Kootenay Lake TSA

Documentation of

Vegetation Resources Inventory Analysis

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 Kootenay Lake TSA by completing a VRI statistical analysis of selected Phase I inventory attributes in the target population of interest. The analysis was based on current standards.

Table 1. The sample size (N), means, ratios of means (Phase II Ground/Phase I Inventory) and standard error of the ratio expressed as a percent of the ratio (SE of ratio (%)) are given by strata for seven attributes for the Kootenay Lake TSA. Shaded cells are associated with small sample sizes

Attribute	Statistic	Stratum						
		YSM	Volume	Audit	(mature)			
		(Immature)	B	Fd&L	Other	P	S	Mature
Age	N	47	16	15	6	6	7	50
(years)	Mean Phase II Ground	30.4	124.7	89.5	107.7	98.5	114.9	107.2
	Mean Phase I inventory	30.6	146.4	94.1	141.7	79.3	185.3	126.4
	Ratio (Phase II/Phase I)	0.993	0.852	0.951	0.761	1.242	0.620	0.848
	SE of Ratio (%)	6.0%	23.2%	16.9%	51.3%	49.5%	21.8%	12.9%
Height	N	45	16	15	6	6	7	50
(m)	Mean Phase II Ground	10.3	18.9	27.4	28.1	21	25.7	23.8
	Mean Phase I inventory	8	19.6	25.7	28.1	20.5	25.7	23.4
	Ratio (Phase II/Phase I)	1.296	0.967	1.063	1.002	1.021	0.998	1.015
	SE of Ratio (%)	14.4%	9.8%	10.7%	22.2%	7.5%	11.6%	5.2%
Basal area	N	49	16	15	6	6	7	50
(m^2/ha)	Mean Phase II Ground	13.2	24.6	38.6	51.9	25	38.9	34.1
7.5 cm+	Mean Phase I inventory	7.9	26.8	39.7	48.6	35.9	28.8	34.8
	Ratio (Phase II/Phase I)	1.682	0.918	0.974	1.067	0.695	1.352	0.981
	SE of Ratio (%)	38.3%	19.2%	28.6%	36.3%	41.8%	37.0%	13.4%
Trees/ha	N	49	16	15	6	6	7	50
7.5 cm+	Mean Phase II Ground	801	795	1062	1043	1156	914	969
	Mean Phase I inventory	2700	595	871	850	710	461	708
	Ratio (Phase II/Phase I)	0.297	1.335	1.219	1.227	1.628	1.984	1.369
	SE of Ratio (%)	38.5%	30.5%	40.6%	15.6%	116.1%	68.2%	21.3%
Lorey	N	23	16	15	6	6	7	50
height	Mean Phase II Ground	9.6	14.9	21.6	23.5	16.5	23.4	19.3
(m)	Mean Phase I inventory	9.1	13.8	19.7	20.9	16.6	18.8	17.5
	Ratio (Phase II/Phase I)	1.053	1.077	1.101	1.126	0.994	1.247	1.106
	SE of Ratio (%)	16.8%	18.3%	13.7%	19.9%	15.0%	19.2%	7.3%
Volume	N	49	16	15	6	6	7	50
Net dwb	Mean Phase II Ground	45.9	139.0	248.6	339.4	121.4	271.0	212.1
(m^3/ha)	Mean Phase I inventory	14.3	139.5	265.4	329.5	177.0	221.6	216.8
12.5 cm+	Ratio (Phase II/Phase I)	3.202	0.997	0.937	1.030	0.686	1.223	0.978
	SE of Ratio (%)	89.6%	23.1%	34.1%	35.5%	54.3%	33.0%	15.0%
Site index	N	39	15	11	2	6	4	38
(m)	Mean Phase II Ground	20.9	11.1	22.9	14.5	16.7	18.3	16.4
	Mean Phase I inventory	18.2	10.7	18.8	11.8	17.2	13.3	14.5
	Ratio (Phase II/Phase I)	1.152	1.034	1.217	1.224	0.970	1.378	1.130
	SE of Ratio (%)	8.5%	17.4%	8.1%	426.7%	10.8%	33.6%	7.5%
Site index	N	43						
(m)	Mean Phase II Ground	20.6						
	Mean Site prod layer	18.9						
	Ratio (Phase II/site)	1.090						
	SE of Ratio (%)	6.2%						

The results (Table 1) for the Volume Audit (mature) portion of the inventory are very good, particularly for height, basal area and volume. This may be due in part to the relatively recent aerial photography. The results for the B and Fd&L substrata (the two largest substrata with 15 and 16 samples respectively) are also very good. The results for the remaining substrata (Other, P, and S) are more variable and should be used with caution. Both model- and attribute-related volume bias are low resulting in an overall low total volume bias.

The agreement between the Phase I and Phase II leading species is 57% for the YSM (immature) stratum and 66% for the Volume Audit (mature) stratum. This may be due in part to the heterogeneity within the polygons, with most having three or more species.

The impact of MPB in the Kootenay Lake TSA is low due to the relatively low fraction of pine leading polygons (13%). The small sample size in this substratum (6 ground plots) limits any conclusions but it appears the Phase I overestimates the live volume and the BCMPB adjustment estimate of dead pine volume is close to the observed dead pine volume. The BCMPB model only adjusts volume and tree/ha.

The results for the YSM portion of the TSA generally show Phase I underestimation of basal area, height and volume. A separate YSM analysis is being conducted and includes a more detailed volume analysis with comparisons to TIPSY and Timber Supply Review yield curves.

The small sample size associated with the THLB portion of the volume audit stratum (13 out of 50 samples) limits analysis. If there is interest in the accuracy and precision of the THLB portion of the volume audit stratum of the inventory, this should be part of the ground sampling plan criteria and sufficient ground samples allocated to the THLB to generate meaningful statistics.

Acknowledgements

This project was coordinated by Graham Hawkins. Thank you to Bob Krahn and Marc Rousseau for providing the data.

Table of Contents

1. Introduction

This report documents the statistical analysis of the Vegetation Resources Inventory (VRI) for the Kootenay Lake Timber Supply Area (TSA).

1.1 Background

The ground sampling plan for the Kootenay Lake TSA is documented in "Kootenay Lake Timber Supply Area TSA 13 – Vegetation resources inventory project implementation plan for volume audit sampling, young stand monitoring and net volume adjustment factor sampling" (Nona Phillips Forestry Consulting 2012b) available from the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO).

1.2 Description of the Target Population Area

The Kootenay Lake TSA is located in south-eastern British Columbia in the Selkirk and Purcell Mountain ranges. It encompasses three major drainage systems (Kootenay Lake, Duncan River and Lardeau River). To the north of the TSA is Glacier National Park and to the south is the Canada-U.S.A. border. The Arrow TSA is to the west and the Invermere and Cranbrook TSAs are to the east.

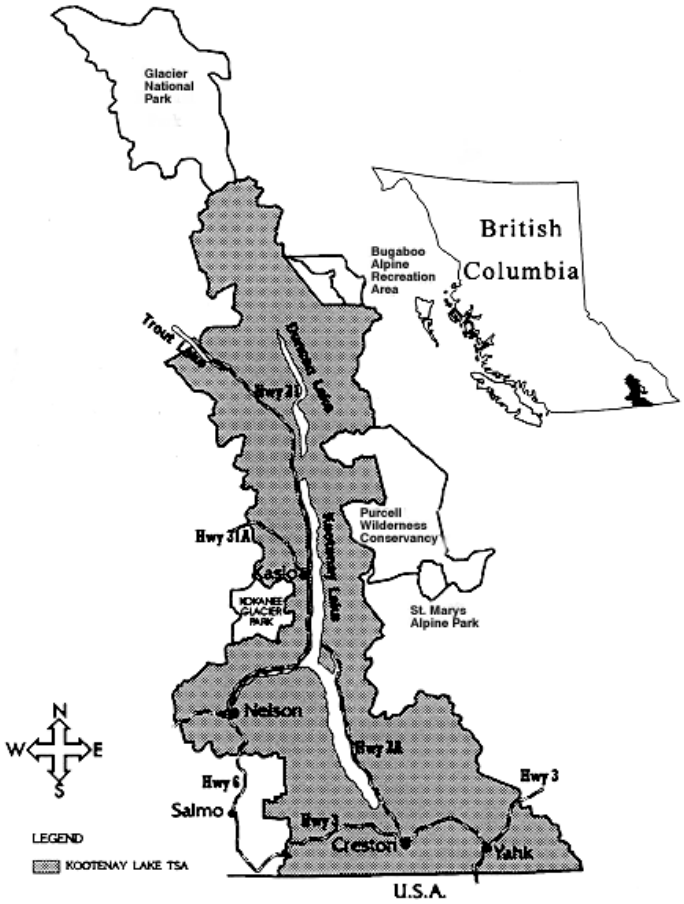

Figure 1. The location of the Kootenay Lake TSA from http://www.for.gov.bc.ca/hts/tsa/tsa13/map.gif

The Kootenay Lake TSA includes moist and wet climatic regions and is commonly referred to as part of the Interior Wet Belt. There are three biogeoclimatic zones in the TSA – 1: Interior Cedar Hemlock (ICH) occupying valley bottoms and lower slopes to about 1400 metres; 2: Engelmann Spruce-Subalpine Fir

(ESSF), the uppermost forested zone, occurring at elevations between 1400 and 2500 metres; and 3: the Interior Mountain-heather Alpine (IMA), occurring at elevations greater than 2250 metres, above the ESSF zone. The main tree species are subalpine fir (Bl), Douglas-fir (Fd), western larch (Lw), spruce (Se and Sx), and lodgepole pine (PL). The Mountain Pine Beetle has been active in the southern portion of the TSA in recent years

Table 2. A summary of the land based taken from Nona Phillips Forestry Consulting (2012a).

Land Classification	Area (ha)	% of TSA
Total TSA Area	**1,240,711**	**100.00%**
Net-downs	**372,643**	**30.03%**
Parks	231,119	18.63%
Private	139,144	11.21%
Indian Reserve	2,380	0.19%
Net Area	**868,068**	**69.97%**
Non-Vegetated	126,863	10.23%
Vegetated	741,205	59.74%
Non-Treed	122,879	9.90%
Treed	618,326	49.84%

The Vegetation Resources Inventory (VRI) project implementation plan (VPIP) for the Kootenay Lake TSA identified two separate populations of interest for Phase II ground sampling:

1. Young Stand Monitoring (YSM) or immature: stands between 15 and 50 years of age (in 2012), *not* restricted to Vegetated Treed (VT) polygons
2. Volume Audit or mature: stands 51 years and older (in 2012) in the Vegetated Treed portion of the landbase.

Exclusions from both the Volume Audit and the YSM land base included Private land, Parks and Indian Reserves. Community Forests and Woodlots have been retained in the Kootenay Lake TSA sampling population.

The area distributions by inventory leading species in each of these two populations of interest are given in Table 3 and Table 4.

Table 3. Kootenay Lake TSA Young Stand Monitoring (YSM – immature) population of interest, by leading species. From Nona Phillips Forestry Consulting 2012b.

Inventory Leading Species	Area (ha)	% of YSM population
Cottonwood (AC)	1,057	2%
Balsam (B)	15,319	27%
Cedar (CW)	2,309	4%
Birch (EP)	1,207	2%
Fir (FD)	7,098	13%
Hemlock (HW)	2,874	5%
Larch (LW)	2,447	4%
Lodgepole pine (PL)	10,124	18%
Spruce (S)	14,224	25%
Total	56,659	100%

Table 4. Kootenay Lake TSA Volume Audit (mature) population of interest, by leading species. From Nona Phillips Forestry Consulting 2012b.

Inventory Leading Species	Area (ha)	% of Volume Audit population
Cottonwood (AT)	4,877	1%
Balsam (B)	172,485	31%
Cedar (CW)	10,371	2%
Birch (EP)	2,162	0%

Inventory Leading Species	Area (ha)	% of Volume Audit population
Fir (FD)	101,987	18%
Hemlock (H)	50,285	9%
Larch (LW)	66,361	12%
Lodgepole pine (PL)	71,370	13%
Spruce (S)	73,031	13%
Total	552,929	100%

1.3 Scope and Objectives

The objective of this project was to provide a VDYP7-based VRI analysis for the Kootenay Lake TSA, based on current standards (FAIB 2011). The analysis was to be carried out for the 50 Volume Audit (mature) samples and the 50 Young Stand Monitoring (Immature) ground samples established in the 2012 field season.

In addition to the standard VRI sample data analysis, an examination of the bias associated with the inventory volume estimates was examined in more detail. Specifically, the relative contributions of the VDYP7 model itself and the inventory attributes used as input for the model on volume bias were investigated. This part of the analysis focused on the Volume Audit (mature) samples.

An examination of the dead volume as estimated using the MFLNRO's British Columbia Mountain Pine Beetle (BCMPB) mortality algorithm was also completed.

Unless otherwise noted, all Phase II attribute values are based on live trees only. Phase I trees/ha and volume/ha have been adjusted for MPB mortality in lodgepole pine and hence reflect live trees. However, the remaining Phase I estimates (i.e. basal area/ha, species composition) are not adjusted for MPB mortality and hence may include some component of dead lodgepole pine.

An addendum to this report, available from MFLNRO, providing stand and stocking tables based on the VRI Phase II data, was produced to address some of the short-term timber supply-related questions in the Kootenay Lake TSA.

2. METHODS

2.1 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 process begins with running the Phase I inventory data through the VDYP7 growth model to project the attributes to the same year as the ground sampling. The Phase I inventory data corresponding to the Phase II ground samples are identified and screened to identify potential data errors and/or inappropriate matching of Phase I and II data. Analysis is usually done at the stratum level, where strata are typically defined by leading species. After calculating and applying the appropriate sampling weights, mean values of the ground samples attributes and the corresponding Phase I inventory attributes are computed. Ratios of these two values (i.e. the mean Phase II ground sample value / the mean Phase I inventory value) are then calculated along with the corresponding sampling errors, by stratum.

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.

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

- Age of the first species (AGE_PROJ_1),
- Height of the first species (HEIGHT_PROJ_1),
- Basal area at 7.5cm+ DBH utilization (BASAL_AREA),
- Trees per hectare at 7.5cm+ DBH utilization (VRI_LIVE_STEMS_PER_HA),

- Lorey height[1] (LH) at 7.5cm+ DBH utilization (LH7.5, generated by VDYP7),
- Volume net top, stump (CU), decay, waste and breakage at 12.5cm+ DBH utilization (LIVE_STANDVOLUME_125), and
- Site index (SITE_INDEX).

2.2 Phase II Sample Selection Pre-Stratification and Weights

The Volume Audit population was pre-stratified by leading species and further stratified by volume classes to ensure adequate representation of the samples across the target population. Polygons were selected with Probability Proportional to Size (polygon area) With Replacement (PPSWR).

Sampling weights (Table 5) were determined from area information presented in the *"Kootenay Lake TSA Sample Selection Report"* (Nona Phillips Forestry Consulting 2012a) and used in the analysis.

Table 5. The sample weights for the Kootenay Lake TSA are given. Sample 69 was removed from the YSM sample and the weights recalculated.

Strata	Substrata	Volume strata	Volume Criteria (m^3/ha)	Area (A) (ha)	Area %	n	Weight (number of hectares represented by each sample) = A/n
Volume audit (mature)	Balsam (B)	1	0-73.55	55,706	32%	5	11,141
		2	73.55-170.55	53,961	31%	5	10,792
		3	>170.55	62,817	36%	6	10,470
		Total		172,484	100%	16	
	Douglas-fir and Larch (Fd&L)	1	0-187.71	49,370	29%	5	9,874
		2	187.71-304.54	59,492	35%	5	11,898
		3	>304.54	59,486	35%	5	11,897
		Total		168,348	100%	15	
	Other (O)	1	0-235.66	19,186	28%	2	9,593
		2	235.66-379.21	22,109	33%	2	11,055
		3	>379.21	26,399	39%	2	13,200
		Total		67,694	100%	6	
	Pine (P)	1	0-136.74	22,168	31%	2	11,084
		2	136.74-227.72	24,883	35%	2	12,442
		3	>227.72	24,321	34%	2	12,161
		Total		71,372	100%	6	
	Spruce (S)	1	0-176.93	22,302	31%	2	11,151
		2	176.93-273.6	24,563	34%	2	12,282
		3	>273.6	26,166	36%	3	8,722
		Total		73,031	100%	7	
	Total			552,929		50	
YSM (Immature)	Original			56,659		50	1,133
	Revised			56,659		49	1,156

3. Data Sources

3.1 Phase I photo-interpreted inventory data

The VRI Management System (VRIMS) inventory data from the Land and Resource Data Warehouse (LRDW), projected to 2012, were provided. Ground sampling was also completed in 2012, so VRIMS data for age, height and volume were used directly in the analysis. Lorey height (LH) at the 7.5cm+ DBH utilization was not provided in the VRIMS file and was generated using VDYP7 Console version 7.7a.33. The Phase I data for the ground sampled polygons are given in Appendix A.

The VRIMS projected volume and trees/ha from the LRDW reflect the application of the BCMPB mortality algorithm. Hence, in addition to live values for these attributes, dead volume/ha and dead trees/ha values (as well as a "stand dead pine percentage" value) were provided. Note that basal area estimates are NOT adjusted in the BCMPB algorithm hence the VRIMS Phase I basal area values that are used in this analysis have NOT been adjusted for pine mortality.

The inventory for this management unit is relatively recent. Table 6 gives the population area distribution by reference year (year of photo acquisition) of the VT portion of the Kootenay Lake TSA greater than 15 years of age. Nearly 89% of the area was flown in either 2005 or 2006. Almost all (92%) of the target population is a VRI inventory standard while 8% is the older FIP standard and less than 1% is classified as "I" (incomplete). The older, FIP areas are Tree Farm 40 and the West Arm Park, not part of the target population.

Table 6. Kootenay Lake TSA area distribution by inventory reference year. Most of the aerial photography was taken in 2005 and 2006. The summary includes VT polygons 15 years and older,

Decade of Reference (photo) year	% of Area	Average polygon size (ha)
1958 – 1959	0%	30.7
1960 – 1969	3%	29.0
1970 – 1979	5%	14.5
1980 – 1989	0%	50.5
1990 – 1999	0%	29.4
2000 – 2010	92%	15.1
2011 – 2012	0%	1.7
Total	100%	15.3

Samples 40 and 41 had a substantial amount of dead volume (120 and 199 m^3/ha respectively) in the Phase I inventory. Plot 42 had 62 m^3/ha. All are in the mature pine strata. All other samples had less than 35 m^3/ha of dead volume. The volume and trees/ha were adjusted for dead pine but no other attributes were adjusted.

3.2 Phase II ground sample data

Nona Phillips Forestry Consulting Ltd. (2012a) documents the selection of the ground samples for the Kootenay Lake TSA. The Phase II data were compiled by MFLNRO July 4, 2013 using the most recent regional NVAF values.

The Phase II site index (SI) value for each sample was computed as the average site index (SI) of the T, L, X and O trees on the "trees_h" file.

The Phase II compiled ground sample attributes are provided in Appendix B.

Sample 96 had no trees measured for age or height and has no site index estimates.

3.3 Data issues related to the statistical adjustment

Scatterplots comparing the Phase I and Phase II attributes were examined for potential outliers (Figure 3). Large differences between the ground sample and photo-based estimates, particularly for basal area, tree/ha and volume, were noted for a number of samples.

Plot 69 does not seem to fit in the YSM (immature) population. It appears to have a number of very large DBH hemlock trees. The ground sample crew recorded that the polygon appears to be in old growth. The orthophotography shows a considerable cover of old trees and very small openings. The ground sample was located in the correct polygon but the Phase I interpretation of the polygon was poor. It was dropped from further analysis and the weights for the YSM (immature) stratum recalculated.

Samples 66, 96 and 97 also showed considerable differences between the Phase I photo interpretation and Phase II ground sample. For sample 96, the ground sample crew noted the sample fell in a patch of residuals and this was confirmed by examining the orthophotography. There were no comments from the ground sample crew for sample 97. It is located in an old clearcut and it is hard to determine if the stocking in the plot is lower than the rest of the polygon. Sample 66 is in a recent clearcut and the age is at or close to the minimum for the YSM population. All three samples were retained.

3.4 Height and Age data matching

MFLRNO data matching procedures (FAIB 2011) were followed to determine the appropriate Phase I and II heights and ages for the comparison ratios.

For each sample, the Phase II ground sample data were matched with the corresponding Phase I inventory data for the same polygon. The ground heights and ages used in the analysis were based on the average values for the T, L, X & O[1] trees for the ground leading species (by basal area at 4cm + DBH utilization) on the ground. The objective in the matching process 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 16) level, conifer-to-conifer (or deciduous-to-deciduous) matches were allowed. However, conifer-deciduous matches were not considered acceptable. Appendix D provides the details for the height and age data matching.

3.5 Site Index

The site index comparison was carried out only for samples where the Phase II and Phase I leading species were the same (Case 1 for height and age matching) or where the 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 (Case 2 for height and age matching). No other cases were considered acceptable matches.

3.6 Site index from Provincial Site productivity layer

The provincial site productivity layer provides an alternative source of site index estimates, particularly for the YSM population. This layer provides site index estimates for up to 22 species. The intersection of the provincial site productivity layer and the YSM ground plots was provided by the FAIB. Of the 49 YSM ground plots, the ground leading species for four plots did not have an associated site index estimate in the site productivity layer. Two of these were CW leading, one HW leading and one with no leading species. Only Case 1 matches were considered.

3.7 Analysis of Dead Pine

The BC Mountain Pine Beetle (BCMPB) model was developed to estimate the volume of mature pine mortality associated with the mountain pine beetle (MPB) infestation. The Phase I inventory typically reports live volume only. However, in areas where the BCMPB model is applied, live volume (and trees/ha) by species for all species as well as dead volume (and trees/ha) for lodgepole pine only are reported.

[1] T or "top height" tree is the largest DBH in 0.01 ha plot, regardless of species; L or "leading species" tree is the largest DBH in 0.01 ha plot, of leading species. T trees are selected and measured at the IPC only whereas L trees are selected at the IPC and all auxiliary plots. If a suitable (age or height) leading species sample tree is not found in any given plot in a cluster, a "replacement" tree will be selected. An "O" tree is the closest suitable (for height and age) tree of the leading species to the 5.64m radius plot center. An "X" tree is the closest suitable tree of the leading species outside of the 5.64m radius plot but within a maximum 25m radius of 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.

The Phase II ground sample provides live and dead volumes, basal area and trees/ha area by species for all species.

To provide an assessment of the dead pine estimates in the Phase I inventory, the following fractions were computed:

- Dead pine volume as a fraction of the live pine volume + dead pine volume;
- Dead pine volume as a fraction of live all species volume + dead pine volume.

4. RESULTS AND DISCUSSION

4.1 Attribute bias

The ratios of the weighted mean Phase II ground sample attribute to the corresponding weighted mean Phase I inventory attribute were computed for each of the seven key attributes identified in Section 2.1. The analysis stratification for the Volume Audit population was based on Phase I inventory leading species. The samples from the YSM population were not post-stratified. The means are given in Table 7 and the ratios in Table 8.

Table 7. Sample-estimated weighted means for the Phase I inventory and Phase II ground sample for seven key inventory attributes, for the target population in the Kootenay Lake TSA. Shading indicates small sample size.

Attribute		Weighted means						
		YSM	Volume Audit (mature)					
		(Immature)	B	Fd&L	Other	P	S	Mature
Age	N	47	16	15	6	6	7	50
(years)	Phase II Ground	30.4	124.7	89.5	107.7	98.5	114.9	107.2
	Phase I inventory	30.6	146.4	94.1	141.7	79.3	185.3	126.4
Height	N	45	16	15	6	6	7	50
(m)	Phase II Ground	10.3	18.9	27.4	28.1	21.0	25.7	23.8
	Phase I inventory	8.0	19.6	25.7	28.1	20.5	25.7	23.4
Basal area	N	49	16	15	6	6	7	50
(m^2/ha)	Phase II Ground	13.2	24.6	38.6	51.9	25.0	38.9	34.1
7.5 cm+	Phase I inventory	7.9	26.8	39.7	48.6	35.9	28.8	34.8
Trees/ha	N	49	16	15	6	6	7	50
7.5 cm+	Phase II Ground	801	795	1062	1043	1156	914	969
	Phase I inventory	2700	595	871	850	710	461	708
Lorey	N	23	16	15	6	6	7	50
Height	Phase II Ground	9.6	14.9	21.6	23.5	16.5	23.4	19.3
(m)	Phase I inventory	9.1	13.8	19.7	20.9	16.6	18.8	17.5
Volume net	N	49	16	15	6	6	7	50
Dwb (m^3/ha)	Phase II Ground	45.9	139.0	248.6	339.4	121.4	271.0	212.1
12.5 cm+	Phase I inventory	14.3	139.5	265.4	329.5	177.0	221.6	216.8
Site index	N	39	15	11	2	6	4	38
(m)	Phase II Ground	20.9	11.1	22.9	14.5	16.7	18.3	16.4
	Phase I inventory	18.2	10.7	18.8	11.8	17.2	13.3	14.5
Site index	N	43						
(m)	Phase II Ground	20.6						
	Site prod layer	18.9						

One surprising result is the Phase II Volume Audit (mature) trees/ha is greater than the YSM (immature trees/ha (969 trees/ha vs. 801 trees/ha). For more discussion of this, see the Kootenay Lake Stand and Stock Table report available from the FAIB.

Overall, the Volume Audit (mature) ratios for height, basal area and volume are close to 1.0 (Table 8). These are important inventory attributes and the results are very good. The average Phase I inventory age is older than the average Phase II ground age. The heights are close so the Phase I overestimation of age leads to an underestimation of the Phase I site index.

The results for the leading species substrata within the Volume audit stratum show considerable variability and are generally associated with small sample sizes. The heights are still very good. The basal area and volume associated with the Pine substrata are considerably underestimated in Phase I, possibly due to overestimates of pine mortality by the BCMPB algorithm.

For the YSM (immature) stratum, the age is very good while height is underestimated leading to an underestimate of site index. The site productivity layer site index estimate is slightly closer than the VRI site index to the ground estimate, possibly because only Case 1 matches are included. Volume, basal area and trees/ha for the YSM (immature) stratum are very sensitive to the utilization level. The Kootenay Lake Young Stand Monitoring report, available from the FAIB), gives a more detailed examination of the YSM (immature) stratum.

Table 8. Ratio of means comparisons (and sampling error % at a 95% confidence level) for seven attributes, for the target populations in the Kootenay Lake TSA. Shading indicates small sample size.

Stratum		N	Ratio of weighted means (with 95% sampling error shown as % of ratio)							
			Age (years)	Height @7.5cm+ (m)	Basal area @7.5cm+ (m^2/ha)	Trees/ha @7.5cm+	Lorey height @7.5cm+ (m)	Volume net Dwb @12.5cm+ (m^3/ha)	Site index (SI) (m)	Site prod layer SI (m)
YSM (immature)		50	0.993 (±6.0%)	1.296 (±14.4%)	1.682 (±38.3%)	0.297 (±38.5%)	1.053 (±16.8%)	3.202 (±89.6%)	1.152 (±8.5%)	1.090 (±6.2%)
Volume audit (mature)	B	16	0.852 (±23.2%)	0.967 (±9.8%)	0.918 (±19.2%)	1.335 (±30.5%)	1.077 (±18.3%)	0.997 (±23.1%)	1.034 (±17.4%)	
	Fd&L	15	0.951 (±16.9%)	1.063 (±10.7%)	0.974 (±28.6%)	1.219 (±40.6%)	1.101 (±13.7%)	0.937 (±34.1%)	1.217 (±8.1%)	
	Other	6	0.760 (±51.3%)	1.002 (±22.2%)	1.067 (±36.3%)	1.227 (±15.6%)	1.126 (±19.9%)	1.030 (±35.5%)	1.224 (±426.7%)	
	P	6	1.242 (±49.5%)	1.021 (±7.5%)	0.695 (±41.8%)	1.628 (±116.1%)	0.994 (±15.0%)	0.686 (±54.3%)	0.970 (±10.8%)	
	S	7	0.620 (±21.8%)	0.998 (±11.6%)	1.352 (±37.0%)	1.984 (±68.2%)	1.247 (±19.2%)	1.223 (±33.0%)	1.378 (±33.6%)	
	Total	50	0.848 (±12.9%)	1.015 (±5.2%)	0.981 (±13.4%)	1.369 (±21.3%)	1.106 (±7.3%)	0.978 (±15.0%)	1.130 (±7.5%)	

4.2 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. In the YSM stratum, approximately half (26 out of 49) of the samples were too short for VDYP7 to estimate volumes or Lorey height. For these samples, the VDYP7 Lorey height was set to missing and the volume set to zero.

The model and attribute-related volume bias analysis focused on the Volume Audit (mature) population, where VDYP7 produced volumes for all samples.

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. 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. It also includes errors associated with estimating the impact of mountain pine beetle. 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 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. Includes errors in original attributes, projection errors, MPB update errors and volume estimation errors.

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

VOL A – VOL B = total bias

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

VOL C - VOL B = Attribute bias – does not include VDYP7 volume estimation errors but includes errors in original attributes, errors in attribute projection and errors in MPB update.

The YSM volume results (Table 9) will not be discussed other than to note the stands are young, with little merchantable volume and the total volume is dominated by attribute bias.

For the Volume audit, overall the results are good. Overall, and for the strata with larger sample sizes (B and Fd&L), all the biases were less than 10%. (Figure 2, Table 9 and Table 10). Model bias is generally larger in magnitude than attribute bias. In comparison to other recent VRI analyses, the attribute bias is low (good) and the model bias is also low. The Pine substratum has a low sample size and the poor results may be MPB-related.

Table 9. Volumes for model-related and attribute-related bias comparison.

Stratum		N	Weighted mean Volume/ha net Dwb at 12.5cm DBH					
			Phase II Ground	VDYP7 Phase I Inventory (VRIMS with MPB adjustment)	VDYP7 volume with Phase II attributes as input (VRIStart)	Model-related volume bias	Attribute-related volume bias	Total volume bias
			A	B	C	A-C	C-B	A-B
YSM (immature)		49	45.9	14.3	29.2	16.6	14.9	31.5
Volume Audit (mature)	B	16	139.0	139.5	128.8	10.2	-10.7	-0.5
	Fd&L	15	248.6	265.4	266.6	-17.9	1.2	-16.7
	O	6	339.4	329.4	369.1	-29.8	39.7	9.9
	P	6	121.4	177.0	162.3	-40.9	-14.7	-55.6
	S	7	271.0	221.6	269.4	1.6	47.8	49.4
	Total	50	212.1	216.8	223.1	-11.0	6.3	-4.7

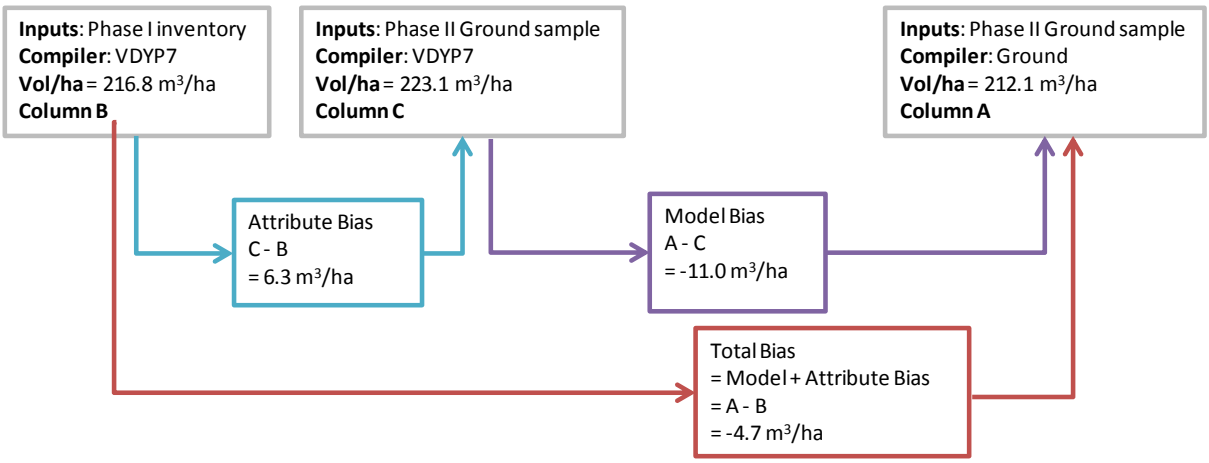

Figure 2. The relationship between the model and attribute components of total volume bias for the mature target population in the Kootenay Lake TSA (from Table 9). A negative bias indicates Phase I overestimation whereas a positive bias indicates underestimation.

The ratios of means of the biases (Table 10) are generally close to one and not statistically different from one.

Table 10. 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. Shaded cells represent small sample sizes where results must be interpreted with caution.

			Ratio of Weighted Mean Volume/ha net dwb at 12.5cm+ DBH (and sampling error at a 95% confidence level)		
			Total bias: Ground/Inventory	Model bias: Ground/VDYP7 (ground attributes)	Attribute bias: VDYP7 (Ground attributes)/Inventory
Stratum		N	(Table 9 A/B)	(Table 9 A/C)	(Table 9 C/B)
YSM (immature)		49	3.202 (±89.6%)	1.569 (±50.1%)	2.041 (±79.6%)
Volume Audit (mature)	B	16	0.997 (±23.1%)	1.079 (±13.1%)	0.924 (±19.6%)
	Fd&L	15	0.937 (±34.1%)	0.933 (±12.2%)	1.004 (±32.5%)
	O	6	1.030 (±35.5%)	0.919 (±22.2%)	1.120 (±33.0%)
	P	6	0.686 (±54.3%)	0.748 (±24.3%)	0.917 (±56.1%)
	S	7	1.223 (±33.0%)	1.006 (±14.2%)	1.215 (±30.7%)
	Total	50	0.978 (±15.0%)	0.951 (±6.8%)	1.029 (±14.2%)

4.3 Leading species comparison

Table 11 and Table 12 summarize the agreement between the leading species in the Phase I inventory files and the leading species from the Phase II ground sample compilation. For the YSM population, 28 out of 49 (57%) of the samples were correctly classified and for the Volume audit, 33 out of 50 (66%) were correctly classified. Although the leading species agreements were not high, some of the samples not considered matches were close. For example, sample 45 had a species composition at the 4.0 utilization of Bl 42 Hw 42 Se 16 while the Phase I species composition was HW 60 CW 20 SE 15 BL 5 and was not considered a match. For sample 92, the Phase II species composition was Cw 43 Fd 42 Ep 13 Pl 02 while the Phase I species composition was FDI 40 EP 40 CW 20, again, not considered a match.

Table 11. The Phase II ground vs. Phase I inventory leading species cross-tabulation for the YSM (Immature) target population in the Kootenay Lake TSA. The shaded cells are correct classifications. The overall correct classification rate is 57%.

Phase I Inventory leading spp	YSM (Immature) Phase II Ground Leading Species @ 4cm DBH utilization								Total	% agreement
	B	C	E	F	H	L	P	S		
None								1	1	0%
B	2	1		1				1	5	40%
C							1	1	2	0%
E										0%
F		2		4	1				7	57%
H		1			2				3	67%
L						1		1	2	50%
P		1	1	1			6	1	10	60%
S	3	1			1		1	13	19	68%
Total	5	6	1	6	4	1	8	18	49	
% agreement	40%	0%	0%	67%	50%	100%	75%	72%	100%	57%

Table 12. The Phase II ground vs. Phase I inventory leading species cross-tabulation for the Volume Audit (mature) target population in the Kootenay Lake TSA. The shaded cells are correct classifications. The overall correct classification rate is 66%.

Phase I Inventory leading spp	Volume Audit (mature) Phase II Ground Leading Species @ 4cm DBH utilization								Total	% agreement
	B	C	E	F	H	L	P	S		
B	14			1				1	16	88%
C										0%
E										0%
F				7	1				8	88%
H	2	1		1	2				6	33%
L				1	3	2	1		7	29%
P							6		6	100%
S	2				3			2	7	29%
Total	18	1	0	10	9	2	7	3	50	
% agreement	78%	0%	0%	70%	22%	100%	86%	67%	100%	66%

4.4 Analysis of Dead Pine

Mountain Pine Beetle has killed most of the lodgepole pine in B.C. In the Kootenay Lake TSA, the year of peak attack was 2008[2], after most of the Phase I aerial photography was acquired. The MFLNRO has developed a methodology to update the Phase I inventory to account for this pine mortality. This procedure applies a kill rate to pine leading polygons and converts some of the live volume and trees/ha to dead volume and trees/ha. All other attributes, including species composition and basal area, are unchanged.

The dead (and live) pine volume is relatively minor except in the Pine substrata and the rest of the discussion focuses on the Pine substratum, despite the small sample size (6). The Phase I inventory

[2] Walton, A. 2012. 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 2011 and the BCMPB Model (year9). 12p.

overestimates the live volume compared to the ground sample but the dead pine estimate is very close. As a consequence, the Phase I estimate of pine mortality is lower than the Phase II estimate.

Table 13. Weighted average volumes/ha (net dwb at 12.5cm+ DBH), by stratum, as well as dead pine volume expressed as a percent of total pine volume as well as total live + dead pine volume.

			Weighted mean volume net of decay, waste & breakage @ 12.5 cm									
			Live all species A		Live - pine only B		Dead - pine only C		Pine mortality as % of pine C/(B+C)		Pine mortality as % of live all + dead Pl C/(A+C)	
Stratum		n	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II
YSM (immature)		49	14.3	45.9	1.3	4.3	0.1	0.6	5%	12%	0%	1%
Volume Audit (mature)	Balsam	16	139.5	139.0	3.0	2.5	2.3	0.8	44%	24%	2%	1%
	Df&L	15	265.4	248.6	26.3	6.8	1.4	10.7	5%	61%	1%	4%
	Other	6	329.4	339.4	0	0	0	0			0%	0%
	Pine	6	177.0	121.4	146.5	85.5	64.3	64.7	30%	43%	27%	35%
	Spruce	7	221.6	271.0	0	4.7	0	0.0			0%	0%
	Total	50	216.8	212.1	27.9	14.5	9.5	11.9	25%	45%	4%	5%

4.5 Limitations of the approach

Attribute definitions in young stands – Some of the Phase I attributes for young stands are obtained from silvicultural records and may have different definition and standards of data collection. In particular, although height and age may have been measured in the field, site index for young stands is usually estimated from SIBEC or from the previous stand.

Sample unit – The Phase I sample unit is the polygon while the Phase II sample unit is a fixed area plot (YSM) 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 a module called 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 merchantable volume – VDYP7 and the Phase II ground compiler use different methods to reduce whole stem merchantable volume to merchantable 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.

BCMPB mortality algorithm – The MPB mortality algorithm is applied to the pine component of the trees/ha and volume/ha estimates from VDYP7. Other attributes such as basal area and species composition are *not* adjusted when this algorithm is implemented. It is important to keep this in mind when interpreting the results for the pine substrata.

Sample sizes – The sample sizes for the leading species substrata within the volume audit (mature) population are small, resulting in estimates with high standard errors.

Target population - THLB – The target population for the volume audit (mature) stratum was the vegetated trees portion of the land base. The Timber Harvesting Land Base (THLB) is a much smaller portion of the land base and only 13 of the 50 volume audit (mature) samples fell within the THLB. This is not a large enough sample size for reliable estimates or conclusions.

5. Conclusions and recommendations

The Kootenay Lake TSA is diverse in terms of species composition. There are five different leading species that have more than 10% of the Volume Audit (mature) portion of the TSA. More than half of the Volume Audit (mature samples) have three or more species in Phase I and the proportion in Phase II is higher.

The results for the Volume Audit (mature) portion of the inventory are very good, particularly for height, basal area and volume. This may be due in part to the relatively recent aerial photography. The results for the B and Fd&L substrata (the two largest substrata with 15 and 16 samples respectively) are also very good. The results for the remaining substrata (Other, P, and S) are more variable and should be used with caution. Both model- and attribute-related volume bias are low resulting in an overall low total volume bias.

The agreement between the Phase I and Phase II leading species is 57% for the YSM (immature) stratum and 66% for the Volume Audit (mature) stratum. This may be due in part to the heterogeneity within the polygons, with most having three or more species.

The impact of MPB in the Kootenay Lake TSA is low due to the relatively low fraction of pine leading polygons (13%). The small sample size in this substratum (6 ground plots) limit any conclusions but it appears the Phase I overestimates the live volume and the BCMPB adjustment estimate of dead volume is close. The BCMPB model only adjusts volume and tree/ha.

The results for the YSM portion of the TSA generally show Phase I underestimation of basal area, height and volume. The 12.5cm utilization level for volume results in very low volumes for the YSM samples. A separate YSM analysis is being conducted (available from the FAIB) and includes a more detailed volume analysis including comparisons to TIPSY and Timber Supply Review yield curves.

The small sample size associated with the THLB portion of the volume audit stratum (13 out of 50 samples) limits any analysis and conclusions that can be drawn.

The following recommendation is based on the analysis here.

- If there is interest in the accuracy and precision of the THLB portion of the volume audit stratum, this should be part of the ground sampling plan criteria and sufficient ground samples allocated to the THLB to generate meaningful statistics.

6. 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.

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Nona Philips Forestry Consulting. 2012a. Kootenay Lake TSA VRI Sample Selection Report. March 2012. 24p.

Nona Philips Forestry Consulting. 2012b. Kootenay Lake Timber Supply Area TSA 13 – Vegetation resources inventory project implementation plan for volume audit sampling, young stand monitoring and net volume adjustment factor sampling. March 12, 2012. 13p + app.

7. Appendix A: Phase I inventory attributes

Table 14. The Phase I input projected attributes are given.

SAMPLE	FEATURE_ID	BEC	Stratum 1	Stratum 3	Sample weight	inventory standard	Polygon area (ha)	Measurement year (for projections)	Reference Year	Projected Age sp1	Projected Height sp1	Projected Age sp2	Projected Height sp2	Input CC%	Projected BA7.5	Projected TPH7.5	Lorey height (m)	Volume NWB 12.5 (m^3/ha)	sp01	pct1	sp02	pct2	sp03	pct3	sp04	pct4	sp05	pct5	sp06	pct6	Dead Volume (m^3/ha)
1	8280844	ESSF	Mature	B	11141	V	5.7	2012	2005	127	13.8	.	.	20	16.7	601	9.4	48.1	BL	100		.		.		.		.		.	.
2	8854894	ESSF	Mature	B	11141	V	7.0	2012	2006	176	14.5	256	26.2	10	6.0	237	11.0	20.5	BL	90	SE	10		.		.		.		.	.
3	8856189	ESSF	Mature	B	11141	V	6.9	2012	2006	206	25.3	186	25.2	15	10.0	111	18.0	66.9	BL	70	LA	30		.		.		.		.	.
4	8814150	ESSF	Mature	B	11141	V	20.4	2012	2006	126	16.7	146	18.5	25	16.0	443	11.5	66.6	BL	90	SE	10		.		.		.		.	.
6	8828872	ESSF	Mature	B	10792	V	29.5	2012	2006	206	20.4	206	22.3	30	29.9	457	14.8	162.2	BL	60	SE	40		.		.		.		.	.
7	8298632	ESSF	Mature	B	10792	V	18.4	2012	2005	67	15.8	77	18.8	40	30.1	1249	11.8	122.9	BL	70	SE	20	PLI	10		.		.		.	.
8	8825117	ESSF	Mature	B	10792	V	8.6	2012	2005	207	21.5	207	21.1	30	30.0	433	15.0	150.3	BL	80	LA	20		.		.		.		.	.
9	8820447	ESSF	Mature	B	10792	V	6.9	2012	2006	146	15.6	166	17.4	30	25.6	646	11.0	97.3	BL	80	SE	20		.		.		.		.	.
10	8844303	ESSF	Mature	B	10792	V	4.9	2012	2006	186	19.5	.	.	20	19.9	357	13.0	83.1	BL	100		.		.		.		.		.	.
11	7924145	ESSF	Mature	B	10470	V	15.8	2012	2006	106	20.9	106	23	40	35.9	780	15.1	212.8	BL	60	SE	40		.		.		.		.	.
12	8207784	ESSF	Mature	B	10470	V	26.0	2012	2006	116	22.8	126	23.3	55	46.4	820	16.3	243.6	BL	80	PLI	10	SE	10		.		.		.	34.2
13	8853748	ESSF	Mature	B	10470	V	6.3	2012	2006	186	24.4	206	26.3	35	34.8	356	17.2	219.1	BL	80	SE	15	LA	5		.		.		.	.
14	8207054	ESSF	Mature	B	10470	V	7.0	2012	2006	166	24.5	186	27.4	50	44.9	837	18.5	325.2	BL	50	SE	40	PLI	10		.		.		.	4.5
15	8849855	ESSF	Mature	B	10470	V	5.0	2012	2006	126	19.7	126	20.7	45	35.7	808	14.0	192.9	BL	60	SE	40		.		.		.		.	.
16	8859739	ICH	Mature	B	10470	V	65.8	2012	2006	96	19	96	22.1	50	37.3	1173	13.8	187.5	BL	70	SE	30		.		.		.		.	.
17	7917864	ICH	Mature	FD+L	9874	V	18.4	2012	2006	66	18.3	.	.	55	28.6	1475	13.9	104.6	FDI	100		.		.		.		.		.	.
18	8061130	ICH	Mature	FD+L	9874	V	5.7	2012	2006	76	23.3	76	21.9	45	26.4	639	18.3	162.1	LW	40	PLI	40	FDI	20		.		.		.	14.9
19	8302511	ICH	Mature	FD+L	9874	V	8.9	2012	2005	77	21.4	77	20	60	31.8	1195	17.3	176.3	LW	70	PLI	30		.		.		.		.	.
20	8058569	ICH	Mature	FD+L	9874	V	17.9	2012	2006	66	22.5	66	20.8	60	38.4	1201	16.0	186.1	LW	50	CW	30	HW	10	FDI	10		.		.	.
21	8058370	ICH	Mature	FD+L	9874	V	29.3	2012	2006	96	25.9	96	26	20	16.2	216	20.8	114.4	LW	80	FDI	10	SE	10		.		.		.	.
22	8058862	ICH	Mature	FD+L	11898	V	8.5	2012	2006	86	25.1	86	24.1	65	41.3	976	20.5	271.1	LW	80	FDI	10	PLI	10		.		.		.	.
23	8331965	ICH	Mature	FD+L	11898	V	39.5	2012	2005	77	22.5	77	20	60	36.7	1105	17.9	215.4	LW	70	PLI	30		.		.		.		.	1.7
24	8295814	ICH	Mature	FD+L	11898	V	5.7	2012	2005	107	24.9	107	25.9	45	31.3	666	19.0	199.4	FDI	90	LW	10		.		.		.		.	.
25	8073114	ICH	Mature	FD+L	11898	V	42.7	2012	2006	106	26.9	.	.	55	36.4	789	20.2	246.9	FDI	100		.		.		.		.		.	.
26	8818170	ICH	Mature	FD+L	11898	V	50.2	2012	2005	127	26.8	127	26.8	50	36.5	803	19.0	229.5	FDI	60	HW	20	CW	20		.		.		.	.
27	8073091	ICH	Mature	FD+L	11897	V	10.1	2012	2006	86	24.1	86	24.1	70	51.8	1154	19.2	334.1	FDI	50	LW	40	PLI	10		.		.		.	5.7

SAMPLE	FEATURE_ID	BEC	Stratum 1	Stratum 3	Sample weight	inventory standard	Polygon area (ha)	Measurement year (for projections)	Reference Year	Projected Age sp1	Projected Height sp1	Projected Age sp2	Projected Height sp2	Input CC%	Projected BA7.5	Projected TPH7.5	Lorey height (m)	Volume NWB 12.5 (m^3/ha)	sp01	pct1	sp02	pct2	sp03	pct3	sp04	pct4	sp05	pct5	sp06	pct6	Dead Volume (m^3/ha)
28	8602780	ICH	Mature	FD+L	11897	V	9.1	2012	2005	87	28.4	87	25.8	55	41.4	679	22.4	334.7	LW	60	PLI	30	FDI	10		.		.		.	.
29	8069113	ICH	Mature	FD+L	11897	V	34.8	2012	2006	126	33.8	126	22.9	60	60.9	678	24.2	507.8	FDI	65	CW	15	LW	10	EP	10		.		.	.
30	8062957	ICH	Mature	FD+L	11897	V	73.2	2012	2006	86	25.2	86	24.2	70	52.3	1156	18.3	325.2	FDI	60	HW	30	SE	5	CW	5		.		.	.
31	8374219	ESSF	Mature	FD+L	11897	V	19.1	2012	2005	127	36	117	23.9	40	55.0	403	25.8	474.0	FDI	60	BL	20	SE	10	LW	10		.		.	.
33	8061806	ICH	Mature	S	11151	V	11.8	2012	2006	76	17.5	76	19.1	25	12.0	465	14.0	60.2	SE	50	FDI	30	LW	10	BL	10		.		.	.
34	8844494	ESSF	Mature	S	12282	V	2.2	2012	2006	226	31.3	206	27.3	35	29.9	200	21.5	255.4	SE	70	BL	30		.		.		.		.	.
35	8129044	ICH	Mature	S	12282	V	24.5	2012	2005	187	28.4	167	24.6	30	29.6	281	20.8	222.8	SE	70	BL	20	LW	10		.		.		.	.
36	8844395	ESSF	Mature	S	8722	V	2.5	2012	2006	266	35.2	246	32.2	40	44.9	399	24.9	444.1	SE	80	BL	20		.		.		.		.	.
37	8206722	ICH	Mature	S	8722	V	9.9	2012	2006	76	22.9	76	23.3	60	42.9	1187	18.5	285.7	SE	40	FDI	30	LW	20	BL	10		.		.	.
38	8819711	ESSF	Mature	S	8722	V	15.5	2012	2006	286	30.1	266	28.2	40	35.0	524	20.7	292.5	SE	60	BL	40		.		.		.		.	.
39	8829624	ESSF	Mature	P	11084	V	14.8	2012	2006	76	15.8	76	15.3	40	21.4	940	12.1	86.4	PLI	60	BL	30	SE	10		.		.		.	1.1
40	8132013	ESSF	Mature	P	11084	V	5.1	2012	2005	57	15.4	.	.	65	32.2	35	12.7	2.8	PLI	100		.		.		.		.		.	119.6
41	8211727	ICH	Mature	P	12442	V	3.4	2012	2006	106	23.5	.	.	65	45.8	463	19.1	156.2	PLI	100		.		.		.		.		.	199.4
42	8212395	ICH	Mature	P	12442	V	45.5	2012	2006	76	19.8	76	19.4	60	36.5	926	16.1	165.0	PLI	90	BL	5	LW	5		.		.		.	61.7
43	8301939	ICH	Mature	P	12161	V	40.1	2012	2005	77	22	87	24.3	50	36.4	908	18.1	267.3	PLI	85	FDI	10	LW	5		.		.		.	.
44	8605481	ICH	Mature	P	12161	V	6.4	2012	2005	81	25.7	82	26.5	60	41.4	950	21.1	361.8	PLI	70	LW	20	SE	10		.		.		.	.
45	8605347	ESSF	Mature	O	9593	V	9.7	2012	2006	76	21.4	76	21.5	70	41.9	1435	16.3	224.5	HW	60	CW	20	SE	15	BL	5		.		.	.
46	8816426	ICH	Mature	O	9593	V	16.1	2012	2006	186	18.5	186	20.4	40	20.3	843	13.7	80.5	HW	70	SE	20	CW	10		.		.		.	.
47	8210855	ICH	Mature	O	11055	V	27.6	2012	2005	80	29.4	82	36.8	70	40.0	548	23.8	342.5	HW	70	LW	20	FDI	10		.		.		.	.
48	8380392	ICH	Mature	O	11055	V	14.2	2012	2006	246	34.2	246	34.4	50	60.1	589	23.8	373.0	HW	90	CW	10		.		.		.		.	.
49	8010560	ICH	Mature	O	13200	V	16.7	2012	2006	206	35.3	206	35.5	55	65.2	565	25.0	474.2	HW	60	CW	30	FDI	10		.		.		.	.
50	8210440	ICH	Mature	O	13200	V	8.0	2012	2005	57	26.5	57	26.6	75	55.2	1187	20.4	394.4	HW	50	CW	30	LW	10	FDI	10		.		.	.
51	8299293	ESSF	Immature	Imm	1156	V	64.0	2012	2005	32	4.9	32	5.7	35	0.0	3408	.	.	SE	90	BL	10		.		.		.		.	.
52	8298302	ESSF	Immature	Imm	1156	V	28.7	2012	2005	37	9.1	37	7.2	60	5.3	747	6.7	3.8	SE	90	BL	10		.		.		.		.	.
53	8299126	ICH	Immature	Imm	1156	V	47.8	2012	2005	32	8	32	6	50	10.0	6275	.	.	SE	65	BL	18	CW	9	HW	8		.		.	.
54	8298362	ESSF	Immature	Imm	1156	V	47.5	2012	2005	30	6	30	5.1	30	4.0	2533	.	.	SE	55	BL	45		.		.		.		.	.
55	8331583	ESSF	Immature	Imm	1156	V	39.0	2012	2005	25	6.7	25	5.1	25	0.0	4936	.	.	HW	50	BL	40	SE	10		.		.		.	.
56	8330409	ICH	Immature	Imm	1156	V	80.3	2012	2005	37	11.1	37	12.3	50	19.9	3232	9.0	5.4	SE	70	PLI	20	LW	10		.		.		.	.
57	8296031	ESSF	Immature	Imm	1156	V	12.5	2012	2005	32	8	.	.	35	5.0	800	6.7	.	PLI	100		.		.		.		.		.	.
58	8329967	ICH	Immature	Imm	1156	V	25.8	2012	2005	29	8.9	.	.	50	4.6	553	7.4	3.1	PLI	100		.		.		.		.		.	.

SAMPLE	FEATURE_ID	BEC	Stratum 1	Stratum 3	Sample weight	inventory standard	Polygon area (ha)	Measurement year (for projections)	Reference Year	Projected Age sp1	Projected Height sp1	Projected Age sp2	Projected Height sp2	Input CC%	Projected BA7.5	Projected TPH7.5	Lorey height (m)	Volume NWB 12.5 (m^3/ha)	sp01	pct1	sp02	pct2	sp03	pct3	sp04	pct4	sp05	pct5	sp06	pct6	Dead Volume (m^3/ha)
59	8330119	ICH	Immature	Imm	1156	V	64.1	2012	2005	37	17.2	37	14.5	70	33.8	2661	13.5	94.5	LW	60	SE	20	PLI	10	BL	10		.		.	.
60	8329648	ICH	Immature	Imm	1156	V	91.3	2012	2005	17	4.6	17	4.2	40	0.0	3982	.	.	PLI	80	LW	10	BL	5	SE	5		.		.	.
61	8300243	ICH	Immature	Imm	1156	V	10.1	2012	2005	27	7.6	27	9.1	65	3.7	425	6.6	3.2	FDI	70	PLI	20	BG	10		.		.		.	.
62	8129253	ICH	Immature	Imm	1156	V	104.2	2012	2005	37	15.2	37	19.7	60	46.9	6470	14.6	92.6	CW	30	SE	30	HW	20	PW	10	BL	5	AC	5	.
64	8128650	ESSF	Immature	Imm	1156	V	92.1	2012	2005	37	9.1	37	7.2	20	4.5	599	6.4	4.0	SE	70	BL	30		.		.		.		.	.
65	7953551	ESSF	Immature	Imm	1156	V	24.3	2012	2006	24	3.4	24	4.7	20	0.0	1000	.	.	SE	60	BL	40		.		.		.		.	.
66	8859609	ESSF	Immature	Imm	1156	I	70.3	2012	2004	18	1.9	21	3.5	3	.	1465	.	.	SX	90	BL	10		.		.		.		.	.
67	8366366	ESSF	Immature	Imm	1156	V	11.9	2012	2006	29	8	29	11	40	9.0	5873	.	.	SE	50	PLI	30	BL	20		.		.		.	.
68	8380926	ESSF	Immature	Imm	1156	V	35.4	2012	2006	27	8.3	27	5.8	30	3.0	335	6.5	1.2	PLI	90	BL	10		.		.		.		.	0.1
69	8213042	ICH	Immature	Imm		V	9.1	2012	2006	45	10.6	45	10.9	35	17.3	1517	7.6	32.1	BL	50	SE	30	HW	20		.		.		.	
70	8070490	ESSF	Immature	Imm	1156	V	13.0	2012	2006	21	2.5	.	.	20	0.0	1588	.	.	SE	100		.		.		.		.		.	.
71	8373936	ICH	Immature	Imm	1156	V	11.6	2012	2005	25	9.8	25	7.6	35	6.9	536	7.7	5.7	PLI	40	CW	20	FDI	20	LW	10	AT	10		.	2.2
72	8069239	ESSF	Immature	Imm	1156	V	12.8	2012	2006	23	6.8	23	3.5	60	15.0	3250	.	.	PLI	60	SE	30	BL	10		.		.		.	.
73	8060558	ESSF	Immature	Imm	1156	V	13.6	2012	2006	41	12.1	41	12.2	40	13.0	1664	10.0	15.3	HW	50	CW	20	SE	20	FDI	10		.		.	.
74	8208181	ICH	Immature	Imm	1156	V	3.9	2012	2006	23	13.4	21	14.5	35	11.0	1254	11.8	10.5	PLI	45	EP	25	FDI	20	LW	10		.		.	1.0
75	8072071	ESSF	Immature	Imm	1156	V	16.0	2012	2006	35	7	35	7	35	7.0	3384	.	.	SE	60	BL	20	CW	20		.		.		.	.
76	8071694	ICH	Immature	Imm	1156	V	30.4	2012	2006	33	5.2	33	6	50	7.0	3490	.	.	SE	60	BL	25	CW	10	HW	5		.		.	.
77	8209349	ESSF	Immature	Imm	1156	V	25.5	2012	2006	37	8.4	37	6.6	10	3.7	484	6.2	2.6	SE	60	HW	20	BL	10	CW	10		.		.	.
78	8064430	ESSF	Immature	Imm	1156	V	26.2	2012	2006	46	18.3	46	18.4	65	31.4	1817	13.3	15.1	FDI	40	HW	30	CW	20	SE	10		.		.	.
80	8073650	ICH	Immature	Imm	1156	V	24.0	2012	2006	36	14.7	36	13.9	60	47.9	8245	12.4	26.9	CW	40	EP	30	HW	20	FDI	10		.		.	.
81	8073211	ICH	Immature	Imm	1156	V	13.0	2012	2006	24	3.9	24	7.1	70	0.0	5856	.	.	SE	55	HW	25	CW	20		.		.		.	.
82	8605332	ESSF	Immature	Imm	1156	V	174.9	2012	2006	42	6.3	42	6.5	50	5.0	2838	.	.	BL	70	SE	20	PLI	10		.		.		.	.
84	7917646	ESSF	Immature	Imm	1156	V	31.1	2012	2006	48	2.5	48	2.6	20	0.0	3806	.	.	BL	80	SE	10	HW	10		.		.		.	.
85	8074669	ICH	Immature	Imm	1156	V	17.2	2012	2006	43	8.5	43	8.8	65	7.2	716	8.4	17.1	FDI	40	CW	40	EP	20		.		.		.	.
86	8075169	ICH	Immature	Imm	1156	V	14.7	2012	2006	20	4.9	20	4.2	40	0.0	3147	.	.	LW	40	FDI	20	HW	10	CW	10	EP	10	AT	10	.
87	8844980	ICH	Immature	Imm	1156	V	49.8	2012	2006	23	6.1	23	4	50	0.0	15036	.	.	FDI	40	HW	30	CW	30		.		.		.	.
88	8833084	ESSF	Immature	Imm	1156	V	142.9	2012	2005	39	8.6	43	5.5	20	3.2	414	5.7	3.6	BL	80	SE	20		.		.		.		.	.
89	8056648	ICH	Immature	Imm	1156	V	19.8	2012	2005	19	3.2	19	2.1	30	1.0	7717	.	.	PLI	40	CW	20	BL	20	LW	10	HW	10		.	.
90	8832982	ESSF	Immature	Imm	1156	V	58.2	2012	2005	16	1.5	24	4.7	2	0.0	1067	.	.	SE	90	BL	10		.		.		.		.	.
91	8830521	ESSF	Immature	Imm	1156	V	83.9	2012	2005	36	7	36	6.1	20	1.0	1576	.	.	BL	57	SE	30	PA	13		.		.		.	.

SAMPLE	FEATURE_ID	BEC	Stratum 1	Stratum 3	Sample weight	inventory standard	Polygon area (ha)	Measurement year (for projections)	Reference Year	Projected Age sp1	Projected Height sp1	Projected Age sp2	Projected Height sp2	Input CC%	Projected BA7.5	Projected TPH7.5	Lorey height (m)	Volume NWB 12.5 (m^3/ha)	sp01	pct1	sp02	pct2	sp03	pct3	sp04	pct4	sp05	pct5	sp06	pct6	Dead Volume (m^3/ha)
92	7932310	ICH	Immature	Imm	1156	V	14.6	2012	2005	21	7.9	21	12.6	30	4.2	357	8.9	8.6	FDI	40	EP	40	CW	20	.	.	.	.	.
93	8054430	ICH	Immature	Imm	1156	V	180.1	2012	2005	30	10	27	12.1	50	5.1	767	7.6	1.9	SE	90	CW	10	.	.	.	.	.	.	.
94	8832807	ICH	Immature	Imm	1156	V	106.8	2012	2005	37	5.1	37	5.2	25	0.0	800	.	.	PLI	80	FDI	20	.	.	.	.	.	.	.
95	8828750	ICH	Immature	Imm	1156	V	41.0	2012	2006	36	4	36	4.3	15	0.0	500	.	.	BL	90	SE	10	.	.	.	.	.	.	.
96	7310828	ICH	Immature	Imm	1156	V	16.4	2012	2006	36	13.5	36	13.6	40	17.8	1829	9.8	30.1	FDI	60	HW	20	CW	20	.	.	.	.	.
97	8820570	ICH	Immature	Imm	1156	V	136.1	2012	2005	37	18.7	37	18.3	60	40.3	1787	18.5	52.8	HW	25	CW	25	FDI	25	SE	15	AT	10	.	.
98	8820364	ICH	Immature	Imm	1156	V	61.8	2012	2005	27	7.6	27	4.8	10	4.4	479	5.2	2.7	FDI	30	HW	30	CW	20	AT	20	.	.	.	.
99	8825872	ESSF	Immature	Imm	1156	V	22.5	2012	2006	21	3	21	3	30	0.0	1500	.	.	SE	60	BL	40	.	.	.	.	.	.	.
100	8814875	ESSF	Immature	Imm	1156	V	70.4	2012	2006	46	8.8	.	.	10	2.9	429	6.7	1.5	SE	100	.	.	.	.	.	.	.	.	.
232	8210891	ICH	Immature	Imm	1156	V	24.8	2012	2005	17	5.5	17	2.2	40	0.0	1076	.	.	PLI	70	SE	30	.	.	.	.	.	.	.
261	8849843	ESSF	Immature	Imm	1156	V	23.6	2012	2006	23	2.5	.	.	20	0.0	1470	.	.	SE	100	.	.	.	.	.	.	.	.	.
265	8074917	ESSF	Immature	Imm	1156	V	29.6	2012	2006	25	2.9	25	5.8	40	0.0	8120	.	.	SE	60	FDI	30	BL	10	.	.	.	.	.
519	8821406	ESSF	Mature	S	11151	V	6.2	2012	2005	207	18.4	187	16.6	25	15.0	373	12.3	64.8	SE	40	BL	40	HW	20	.	.	.	.	.
532	8283273	ESSF	Mature	B	11141	V	53.8	2012	2005	87	16.3	87	17.4	15	13.5	294	11.4	63.2	BL	80	SE	20	.	.	.	.	.	.	.

8. Appendix B: Phase II compiled ground attributes

Table 15. The Phase II compiled ground attributes are given.

Sample	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
1	Bl 100	26.6	659	18.3	177.0
2	Bl 75 La 25	11.2	613	8.7	37.5
3	Bl 100	2.8	127	6.2	12.3
4	Bl 87 Se 13	26.0	957	7.9	128.2
6	Bl 81 Se 19	28.8	786	16.7	178.4
7	Se 38 Bl 29 Pw 25 Pl 08	22.0	1399	12.0	70.6
8	Bl 79 La 14 Se 07	31.2	661	19.3	200.5
9	Bl 80 Pl 13 Pa 07	14.0	274	15.6	79.2
10	Bl 60 Se 40	17.5	211	16.3	122.2
11	Bl 71 Se 21 Cw 08	16.8	246	11.7	113.8
12	Bl 89 Se 11	25.2	888	17.3	133.3
13	Bl 65 Se 35	36.0	1231	21.4	217.3
14	Bl 73 Se 27	52.8	2230	15.8	282.7
15	Bl 62 Se 38	31.2	870	20.1	190.0
16	Fd 50 Bl 21 Hw 13 Pl 08 Lw 08	43.2	1296	20.9	246.8
17	Fd 89 Ep 11	25.2	594	18.2	170.1
18	Pl 25 Fd 25 Ep 25 Sx 13 Lw 12	11.2	298	15.0	53.1
19	Hw 43 Lw 34 Cw 14 Pw 03 Fd 03	43.4	1908	21.7	223.5
20	Hw 52 Bl 22 Lw 13 Sx 09 Cw 04	55.2	2780	16.3	247.3
21	Hw 45 Lw 18 Pl 18 Cw 09 Bl 10	11.2	1028	7.9	15.0
22	Fd 93 Pl 07	33.6	671	28.7	240.2
23	Lw 44 Fd 22 Sx 11 Bl 11 Pl 12	12.6	589	17.8	64.9
24	Fd 43 Cw 17 Py 13 Lw 09 Bg 04	41.4	729	25.5	307.6
25	Fd 48 Cw 40 Lw 08 Pl 04	30.8	592	17.7	190.3
26	Fd 55 Hw 28 Cw 17	69.6	2568	24.1	464.8
27	Hw 61 Cw 22 Fd 11 Sx 04 Pw 02	68.6	2321	23.5	379.2
28	Lw 67 Pl 11 Ep 11 Fd 06 At 05	32.4	847	23.9	215.9
29	Fd 75 Lw 18 Bg 07	37.8	300	25.4	317.7
30	Fd 38 Cw 35 Hw 18 Lw 09	81.6	869	28.5	595.6
31	Fd 43 Cw 29 Bl 14 At 14	16.8	57	25.5	153.5
33	Se 45 Pl 36 Hw 09 At 10	15.4	289	14.4	87.1
34	Se 57 Bl 43	25.2	227	30.5	224.0
35	Hw 52 Cw 28 Sx 14 Bl 06	60.0	1869	19.9	386.0
36	Bl 56 Se 41 Cw 03	48.6	469	31.6	443.2
37	Bl 44 Hw 41 Sx 06 Lw 06 Cw 03	76.8	2709	16.7	379.1
38	Se 60 Bl 40	24.0	263	31.4	219.7
39	Pl 38 Bl 33 Se 29	24.0	1161	13.8	113.9
40	Pl 60 Bl 30 Se 07 Fd 03	26.6	2666	11.6	69.5
41	Pl 63 Bl 16 Lw 16 Fd 05	34.2	1413	14.6	156.3
42	Pl 83 Fd 08 Lw 09	12.0	422	15.9	64.8
43	Pl 100	12.6	264	19.0	76.8
44	Pl 45 Sx 28 Lw 24 Cw 03	40.6	1156	23.8	242.4
45	Bl 42 Hw 42 Se 16	57.6	1942	16.2	307.0
46	Hw 67 Cw 17 Tw 16	60.0	1210	13.8	300.5
47	Cw 36 Fd 23 Lw 23 Hw 14 Bl 04	29.4	817	23.9	176.8
48	Hw 70 Cw 26 Bl 04	48.0	588	25.4	330.7

Sample	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
49	Fd 40 Cw 40 Sx 08 Bl 08 Hw 04	60.0	495	25.6	494.8
50	Bg 32 Hw 29 Cw 19 Lw 10 At 06	55.8	1386	31.9	379.2
51	Se 60 Bl 40	0.3	25	.	0.3
52	Se 64 Bl 30 Cw 06 Pw tr	23.6	2552	7.7	27.6
53	Sx 63 Bl 23 Cw 08 Hw 04 Pw 02	16.0	1176	.	29.7
54	Se 78 Bl 22	10.5	700	.	23.7
55	Hw 46 Bl 37 Cw 10 Pw 07	6.1	400	.	17.6
56	Pl 58 Lw 25 Sx 13 Fd 02 Pw 02	11.3	926	9.0	19.4
57	Pl 91 Se 05 Bl 04	18.4	976	7.5	37.8
58	Pl 100	28.0	1951	12.9	74.7
59	Sx 93 Bl 07	26.7	876	12.2	107.0
60	Pl 84 Sx 14 Bl 02	6.4	650	.	2.9
61	Fd 42 Pl 35 Lw 18 Bg 04 Ac 01	25.7	2126	9.8	65.4
62	Sx 80 Bl 08 Pw 06 Ac 04 Pl 01	32.6	1551	10.3	103.0
64	Bl 54 Se 46	6.9	325	8.3	20.5
65	Se 100	7.5	876	.	4.4
66	Se 100	0.0	0	.	0.0
67	Bl 50 Se 40 Pl 10	21.4	2076	.	32.0
68	Pl 100	0.9	25	7.9	9.1
70	Se 100	0.0	0	.	0.0
71	Pl 60 Fd 30 Lw 05 Ep 03 Sx 02	11.7	1026	7.4	9.5
72	Pl 51 Lw 26 Sx 17 Bl 06	9.8	901	.	10.6
73	Hw 82 Cw 10 Bl 04 Sx 04	24.7	1376	9.2	80.0
74	Ep 62 Sx 31 Pl 07	3.4	300	8.3	5.1
75	Se 78 Cw 13 Bl 09	16.9	675	.	60.7
76	Sx 54 Hw 14 Bl 14 Cw 11 Pw 07	4.2	400	.	6.1
77	Cw 37 Bl 25 Hw 24 Se 14	13.6	725	7.8	35.2
78	Hw 62 Cw 19 Bl 15 Se 04	24.5	725	11.9	138.8
80	Pl 32 Fd 29 Cw 26 Ep 09 Bg 02	25.9	1701	11.8	90.7
81	Hw 33 Pw 30 Cw 23 Ep 07 Fd 04	16.7	1226	.	60.6
82	Bl 80 Se 14 Fd 03 Hw 02 Lw 01	24.8	801	.	114.4
84	Cw 45 Bl 25 Hw 20 Sx 10	17.3	625	.	69.5
85	Fd 44 Cw 29 Ep 12 Hw 08 Ac 06	18.2	1476	9.4	58.9
86	Lw 71 Hw 08 Fd 07 Sx 06 Cw 05	11.2	926	.	15.1
87	Fd 72 Cw 12 Lw 09 Sx 04 Hw 03	4.9	125	.	29.5
88	Bl 53 Se 47	22.7	1251	9.3	69.9
89	Cw 67 Pl 17 Ep 11 Bl 02 Fd 03	1.8	325	.	0.0
90		0.0	0	.	0.0
91	Se 100	0.2	25	.	0.0
92	Cw 43 Fd 42 Ep 13 Pl 02	10.5	951	8.5	12.3
93	Sx 90 Ac 07 Cw 02 Ep 01	14.9	1101	8.6	26.3
94	Fd 64 Cw 32 Ep 03 Sx 01	23.5	1076	.	135.8
95	Fd 100	7.4	400	.	21.0
96	Cw 56 Hw 41 Tw 03	50.2	350	16.7	525.8
97	Cw 48 Hw 29 Sx 10 Bl 07 Fd 06	9.9	801	8.2	20.6
98	Fd 96 Pw 03 Hw 01	19.2	926	11.9	66.1
99	Se 51 Pl 27 Bl 22	1.0	125	.	0.0
100	Bl 73 Se 27	12.4	1226	5.8	9.9
232	Se 56 Pl 44	0.2	25	.	0.0

Sample	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
261	Se 100	2.4	425	.	0.0
265	Se 93 Fd 07	0.0	0	.	0.0
519	Hw 42 Bl 33 Cw 17 Se 08	28.8	699	21.2	200.9
532	Bl 92 Hm 08	11.0	365	11.3	54.6

9. Appendix C: Scatterplots to find potential outliers

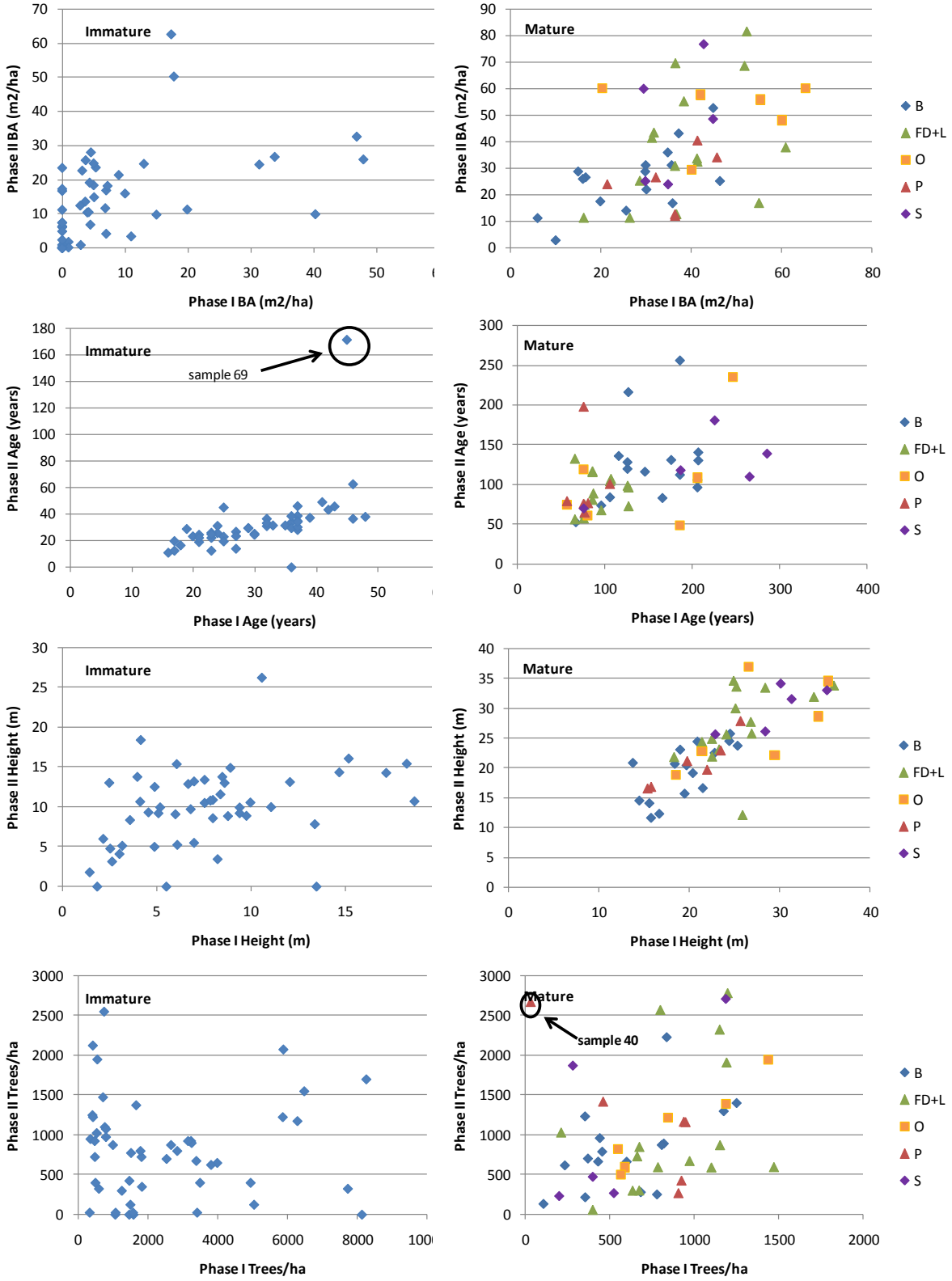

Figure 3. The Phase I inventory and Phase II Ground data are plotted for the seven attributes of interest. Potential outliers are identified.

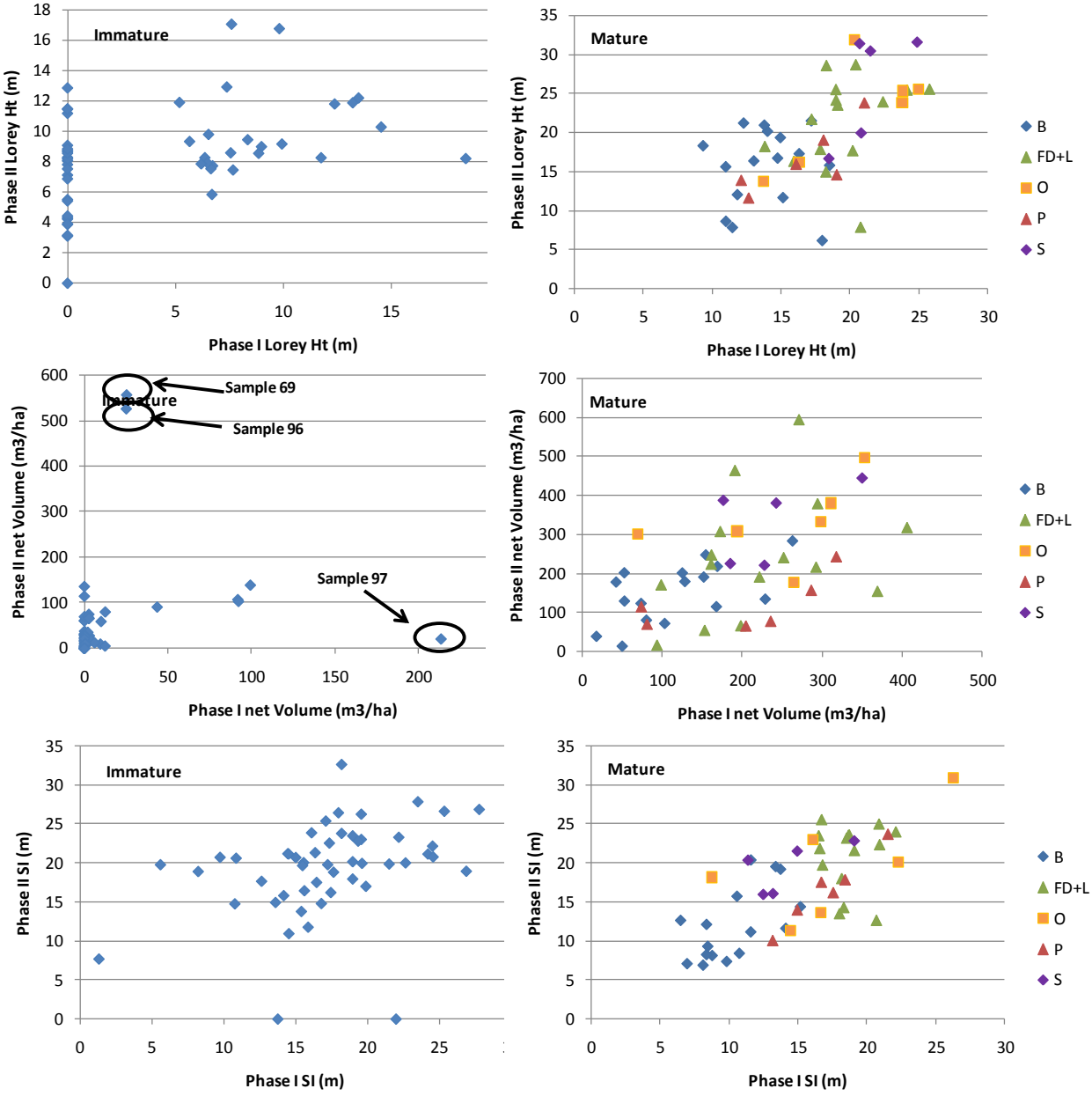

Figure 3 (cont.)

10. APPENDIX D: 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 16. 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 17. The results of matching the Phase I inventory and Phase II ground heights and ages.

Sample	Phase II (ground) leading species attributes					Phase I (Inventory)				
	Species @ 4cm DBH	Mean		Sample size		Leading species	Secondary species	Case of match	Age for match	Height for match
		Age[3]	Height[4]	Age[5]	Height[6]					
1	Bl	216	20.8	5	5	BL		1	127	13.8
2	Bl	131	14.5	5	5	BL	SE	1	176	14.5
3	Bl	96	23.7	5	5	BL	LA	1	206	25.3
4	Bl	120	12.3	5	5	BL	SE	1	126	16.7
6	Bl	105	19.1	5	5	BL	SE	1	206	20.4
7	Se	53	11.6	5	5	BL	SE	2	77	18.8
8	Bl	140	16.6	5	6	BL	LA	1	207	21.5
9	Bl	116	14.0	5	5	BL	SE	1	146	15.6
10	Bl	112	15.7	4	4	BL		1	186	19.5
11	Bl	84	24.4	5	5	BL	SE	1	106	20.9
12	Bl	136	22.5	5	5	BL	PLI	1	116	22.8
13	Bl	256	24.5	5	5	BL	SE	1	186	24.4

[3] Age = age_tlxo
[4] Height = ht_tlxo
[5] Sample size for age = n_age_tlxo
[6] Sample size for height = n_ht_tlxo

Sample	Phase II (ground) leading species attributes					Phase I (Inventory)				
	Species @ 4cm DBH	Mean Age[3]	Mean Height[4]	Sample size Age[5]	Sample size Height[6]	Leading species	Secondary species	Case of match	Age for match	Height for match
14	Bl	83	25.7	5	5	BL	SE	1	166	24.5
15	Bl	128	20.4	5	5	BL	SE	1	126	19.7
16	Fd	74	23.0	5	5	BL	SE	3	96	19.0
17	Fd	56	21.8	5	5	FDI		1	66	18.3
18	Pl	58	23.1	5	6	LW	PLI	2	76	21.9
19	Hw	75	24.4	2	2	LW	PLI	3	77	21.4
20	Hw	132	21.9	5	5	LW	CW	3	66	22.5
21	Hw	68	12.1	5	5	LW	FDI	3	96	25.9
22	Fd	81	30.0	5	5	LW	FDI	2	86	24.1
23	Lw	63	24.9	5	5	LW	PLI	1	77	22.5
24	Fd	107	34.6	5	6	FDI	LW	1	107	24.9
25	Fd	104	25.7	5	5	FDI		1	106	26.9
26	Fd	73	27.7	5	5	FDI	HW	1	127	26.8
27	Hw	117	25.6	5	5	FDI	LW	3	86	24.1
28	Lw	89	33.5	5	5	LW	PLI	1	87	28.4
29	Fd	99	31.9	5	5	FDI	CW	1	126	33.8
30	Fd	116	33.6	5	5	FDI	HW	1	86	25.2
31	Fd	96	33.8	3	3	FDI	BL	1	127	36.0
33	Se	45	11.3	1	1	SE	FDI	1	76	17.5
34	Se	181	31.5	5	5	SE	BL	1	226	31.3
35	Hw	118	26.1	5	5	SE	BL	3	187	28.4
36	Bl	110	33.0	5	5	SE	BL	2	246	32.2
37	Bl	70	25.6	5	5	SE	FDI	3	76	22.9
38	Se	139	34.1	5	5	SE	BL	1	286	30.1
39	Pl	198	16.8	5	6	PLI	BL	1	76	15.8
40	Pl	80	16.6	5	5	PLI		1	57	15.4
41	Pl	101	22.9	5	5	PLI		1	106	23.5
42	Pl	77	21.1	5	5	PLI	BL	1	76	19.8
43	Pl	66	19.7	5	6	PLI	FDI	1	77	22.0
44	Pl	77	27.8	5	5	PLI	LW	1	81	25.7
45	Bl	119	22.8	5	5	HW	CW	3	76	21.4
46	Hw	49	18.8	1	1	HW	SE	1	186	18.5
47	Cw	61	22.1	4	4	HW	LW	3	80	29.4
48	Hw	235	28.6	5	6	HW	CW	1	246	34.2
49	Fd	108	34.6	5	5	HW	CW	3	206	35.3
50	Bg	75	37.0	5	5	HW	CW	3	57	26.5
51	Se	31	5.0	2	2	SE	BL	1	32	4.9
52	Se	35	10.0	2	4	SE	BL	1	37	9.1
53	Sx	37	10.9	3	4	SE	BL	1	32	8.0
54	Se	25	9.1	4	4	SE	BL	1	30	6.0
55	Hw	45	12.9	2	2	HW	BL	1	25	6.7
56	Pl	28	10.0	2	5	SE	PLI	2	37	12.3
57	Pl	33	8.6	2	4	PLI		1	32	8.0
58	Pl	30	14.9	3	5	PLI		1	29	8.9
59	Sx	39	14.3	4	5	LW	SE	2	37	14.5
60	Pl	20	9.3	3	4	PLI	LW	1	17	4.6
61	Fd	27	10.5	4	4	FDI	PLI	1	27	7.6
62	Sx	35	16.1	2	4	CW	SE	2	37	19.7
64	Bl	35	9.2	4	4	SE	BL	2	37	7.2

Sample	Phase II (ground) leading species attributes					Phase I (Inventory)				
	Species @ 4cm DBH	Mean		Sample size		Leading species	Secondary species	Case of match	Age for match	Height for match
		Age[3]	Height[4]	Age[5]	Height[6]					
65	Se	26	8.4	3	5	SE	BL	1	24	3.4
66	Se	17	.	0	1	SX	BL	1	18	.
67	Bl	30	10.7	4	4	SE	PLI	3	29	8.0
68	Pl	14	3.5	2	2	PLI	BL	1	27	8.3
70	Se	19	3.2	2	2	SE		1	21	2.5
71	Pl	23	8.9	2	4	PLI	CW	1	25	9.8
72	Pl	22	9.7	3	3	PLI	SE	1	23	6.8
73	Hw	49	13.2	4	5	HW	CW	1	41	12.1
74	Ep	13	7.9	4	4	PLI	EP	2	21	14.5
75	Se	32	13.2	4	4	SE	BL	1	35	7.0
76	Sx	32	10.0	3	3	SE	BL	1	33	5.2
77	Cw	46	11.6	1	2	SE	HW	3	37	8.4
78	Hw	37	15.5	2	2	FDI	HW	2	46	18.4
80	Pl	34	14.4	3	4	CW	EP	3	36	14.7
81	Hw	31	18.4	3	3	SE	HW	2	24	7.1
82	Bl	43	15.4	4	5	BL	SE	1	42	6.3
84	Cw	38	13.1	4	4	BL	SE	3	48	2.5
85	Fd	46	13.8	4	4	FDI	CW	1	43	8.5
86	Lw	23	12.5	5	5	LW	FDI	1	20	4.9
87	Fd	26	5.3	2	2	FDI	HW	1	23	6.1
88	Bl	37	13.0	3	4	BL	SE	1	39	8.6
89	Cw	29	5.1	3	3	PLI	CW	2	19	2.1
90		11	1.8	1	1	SE	BL	5	.	.
91	Se	30	5.5	1	1	BL	SE	2	36	6.1
92	Cw	25	10.8	5	5	FDI	EP	3	21	7.9
93	Sx	25	10.6	4	4	SE	CW	1	30	10.0
94	Fd	30	9.2	4	4	PLI	FDI	2	37	5.2
95	Fd	39	13.8	2	2	BL	SE	3	36	4.0
96	Cw	.	.	.	.	FDI	HW	3	.	.
97	Cw	34	10.7	4	4	HW	CW	2	37	18.3
98	Fd	24	13.4	4	4	FDI	HW	1	27	7.6
99	Se	22	6.0	3	3	SE	BL	1	21	3.0
100	Bl	63	8.9	3	4	SE		3	46	8.8
232	Se	13	.	0	1	PLI	SE	2	17	.
261	Se	25	4.8	4	5	SE		1	23	2.5
265	Se	20	4.1	2	2	SE	FDI	1	25	2.9
519	Hw	130	20.7	4	4	SE	BL	3	207	18.4
532	Bl	145	15.0	5	5	BL	SE	1	87	16.3

11. Appendix E: Scatterplots and residuals

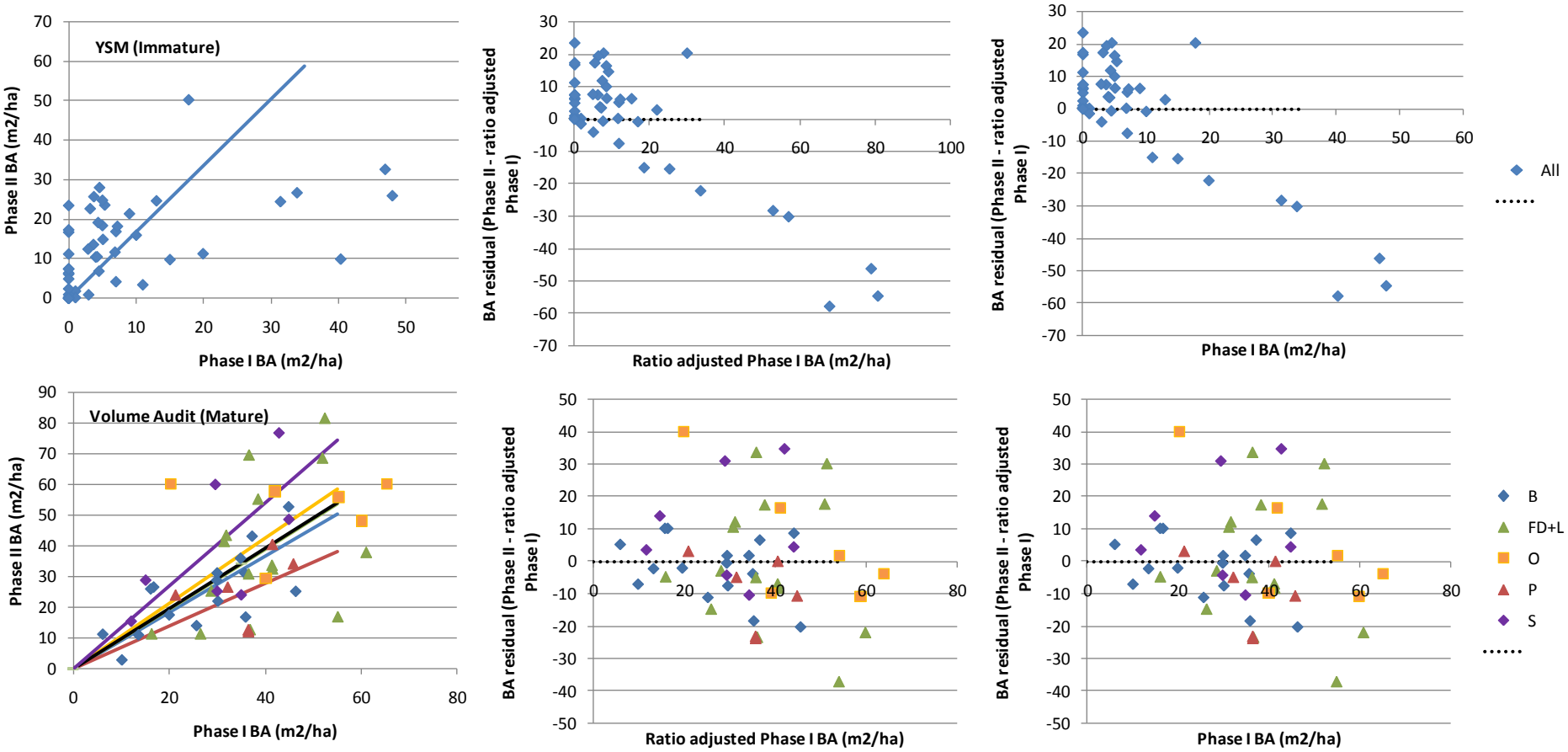

Figure 4. The scatterplots for BA are given. The top left graph gives the Phase I photo and Phase II ground estimates of basal area for the YSM (Immature) stratum with a line representing the ratio. The top middle graph plots the residuals against the adjusted Phase I BA. The top right graph plots the 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). The bottom graphs are similar except in the bottom left, the ratios are given by leading species. The black line is the ratio for all Volume Audit (mature) samples.

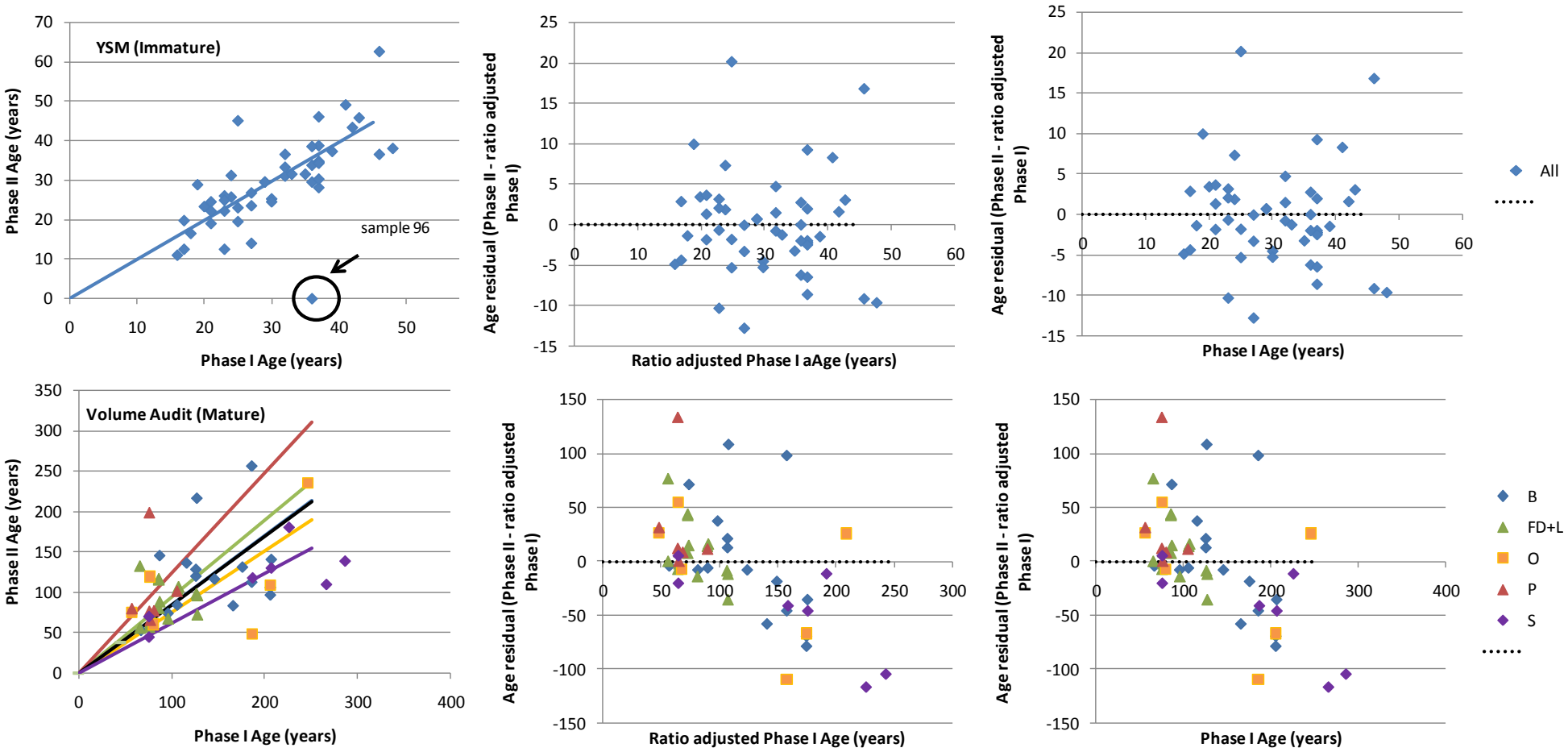

Figure 5. The scatterplots for Age are given.

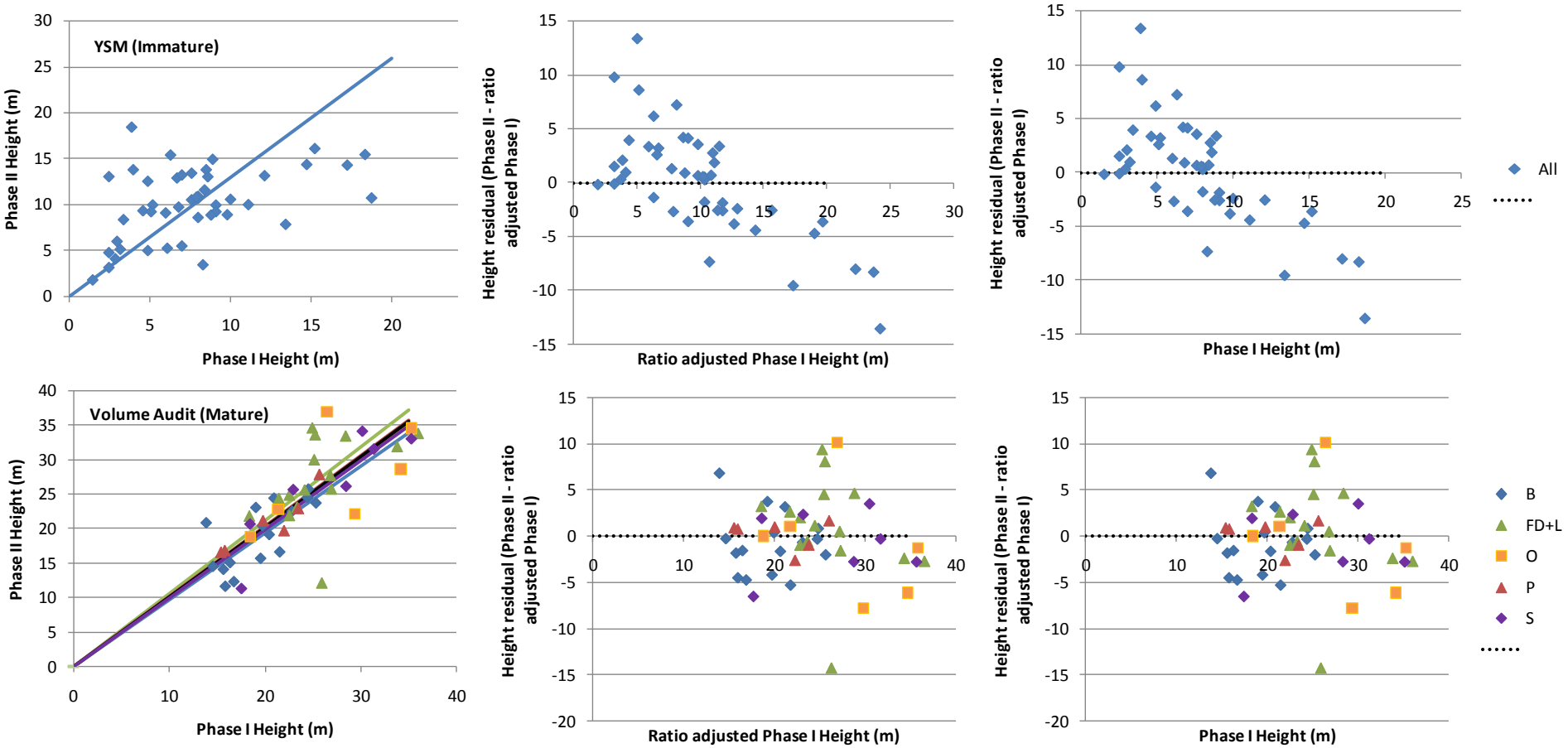

Figure 6. The scatterplots for Height are given.

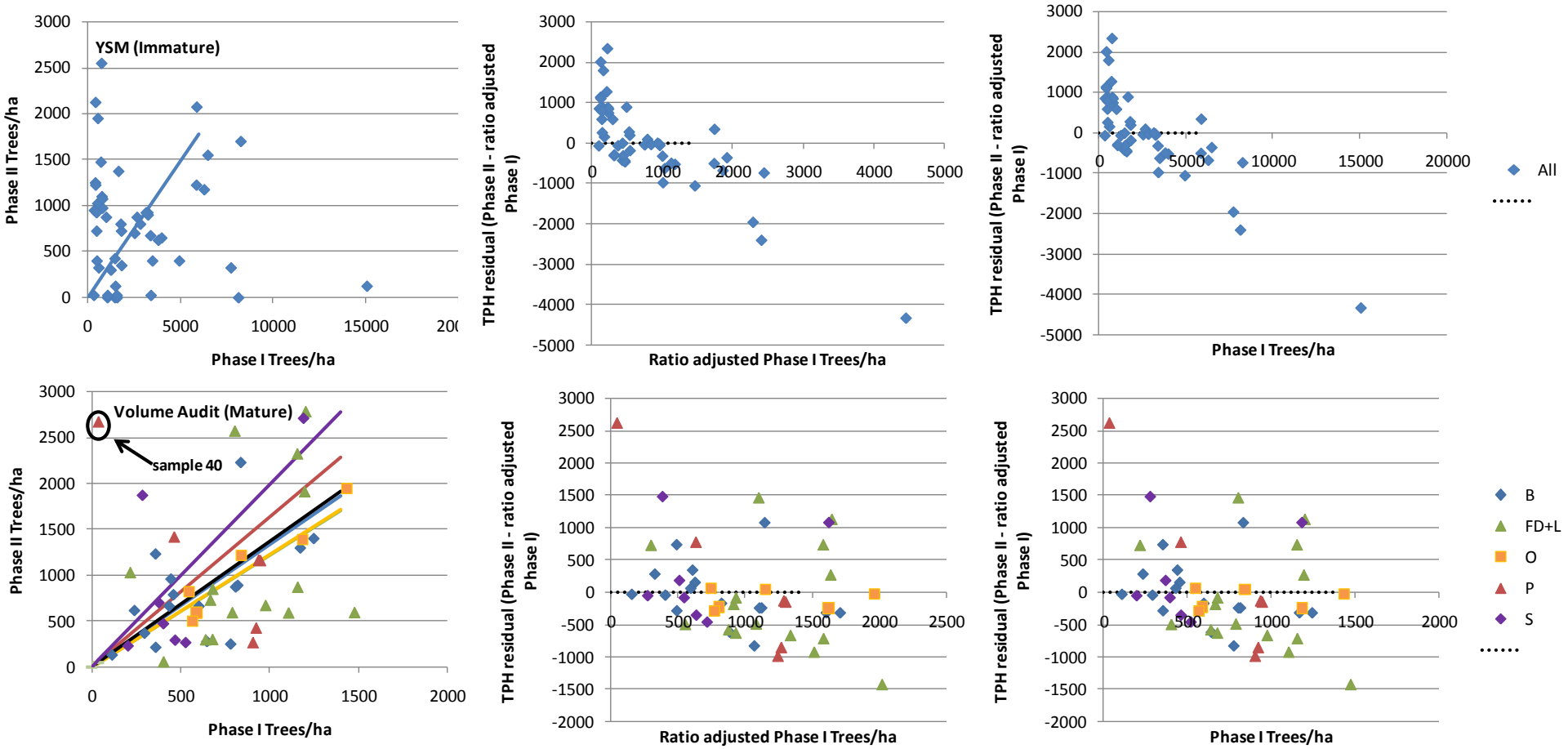

Figure 7. The scatterplots for Trees/ha are given.

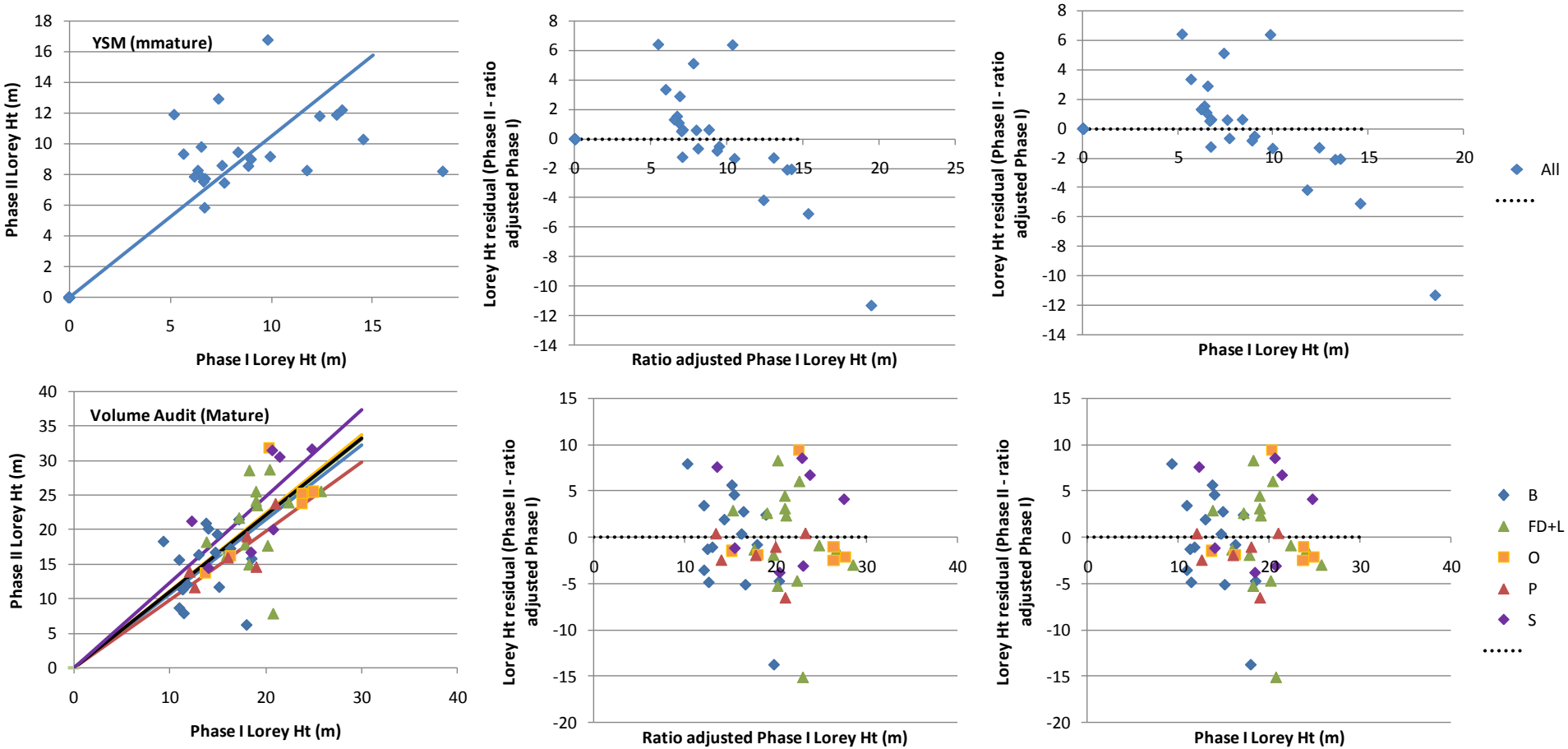

Figure 8. The scatterplots for Lorey height are given. In the YSM (Immature) stratum, 26 of 49 plots had missing values for Phase I Lorey height.

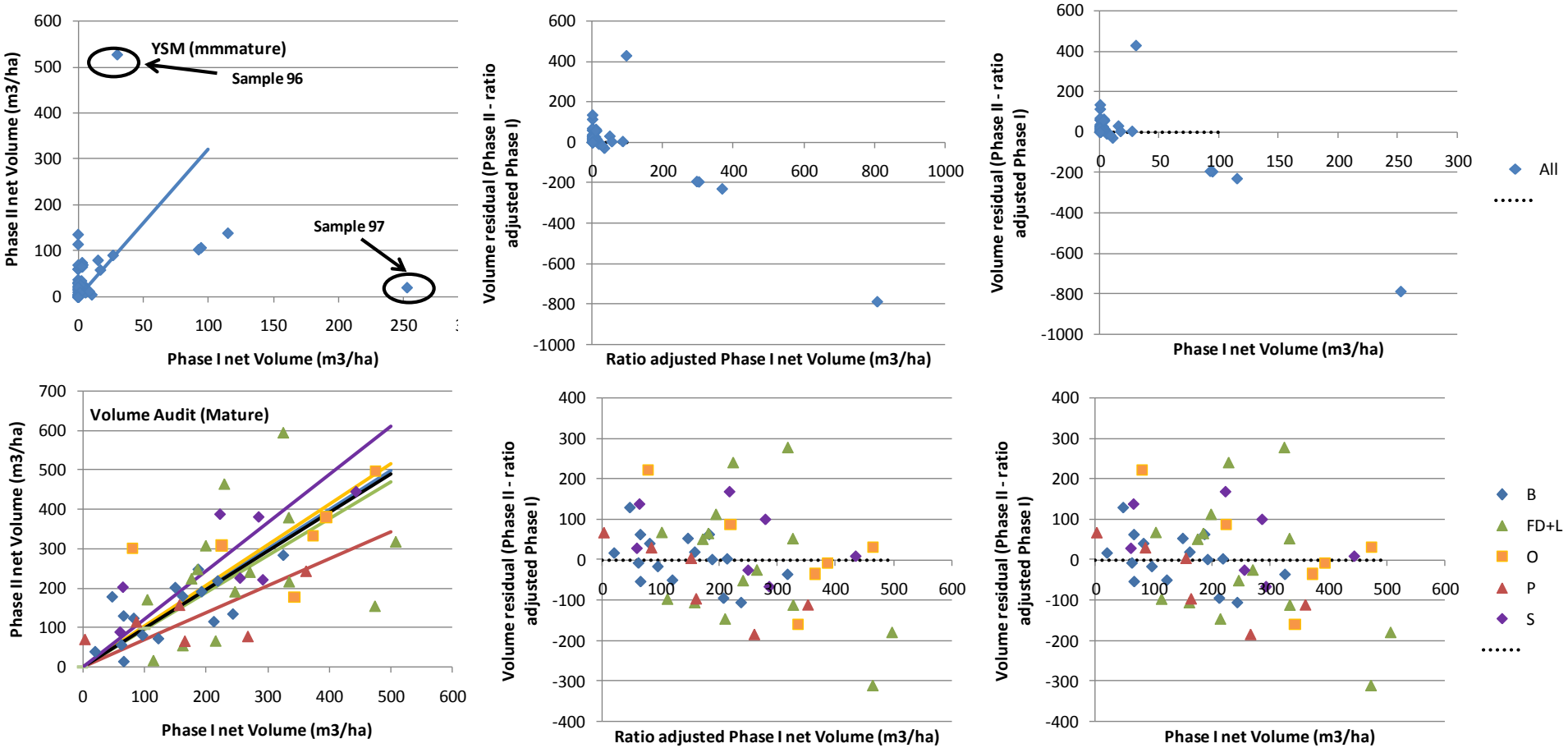

Figure 9. The scatterplots for Volume net of decay, waste and breakage are given.

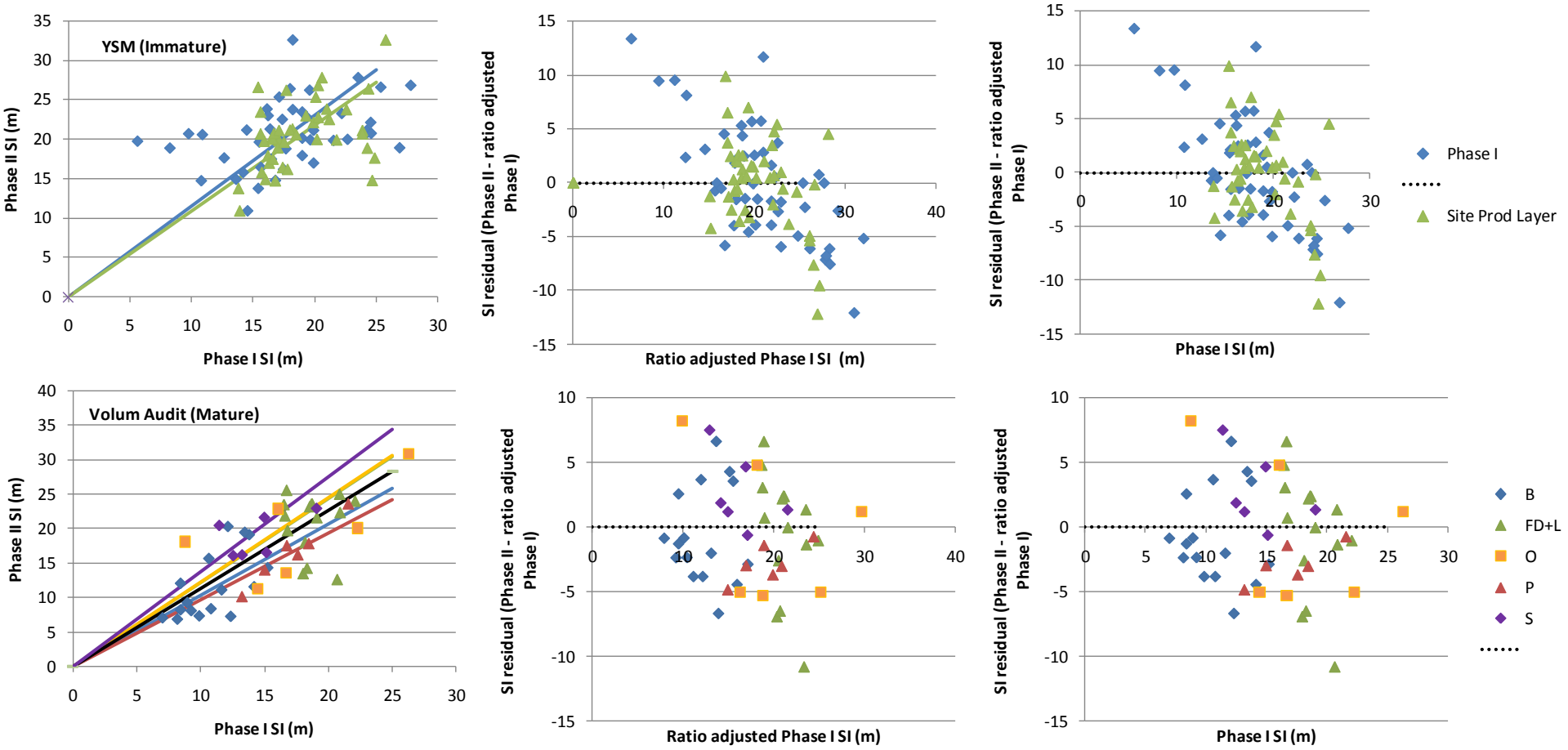

Figure 10. The scatterplots for Site index are given. For the YSM (immature) population, the Phase I VRI site index estimates are given as well as the estimates from the site productivity layer.

12. Appendix F: Graphs of total volume bias, model bias and attribute bias.

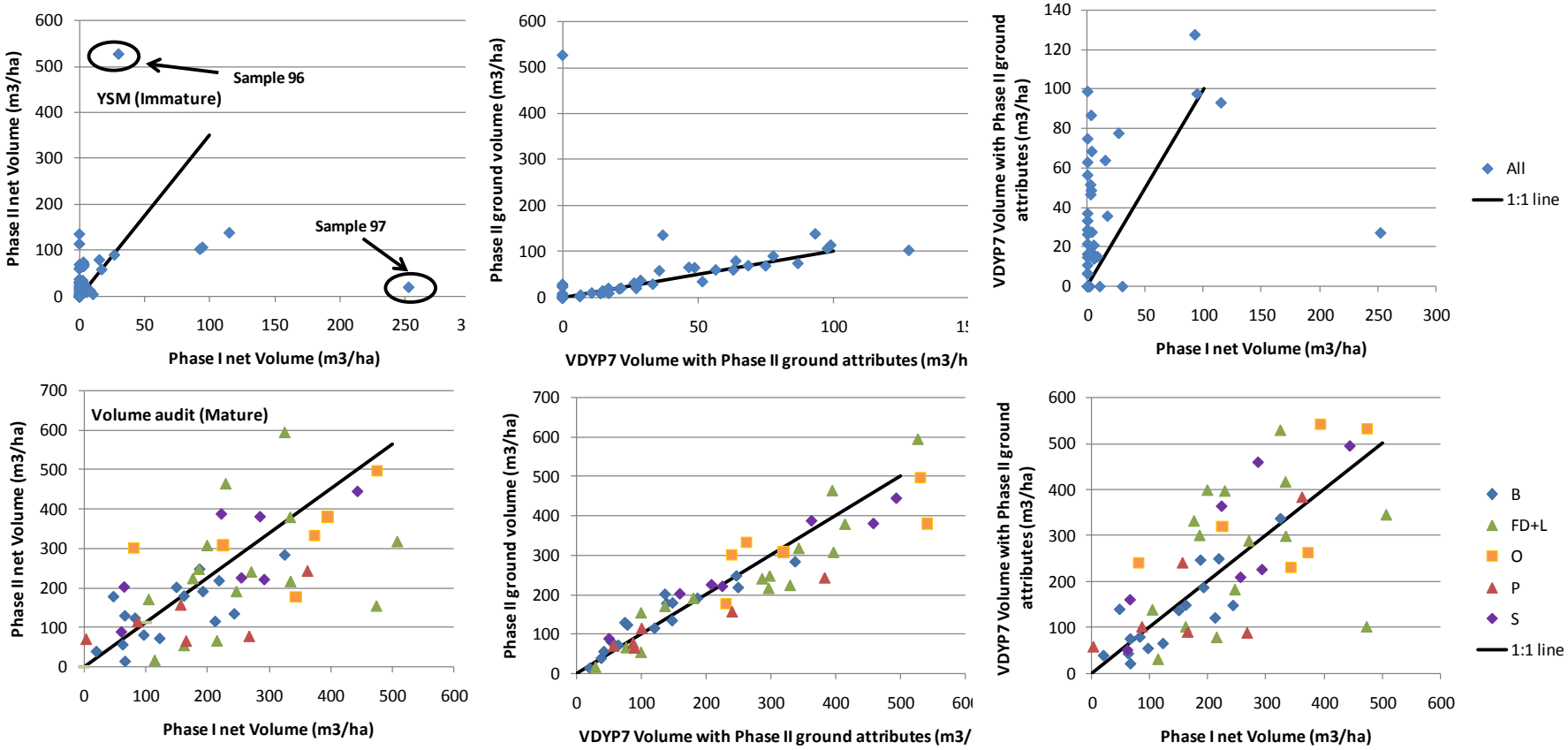

Figure 11. The left column of graphs illustrates the total volume error (Phase I vs. Phase II volume). There are two potential sources of volume error in Phase I. First, the attributes fed into VDYP7 could be incorrect (attributed-related volume error). Second, the volume estimation routines in VDYP7 could be biased (model-related volume error). Total volume error = attribute-related volume error + model-related volume error. The centre column of graphs 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 right column of graphs 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. In the YSM (immature) stratum, 27 of 49 plots were short and the VDYP7 volumes were missing and set to zero.