Fd 65 At 18 Cw 12 Ep 05	30.6	744	18.5	176	65
S+B	0231-0344-QO1	2016	S 81 Bl 12 Ac 07	28.8	502	24.2	254	16
Fd	0231-0346-QO1	2016	Fd 80 Pl 19 S 01	4.0	260	10.1	11	0
Fd	0231-0347-QO1	2016	Fd 47 At 35 Pl 18	23.8	1214	17.0	125	13
S+B	0231-0348-QO1	2016	S 50 Bl 43 At 07	16.2	469	15.9	123	75
S+B	0231-0350-QO1	2016	Bl 44 S 25 Cw 25 Fd 06	22.4	1636	14.4	94	11
S+B	0231-0353-QO1	2016	Bl 65 S 24 Ac 11	30.6	804	19.3	203	18
Pine	0231-0355-QO1	2016	Bl 60 S 40	18.0	365	21.1	138	74
Pine	0231-0358-QO1	2016	S 68 At 27 Fd 05	29.4	481	24.1	253	87
Pine	0231-0359-QO1	2016	Fd 64 S 36	25.2	155	36.6	308	108
S+B	0231-0361-QO1	2016	Bl 100	11.2	266	19.8	77	115
S+B	0231-0363-QO1	2016	Bl 90 S 10	9.0	268	11.6	40	4
S+B	CAR1-0681-MO1	2013	S 100	26.4	776	20.3	189	5
S+B	CAR1-0701-MO1	2013	S 76 Bl 24	48.0	1101	29.3	494	215
Fd	CAR1-1316-MO1	2013	Fd 100	7.6	250	10.3	23	0
Oth	CAR1-1331-MO1	2013	Fd 88 Pl 12	12.2	650	12.5	39	16
Fd	CAR1-1336-MO1	2013	S 41 Fd 34 At 22 Pl 03	25.6	1951	14.5	107	67
S+B	CAR1-1341-MO1	2013	S 87 Bl 13	17.7	375	19.3	126	0
Fd	CAR1-3816-MO1	2013	Cw 63 Bl 15 S 08 Fd 08 Ep 06	61.1	1426	19.5	372	8
S+B	CAR1-3821-MO1	2013	Cw 52 S 37 At 11	29.4	1051	21.6	238	75
Fd	CAR1-4436-MO1	2013	Fd 99 Pl 01	19.5	951	18.0	105	4
Fd	CAR1-4446-MO1	2013	Fd 93 Pl 07	14.5	250	23.9	100	67
Pine	CAR1-6941-MO1	2013	Fd 55 S 24 Bl 12 Cw 09	50.0	851	27.2	467	131
Oth	CAR1-7561-MO1	2013	At 93 Fd 04 S 03	7.7	275	13.7	37	19
Pine	CAR1-7571-MO1	2013	Fd 40 Pl 27 S 26 At 07	7.3	550	13.0	25	120
S+B	CAR1-7581-MO1	2013	Bl 47 S 43 At 10	34.2	425	28.4	369	20
Fd	CAR1-8206-MO1	2013	Fd 100	15.6	325	14.6	72	1
Pine	CAR1-8211-MO1	2013	Pl 58 Fd 39 S 03	11.5	625	16.8	58	178
Fd	CMI1-0122-FR2	2012	Fd 100	11.1	300	16.7	56	3
Pine	CMI1-0279-FR1	2013	Fd 84 Sx 09 Pl 07	1.8	125	10.0	5	154
Fd	CMI1-0410-FR1	2013	Fd 92 At 08	25.4	951	17.7	133	6
Fd	CMI1-0500-FR2	2013	Fd 95 Pl 05	15.3	1101	12.7	49	107
S+B	CMI1-0513-FR1	2012	Sx 71 Pl 16 At 13	22.5	1726	13.9	74	62
Fd	KMHY-0219-YO1	2015	Fd 67 Pl 33	4.8	225	11.7	16	1

10. Appendix C: Site index

Table 21. Site index (SI) estimates are given by species and source.

	Strata	Ground		case	Phase	I						PSPL									
Clstr_id		**Sp1**	**SI1**		**Sp1**	**Sp2**	**SI1**	**SI2**	AT	BL	CW	EP	FD	**HM**	**HW**	**PL**	**PY**	**SB**	**SE**	**SX**	**YC**
0231-0014-QO1	Fd	Sx	15.1	2	FDI	SX	18.3	16.2	19.4	20.0	16.4	18.9	22.9			23.7				20.8	16.4
0231-0023-QO1	Fd	Fd	14.2	1	FD		12.6	12.6	19.5				17.1			19.6				19.2	
0231-0024-QO1	Fd	Fd	21.8	1	FD	SX	12.5	8.0	17.3			19.1	17.1			19.6				19.2	
0231-0025-QO1	Fd	Fd		1	FDI		13.3	13.3	17.8				17.1			19.6				19.2	
0231-0026-QO1	Fd	Fd		1	FDI	AT	17.2	18.2	17.0	20.0		19.3	20.8			19.6				19.2	
0231-0027-QO1	Fd	Fd		1	FDI		18.0	18.0	19.8	19.5		18.7	21.0			21.8		10.5		21.0	
0231-0029-QO1	Fd	At	23.9	5	FDI	PLI	17.5	17.5	20.4	18.8		19.5	19.9			22.5		11.0		15.0	
0231-0039-QO1	Fd	Fd	21.9	1	FDI	SX	18.2	14.6	16.6	18.3		17.2	15.0			15.0				18.6	
0231-0044-QO1	Fd	Fd		1	FDI		12.2	12.2	19.0				20.2			20.6				20.0	
0231-0045-QO1	Fd	Fd	15.4	1	FDI	AT	14.4	14.0	18.0				17.1			19.6				19.2	
0231-0048-QO1	Fd	Fd	21.5	1	FDI	SX	17.6	15.6	17.0	18.7		18.1	20.8			19.6				19.2	
0231-0052-QO1	Fd	Fd	13.3	1	FD	PL	12.2	10.1	18.1				20.2			20.6				20.0	
0231-0074-QO1	Fd	Fd	11.2	1	FDI		12.7	12.7	14.4				17.1			19.6				19.2	
0231-0076-QO1	Fd	Fd		1	FDI		15.8	15.8	16.5				20.2			20.6				20.0	
0231-0080-QO1	Fd	Fd	19.0	1	FDI	AT	16.9	16.4	17.5				19.8			20.5				19.9	
0231-0084-QO1	Fd	Fd	12.8	1	FDI		12.4	12.4	16.7				17.1			19.6				19.2	
0231-0091-QO1	Fd	Fd	15.9	1	FDI	AT	15.1	15.2	17.2				17.1			19.6				19.2	
0231-0093-QO1	Fd	Fd	20.3	1	FDI	SX	22.2	22.5	17.0	18.8		18.1	20.8			19.6				19.2	
0231-0096-QO1	Fd	Fd	11.8	1	FDI		14.1	14.1	14.8				17.1			19.6				19.2	
0231-0098-QO1	Fd	Pl	9.6	2	FDI	PLI	16.0	12.7	15.7				20.2			20.6				20.0	
0231-0106-QO1	Fd	Fd	16.0	1	FDI		14.6	14.6					16.8			18.0	15.4				
0231-0108-QO1	Fd	Se	11.4	3	FDI	PLI	15.3	14.8		15.0			18.0			15.9				14.1	
0231-0109-QO1	Fd	Fd		1	FDI		13.5	13.5					17.1			19.6				19.2	
0231-0110-QO1	Fd	Fd	11.1	1	FDI	PY	10.0	7.1				18.8	9.0				11.9				
0231-0111-QO1	Fd	Fd	16.8	1	FDI		14.1	14.1					17.1			19.6				19.2	
0231-0112-QO1	Fd	Fd	16.9	1	FDI	SX	14.8	14.1					20.2			20.6				20.0	
0231-0113-QO1	Fd	Fd	20.2	1	FDI	SX	16.1	15.9	16.5				17.1			19.6				19.2	
0231-0117-QO1	Fd	Fd		1	FDI	PY	8.7	7.2				18.0	16.6				15.4				
0231-0201-QO1	Fd	S		3	FDI	PLI	14.6	16.9		12.0			15.0			16.0				12.0	
0231-0207-QO1	Fd	Fd	9.1	1	FDI	PLI	9.9	10.6	14.9			17.8	9.0			17.6	9.0				
0231-0215-QO1	Fd	Fd	9.3	1	FDI		15.1	15.1					16.6				15.4				
0231-0224-QO1	Fd	Fd	11.8	1	FDI	SX	15.6	13.8	15.4				17.1			19.6				19.2	
0231-0226-QO1	Fd	Fd	11.6	1	FDI	SX	16.6	22.9	14.5				17.1			19.6				19.2	
0231-0227-QO1	Fd	Fd	14.0	1	FDI		16.3	16.3					19.8			20.5				19.9	
0231-0229-QO1	Fd	Fd	10.1	1	FDI		17.7	17.7					17.1			19.6				19.2	
0231-0233-QO1	Fd	Fd	10.9	1	FDI		13.2	13.2	16.3				17.1			19.6				19.2	
0231-0249-QO1	Fd	Fd	16.5	1	FDI	PLI	14.1	13.5	16.0				21.7			18.3				21.0	
0231-0253-QO1	Fd	Fd	19.0	1	FDI	AT	15.9	16.9	16.2				17.1			19.6				19.2	
0231-0255-QO1	Fd	Fd	14.9	1	FDI		15.3	15.3	15.6				17.1			19.6				19.2	
0231-0256-QO1	Fd	Fd	6.6	1	FDI		14.1	14.1	16.1				17.1			19.6				19.2	
0231-0260-QO1	Fd	Fd	10.7	1	FDI	PLI	11.4	8.2	14.4				20.2			20.6				20.0	
0231-0261-QO1	Fd	Fd	13.8	1	FDI		15.0	15.0	14.0				20.2			20.6				20.0	
0231-0276-QO1	Fd	Fd	11.5	1	FDI	PLI	15.1	12.9	17.5				17.1			19.6				19.2	
0231-0294-QO1	Fd	Fd	11.1	1	FD		10.0	10.0	17.0				17.1			19.6				19.2	
0231-0298-QO1	Fd	S	15.3	2	FDI	SX	15.0	12.5	15.2	18.0			18.0			21.0				21.0	
0231-0306-QO1	Fd	Fd	13.8	1	FDI		15.7	15.7	18.0				17.1			19.6				19.2	
0231-0308-QO1	Fd	Fd	11.1	1	FDI		15.1	15.1	18.6				17.1			19.6				19.2	
0231-0314-QO1	Fd	Fd	15.7	1	FDI	SX	13.5	10.1		18.0			18.0			21.0				18.0	
0231-0316-QO1	Fd	S	22.9	3	FDI	AT	18.0	17.7	17.2	19.5		18.8	21.0			21.8		10.7		21.0	
0231-0317-QO1	Fd	Fd	16.5	1	FDI	AT	20.8	19.7				18.6	19.1			19.9				19.9	
0231-0322-QO1	Fd	S	14.9	2	FDI	SX	17.8	15.9	18.1				20.5			20.1				20.2	
0231-0324-QO1	Fd	Fd	15.5	1	FD	AT	15.1	15.7	18.5				16.8			18.0				18.7	
0231-0331-QO1	Fd	Cw	16.9	3	FDI	EP	18.4	14.4	20.2			19.2	21.0			21.8		11.2		21.0	
0231-0335-QO1	Fd	Fd	16.9	1	FDI	AT	14.4	15.8	20.1				17.1			19.6				19.2	
0231-0338-QO1	Fd	Fd	18.7	1	FD	PL	12.7	12.5	19.0				20.2			18.3				15.5	
0231-0342-QO1	Fd	Fd	13.7	1	FDI	SX	21.7	22.8	19.0	18.8		18.3	19.9			22.5		10.7		15.0	
0231-0346-QO1	Fd	Fd	13.1	1	FDI	SX	12.4	7.9								20.5				20.7	
0231-0347-QO1	Fd	Fd	14.0	1	FD	AT	13.7	18.2	19.6				17.1			19.6				19.2	
CAR1-1316-MO1	Fd	Fd	12.5	1	FDI		9.0	9.0					15.0				15.0				

	Strata	Ground		case	Phase	I					PSPL									
Clstr_id		**Sp1**	**SI1**		**Sp1**	**Sp2**	**SI1**	**SI2**	AT	BL	CW	EP	FD	**HM**	**HW**	**PL**	**PY**	**SB**	**SE**	**SX**	**YC**
CAR1-1336-MO1	Fd	S	13.3	2	FDI	SX	16.3	13.5	15.1				20.0			20.2				20.0	
CAR1-3816-MO1	Fd	Cw		3	FDI	SX	18.4	16.6	19.5	20.7	16.5	18.8	23.6			22.9				22.4	16.5
CAR1-4436-MO1	Fd	Fd	11.4	1	FDI		12.5	12.5	16.2				17.1			19.6				19.2	
CAR1-4446-MO1	Fd	Fd	7.7	1	FDI	SX	16.3	13.5	16.5				17.1			19.6				19.2	
CAR1-8206-MO1	Fd	Fd	6.6	1	FDI	PLI	11.4	11.1	15.4				16.6			17.8	15.4				
CMI1-0122-FR2	Fd	Fd	12.8	1	FDI	AT	13.2	13.2	15.2				17.1			19.6				19.2	
CMI1-0410-FR1	Fd	Fd	18.8	1	FDI	AT	15.8	17.9	18.8			19.4	17.1			19.6				19.2	
CMI1-0500-FR2	Fd	Fd	16.5	1	FDI	AT	16.0	17.4	17.0	19.0		18.5	20.8			19.6				19.2	
KMHY-0219-YO1	Fd	Fd	15.2	1	FDI	PLI	13.6						20.2			20.6				20.0	
0231-0031-QO1	Oth	Sx	21.7	4	AT	PLI	18.0	19.8	20.0	20.0	16.4	19.4	22.9			23.7				20.8	16.4
0231-0068-QO1	Oth	Sx	17.7	2	AC	SX	14.5	13.9	17.6				17.1			18.2				15.4	
0231-0071-QO1	Oth	Sx	20.3	4	AT	FDI	16.7	16.2	17.0	18.9		18.5	20.8			19.6				19.2	
0231-0092-QO1	Oth	Pl	16.3	4	AT	FDI	17.2	17.5	16.1				17.1			19.6				19.2	
0231-0213-QO1	Oth	S	14.7	2	AT	SX	19.4	14.6					20.2			20.6				20.0	
0231-0217-QO1	Oth	S	15.4	4	AT	FDI	18.6	18.0	16.5				21.9			18.0				21.2	
0231-0231-QO1	Oth	S	13.7	2	AT	SX	14.2	11.3	15.6				17.1			19.4				18.7	
0231-0266-QO1	Oth	S	19.2	5	AT	EP	16.2	16.9	17.0	19.0		18.5	20.8			19.6				19.2	
0231-0280-QO1	Oth	At	18.5	1	AT	FDI	15.4	16.3	17.7	15.0			18.0			18.0				18.0	
0231-0310-QO1	Oth	Fd	23.0	2	AT	FDI	21.5	19.1	17.2	18.0	12.0	18.3	19.4			21.0				21.0	12.0
0231-0319-QO1	Oth	S	16.5	2	AT	SX	23.9	21.4	17.0			19.2	18.3			20.9				18.9	
0231-0329-QO1	Oth	Fd	19.7	5	EP	AT	14.6	14.6	17.7		15.0	19.1	23.1			21.0	18.0			18.0	15.0
CAR1-1331-MO1	Oth	Fd	15.6	4	AT	PLI	20.5	14.5					17.1			19.6				19.2	
CAR1-7561-MO1	Oth	At	13.0	1	AT	PL	15.1	13.6	15.9				17.1			19.6				19.2	
0231-0010-QO1	Pine	Pl	13.5	1	PLI	SX	17.6			19.5			18.6			19.8			15.0	15.0	
0231-0056-QO1	Pine	Sx	12.3	2	PLI	SX	15.1	12.4	19.1				17.1			18.2				15.4	
0231-0064-QO1	Pine	Pl	10.6	1	PLI	FDI	15.4	18.5	17.4				17.1			19.6				19.2	
0231-0065-QO1	Pine	Pl	11.9	1	PLI	FDI	13.6	13.8	17.0				16.8			18.0				17.8	
0231-0086-QO1	Pine	Pl	7.9	1	PLI	FDI	8.1	8.6	13.6				17.1			19.6				19.2	
0231-0087-QO1	Pine	At		5	PLI		6.2	6.2	16.3				17.1			19.6				19.2	
0231-0104-QO1	Pine	At	18.2	2	PLI	AT	17.4									18.0				21.0	
0231-0278-QO1	Pine	Fd	11.7	3	PLI		11.3	11.3	17.3				16.8			18.0				17.7	
0231-0301-QO1	Pine	S	19.8	3	PLI	AT	21.5	20.8	17.0	19.3		19.0	20.8			19.6				19.2	
0231-0312-QO1	Pine	S	14.1	3	PLI	AT	15.7	19.7	17.8	18.8		18.7	19.3			21.0				21.0	
0231-0355-QO1	Pine	Bl	8.2	3	PLI	SE	16.7	14.2		9.0						9.0			9.0	9.0	
0231-0358-QO1	Pine	S	24.1	3	PLI	AT	22.2	20.5	20.0	19.5		18.5	21.0			21.8		10.7		21.0	
0231-0359-QO1	Pine	Fd	24.3	2	PLI	FDI	17.1	16.8	17.5	19.0		17.3	15.0			15.0				19.0	
CAR1-6941-MO1	Pine	Fd	23.2	3	PLI	SX	16.5	14.6	20.3	20.0	16.4	17.8	22.9			23.7				20.8	16.4
CAR1-7571-MO1	Pine	Fd	12.7	3	PLI	SX	16.3	17.7	18.5				17.1			19.6				19.2	
CAR1-8211-MO1	Pine	Pl		1	PLI	SX	10.0	8.3		15.0						18.0				15.0	
CMI1-0279-FR1	Pine	Fd	10.9	2	PLI	FDI	13.1	15.5	18.4	18.5		18.6	21.0			21.8				21.0	
0231-0005-QO1	S+B	Bl		2	SE	BL	13.4	11.4		17.6						17.2			15.0	15.0	
0231-0009-QO1	S+B	Fd	20.8	2	SX	FDI	21.9	21.7	19.7	20.3		19.2	21.0			23.8		11.2		21.0	
0231-0011-QO1	S+B	Bl	8.9	2	SE	BL	12.6	9.6		17.6						17.2			15.0	15.0	
0231-0012-QO1	S+B	Fd	20.5	3	SE	PLI	14.7	15.6		19.5			19.7			19.8			15.0	15.0	
0231-0013-QO1	S+B	Sx	19.1	1	SE	CW	18.5	9.3		19.5			19.7			19.8			15.0	15.0	
0231-0019-QO1	S+B	Fd	19.9	3	SX	PLI	16.6	15.4	19.0	18.9		18.7	21.0			21.8				21.0	
0231-0043-QO1	S+B	Sx	13.6	1	SX	FD	8.0	12.0	18.1				16.8			18.0				18.1	
0231-0050-QO1	S+B	Bl	8.5	2	SE	BL	9.9	8.9		12.0			17.0			15.0			12.0	12.0	
0231-0051-QO1	S+B	Se	18.4	2	BL	SE	15.6	16.8		12.0			18.0			15.0			12.0	12.0	
0231-0060-QO1	S+B	Fd	21.3	3	SX	AT	10.3	11.5	17.0	18.9		18.4	20.8			19.6				19.2	
0231-0062-QO1	S+B	Bl	19.1	2	SX	BL	12.4	14.2		18.0			18.0			21.0				21.0	
0231-0067-QO1	S+B	Sx	14.9	1	SX	AT	18.6	18.0	15.9				17.1			19.6				19.2	
0231-0070-QO1	S+B	Sx	22.2	1	SX	AT	16.7	18.8	17.0	18.8		18.4	20.8			19.6				19.2	
0231-0221-QO1	S+B	Bl	10.4	3	SX	PLI	18.2	14.9		12.0			15.0			15.5				14.8	
0231-0238-QO1	S+B	S	18.8	1	SX	FDI	16.7	18.3		12.0			15.0			15.5				14.8	
0231-0242-QO1	S+B	Fd	13.2	2	SX	FDI	22.0	21.4	17.4				17.1			19.6				19.2	
0231-0245-QO1	S+B	S	16.0	1	SX	PLI	15.1	13.6					17.1			19.6				19.2	
0231-0271-QO1	S+B	S	13.9	1	SX	PLI	15.6	15.5	16.1				19.8			20.5				19.9	
0231-0286-QO1	S+B	At	14.4	2	SX	AT	13.9	13.1	17.0	18.7		18.6	20.8			19.6				19.2	
0231-0291-QO1	S+B	At	15.6	2	SX	AT	14.0	14.3	15.7				19.8			20.3				20.0	
0231-0296-QO1	S+B	Bl	17.9	1	BL	SE	11.8	14.9	18.5	15.0			18.0			18.0				18.0	
0231-0326-QO1	S+B	Cw	12.0	3	BL	SX	7.8	13.5	18.9	19.1	17.5	18.8	22.6			21.0				21.0	17.5

	Strata	Ground		case	Phase	I					PSPL									
Clstr_id		**Sp1**	**SI1**		**Sp1**	**Sp2**	**SI1**	**SI2**	AT	BL	CW	EP	FD	**HM**	**HW**	**PL**	**PY**	**SB**	**SE**	**SX**	**YC**
0231-0332-QO1	S+B	Fd		2	SX	FDI	22.8	21.7	19.4			18.8	21.0			21.8		10.8		21.0	
0231-0344-QO1	S+B	S	17.2	1	SX	PLI	12.4	12.3	18.4	18.9		18.3	21.0			21.3				20.6	
0231-0348-QO1	S+B	S	14.7	1	SX	FDI	12.9	16.7	19.4	19.2	17.6	18.9	23.5	18.0	18.0	21.0				21.3	17.6
0231-0350-QO1	S+B	Bl	14.0	3	SX	CW	12.9	7.0	18.7	19.5	15.0	18.7	23.2			21.0				18.5	15.0
0231-0353-QO1	S+B	Bl	13.8	1	BL	SX	10.6	8.6	19.0	23.2	18.3	18.7	21.0			21.0				25.0	18.3
0231-0361-QO1	S+B	Bl	9.1	1	BL	SE	9.0	9.3		17.6						17.2			15.0	15.0	
0231-0363-QO1	S+B	Bl	9.1	1	BL		4.6	4.6		11.9											
CAR1-0681-MO1	S+B	S		1	SX	FD	11.2	14.7	18.3				18.3			19.8				18.6	
CAR1-0701-MO1	S+B	S		1	SX	BL	12.7	13.5	16.4	15.0			18.0			18.0				15.0	
CAR1-1341-MO1	S+B	S	18.2	1	SX	FDI	14.6	17.0		12.0			15.0			15.5				14.8	
CAR1-3821-MO1	S+B	Cw	12.6	3	SX	FDI	18.1	17.4	20.1	20.7	16.0	19.5	24.8			24.1				24.1	16.0
CAR1-7581-MO1	S+B	Bl	22.0	3	SX	AT	14.7	18.2	17.9	15.0			18.0			18.0				18.0	
CMI1-0513-FR1	S+B	Sx	20.4	1	SX	AT	13.5	18.1								20.3				21.6	

11. Appendix D: Scatterplots to find potential outliers

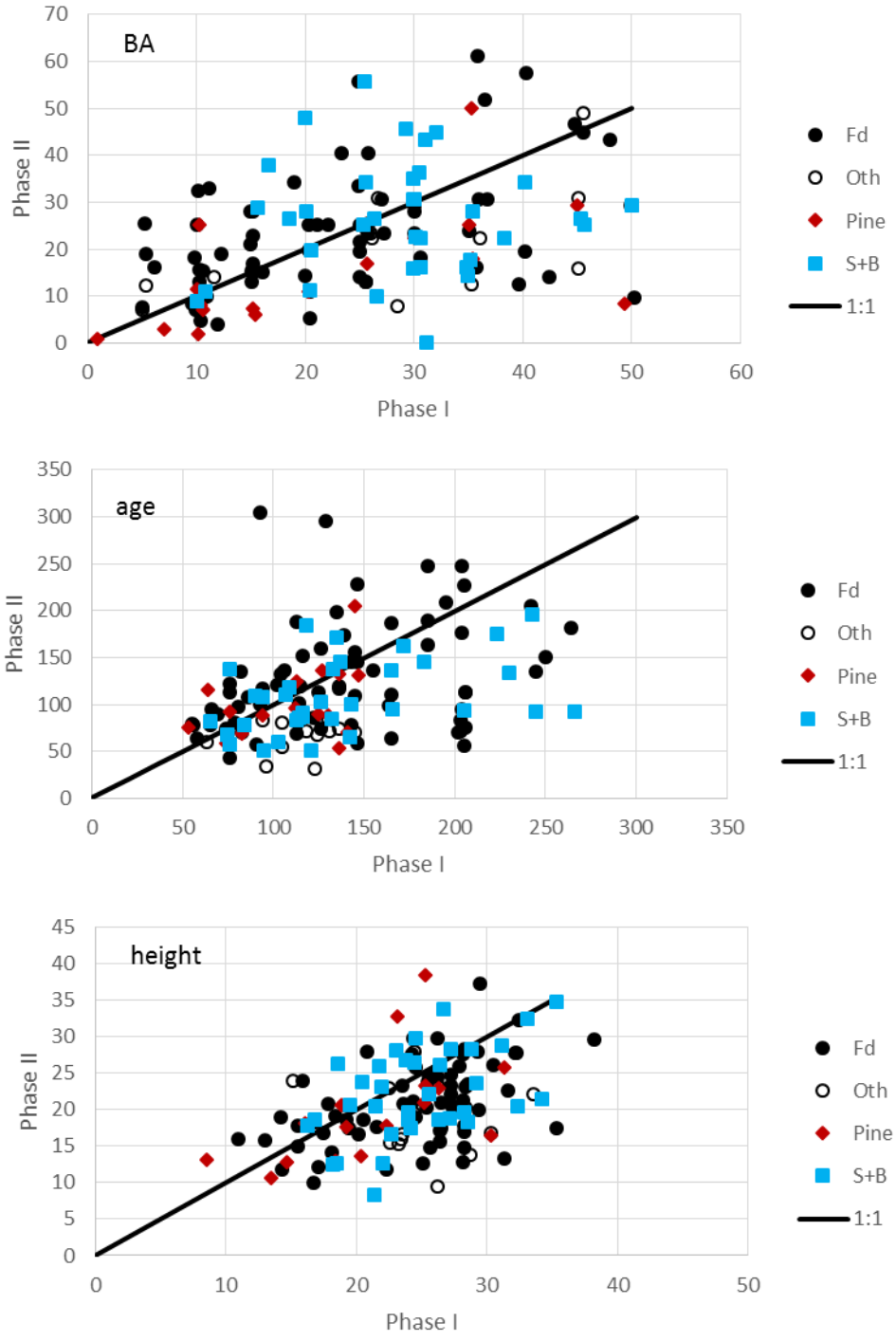

Figure 9. The Phase I inventory and Phase II Ground data are plotted for the seven attributes of interest. The Phase I attributes are for the primary layer.

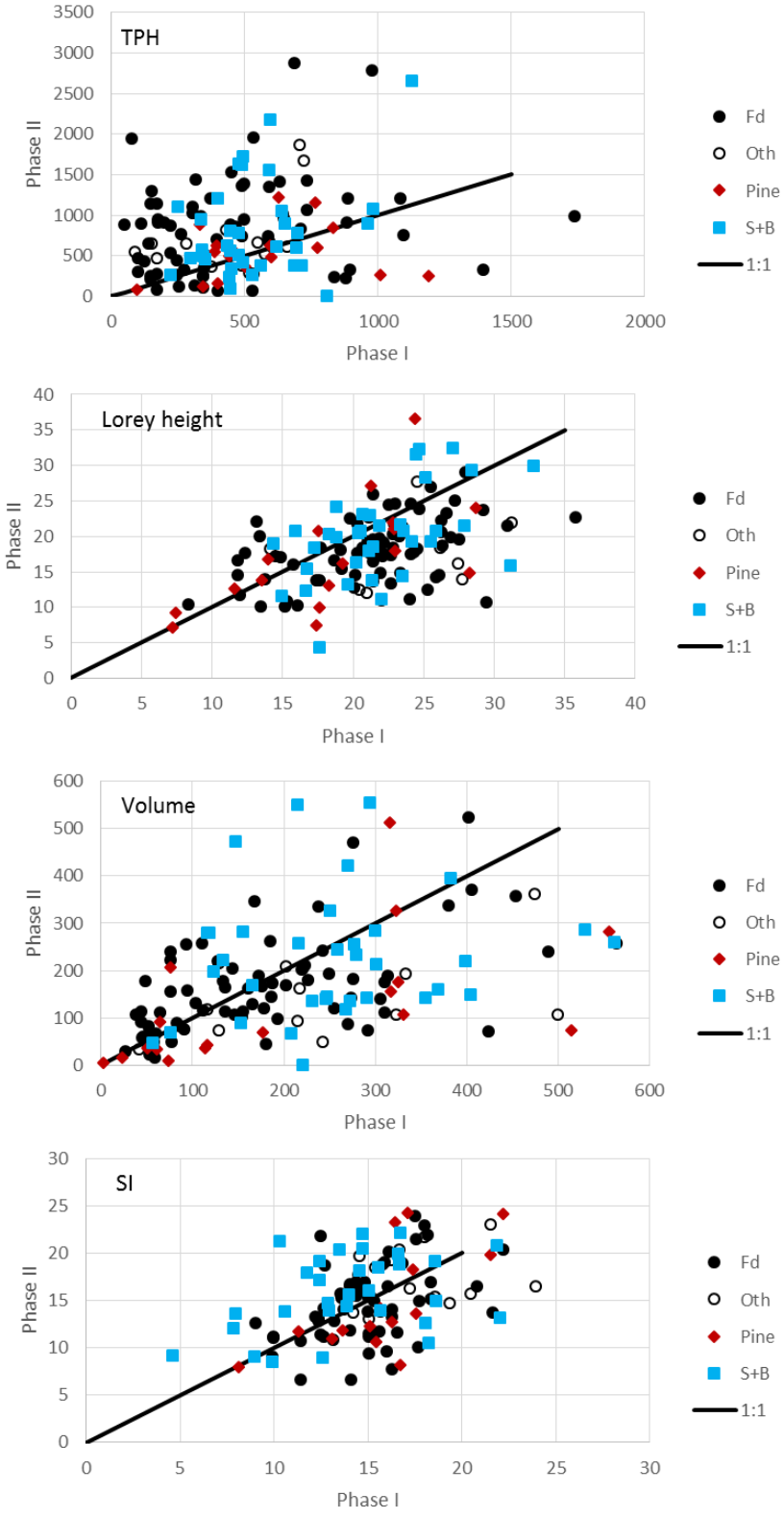

Figure 9 (cont.).

12. APPENDIX E: HEIGHT AND AGE MATCHING

The current standard for Phase II ground age and height is based on the average of the T, L, X and O trees. The five possible matching cases are as follows:

Case 1: Phase I leading species matches the Phase II leading species at the Sp0 level
Case 2: Phase I second species matches the Phase II leading species at the Sp0 level
Case 3: Phase I leading species matches the Phase II leading species on a conifer-to-conifer (or deciduous-to deciduous) basis
Case 4: Phase I second species matches the Phase II leading species on a conifer-to-conifer (or deciduous-to deciduous) basis
Case 5: No match

Table 22. The Sp0 groupings are given.

Sp0 Code	Species	Description
AC	AC	Poplar
AT	AT	Trembling Aspen
B	B, BA, BG, BL	Fir
C	CW	Western Red Cedar
D	DR	Alder
E	E, EA, EP	Birch
F	FD	Douglas Fir
H	H, HM, HW	Hemlock
L	L, LA, LT, LW	Larch
MB	MB	Broadleaf Maple
PA	PA, PF	Whitebark & Limber Pine
PL	PJ, PL	Lodgepole & Jack Pine
PW	PW	Western White Pine
PY	PY	Yellow Pine
S	S, SB, SE, SS, SW, SX	Spruce
Y	Y	Yellow Cedar

Table 23. The results of matching the Phase I inventory and Phase II ground heights and ages.

Sample	**strata**	**Phase II (ground) leading species attributes**						**Phase I (Inventory)**			
		Species @ 4cm DBH	Mean Age[6]	Mean Height[7]	Sample size Age[8]	Sample size Height[9]	Case of match	leading species	secondary species	Age for match	Height for match
0231-0014-QO1	Fd	Sx	101	23.5	3	3	2	FDI	SX	114	26.7
0231-0023-QO1	Fd	Fd	150	21.0	5	5	1	FD		250	27.2
0231-0024-QO1	Fd	Fd	134	29.8	5	5	1	FD	SX	230	26.2
0231-0025-QO1	Fd	Fd	205	27.6	5	5	1	FDI		242	28.2
0231-0026-QO1	Fd	Fd	174	37.2	5	5	1	FDI	AT	139	29.5
0231-0027-QO1	Fd	Fd	199	26.2	6	5	1	FDI		135	30.5
0231-0029-QO1	Fd	At	75	28.0	5	5	5	FDI	PLI		
0231-0039-QO1	Fd	Fd	135	29.6	5	5	1	FDI	SX	245	38.2
0231-0044-QO1	Fd	Fd	209	27.6	5	5	1	FDI		195	24.2
0231-0045-QO1	Fd	Fd	113	23.4	5	5	1	FDI	AT	125	23.5
0231-0048-QO1	Fd	Fd	111	32.3	5	5	1	FDI	SX	165	32.4

[6] Age = age_tlxo
[7] Height = ht_tlxo
[8] Sample size for age = n_age_tlxo
[9] Sample size for height = n_ht_tlxo

Sample	strata	Phase II (ground) leading species attributes						Phase I (Inventory)			
		Species @ 4cm DBH	Mean Age[6]	Mean Height[7]	Sample size Age[8]	Sample size Height[9]	Case of match	leading species	secondary species	Age for match	Height for match
0231-0052-QO1	Fd	Fd	80	15.9	5	5	1	FD	PL	55	11.0
0231-0074-QO1	Fd	Fd	117	16.9	5	5	1	FDI		94	17.5
0231-0076-QO1	Fd	Fd	189	29.7	3	3	1	FDI		113	24.4
0231-0080-QO1	Fd	Fd	85	24.9	5	5	1	FDI	AT	122	27.2
0231-0084-QO1	Fd	Fd	137	19.1	5	5	1	FDI		106	18.4
0231-0091-QO1	Fd	Fd	146	24.5	5	5	1	FDI	AT	143	26.3
0231-0093-QO1	Fd	Fd	81	25.9	5	5	1	FDI	SX	79	27.9
0231-0096-QO1	Fd	Fd	137	20.3	5	6	1	FDI		155	25.4
0231-0098-QO1	Fd	Pl	79	12.1	5	5	2	FDI	PLI	65	13.8
0231-0106-QO1	Fd	Fd	227	27.9	5	5	1	FDI		205	29.2
0231-0108-QO1	Fd	Se	98	17.8	5	5	3	FDI	PLI	164	28.3
0231-0109-QO1	Fd	Fd	248	22.0	5	5	1	FDI		204	27.2
0231-0110-QO1	Fd	Fd	177	16.6	5	5	1	FDI	PY	204	20.1
0231-0111-QO1	Fd	Fd	83	21.2	5	5	1	FDI		203	28.1
0231-0112-QO1	Fd	Fd	182	27.7	5	5	1	FDI	SX	264	32.1
0231-0113-QO1	Fd	Fd	95	27.8	5	5	1	FDI	SX	204	32.2
0231-0117-QO1	Fd	Fd	296	19.0	4	4	1	FDI	PY	129	14.2
0231-0201-QO1	Fd	S	164	28.2	3	3	3	FDI	PLI	185	28.3
0231-0207-QO1	Fd	Fd	190	18.6	4	5	1	FDI	PLI	185	19.2
0231-0215-QO1	Fd	Fd	155	17.2	5	5	1	FDI		145	26.4
0231-0224-QO1	Fd	Fd	75	13.4	5	5	1	FDI	SX	206	31.3
0231-0226-QO1	Fd	Fd	132	19.0	5	5	1	FDI	SX	104	24.6
0231-0227-QO1	Fd	Fd	228	23.4	5	5	1	FDI		146	28.5
0231-0229-QO1	Fd	Fd	113	17.5	5	5	1	FDI		206	35.3
0231-0233-QO1	Fd	Fd	159	17.6	5	5	1	FDI		126	21.6
0231-0249-QO1	Fd	Fd	57	14.9	5	5	1	FDI	PLI	205	28.2
0231-0253-QO1	Fd	Fd	64	20.0	5	5	1	FDI	AT	165	29.4
0231-0255-QO1	Fd	Fd	187	23.2	5	5	1	FDI		165	28.3
0231-0256-QO1	Fd	Fd	247	23.2	6	6	1	FDI		185	27.3
0231-0260-QO1	Fd	Fd	101	15.0	4	4	1	FDI	PLI	93	15.5
0231-0261-QO1	Fd	Fd	90	18.3	5	5	1	FDI		69	16.8
0231-0276-QO1	Fd	Fd	109	15.6	5	5	1	FDI	PLI	145	26.4
0231-0294-QO1	Fd	Fd	153	17.8	5	5	1	FD		116	15.5
0231-0298-QO1	Fd	S	120	24.6	5	5	2	FDI	SX	136	24.8
0231-0306-QO1	Fd	Fd	74	14.9	5	5	1	FDI		126	25.6
0231-0308-QO1	Fd	Fd	145	17.5	5	5	1	FDI		146	26.5
0231-0314-QO1	Fd	Fd	113	20.5	5	5	1	FDI	SX	206	27.3
0231-0316-QO1	Fd	S	59	22.6	5	5	3	FDI	AT	146	31.6
0231-0317-QO1	Fd	Fd	123	23.8	5	5	1	FDI	AT	76	25.4
0231-0322-QO1	Fd	S	95	17.4	5	5	2	FDI	SX	96	23.2
0231-0324-QO1	Fd	Fd	120	20.8	5	5	1	FD	AT	115	23.6
0231-0331-QO1	Fd	Cw	43	11.8	5	5	3	FDI	EP	76	22.3
0231-0335-QO1	Fd	Fd	117	25.9	5	5	1	FDI	AT	136	24.5
0231-0338-QO1	Fd	Fd	98	23.9	5	5	1	FD	PL	81	15.9
0231-0342-QO1	Fd	Fd	114	20.9	5	5	1	FDI	SX	76	26.5
0231-0346-QO1	Fd	Fd	57	10.0	3	3	1	FDI	SX	91	16.8
0231-0347-QO1	Fd	Fd	107	20.8	5	5	1	FD	AT	86	17.9
CAR1-1316-MO1	Fd	Fd	72	14.2	2	1	1	FDI		203	18.1

Sample	strata	Phase II (ground) leading species attributes						Phase I (Inventory)			
		Species @ 4cm DBH	Mean Age[6]	Mean Height[7]	Sample size Age[8]	Sample size Height[9]	Case of match	leading species	secondary species	Age for match	Height for match
CAR1-1336-MO1	Fd	S	79	17.0	4	4	2	FDI	SX	123	24.4
CAR1-3816-MO1	Fd	Cw	305		4	0	3	FDI	SX	93	
CAR1-4436-MO1	Fd	Fd	71	12.6	4	4	1	FDI		202	25.1
CAR1-4446-MO1	Fd	Fd	67	12.9	3	4	1	FDI	SX	142	28.2
CAR1-8206-MO1	Fd	Fd	135	11.8	4	3	1	FDI	PLI	82	14.3
CMI1-0122-FR2	Fd	Fd	121	20.7	3	2	1	FDI	AT	102	19.2
CMI1-0410-FR1	Fd	Fd	69	21.1	3	3	1	FDI	AT	113	24.4
CMI1-0500-FR2	Fd	Fd	71	18.6	5	4	1	FDI	AT	83	20.5
KMHY-0219-YO1	Fd	Fd	64	15.8	2	2	1	FDI	PLI	58	13.0
0231-0031-QO1	Oth	Sx	83	28.0	5	5	4	AT	PLI	94	25.4
0231-0068-QO1	Oth	Sx	68	19.5	5	5	2	AC	SX	114	23.6
0231-0071-QO1	Oth	Sx	72	23.4	5	5	4	AT	FDI	133	27.3
0231-0092-QO1	Oth	Pl	31	9.4	5	5	4	AT	FDI	123	28.4
0231-0213-QO1	Oth	S	71	16.8	5	5	2	AT	SX	145	28.5
0231-0217-QO1	Oth	S	85	20.3	5	5	4	AT	FDI	145	31.5
0231-0231-QO1	Oth	S	74	16.0	5	5	2	AT	SX	126	21.8
0231-0266-QO1	Oth	S	54	16.7	5	5	5	AT	EP		
0231-0280-QO1	Oth	At	80	22.9	5	5	1	AT	FDI	105	22.5
0231-0310-QO1	Oth	Fd	34	13.7	5	5	2	AT	FDI	96	27.0
0231-0319-QO1	Oth	S	88	22.1	5	5	2	AT	SX	116	32.8
0231-0329-QO1	Oth	Fd	79	23.9	5	5	5	EP	AT		
CAR1-1331-MO1	Oth	Fd	60	15.5	3	3	4	AT	PLI	63	15.5
CAR1-7561-MO1	Oth	At	71	15.3	3	3	1	AT	PL	118	23.2
0231-0010-QO1	Pine	Pl	131	22.9	5	5	1	PLI	SX	147	26.3
0231-0056-QO1	Pine	Sx	90	17.9	5	5	2	PLI	SX	115	21.8
0231-0064-QO1	Pine	Pl	75	12.8	5	5	1	PLI	FDI	53	14.6
0231-0065-QO1	Pine	Pl	88	13.0	5	5	1	PLI	FDI	94	18.4
0231-0086-QO1	Pine	Pl	116	13.1	4	4	1	PLI	FDI	64	8.5
0231-0087-QO1	Pine	At					5	PLI			
0231-0104-QO1	Pine	At	88	23.4	5	5	2	PLI	AT		
0231-0278-QO1	Pine	Fd	58	10.6	5	5	3	PLI		74	13.5
0231-0301-QO1	Pine	S	53	16.5	5	5	3	PLI	AT	136	30.3
0231-0312-QO1	Pine	S	93	20.7	5	5	3	PLI	AT	76	18.8
0231-0355-QO1	Pine	Bl	205	20.9	4	4	3	PLI	SE	145	25.2
0231-0358-QO1	Pine	S	70	25.7	5	5	3	PLI	AT	141	31.3
0231-0359-QO1	Pine	Fd	133	38.5	5	5	2	PLI	FDI	136	28.6
CAR1-6941-MO1	Pine	Fd	96	32.8	3	3	3	PLI	SX	112	23.1
CAR1-7571-MO1	Pine	Fd	69	13.7	2	2	3	PLI	SX	83	20.4
CAR1-8211-MO1	Pine	Pl	137	18.1	4	4	1	PLI	SX	127	16.1
CMI1-0279-FR1	Pine	Fd	125	17.6	1	1	2	PLI	FDI	93	21.4
0231-0005-QO1	S+B	Bl	176	28.8	5	5	2	SE	BL	203	27.1
0231-0009-QO1	S+B	Fd	138	34.8	5	5	2	SX	FDI	133	36.4
0231-0011-QO1	S+B	Bl	163	18.9	5	5	2	SE	BL	132	19.2
0231-0012-QO1	S+B	Fd	83	26.4	5	5	3	SE	PLI	113	24.5
0231-0013-QO1	S+B	Sx	110	28.3	5	5	1	SE	CW	107	28.8
0231-0019-QO1	S+B	Fd	108	26.8	5	5	3	SX	PLI	94	23.8
0231-0043-QO1	S+B	Sx	134	26.0	5	5	1	SX	FD	230	26.3
0231-0050-QO1	S+B	Bl	171	20.7	5	5	2	SE	BL	135	18.6

Sample	strata	Phase II (ground) leading species attributes						Phase I (Inventory)			
		Species @ 4cm DBH	Mean Age[6]	Mean Height[7]	Sample size Age[8]	Sample size Height[9]	Case of match	leading species	secondary species	Age for match	Height for match
0231-0051-QO1	S+B	Se	118	29.8	5	5	2	BL	SE	114	27.6
0231-0060-QO1	S+B	Fd	86	26.3	5	5	3	SX	AT	114	18.6
0231-0062-QO1	S+B	Bl	145	23.7	5	5	2	SX	BL	153	27.2
0231-0067-QO1	S+B	Sx	78	18.7	5	5	1	SX	AT	84	23.9
0231-0070-QO1	S+B	Sx	60	22.1	5	5	1	SX	AT	103	25.5
0231-0221-QO1	S+B	Bl	68	8.3	4	4	3	SX	PLI	75	21.3
0231-0238-QO1	S+B	S	109	28.1	5	5	1	SX	FDI	90	23.1
0231-0242-QO1	S+B	Fd	82	16.6	5	5	2	SX	FDI	65	23.4
0231-0245-QO1	S+B	S	51	12.6	5	5	1	SX	PLI	95	22.0
0231-0271-QO1	S+B	S	58	12.7	5	5	1	SX	PLI	76	18.5
0231-0286-QO1	S+B	At	92	19.7	5	5	2	SX	AT	116	20.5
0231-0291-QO1	S+B	At	68	17.8	5	5	2	SX	AT	75	17.7
0231-0296-QO1	S+B	Bl	102	26.0	5	5	1	BL	SE	126	21.7
0231-0326-QO1	S+B	Cw	146	18.7	5	5	3	BL	SX	137	16.8
0231-0332-QO1	S+B	Fd	138	33.7	3	3	2	SX	FDI	76	26.5
0231-0344-QO1	S+B	S	88	23.1	5	5	1	SX	PLI	116	21.9
0231-0348-QO1	S+B	S	93	21.5	5	5	1	SX	FDI	266	34.2
0231-0350-QO1	S+B	Bl	95	18.3	5	5	3	SX	CW	166	28.5
0231-0353-QO1	S+B	Bl	94	18.6	5	5	1	BL	SX	205	26.3
0231-0361-QO1	S+B	Bl	136	20.4	5	5	1	BL	SE	165	21.4
0231-0363-QO1	S+B	Bl	93	12.4	5	5	1	BL		245	18.2
CAR1-0681-MO1	S+B	S	184	23.7	4	4	1	SX	FD	118	20.5
CAR1-0701-MO1	S+B	S	196	32.4	4	3	1	SX	BL	243	33.1
CAR1-1341-MO1	S+B	S	66	19.7	5	5	1	SX	FDI	142	28.2
CAR1-3821-MO1	S+B	Cw	100	20.5	2	2	3	SX	FDI	143	32.3
CAR1-7581-MO1	S+B	Bl	85	28.3	3	3	3	SX	AT	132	27.3
CMI1-0513-FR1	S+B	Sx	52	17.5	4	4	1	SX	AT	121	24.1

13. Appendix F: Scatterplots and residuals

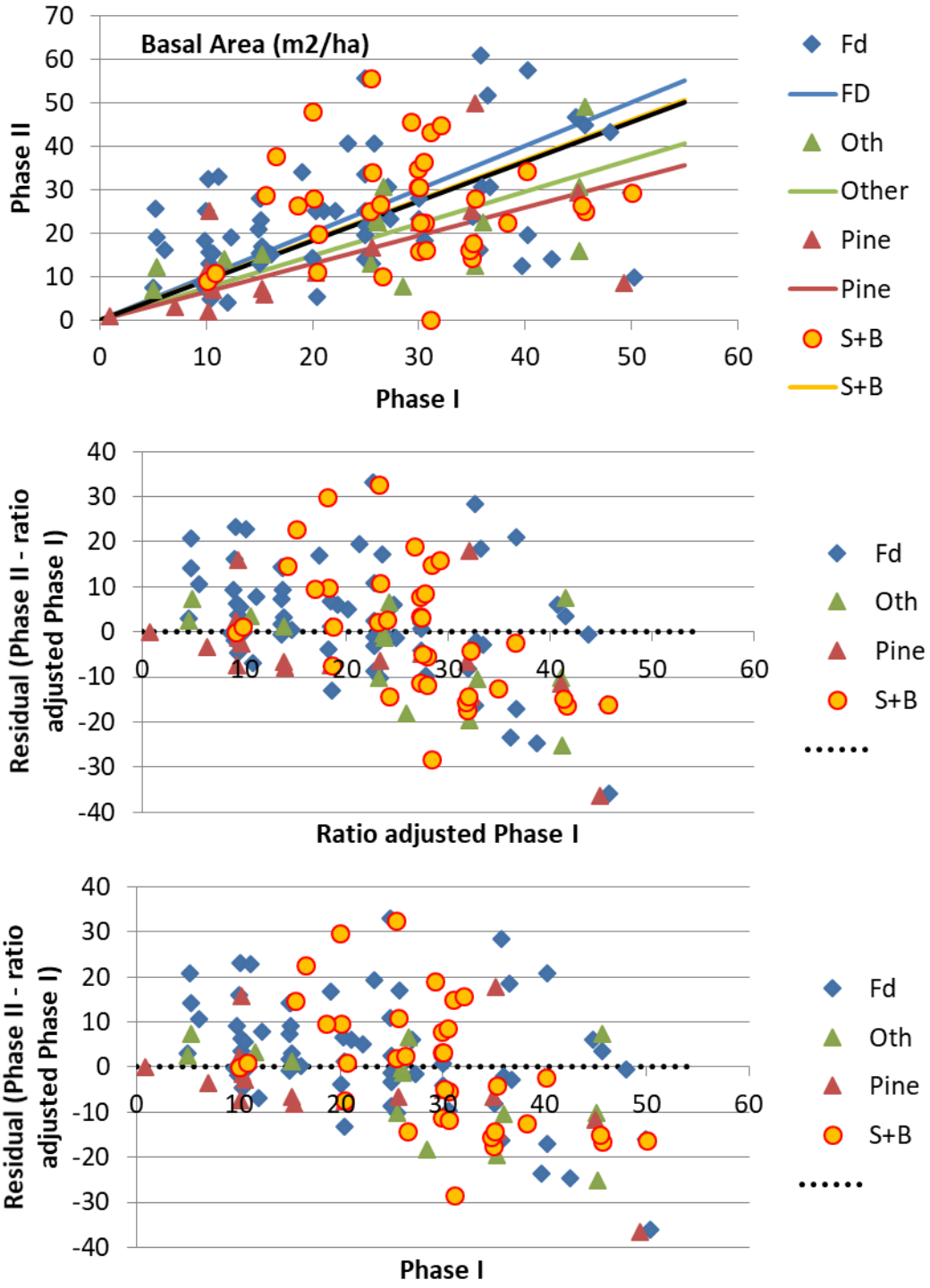

Figure 10. The scatterplots for BA are given. Residual trees are included. The top graph gives the Phase I photo and Phase II ground estimates of basal area for the Volume audit sub population. The coloured lines give the ratios while the black line is the ratio for all Volume Audit (mature) samples. The middle graph plots the residuals against the adjusted Phase I BA. The bottom graph plots the residuals against the Phase I BA. Ideally the residuals would be scattered uniformly around the x-axis. The slight downward trend is

not uncommon and may indicate the need for a regression estimator rather than a ratio (i.e., the need for an intercept).

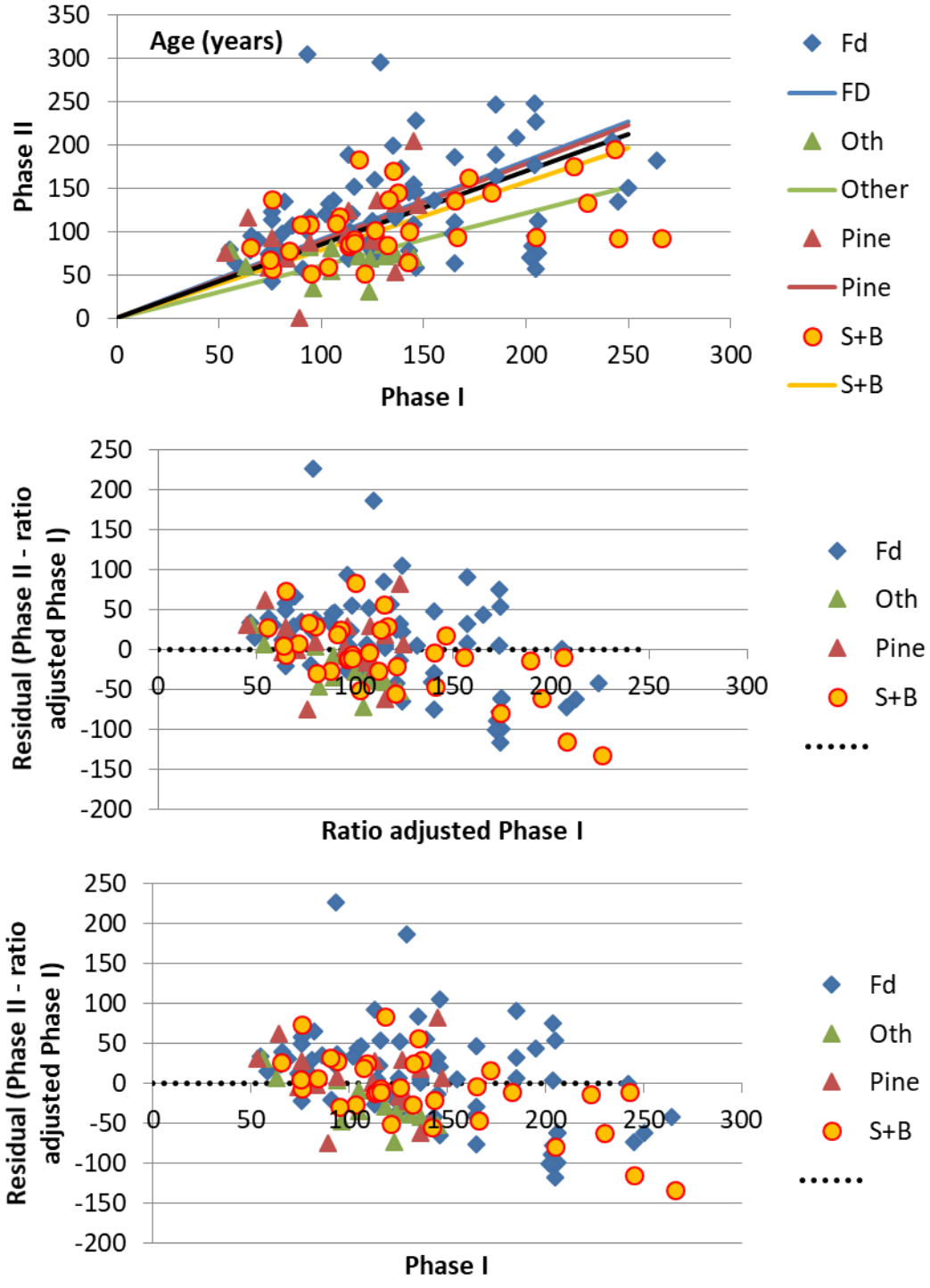

Figure 11. The scatterplots for Age are given.

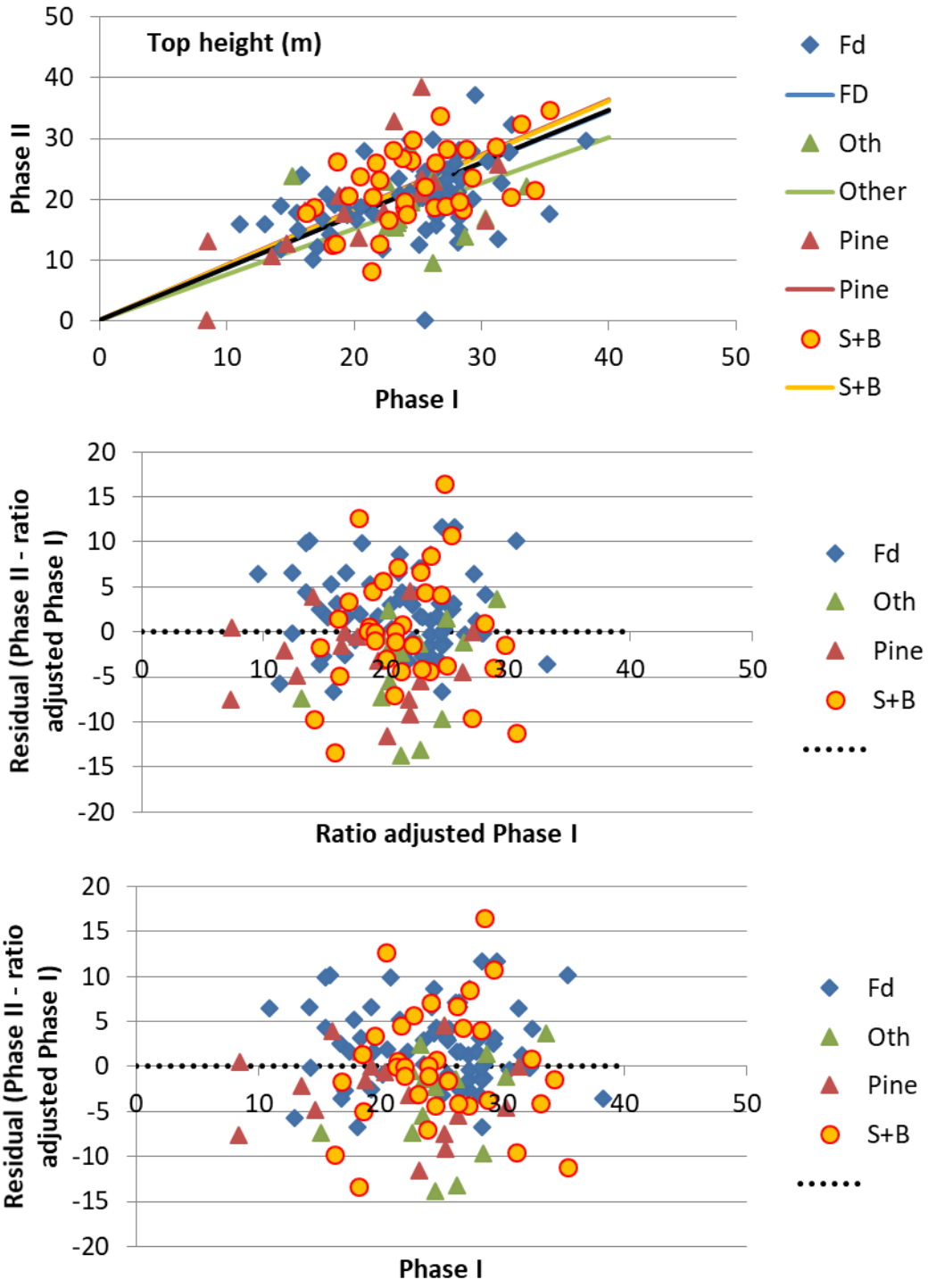

Figure 12. The scatterplots for Height are given.

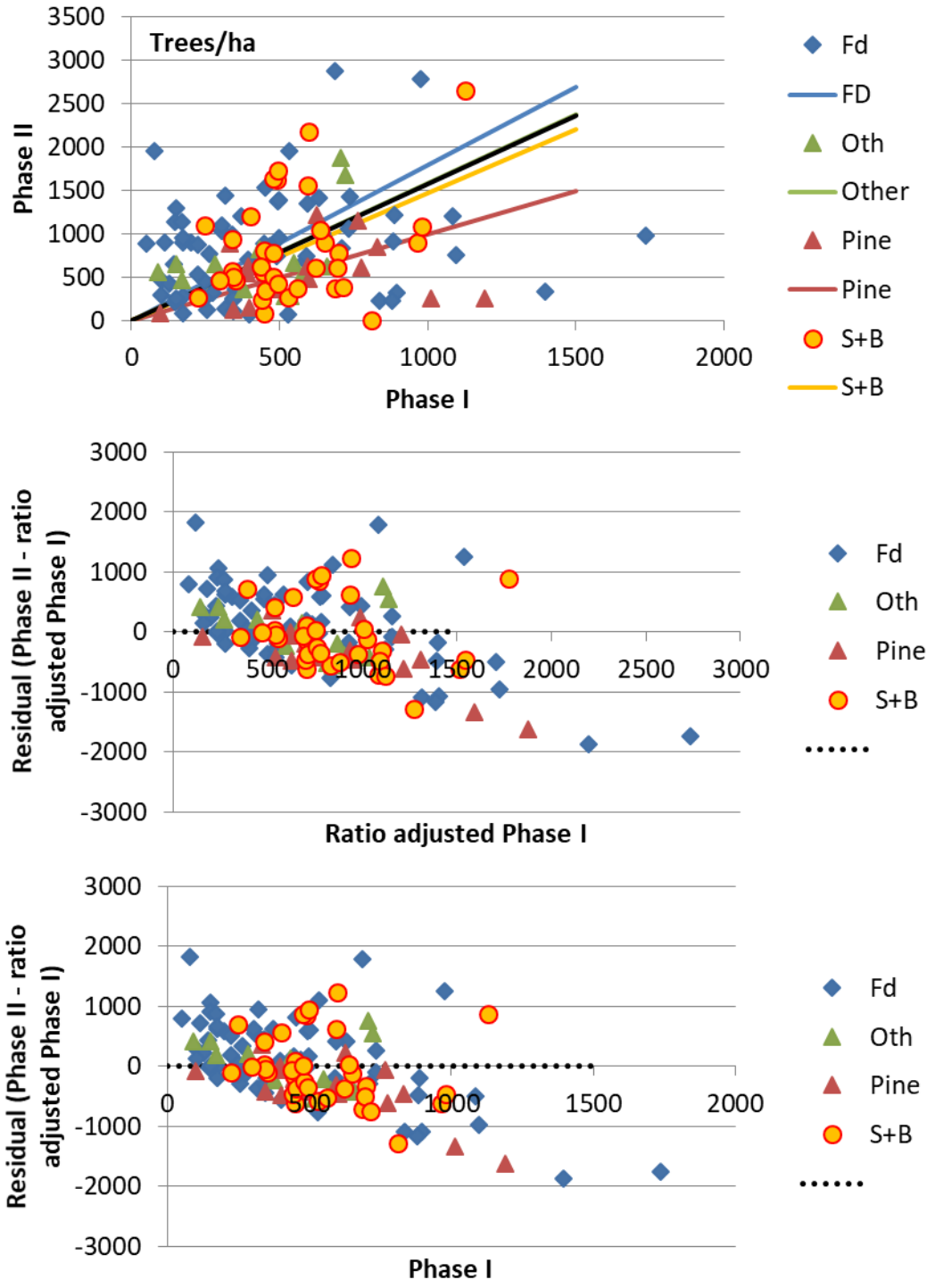

Figure 13. The scatterplots for Trees/ha are given.

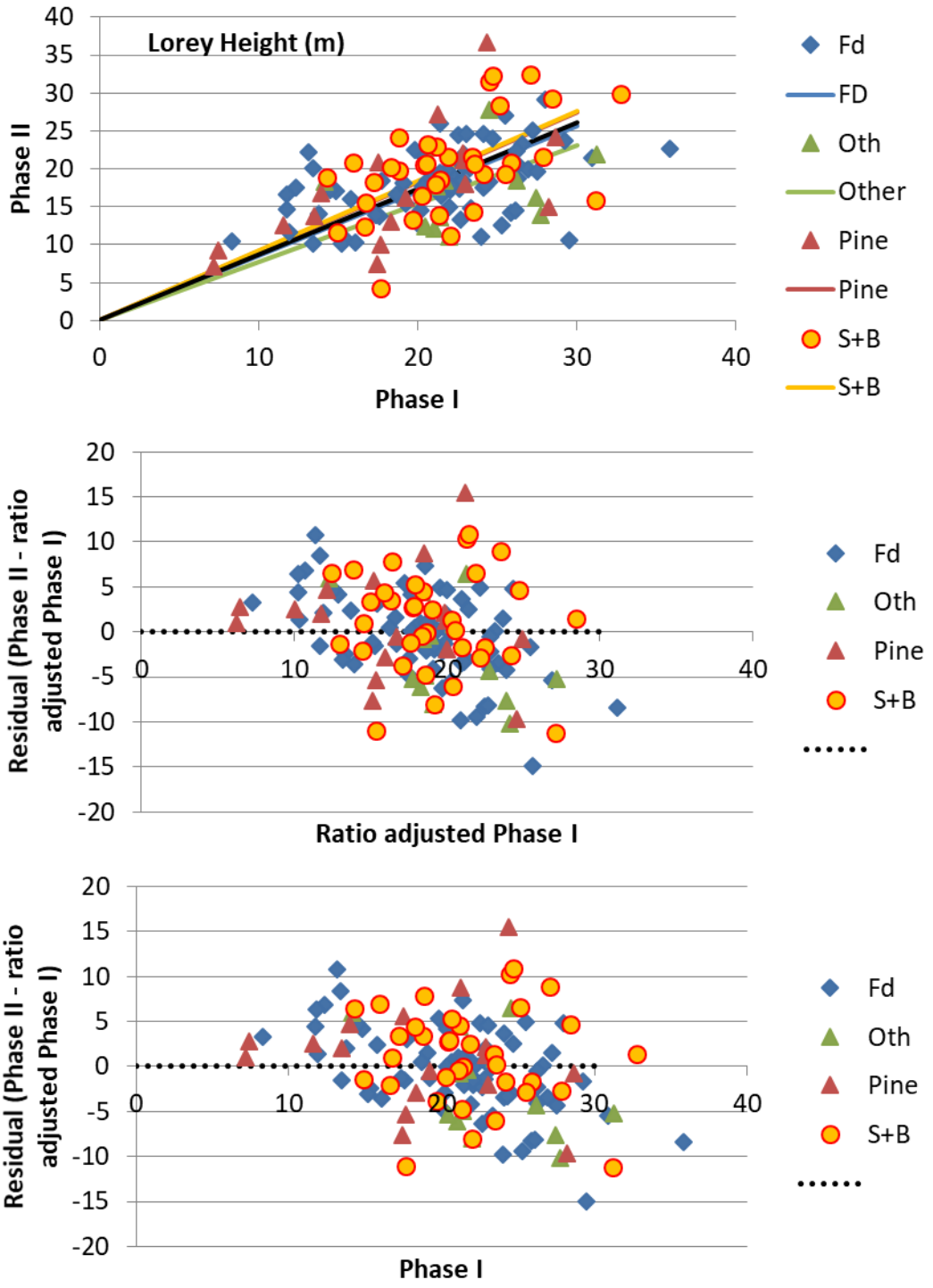

Figure 14. The scatterplots for Lorey height are given.

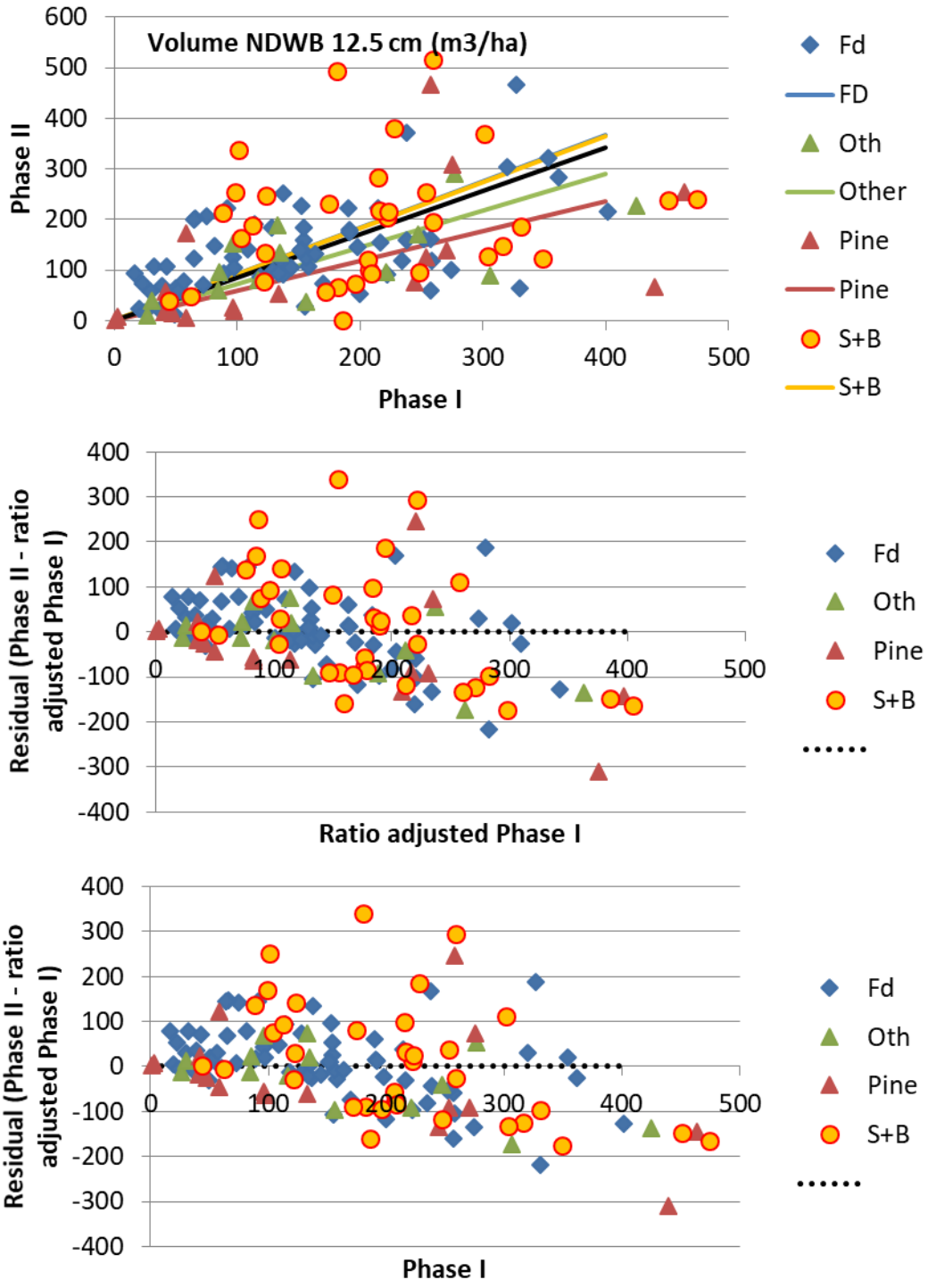

Figure 15. The scatterplots for Volume net of decay, waste and breakage are given.

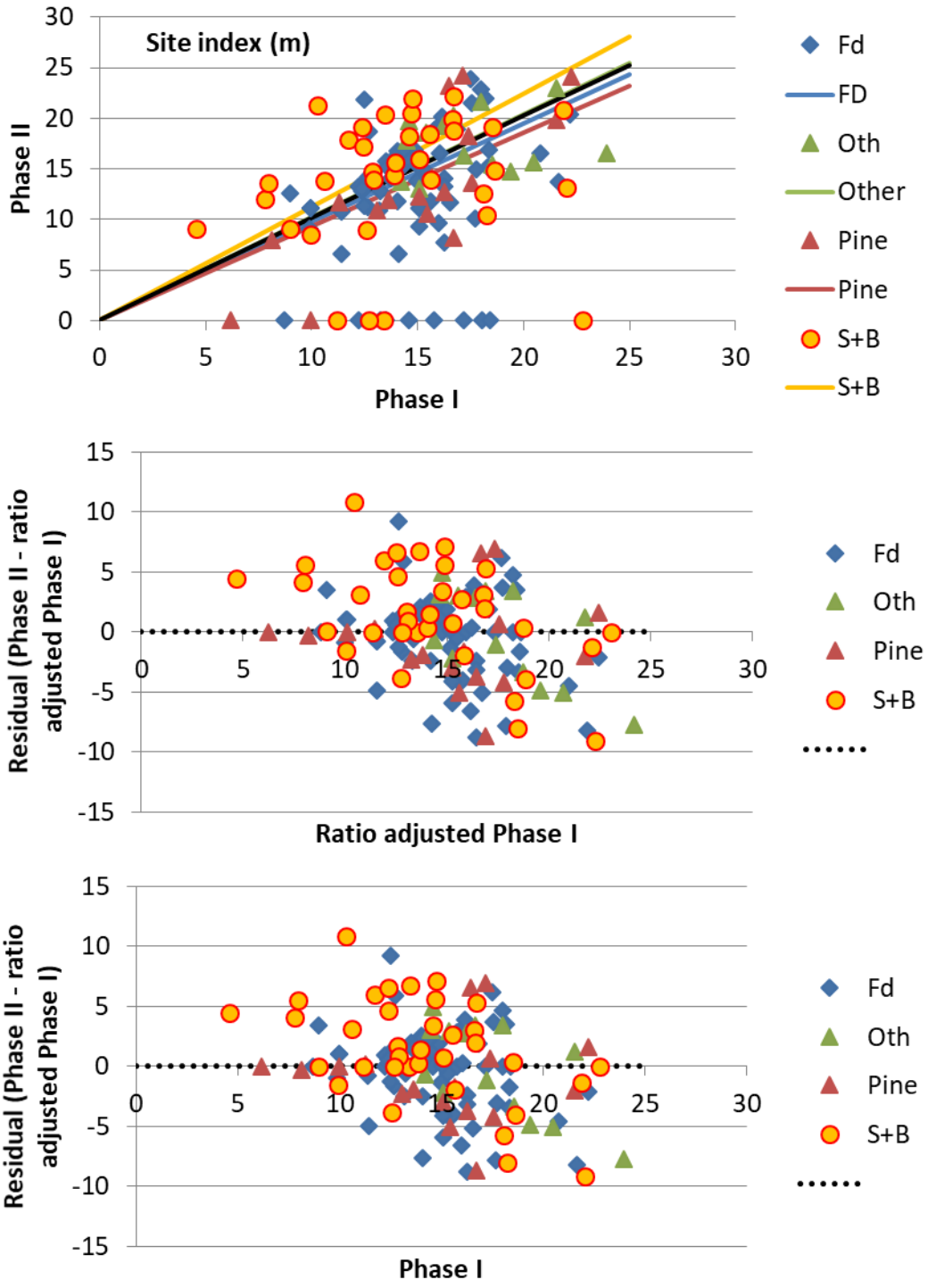

Figure 16. The scatterplots for Site index are given.