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**TFL18**

**Documentation of  
Vegetation Resources Inventory Statistical Analysis**

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

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**Revised November 16, 2012**

## Executive Summary

The objective of this project was to provide an assessment of the accuracy of the Phase I inventory of TFL 18 by completing a VRI statistical analysis of selected Phase I inventory attributes in the target population of interest. The analysis was based on current Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) standards.

Much of the lodgepole pine in TFL 18 has been killed by mountain pine beetle (MPB) and most of the mortality occurred between the Phase I photo acquisition and Phase II ground sampling. Phase I was adjusted using the current BCMPB depletion model.

The analysis focused on seven attributes: age, height, basal area of trees with Dbh  $\geq 7.5$  cm, trees/ha of trees with Dbh  $\geq 7.5$  cm, Lorey height, volume/ha net of decay waste and breakage of trees with Dbh  $\geq 12.5$  cm and site index. The ratios of means are given in Table 1. A ratio greater than 1 indicates that, on average, the Phase I inventory is underestimating an attribute, based on the Phase II ground sample. Similarly, a ratio  $< 1$  indicates overestimation. A ratio close to 1 indicates little bias.

**Table 1.** The ratios of means (Phase II Ground/Phase I Inventory) are given by strata for seven attributes for TFL 18. Shaded cells are associated with small sample sizes

Stratum	Leading species substratum	n	Ratio of weighted means (with 95% sampling error shown as % of the ratio)						
			Age (years)	Height (m)	Basal area (m <sup>2</sup> /ha)	Trees/ha	Lorey height (m)	Volume net dwb (m <sup>3</sup> /ha)	SI (m)
Immature	All	21	1.172 (15.1%)	1.621 (19.8%)	1.311 (51.2%)	0.205 (49.5%)			1.309 (12.8%)
Mature	Balsam	16	1.214 (22.9%)	0.994 (9.5%)	1.14 (14.8%)	1.216 (32.7%)	0.922 (10.9%)	1.204 (16.0%)	0.847 (18.4%)
	Df/pine/oth	14	0.957 (25.1%)	0.904 (10.1%)	0.626 (28.3%)	2.37 (41.3%)	0.788 (14.5%)	0.637 (41.4%)	0.999 (21.3%)
	Spruce	21	1.07 (13.4%)	0.939 (9.2%)	0.742 (21.7%)	1.453 (26.1%)	0.766 (12.7%)	0.650 (25.0%)	0.901 (16.3%)
	Subtotal	51	1.08 (10.8%)	0.942 (5.6%)	0.814 (14.0%)	1.515 (22.0%)	0.821 (7.8%)	0.777 (17.2%)	0.903 (10.5%)

The Phase I volume overestimation is 29% for the mature stratum. Some of this is due to an overestimate of the live pine volume.

For the Df/pine/Oth and spruce substrata, Phase I is overestimating basal area and volume. In contrast, for balsam, Phase I is underestimating basal area and volume. The leading species identification in the Df/Pine/Oth was poor with 1 out of 14 polygons having the same leading species in Phase I and Phase II. The misclassification is likely to affect volume and Lorey height estimates.

There is almost no live pine in the Phase II ground plots and the dead pine volume expressed as a percentage of live volume all species + dead volume pine is higher on the ground plots than in Phase I.

Based on the statistical analysis here, the following recommendations and observations are made.

- The Phase I volume estimates for the mature stratum should be used with caution as they tend to overestimate the volume by approximately 29% and have high sampling errors. The biggest differences are in the Df/pine/Oth substratum and likely due to MPB kill.
- Without the BCMPB adjustment for MPB kill, the volume overestimation would be even higher and the BCMPB should be used. The BCMPB adjustment is restricted to volume and stems/ha.
- The MPB has killed most of the susceptible pine within the TFL but many of the inventory descriptions still include the pine component in the species composition, leading species height and age, basal area and site index. A new Phase I would provide complete post-MPB polygon descriptions.

## **Acknowledgements**

This project was coordinated by Graham Hawkins. Thank you to Bob Krahn, Tim Salkeld and Ed Fong for providing the data. Thank you to Graham Hawkins, Bob Krahn, Mike Clarkson, Sam Otukol, Will Smith, Matt Makar and Chris Mulvihill for contributing to the project. Thank you to Terry Lazaruk (Canfor) for his suggestions for improving the report.

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## 1. Introduction

### 1.1 Background

Details of the ground sample planning for TFL 18 are given in “*Canadian Forest Products Ltd. Tree Farm Licence 18 Vegetation Resources Inventory Project Implementation Plan for Ground Sampling and Net Volume Adjustment Factor Sampling*” (Nona Philips Forestry Consulting 2011) available from the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO).

### 1.2 Description of the Target Population Area

The target population for TFL 18 is the vegetated treed portion of the TFL and the immature and mature strata within this population.

- Mature – 51 years and older, and
- Immature – 15 to 50 years.

The landbase is summarized in Table 1. The majority of the target population (Vegetated treed polygons  $\geq$  15 years old) is dominated by spruce leading polygons (41%), followed by balsam (29%) and then pine (21%) and other species (9%).

**Table 1.** The land base of TFL 18 is summarized.

Land Classification	Area (ha)	% of TFL	% of Vegetated
Total area	74,297	100%	
Non-vegetated	1,411	2%	
Vegetated	72,886	98%	
Non-treed	5,187		7%
Treed	67,699		91%

### 1.3 Scope and objectives

The objective of this project was to provide a VDYP7-based VRI statistical analysis for TFL 18, based on current MFLNRO standards (FAIB 2011) and the Churlish (2011a) analysis of Quesnel East. The analysis is based on 72 Phase II samples established in the 2011 field season. Unless otherwise indicated, the attribute values are based on live trees only. The analysis includes examining model and attribute-related components of volume bias.

In addition, the depletions for mountain pine beetle were evaluated.

## 2. METHODS

### 2.1 Overview of VRI Statistical Analysis

The goal of the VRI statistical analysis is to evaluate the accuracy of the Phase I photo-interpreted inventory data using the Phase II ground sample data as the standard for comparison.

The process involves first projecting Phase I inventory data to the year of ground sampling using the VDYP7 growth model. The Phase I inventory data corresponding to the Phase II ground samples are identified and data screening is undertaken to identify potential data errors and/or inappropriate matching of Phase I and II data. Analysis is usually undertaken at the stratum level, where strata are typically defined by age or leading species. After calculating and applying the appropriate sampling weights, mean values of the ground sample attributes and the corresponding Phase I inventory attributes are computed. The ratio of these two values (i.e. the mean Phase II ground sample value divided by the mean Phase I inventory value) is 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 are an indication of the risk and uncertainty associated with the sampling process.

Seven timber attributes are considered in the current VRI ground sample data analysis:

- Age of the first species,
- Height of the first species,
- Basal area at 7.5 cm+ Dbh utilization (BA7.5),
- Trees per hectare at 7.5 cm+ Dbh utilization (TPH7.5),
- Lorey height at 7.5 cm+ Dbh utilization (LH7.5),
- Volume net top, stump (CU), decay, waste and breakage at 12.5 cm+ Dbh utilization, and
- Site index.

The analysis of model and attribute-related components of volume bias follow the Strathcona TSA analysis by Churlish and Jahraus (2011b).

## **2.2 Population for Analysis**

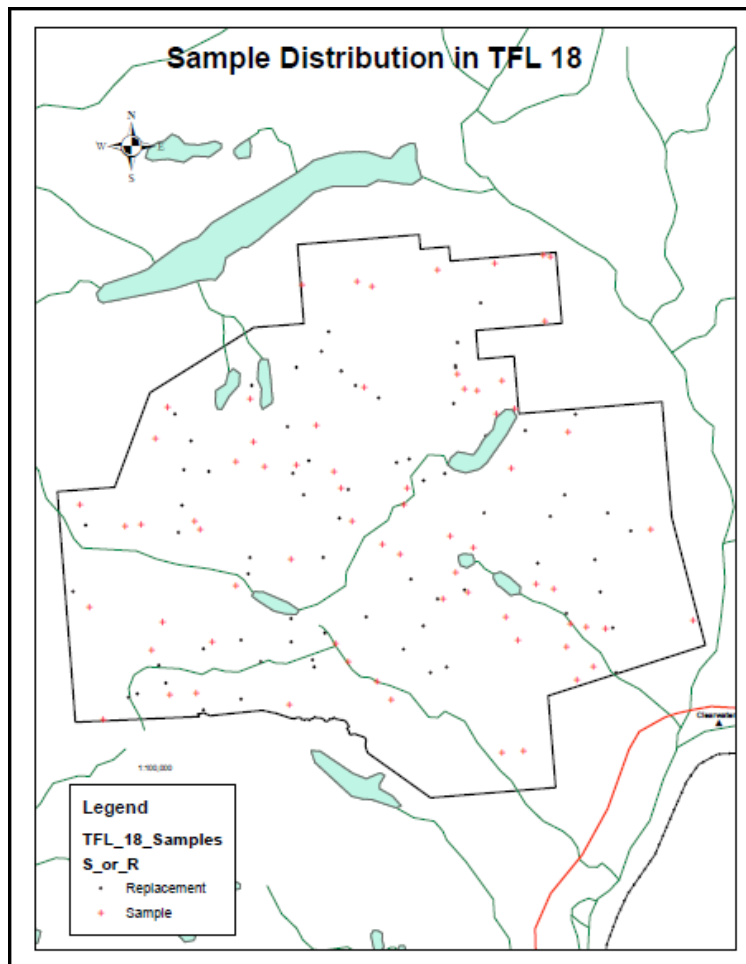
The population of interest for this analysis consists of the vegetated treed polygons, 15 years of age and greater. There were no exclusions made from the TFL 18 land base in deriving the sampling population. The total area of this population of interest was approximately 62,000 ha (see Table 2 for details).

## **2.3 Phase II Sample Selection Pre-Stratification and Weights**

For the sample selection, pre-stratification was carried out based on age groupings: Immature (15-50 years) and mature (greater than 50 years old). Further sub-stratification, by leading species group, was applied in the mature age class to ensure adequate representation of the samples across the target population (Figure 1 and Table 2). Two additional plots were established – samples 55 and 105.

**Table 2.** The sample weights for TFL 18 are given. Two additional ground samples were established.

Land base Age class	Stratum	Area (ha) (A)	% of area	Planned		Actual	
				Number of samples (n)	Weight = A/n	Number of samples (n)	Weight = A/n
Immature	<b>All</b>	<b>14,607</b>		<b>20</b>	730.4	<b>21</b>	695.6
Mature	Spruce	18,368	39%	20	918.4	21	874.7
	Balsam	15,873	34%	16	992.1	16	992.1
	Other	13,009	28%	14	929.2	14	929.2
	<b>Subtotal</b>	<b>47,250</b>	100%	<b>50</b>		<b>51</b>	



**Figure 1.** The locations of the Phase II ground samples are given.

## 2.4 Data Sources

### 2.4.1 Phase I photo-interpreted inventory data

The MFLNRO provided the Phase I data projected to 2011. This projection included the application of the BCMPB depletion algorithm to account for the impact of mountain pine beetle between Phase I and Phase II. Approximately 70% of the population of interest (VT polygons 15 years or older) correspond to the photo acquisition year of 2007 (Table 3). Eighty-six percent of the photos were taken in 2000 or later and 2% are from earlier than 1990.

**Table 3.** The proportion of the population (vegetated trees > 15 years old in 2011) is given, based on area.

Year of photography	Proportion of population
≤ 1969	0%
1970-1979	1%
1980-1989	0%
1990-1999	12%
2000-2006	9%
2007	70%
2008	6%

Loirey height was estimating using VDYP7 Console version 7.7a.33. The leading species site index (SI) was estimated using SiteTools 3.3 and the projected height and age of the leading species. The SI was for the

secondary species was also estimated. In some cases the VDYP7 volume was blank. This only occurred in the immature stratum, generally for short polygons. These blanks were interpreted as zeroes. In some cases the VDYP7 Lorey height was missing. Again, this happened in the immature stratum for short polygons. For Lorey height, blanks were interpreted as missing values.

#### **2.4.2 Phase II ground sample data**

The Phase II ground samples were provided by MFLNRO. All were measured in 2011. The Phase II ground SI was estimated as the average SI of the T, L, X and O trees.

#### **2.4.3 Data issues**

The Phase I data for sample 102 was replaced by data provided by the MFLNRO from silvicultural records. This moved the sample from the mature stratum to the immature stratum. The map\_id for sample 57 was changed from 922P078 to 92P078. The polygon for sample 42 was changed from 4565975 to 45656977.

#### **2.4.4 Height and Age matching**

The data matching followed the FAIB (2011) procedures and standards document. For each VRI sample polygon, the Phase II ground sample data was 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 trees for the ground leading species (by basal area at 4 cm + 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 level, conifer-to-conifer (or deciduous-to-deciduous) matches were allowed. However, conifer-deciduous matches were not considered acceptable. Section 9 (Appendix D) provides the details for the height and age data matching. Section 3.3 provides a comparison between the Phase I inventory leading species and the Phase II ground sample leading species.

Of the 72 samples used in the analysis, 40 (or 56%) had a match between the inventory leading species and the ground leading species at 4 cm+ Dbh utilization (Table 9). A further 23 samples (32%) were matched based on the ground leading and inventory secondary species. Nine (9) samples (the remaining 12%) were matched on a conifer-to-conifer or deciduous-to-deciduous basis. All of the samples were an acceptable match and none were therefore excluded from the development of the age and height comparison ratios.

#### **2.4.5 Site index**

The height and age matching rules were used for site index but only cases 1 and 2 were considered satisfactory matches. That is, if the Phase I and Phase II leading species were the same, the Phase I SI and Phase II leading species SI were matched. Also, if the Phase I leading species and Phase II secondary species were the same, the Phase I SI (leading species) and Phase II secondary species SI were matched. No other cases were considered matches. Therefore, 9 samples were not used.

### **2.5 Analysis of Dead Pine**

Mountain pine beetle (MPB) has caused significant lodgepole pine mortality in TFL 18. TFL 18 is surrounded by the 100 Mile House and Kamloops TSAs for which the peak year of red attack was 2006<sup>1</sup>. The majority of the aerial photography was flown in 2007 but some was earlier and some MPB impact between Phase I and Phase II was anticipated. Unlike the analysis of Churlish (2011a), TFL 18 has been adjusted using the BCMPB model.

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<sup>1</sup> Provincial-level projection for 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 (year 9) by Adrian Walton, BC Forest Service dated Feb 28, 2012.

Usually, the Phase I inventory only assesses live volume. After being adjusted by the BCMPB model, it contains live volume, by species, of all species and dead volume of lodgepole pine. The Phase II ground sample includes live and dead volume by species for all species. Using the Phase II ground data, the following fractions were computed.

- Dead pine expressed as a fraction of live volume of pine + dead volume of pine (PI/PI dead fraction) and
- Dead pine expressed as a fraction of live volume all species + dead volume of pine (PI/(PI + live) fraction).

## **2.6 Intermediate Utilization Balsam**

In Canfor's Vegetation Resource Inventory Strategic Inventory Plan (VSIP, Canfor 2005), residual or intermediate utilization (IU) Balsam stands were defined as Balsam stands created through partial cutting of spruce leading stands from 1945 to 1979 as identified in the Forest Inventory Production (FIP) files available then. JS Thrower and Associates sampled some of these IU Balsam polygons and found species composition in the FIP files was comparable to the ground species composition and that site index and net merchantable volume were underestimated by the FIP inventory. This underestimation was significant but the data were not considered statistically acceptable for timber supply calculations. Although the Phase II sampling is statistically acceptable, based on Phase I only 3 samples meet the IU Balsam definition (Balsam leading with a year of origin from 1945-1979). It is recommended that if there is interest in the Phase I estimates associated with IU Balsam in the current inventory, this be analyzed separately with sampling plan designed specifically to address the IU Balsam questions.

## **3. Results and Discussion**

### **3.1 Attribute bias**

The Phase I inventory and Phase II ground sample weighted means were computed by strata for the seven key attributes identified in section 2.1 and are given in Table 4. The ratios of means were calculated for the same seven attributes and are given in Table 5.

**Table 4.** The weighted means for the Phase I inventory and Phase II ground samples are given for TFL 18. Shading indicates conditions with small sample sizes.

Attribute	Statistic	Immature	Mature			
			Balsam	Df/Pine/Oth	Spruce	Subtotal
Age (years)	n	21	16	14	21	51
	Phase II Ground mean	26.6	136.9	125.6	173.0	147.8
	Phase I inventory mean	22.7	112.8	131.3	161.7	136.9
Height (m)	n	21	16	14	21	51
	Phase II Ground mean	8.1	17.9	24.0	25.1	22.4
	Phase I inventory mean	5.0	18.0	26.5	26.7	23.7
Basal area (m <sup>2</sup> /ha)	n	21	16	14	21	51
	Phase II Ground mean	8.1	28.3	22.7	22.4	24.5
	Phase I inventory mean	6.2	24.9	36.3	30.1	30.1
Trees/ha at 7.5 cm+ Dbh	n	21	16	14	21	51
	Phase II Ground mean	763	1179	1102	738	987
	Phase I inventory mean	3718	970	465	508	651
Lorey height (m)	n	4 <sup>2</sup>	16	14	21	50
	Phase II Ground mean	6.8	15.3	19.2	18.9	17.8
	Phase I inventory mean	8.2	16.6	24.3	24.7	21.9
Volume (m <sup>3</sup> /ha) at 12.5 cm+ Dbh net dwb	n	21 <sup>3</sup>	16	14	21	51
	Phase II Ground mean	12.8	157.3	125.2	153.3	146.9
	Phase I inventory mean	0.9	130.7	196.7	235.7	189.7
SI (m)	n	16	16	8	21	45
	Phase II Ground mean	20.5	10.5	16.0	11.9	12.1
	Phase I inventory mean	15.7	12.4	16.0	13.2	13.4

**Table 5.** The ratios of means (Phase II Ground/Phase I Inventory) are given by strata for TFL 18.

Stratum	Leading species substratum	n	Ratio of weighted means (with 95% sampling error shown as % of the ratio)						
			Age (years)	Height (m)	Basal area (m <sup>2</sup> /ha)	Trees/ha	Lorey height (m)	Volume net dwb (m <sup>3</sup> /ha)	SI (m)
Immature	All	21	1.172 (15.1%)	1.621 (19.8%)	1.311 (51.2%)	0.205 (49.5%)			1.309 (12.8%)
Mature	Balsam	16	1.214 (22.9%)	0.994 (9.5%)	1.14 (14.8%)	1.216 (32.7%)	0.922 (10.9%)	1.204 (16.0%)	0.847 (18.4%)
	Df/pine/oth	14	0.957 (25.1%)	0.904 (10.1%)	0.626 (28.3%)	2.37 (41.3%)	0.788 (14.5%)	0.637 (41.4%)	0.999 (21.3%)
	Spruce	21	1.07 (13.4%)	0.939 (9.2%)	0.742 (21.7%)	1.453 (26.1%)	0.766 (12.7%)	0.650 (25.0%)	0.901 (16.3%)
	Subtotal	51	1.08 (10.8%)	0.942 (5.6%)	0.814 (14.0%)	1.515 (22.0%)	0.821 (7.8%)	0.777 (17.2%)	0.903 (10.5%)

### 3.2 Model and Attribute-related volume bias

This section focuses on the mature stratum (> 50 years old) and volume net of decay, waste and breakage at the 12.5 cm utilization level. In the immature stratum, some of the Phase II ground plots were too

<sup>2</sup> In the immature stratum, for 17 out of 21 samples the Phase I Lorey height was blank. These were set to missing values and not used in calculating the means.

<sup>3</sup> In the immature stratum, for 17 out of 21 samples the Phase I volume was blank. These were set to zero and used in calculating the ratios.

short for VYPD7 to estimate volumes for Table 6. For these plots, the VDYP7 volume based on Phase II attributes (column C of Table 6) was set to zero.

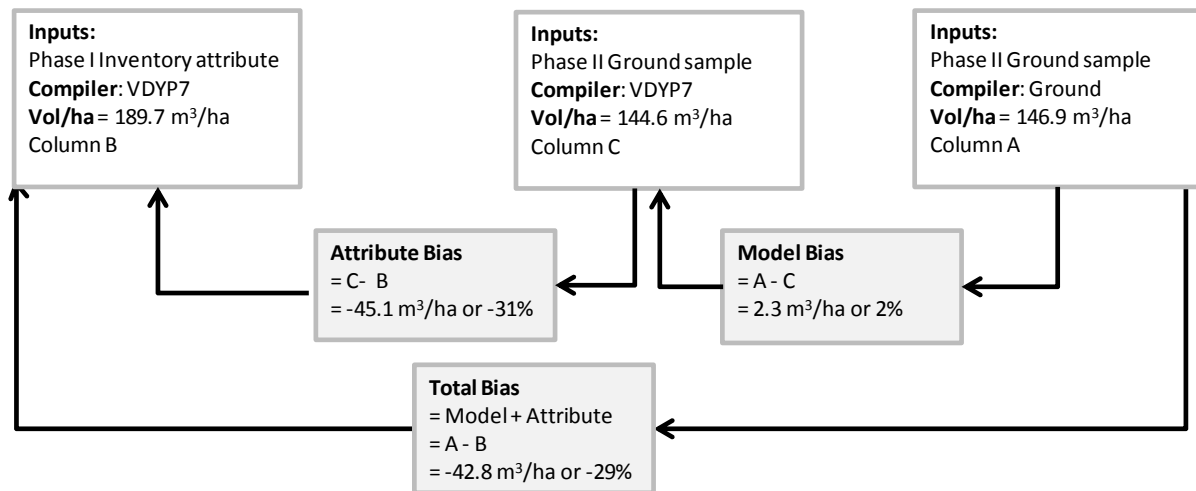
The adjustment ratio for volume for the mature stratum is 0.777 with a standard error of 17.2% indicating the Phase II ground volumes are approximately 78% of the Phase I inventory volumes. Within the mature stratum there is a slight underestimation of Balsam volume in Phase I and a larger overestimation of the remaining substrata (primarily spruce). A slight underestimation of balsam was observed in TFL 53, a larger underestimation in Mackenzie and an overestimation in Quesnel East.

The volume bias was partitioned into model-related and attribute-related bias. VDYP7 was run using the Phase II ground attributes as input (column C of Table 6). The difference between the Phase II ground volume (column A) and column C is assumed to be model-related bias, due to errors in the volume estimation routines in VDYP7. The difference between the VDYP7 volume estimates using the Phase I attributes (column B) and column C is assumed to be attribute-related bias.

**Table 6.** Weighted mean volumes net DWB (Dbh  $\geq$  12.5 cm) by stratum for TFL 18. For the bias, the mean is followed by the mean expressed as a percentage of the Phase I volume (B).

Stratum	Leading species substratum	n	Weighted mean volume (m <sup>3</sup> /ha) estimates net DWB for Dbh $\geq$ 12.5cm					
			Phase II ground A	VDYP7 Phase I (VRIStart) attributes) B	VDYP7 with Phase II attributes as input C	Model-related volume bias A-C	Attribute-related volume bias C-B	Total volume bias A-B
Immature	All	21	12.8	0.9	9.0	3.9 (431%)	8.1 (896%)	11.9 (1326%)
Mature	Balsam	16	157.3	130.7	135.1	22.2 (17%)	4.4 (3%)	26.6 (20%)
	Df/pine	14	125.2	196.7	140.7	-15.4 (-8%)	-56.1 (-29%)	-71.5 (-36%)
	Spruce	21	153.3	235.7	155.5	-2.2 (-1%)	-80.2 (-34%)	-82.4 (-35%)
	Subtotal	51	146.9	189.7	144.6	2.3 (1%)	-45.1 (-24%)	-42.8 (-23%)

The relationship between the bias components is given in Figure 2.



**Figure 2.** The relationship between the volume and bias estimates is given for the mature stratum in Table 6. A negative bias indicates overestimation and a positive bias indicates underestimation. The biases are given in absolute terms as well as percent relative to the Phase II ground volume.

The model-related volume bias is small and positive, indicating VDYP7 is slightly underestimating volume. The underestimation is very small for the Spruce plots (< 2%) and greater for the other plots in the mature stratum. The attribute-related volume bias is negative for the mature stratum indicating the Phase I attributes are overestimated. This is confirmed by the ratios in Table 5 which are generally less than 1 for the mature stratum for height and basal area, key drivers in VDYP7. The model-related volume tends to

cancel some of the attribute-related bias resulting in a smaller, generally negative total volume bias. The dominance of attribute bias in the total bias is further illustrated in Figure 11.

The same conclusions are reached examining the ratios in Table 7. For example, the Mature subtotal total bias ratio (0.777) indicates the overall the mature volume is overestimated (by about 29%). The model bias ratio is greater than one, indicating the VDYP7 slightly underestimates volume. The attribute bias ratio is less than 1 indicating inaccuracies in the Phase I estimates lead to an overestimation of volume.

**Table 7.** The ratios of mean volumes (net DWB Dbh  $\geq$  12.5cm) representing total, model and attribute bias, with associated sampling error % at a 95% confidence level for TFL 18. VRISart was used.

Stratum	Leading species substratum	n	Ratio of weighted mean volume/ha net DWB Dbh $\geq$ 12.5cm		
			Total bias: ground/Inventory (A/B)	Model bias: Ground/VDYP7(Ground attributes) (A/C)	Attribute bias: VDYP7 (Ground attributes)/Inventory (C/B)
Immature	All	21			
Mature	Balsam	16	1.204 (16.0%)	1.164 (5.9%)	1.034 (16.7%)
	Df/pine	14	0.637 (41.4%)	0.890 (8.0%)	0.715 (42.0%)
	Spruce	21	0.650 (25.0%)	0.986 (10.2%)	0.660 (25.5%)
	Subtotal	51	0.777 (17.2%)	1.016 (5.9%)	0.765 (17.0%)

Basal area ( $\text{m}^2/\text{ha}$ ) is an important driver of volume in VDYP7. In order to assess the contribution of errors in the Phase I basal area estimates to the volume bias, a number of additional VDYP7 projections were undertaken.

- VDYP7 was run using the Phase II ground measurements as input except the Phase II basal area was replaced with the Phase I basal area (projected to 2011) (column D in Table 8).
- VDYP7 was run using the Phase I attributes projected to 2011 as inputs except Phase I basal area was replaced with the Phase II basal area (column E in Table 8).

In Table 8, columns A and E use the same basal area as input (Phase II) and columns B and D use the same basal area as input (Phase I). Columns A and E are not particularly close indicating additional factors are contributing to differences. One of factors could be leading species height. The Phase I and Phase II height estimates are very close for the Balsam substratum and columns A and E in Table 8 are close. The differences between Phase I and Phase II height are greatest for the Spruce stratum and column A and E are greatest for Spruce as well. The Df/Pine/Oth substratum height differences and differences between columns A and E are intermediate.

**Table 8.** The influence of basal area on attribute-related volume bias for TFL 18.

Stratum	Leading species substratum	n	Weighted mean volume/ha net DWB Dbh $\geq$ 12.5cm				
			VDYP7 Phase I Phase II ground A	VDYP7 with Phase II attributes (VRISart) B	VDYP7 with Phase II attributes as input C	VDYP7 with Phase II attributes except BA is from VRISart D	VDYP7 with Phase I attributes except BA from Phase II E
Immature	All	21	12.8	0.9	9.0	8.3	3.2
Mature	Balsam	16	157.3	130.7	135.1	116.7	149.5
	Df/pine	14	125.2	196.7	140.7	223.7	180.0
	Spruce	21	153.3	235.7	155.5	207.4	182.9
	Subtotal	51	146.9	189.7	144.6	181.4	170.9

The results are different from those of Churlish and Jahraus (2011b) for Strathcona who found the total bias was dominated by attribute-related bias and basal area dominates the attribute-related bias.

### 3.3 Leading species comparison

Table 9 to 11 summarize the correspondence between the leading species from the Phase I inventory and the leading species from the Phase II ground sample compilation. For the immature stratum, 52% (11 out of 21) of the inventory and the ground samples had the same leading species. For the immature stratum, 57% (29 out of 51) of the samples had the same leading species. Most of the issues in the mature stratum were in the Df/Pine/Oth substratum where the Phase I and Phase II leading species matched in only 1 out of 14 polygons. Of the 13 mismatches in the Df/Pine/Oth substratum, 11 were pine leading in Phase I and none were pine leading in Phase II.

**Table 9.** The Phase I and Phase II leading species are cross tabulated by maturity.

Maturity	Phase I Species	Phase II species						Total
		Bl	Cw	Fd	Hw	Pl	S (Sb/Sx)	
Immature	At						1	1
	BL					1	2	3
	FD			1				1
	PL	1				4		5
	S (Sb/Sx)	4				1	6	11
	Subtotal	5		1		6	9	21
Mature	BL	13					3	16
	FD	1		1			1	3
	PL	2	1	2	1		5	11
	S (Sb/Sx)	6					15	21
	Subtotal	22	1	3	1		24	51
Grand total		27	1	4	1	6	33	72

**Table 10.** The Phase I and Phase II leading species are cross tabulated by maturity. Each cell is expressed as a percent of the row (Phase I) total.

Maturity	Phase I Species	Phase II species						Total
		Bl	Cw	Fd	Hw	Pl	S (Sb/Sx)	
Immature	At	0%	0%	0%	0%	0%	100%	100%
	BL	0%	0%	0%	0%	33%	67%	100%
	FD	0%	0%	100%	0%	0%	0%	100%
	PL	20%	0%	0%	0%	80%	0%	100%
	S (Sb/Sx)	36%	0%	0%	0%	9%	55%	100%
	Total	24%	0%	5%	0%	29%	43%	100%
Mature	BL	81%	0%	0%	0%	0%	19%	100%
	FD	33%	0%	33%	0%	0%	33%	100%
	PL	18%	9%	18%	9%	0%	45%	100%
	S (Sb/Sx)	29%	0%	0%	0%	0%	71%	100%
	Subtotal	43%	2%	6%	2%	0%	47%	100%
Grand total		38%	1%	6%	1%	8%	46%	100%

**Table 11.** The Phase I and Phase II leading species are cross tabulated by maturity. Each cell is expressed as a percent of the column (Phase II) subtotal. If the subtotal is zero, the cell is left blank.

Maturity	Phase I Species	Phase II species						Total
		Bl	Cw	Fd	Hw	Pl	S (Sb/Sx)	
Immature	At	0%		0%		0%	11%	5%
	BL	0%		0%		17%	22%	14%
	FD	0%		100%		0%	0%	5%
	PL	20%		0%		67%	0%	24%
	S (Sb/Sx)	80%		0%		17%	67%	52%
	Total	100%		100%		100%	100%	100%
Mature	BL	59%	0%	0%	0%		13%	31%
	FD	5%	0%	33%	0%		4%	6%
	PL	9%	100%	67%	100%		21%	22%
	S (Sb/Sx)	27%	0%	0%	0%		63%	41%
	Subtotal	100%	100%	100%	100%		100%	100%
Grand total		100%	100%	100%	100%	100%	100%	100%

Overall, the leading species was correctly identified by the Phase I inventory 56% of the time. Most of the confusion was with anything pine-leading in Phase I and between balsam (Phase II) and spruce (Phase I).

There were 32 samples where the leading species did not match. Of these, the Phase I second species matches the Phase II leading species for 23 samples. Of the remaining 9 samples, 5 were PL leading in Phase I (and likely affected by MPB) and 3 had the Phase I lead species match the Phase II second species (Table 12).

**Table 12.** The leading species matching is summarized by case. Case 1 = Phase I and Phase II leading species match. Case 2 = Phase I second and Phase II leading species match. Case 3 = Phase I and phase II species match at the genus level.

Maturity	Phase I species	Case 1	Case 2	Case 3	Comment on Case 3 samples
Immature	All	11	7	3	Phase I lead species matches the Phase II second species
Mature	Balsam	13	3		
	Df/pine	1	7	6	5 out of 6 samples were PL leading in Phase I
	Spruce	15	6		
	Subtotal	29	16	6	

### 3.4 Analysis of Dead Pine

Using the Phase II ground data, the following fractions were computed.

- Dead pine expressed as a fraction of live volume of pine + dead volume of pine (PI dead/(PI live + PI dead) fraction) and
- Dead pine expressed as a fraction of live volume all species + dead volume of pine (PI dead/(PI dead + all live) fraction).

Only the second fraction (PI/(PI + live)) is available from the Phase I BCMPB adjusted inventory.

The live and dead volumes (all species) are given in Table 13. The total volume (live + dead) for the immature and mature stratum subtotal are close to one, but the percent kill (dead/total volume) in Phase I is less than that in Phase II. This was further examined to see whether the MPB depletion rate was too low. Table 14 gives the live and dead volumes for pine only. In Phase II nearly all the pine volume is dead in the mature stratum while in the Phase I it is 50% or less. Within the mature stratum, the balsam and spruce substrata have little live pine so the underestimation of pine kill has the biggest impact in the Df/Pine/Oth substratum.

The Balsam substratum has the lowest dead volume and also has the closest agreement between Phase I and Phase II (and the only substratum where the Phase I estimate of volume is less than the Phase II measurement). For Df/Pine/Oth and spruce, the dead volume is much higher ( $>100 \text{ m}^3/\text{ha}$ ). For Df/Pine/Oth, most of the dead volume is pine whereas in the spruce substratum about half is pine.

Within the Df/Pine/Oth substratum, 11 out of 14 polygons were PL leading in Phase I and the impact of what appears to be an underestimation of the kill percentage has the biggest impact.

Some of the differences between the Phase I photo and Phase II ground estimates of volume appear to be due to an underestimation of the pine kill.

**Table 13.** The volume of all species (net of decay, waste and breakage for  $\text{Dbh} \geq 12.5\text{cm}$ ) is summarized by Phase and stratum. The kill % gives the fraction of total volume that is dead.

Stratum	N	Live – all species		Dead – all species		Total (live all + dead all)		Phase II/ Phase I (F/E)	Kill %	
		Phase I	Phase II	Phase I	Phase II	Phase I	Phase II		Phase I	Phase II
		(A)	(B)	(C)	(D)	(E = A + C)	(F = B + D)		(C/E)	(D/F)
Immature	21	0.9	12.8	0.0	2.6	0.9	15.4	16.858	1%	17%
Balsam	16	130.7	157.3	0.2	49.2	130.9	206.5	1.578	0%	24%
Df/Pine/Oth	14	196.7	125.2	80.9	108.0	277.6	233.2	0.840	29%	46%
Spruce	21	235.7	153.3	12.7	112.6	248.4	265.9	1.071	5%	42%
Mature	51	189.7	146.9	59.2	91.0	248.9	238.0	0.956	24%	38%

**Table 14.** The pine volume (net of decay, waste and breakage for  $\text{Dbh} \geq 12.5\text{cm}$ ) is summarized by Phase and stratum. The kill % gives the fraction of pine volume that is dead. This is the dead pine (PI dead/(PI live + PI dead) fraction) expressed as a percent.

Stratum	N	Live – PI		Dead - PI		Total (live PI + dead PI)		Phase II/ Phase I (F/E)	Kill %	
		Phase I	Phase II	Phase I	Phase II	Phase I	Phase II		Phase I	Phase II
		(A)	(B)	(C)	(D)	(E = A + C)	(F = B + D)		(C/E)	(D/F)
Immature	21	0.5	2.2	0.0	2.1	0.6	4.3	7.766	2%	48%
Balsam	16	7.6	0.4	0.2	11.2	7.8	11.6	1.483	3%	96%
Df/Pine/Oth	14	81.8	8.6	80.9	93.5	162.6	102.1	0.628	50%	92%
Spruce	21	22.4	0.0	12.7	58.5	35.1	58.5	1.670	36%	100%
Mature	51	33.8	3.8	27.3	52.2	61.0	82.6	1.353	45%	93%

**Table 15.** The non-pine volume (net of decay, waste and breakage for  $\text{Dbh} \geq 12.5\text{cm}$ ) is summarized by Phase and stratum. The kill % gives the fraction of non pine volume that is dead

Stratum	N	Live – non pine		Dead – non pine		Total (live non PI + dead non PI)		Phase II/ Phase I (F/E)	Kill %	
		Phase I	Phase II	Phase I	Phase II	Phase I	Phase II		Phase I	Phase II
		(A)	(B)	(C)	(D)	(E = A + C)	(F = B + D)		(C/E)	(D/F)
Immature	21	0.4	10.6	0.0	0.5	0.4	11.1	30.933	0%	4%
Balsam	16	123.0	156.8	0.0	38.0	123.0	194.9	1.584	0%	20%
Df/Pine/Oth	14	115.0	116.6	0.0	14.5	115.0	131.2	1.141	0%	11%
Spruce	21	213.3	153.3	0.0	54.1	213.3	207.4	0.972	0%	26%
Mature	51	155.9	143.1	0.0	37.8	155.9	154.4	0.990	0%	21%

Table 16 gives the dead pine volume as the fraction of the live volume all species + dead volume pine. Since Phase I only includes dead volume for pine, these are the fractions that should be close. Table 17 give the same fraction except expressed in terms of tree/ha (TPH) rather than volume. Note that volume uses a 12.5 cm utilization and TPH uses a 7.5 cm utilization so some differences between the % kill in

Table 16 and Table 17 are expected. The kill % in Phase I is lower for volume than TPH indicating that smaller than average trees are dying. The kill % in Phase II is higher for volume than TPH indicating larger than average trees are dying.

**Table 16.** The live volume (all species) and dead volume (pine) is summarized by Phase and stratum. The kill % gives the fraction dead pine volume/(dead pine volume + live all species volume). Note the Phase I Kill % is the same as that in Table 13 because Phase I only includes dead volume of PI. The utilization level is 12.5 cm.

Stratum	N	Live – all species		Dead – pine		Total (live all + dead PI)		Phase II/	Kill %	
		Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Phase I	Phase I	Phase II
		(A)	(B)	(C)	(D)	(E = A + C)	(F=B + D)	(F/E)	(C/E)	(D/F)
Immature	21	0.9	12.8	0.0	2.1	0.9	14.9	16.337	1%	14%
Balsam	16	130.7	157.3	0.2	11.2	130.9	168.5	1.287	0%	7%
Df/Pine/Oth	14	196.7	125.2	80.9	93.5	277.6	218.7	0.788	29%	43%
Spruce	21	235.7	153.3	12.7	58.5	248.4	211.8	0.853	5%	28%
Mature	51	189.7	146.9	27.3	52.2	217.0	199.2	0.918	13%	26%

**Table 17.** The live trees/ha (TPH) (all species) and dead TPH (pine) is summarized by Phase and stratum. The kill % gives the fraction dead pine TPH/(dead pine TPH + live all species TPH). The utilization level is 7.5 cm.

Stratum	N	Live – all species		Dead – pine		Total (live all + dead PI)		Phase II/	Kill %	
		Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Phase I	Phase I	Phase II
		(A)	(B)	(C)	(D)	(E = A + C)	(F=B + D)	(F/E)	(C/E)	(D/F)
Immature	21	3718	763	5	49	3723	812	0.218	0%	6%
Balsam	16	970	1179	8	14	977	1193	1.221	1%	1%
Df/Pine/Oth	14	465	1102	465	347	930	1449	1.558	50%	24%
Spruce	21	508	738	74	79	582	818	1.405	13%	10%
Mature	51	651	987	159	131	811	1118	1.379	20%	12%

### 3.5 Issues

No issues were identified.

### 3.6 Limitations of the Approach

There are a number of limitations to the approach taken here.

**Attribute definitions** – The unprojected Phase I and Phase II have slightly different definitions of attributes. The Phase I basal area is the total cross sectional area, at breast height, of all living trees visible to the photo interpreter in the dominant, codominant and high intermediate crown positions for each tree layer in the polygon (FAIB 2010). For Phase II, it is the cross sectional area of all living trees with Dbh > 7.5 cm. The Phase I leading species height is the average height by layer, weighted by basal area, of the dominant, codominant and high intermediate trees for the leading species within each layer. Phase I density is the average number of living trees visible to the photo interpreter in the dominant, codominant and high intermediate crown positions in each tree layer in the polygon. The unprojected Phase I attributes are used as input to VDYP7 and projected to the year of ground sampling. These projected Phase I attributes have the same utilization definitions as Phase II. The differences in definitions of Phase I and Phase II attributes are expected to have a larger effect on the immature stratum where more trees are expected to be below the 7.5 cm Dbh utilization limit.

Some of the Phase I estimates for young stands come from silvicultural records and may be collected to different standards, different levels of error checking and different definitions. In particular, the height

and age may have been measured in the field while the site index may have been estimated from SIBEC<sup>4</sup> or the previous stand.

**Sample Unit** – In Phase I the sample unit is the polygon and in Phase II it is generally a five plot cluster within the polygon. Some of the differences between Phase I and Phase II may arise because Phase II is a subsample of the polygon and may not fully capture some of the within polygon variation considered by photo interpreters when assigning a VRI label to reflect the overall polygon.

**VDYP7** – VDYP7 is used to project the Phase I inventory to the year of ground sampling. For very young polygons, VDYP7 uses VRIYoung which does not estimate a full suite of inventory attributes – rather it projects dominant height and basal area (and age) until the polygon meets the minimum criteria of breast height age  $\geq 6$  years, dominant height  $\geq 6$  m and basal area ( $7.5 \text{ cm}^+$ )  $\geq 2 \text{ m}^2$ . Basal area is then predicted from age and site height. VDYP7 may not be the most appropriate model for projecting young managed stands.

The volume compiler error is generally low (the mature stratum model-related bias is 1% in TFL 18) but is higher for Balsam (17% in TFL 18 based on 16 samples). This may indicate issues with the Balsam volume equations in VDYP7.

**Net merchantable volume** – VDYP7 and the ground compiler use different methods of reducing the gross merchantable volume to merchantable net of decay waste and breakage. The ground compiler methods are considered more accurate and precise. However, the net factoring approach used in the ground compiler cannot be implemented in VDYP7 because of different resolutions (tree vs. stand summary).

Table 18 gives the gross total whole stem volume as well as the volume net of decay waste and breakage. For Balsam leading polygons, the whole stem volume is closer than the net volume but for Df/Pine and Spruce, the net volume differences have increased.

**Table 18.** The average volume is given by Phase and leading species. All volumes are at for Dbh  $\geq 12.5$  cm.

Stratum	Leading species substratum	n	Volume net of dwb (m <sup>3</sup> /ha)			Whole stem volume (m <sup>3</sup> /ha)		
			Phase I	Phase II	Ratio Phase II/ Phase I	Phase I	Phase II	Ratio Phase II/ Phase I
Immature	All	21						
Mature	Balsam	16	130.7	157.3	1.204	163.9	176.1	1.074
	Df/pine	14	196.7	125.3	0.636	231.6	141.5	0.611
	Spruce	21	235.7	153.3	0.650	284.4	169.6	0.596
	Subtotal	51	189.1	146.9	0.777	229.4	164.0	0.7151

## 4. Conclusions and recommendations

MPB has had a significant impact in TFL 18 and much of the impact occurred between the photo acquisition for Phase I and the Phase II ground sampling.

The VRI statistical analysis for TFL 18 suggests, for the mature stratum, that the inventory age and height are very well estimated. As a consequence, SI was also well estimated. Basal area is overestimated by about 17% and Lorey height by about 23% leading to an overestimation of volume of about 29%. Trees/ha was the worst Phase I attribute and was underestimated by about 46%. The standard error for the leading species height and Lorey height adjustment ratios was less than the target of 10%. Leading species age and site index were close to the target standard error. The standard errors associated with the ratios are generally higher than previous analyses for other areas. The Spruce and Df/Pine/oth

<sup>4</sup> Nigh, G.B. Nigh, G.D. and P.J. Martin. 2006. Selecting a method to estimate site index. B.C. Min. For. and Range, Res. Br. Land Manage. Handb. Field Guide Insert 12.

<http://www.for.gov.bc.ca/hfd/pubs/Docs/Fgi/Fgi12.pdf>

substrata tend to have similar ratios and Phase I is overestimating basal area and volume. The Balsam substratum has consistently larger ratios (except for SI) and Phase I is underestimating basal area and volume.

The volume bias for the mature stratum was further analyzed. Volume was overestimated by about 43 m<sup>3</sup>/ha or about 29%. The contribution of the attribute errors (photo interpretation errors) was -45 m<sup>3</sup>/ha and the contribution of the VDYP7 volume estimation algorithm was about 2 m<sup>3</sup>/ha. Some of the attribute estimation error is due to basal area but the bias analysis shows more than half of the attribute estimation remains once basal area is corrected. Some of the differences are due to an underestimation of the proportion of pine that is dead.

Overall, the leading species was correctly identified by the Phase I inventory 56% of the time. Most of the disagreement was the relative abundance (leading vs. secondary species) rather than incorrect species identification. Most of the disagreement occurred in the Df/Pine/Oth substratum where 1 out of 14 polygons had the same leading species in Phase I and Phase II. Most of these were pine-leading in Phase I and likely affected by MPB. Incorrect identification of the leading species and species composition is likely to affect all attributes estimated in VDYP7, particularly volume and Lorey height.

The Df/Pine/Oth substratum was the most impacted by MPB and, in general, has the largest differences between Phase I and Phase II and the highest standard errors associated with the Phase II/Phase I ratios.

Based on the statistical analysis here, the following recommendations are made.

- The Phase I volume estimates for the mature stratum should be used with caution as they tend to overestimate the volume by approximately 29% and have high sampling errors. The biggest differences are in the Df/pine/Oth substratum and likely due to MPB kill.
- Without the BCMPB adjustment for MPB kill, the volume overestimation would be even higher and the BCMPB should be used. The BCMPB adjustment is restricted to volume and stems/ha.
- The MPB has killed most of the susceptible pine within the TFL but many of the inventory descriptions still include the pine component in the species composition, leading species height and age, basal area and site index. A new Phase I would provide complete post-MPB polygon descriptions.

## **5. Literature cited**

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- Nona Philips Forestry Consulting. 2011. Canadian Forest Products Ltd. Tree Farm License 18 – Vegetation resources inventory project implementation plan for ground sampling and net volume adjustment factor sampling. March 5, 2011. 15p + app.

## 6. Appendix A: Phase I inventory attributes

**Table 19.** The Phase I input (unprojected) attributes are given.

SAMPLE	FEATURE_ID	BEC	Stratum 1	Sample weight	inventory standard	Measurement year (for projections)	Reference Year	Input Age sp1	Input Height sp1	Input Age sp2	Input Height sp2	Input CC%	Input BA7.5	Input TPH7.5	sp01	pct1	sp02	pct2	sp03	pct3	sp04	pct4	sp05	pct5	sp06	pct6
1	7207160	SBS	Immature	695.6	V	2009	1/11/2002	9	0.6	9	0.8	20	1	2471	BL	50	SX	30	FD	10	PL	10		0		0
2	7211001	ESSF	Immature	695.6	V	2009	1/11/1996	15	2.5	15	2.4	15	3	6552	BL	55	SX	41	PL	3	AC	1		0		0
3	7205320	ICH	Immature	695.6	V	2009	1/11/2002	18	0.8	5	0.5	15	0	2495	BL	58	SX	22	PL	20		0		0		0
7	7207514	SBS	Immature	695.6	V	2009	1/11/2005	13	4.4	16	3	20	10	3980	PL	65	BL	15	FD	10	AT	5	SX	5		0
8	7207582	SBS	Immature	695.6	V	2009	1/11/2004	11	3.9	0	0	10	20	14500	PL	100		0		0		0		0		0
9	7205981	SBS	Immature	695.6	V	2009	1/11/2007	19	8	19	12	5	8	2000	PL	75	AT	25		0		0		0		0
10	7211659	ESSF	Immature	695.6	V	2009	1/11/2003	11	3.4	9	1.2	20	5	3240	PL	70	SX	20	BL	10		0		0		0
11	7211828	ESSF	Immature	695.6	V	2009	1/11/2007	20	5	0	0	10	10	5000	PL	100		0		0		0		0		0
17	7207837	ICH	Immature	695.6	V	2009	1/11/2007	30	6	30	5	10	5	1500	FD	50	CW	35	HW	15		0		0		0
18	7205545	ICH	Immature	695.6	V	2009	1/11/2007	23	12	23	7	15	20	4043	AT	40	SX	39	PL	13	FD	6	BL	2		0
21	7206174	SBS	Immature	695.6	V	2009	1/11/2007	20	5	20	4	25	2	1200	SX	90	BL	10		0		0		0		0
22	7210339	ESSF	Immature	695.6	V	2009	1/11/2006	12	2.4	10	2	15	2	4850	SX	60	BL	40		0		0		0		0
23	7211387	SBS	Immature	695.6	V	2009	1/11/2003	12	1.7	9	2.1	10	1	4943	SX	51	PL	28	BL	21		0		0		0
24	7210057	ESSF	Immature	695.6	V	2009	1/11/2004	11	2.7	10	1.4	15	10	10800	SX	50	BL	45	PL	5		0		0		0
25	7212478	ESSF	Immature	695.6	V	2009	1/11/2000	11	2.6	10	2.5	20	2	2145	SX	93	BL	7		0		0		0		0
26	7209297	ESSF	Immature	695.6	V	2009	1/11/2007	20	5	20	4	20	5	2250	SX	60	BL	40		0		0		0		0
27	7211874	ESSF	Immature	695.6	V	2009	1/11/2001	12	2.2	12	3.9	25	10	4375	SX	87	PL	7	BL	5	AC	1		0		0
28	7212308	ESSF	Immature	695.6	V	2009	1/11/2007	20	6	20	3.5	20	2	1300	SX	80	BL	10	PL	10		0		0		0
29	7209479	ESSF	Immature	695.6	V	2009	1/11/2007	20	4.5	20	2.5	20	5	3100	SX	85	BL	15		0		0		0		0
30	7210746	SBS	Immature	695.6	V	2009	1/11/2007	22	3.2	22	4.7	15	10	2550	SX	60	PL	30	BL	10		0		0		0
102	7212537	ESSF	Immature	695.6	V	2009	1/11/2008	16	2.8	11	1.1	35	0	2400	SX	80	BL	20		0		0		0		0
41	7207690	SBS	Spruce	874.7	V	2009	1/11/2007	150	31	150	28	5	45	600	SX	60	PL	20	FD	10	AT	10		0		0
42	7654389	ESSF	Spruce	874.7	V	2009	1/11/1992	76	21	80	20	8	40	1200	SX	70	PL	20	BL	10		0		0		0
43	7211509	ESSF	Spruce	874.7	V	2009	1/11/2007	150	29	115	22	5	40	650	SX	40	BL	40	PL	15	FD	5		0		0

SAMPLE	FEATURE_ID	BEC	Stratum 1	Sample weight	inventory standard	Measurement year (for projections)	Reference Year	Input Age sp1	Input Height sp1	Input Age sp2	Input Height sp2	Input CC%	Input BA7.5	Input TPH7.5	sp01	pct1	sp02	pct2	sp03	pct3	sp04	pct4	sp05	pct5	sp06	pct6
44	7209309	ESSF	Spruce	874.7	V	2009	1/11/1992	290	34	240	27	10	45	500	SX	55	BL	45		0	0		0		0	
45	7208820	ICH	Spruce	874.7	V	2009	1/11/2007	200	31	160	27	5	40	600	SX	50	BL	30	PL	15	FD	5		0		0
46	7209103	ESSF	Spruce	874.7	V	2009	1/11/2007	260	32	200	25	15	35	425	SX	70	BL	25	PL	5		0		0		0
47	7210578	SBS	Spruce	874.7	V	2009	1/11/2007	150	32	140	26	5	35	435	SX	60	BL	25	PL	15		0		0		0
55	7209400	SBS	Spruce	874.7	V	2009	1/11/2007	225	31	260	28	10	40	530	SX	60	PL	25	BL	15		0		0		0
56	7206662	SBS	Spruce	874.7	V	2009	1/11/2007	70	16	50	14	15	5	250	SX	40	PL	20	BL	20	LW	10	AT	10		0
57	7206908	SBS	Spruce	874.7	V	2009	1/11/2007	100	26	100	28	20	10	200	SX	80	AT	10	BL	10		0		0		0
58	7211333	ESSF	Spruce	874.7	V	2009	1/11/2007	80	14	80	14	10	15	1200	SX	40	BL	40	CW	20		0		0		0
59	7212127	ESSF	Spruce	874.7	V	2009	1/11/2007	240	28	200	21	10	5	80	SX	80	BL	20		0		0		0		0
60	7208586	ESSF	Spruce	874.7	V	2009	1/11/2007	125	28	115	21	15	20	325	SX	50	BL	35	PL	14	AT	1		0		0
65	7206973	SBS	Spruce	874.7	V	2009	1/11/1992	147	33	150	27	5	40	475	SX	40	BL	30	FD	30		0		0		0
66	7206866	SBS	Spruce	874.7	V	2009	1/11/2007	140	29	125	23	10	35	530	SX	70	BL	20	AT	5	PL	5		0		0
67	7211143	ICH	Spruce	874.7	V	2009	1/11/1992	160	22	110	20	0	30	800	SX	50	BL	25	PL	15	FD	10		0		0
68	7211835	ESSF	Spruce	874.7	V	2009	1/11/2007	225	29	160	24	10	30	450	SX	50	BL	50		0		0		0		0
69	7211916	SBS	Spruce	874.7	V	2009	1/11/2007	140	31	180	28	15	30	300	SX	50	PL	30	BL	20		0		0		0
70	7209413	ESSF	Spruce	874.7	V	2009	1/11/1992	81	21	80	18	15	25	725	SX	48	BL	35	PL	17		0		0		0
71	7208946	ESSF	Spruce	874.7	V	2009	1/11/2008	255	25.5	0	0	10	24	500	SX	100		0		0		0		0		0
72	7209339	ESSF	Spruce	874.7	V	2009	1/11/2007	160	30	140	23	10	30	400	SX	40	BL	30	PL	30		0		0		0
80	7210548	ESSF	Balsam	992.1	V	2009	1/11/2007	50	8.5	45	8.5	15	10	750	BL	50	SX	30	FD	10	PL	10		0		0
81	7209978	ESSF	Balsam	992.1	V	2009	1/11/2007	100	12	120	12	0	5	175	BL	85	SX	15		0		0		0		0
82	7210119	ESSF	Balsam	992.1	V	2009	1/11/2007	60	12	60	14	5	10	1000	BL	80	SX	20		0		0		0		0
83	7211830	SBS	Balsam	992.1	V	2009	1/11/2001	75	12.8	105	19	25	5	320	BL	49	SX	38	FD	10	PL	3		0		0
88	7210732	SBS	Balsam	992.1	V	2009	1/11/2007	120	17	150	23	15	15	500	BL	85	SX	15		0		0		0		0
89	7209937	ESSF	Balsam	992.1	V	2009	1/11/2007	50	14	50	16	5	20	900	BL	60	SX	40		0		0		0		0
90	7210019	ESSF	Balsam	992.1	V	2009	1/11/2007	65	18	65	18	10	25	1000	BL	75	SX	25		0		0		0		0
91	7207972	ESSF	Balsam	992.1	V	2009	1/11/2008	66	16.1	70	18	10	39	2880	BL	95	SX	5		0		0		0		0
92	7209129	ESSF	Balsam	992.1	V	2009	1/11/2007	100	18	100	20	10	20	800	BL	60	PL	25	SX	15		0		0		0
98	7208133	ICH	Balsam	992.1	V	2009	1/11/2007	120	24	160	27	10	40	800	BL	50	SX	40	CW	10		0		0		0

SAMPLE	FEATURE_ID	BEC	Stratum 1	Sample weight	inventory standard	Measurement year (for projections)	Reference Year	Input Age sp1	Input Height sp1	Input Age sp2	Input Height sp2	Input CC%	Input BA7.5	Input TPH7.5	sp01	pct1	sp02	pct2	sp03	pct3	sp04	pct4	sp05	pct5	sp06	pct6
99	7208136	ESSF	Balsam	992.1	V	2009	1/11/2007	160	20	160	24	10	25	500	BL	55	SX	45		0	0		0		0	
101	7211510	ESSF	Balsam	992.1	V	2009	1/11/2007	130	16	185	21	10	35	900	BL	60	SX	35	PL	5	0		0		0	
103	7205966	SBS	Balsam	992.1	V	2009	1/11/2007	70	18	80	22	10	30	850	BL	40	FD	30	SX	15	AT	10	PL	5	0	
104	7206269	ESSF	Balsam	992.1	V	2009	1/11/2007	200	20	200	21	5	25	700	BL	40	PL	35	SX	25		0		0	0	
105	7206196	ESSF	Balsam	992.1	V	2009	1/11/2007	140	24	140	27	0	35	650	BL	45	SX	40	FD	10	AT	5		0	0	
106	7210274	ESSF	Balsam	992.1	V	2009	1/11/1992	200	22	200	24	10	30	650	BL	65	SX	35		0	0		0		0	
112	7206175	SBS	Df_Pine_O	929.2	V	2009	1/11/2007	120	25	120	24	15	10	150	PL	70	BL	15	SX	10	AT	5		0	0	
113	7212457	SBS	Df_Pine_O	929.2	V	2009	1/11/2007	200	29	200	33	5	20	200	PL	40	SX	40	BL	20		0		0	0	
114	7212316	SBS	Df_Pine_O	929.2	V	2009	1/11/1992	177	32	150	29	10	5	60	FD	80	SX	20		0	0		0		0	
118	7207380	SBS	Df_Pine_O	929.2	V	2009	1/11/2007	160	28	140	21	10	35	400	PL	80	BL	15	SX	5		0		0	0	
119	7210936	ICH	Df_Pine_O	929.2	V	2009	1/11/2007	70	18	70	18	0	40	2500	PL	95	FD	5		0	0		0		0	
120	7211366	SBS	Df_Pine_O	929.2	V	2009	1/11/2007	90	20	100	23	5	30	600	PL	50	SX	30	BL	20		0		0	0	
121	7212673	SBS	Df_Pine_O	929.2	V	2009	1/11/2007	200	29	200	33	15	30	425	PL	65	SX	25	BL	5	AC	5		0	0	
122	7212705	ESSF	Df_Pine_O	929.2	V	2009	1/11/2007	115	24	115	22	5	35	725	PL	60	BL	25	SX	15		0		0	0	
128	7205868	ICH	Df_Pine_O	929.2	V	2009	1/11/2007	140	32	100	23	0	45	600	FD	60	PL	30	SX	5	BL	5		0	0	
129	7207906	ICH	Df_Pine_O	929	V	2009	1/11/2007	115	23	120	25	5	45	800	PL	50	FD	40	SX	10		0		0	0	
130	7207127	SBS	Df_Pine_O	929	V	2009	1/11/2007	140	29	150	32	5	50	750	PL	50	SX	20	BL	20	AT	10		0	0	
131	7210024	ICH	Df_Pine_O	929	V	2009	1/11/2007	90	23	90	23	0	55	1800	PL	95	FD	5		0	0		0		0	
132	7207844	ICH	Df_Pine_O	929	V	2009	1/11/1992	52	21	50	20	0	45	1200	FD	80	CW	15	PL	5		0		0	0	
133	7211196	ICH	Df_Pine_O	929	V	2009	1/11/2007	120	22	120	25	0	45	1400	PL	75	FD	20	SX	5		0		0	0	

**Table 20.** The Phase I Projected attributes are given (from MFLNRO with the exception of Lorey height).

Sample	Leading species Age	Leading species height	Second species Age	Second species height	(Dbh $\geq$ 7.5 cm)		(Dbh $\geq$ 12.5 cm)	
					Basal area (m <sup>2</sup> /ha)	Trees/ha	Lorey height (m)	Volume net DWB (m <sup>3</sup> /ha)
1	18	2.67	18	2.17	1	2471		
2	30	4.11	30	3.61	3	6552		
3	27	5.88	14	1.28	0	2495		
7	19	6.09	22	3.39	10	3980		
8	18	5.65	.	.	20	4500		
9	23	11.6	23	13.6	4.19	238	11.2	15.2
10	19	7.82	17	2.02	0.69	43.3	6.34	0.85
11	24	7.7	.	.	1.06	66.1	7.29	0.88
17	34	6.99	34	5.99	5	1500		
18	27	10.8	27	5.82	1.02	66.5	7.77	2.02
21	24	3.6	24	3.1	2	1200		
22	17	1.2	15	0.8	2	4850		
23	20	2.77	17	5.67	1	4943		
24	18	1.32	17	0.02	10	800		
25	22	2.32	21	2.22	2	2145		
26	24	2.42	24	1.42	5	2250		
27	22	2.32	22	6.32	10	4375		
28	24	3.41	24	1.31	2	1300		
29	24	2.42	24	0.72	5	3100		
30	26	3.31	26	7.81	10	2550		
102	19	1.72	14	0.02	0	2400		
41	154	31.4	154	28.2	45.1	495	28.4	348
42	95	25.2	99	21.9	42.7	841	20.9	305
43	154	29.4	119	22.5	39.6	535	24	306
44	309	34.6	259	27.7	44.5	440	28.6	392
45	204	31.3	164	27.3	39.4	502	27.6	333
46	264	32.2	204	25.2	34.7	382	28	312
47	154	32.4	144	26.4	35	367	28.7	303
55	229	31.2	264	28	39.6	454	27.2	330
56	74	17	54	14.9	5.27	189	15.7	27.8
57	104	26.7	104	28.4	10.1	175	25.3	85.2
58	84	14.6	84	14.7	10.8	464	12.4	49.7
59	244	28.3	204	21.3	4.9	68.8	26.7	41.1
60	129	28.5	119	21.5	20	273	24.5	164
65	166	34.6	169	28.4	40.2	408	31	386
66	144	29.4	129	23.4	34.8	470	25.5	287
67	179	23.9	129	22.3	29.6	610	21.6	186
68	229	29.2	164	24.3	29.8	386	25.2	245
69	144	31.4	184	28.1	30.4	263	27.7	259
70	100	24.9	99	21.4	27.3	512	21.6	190
71	258	25.7	.	.	23.6	451	22.4	176
72	164	30.4	144	23.4	30.1	312	26.4	224
80	54	9.5	49	9.7	6.94	338	8.67	20.6
81	104	12.5	124	12.5	5.18	144	11.8	19.1
82	64	13	64	15.1	7.05	353	10.8	29.9
83	85	14.7	115	20.6	6.06	192	16.4	35.7
88	124	17.5	154	23.4	14.3	338	16.4	76.2
89	54	15.3	54	17.5	19.9	617	13.8	99.7

Sample	Leading species Age	Leading species height	Second species Age	Second species height	(Dbh ≥ 7.5 cm)			(Dbh ≥ 12.5 cm)
					Basal area (m <sup>2</sup> /ha)	Trees/ha	Lorey height (m)	Volume net DWB (m <sup>3</sup> /ha)
90	69	19.2	69	19.1	24.3	670	15.8	136
91	69	16.8	73	18.8	26.3	1129	11.8	118
92	104	18.6	104	20.3	18.6	507	17.3	116
98	124	24.5	164	27.4	39.5	635	22.8	292
99	164	20.3	164	24.4	24.5	400	20.6	163
101	134	16.5	189	21.4	33.5	651	16.3	171
103	74	18.9	84	22.7	30.5	652	18.6	187
104	204	20.3	204	21.1	23.9	544	19.5	162
105	144	24.4	144	27.5	34.7	535	24	271
106	219	23.2	219	25.5	29.1	509	21.6	195
112	124	25.2	124	24.5	10.3	123	24	70.3
113	204	29.1	204	33.2	19.9	167	28.7	161
114	196	33.2	169	30.7	5.37	58.6	32.8	50.2
118	164	28.1	144	21.4	35.1	379	25.4	303
119	74	18.6	74	18.8	41	593	17.1	48.4
120	94	20.4	104	23.7	30.3	283	20	95.8
121	204	29.1	204	33.2	29.9	276	28.9	193
122	119	24.3	119	22.5	35.1	515	22	211
128	144	32.4	104	23.3	45.4	516	26.7	359
129	119	23.3	124	25.4	45.4	550	22.6	235
130	144	29.2	154	32.4	49.7	607	26.5	394
131	94	23.4	94	23.6	55.7	238	22.6	40.3
132	71	26.8	69	26.1	56.3	1000	22.4	381
133	124	22.3	124	25.4	45.1	847	20.9	212

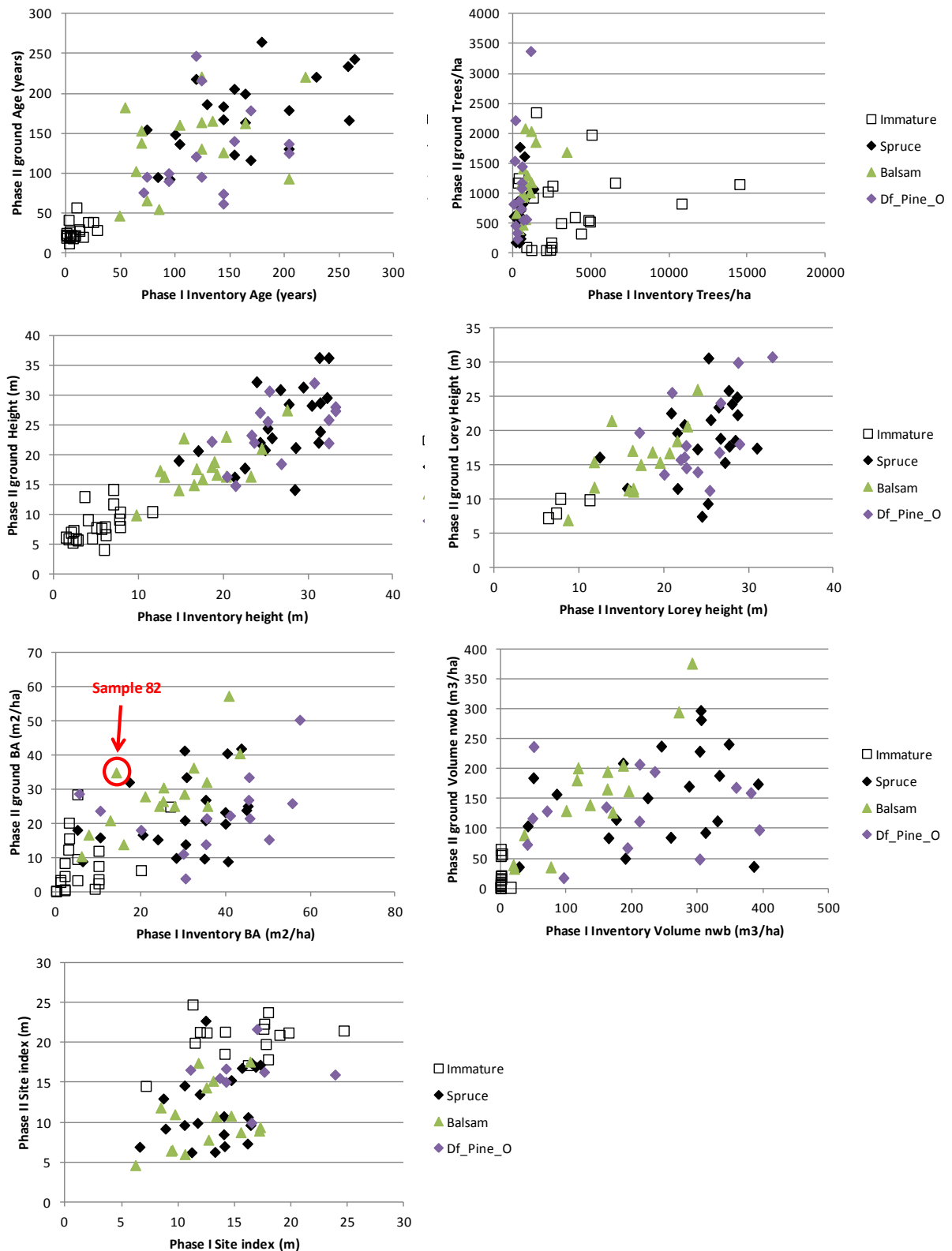
## 7. Appendix B: Phase II compiled ground attributes

**Table 21.** The Phase II compiled ground attributes are given.

Sample	Species composition At Dbh ≥ 4.0 cm	Basal area (m <sup>2</sup> /ha) Dbh ≥ 7.5 cm	Trees/ha Dbh ≥ 7.5 cm	Lorey height (m) Dbh ≥ 7.5 cm	Live volume net DWB (m <sup>3</sup> /ha) Dbh ≥ 12.5 cm
1	Sx 53 Pl 43 Fd 04	3.0	175	5.5	8
2	Sx 66 Bl 18 Pl 16	20.3	1176	10.0	83
3	Pl 56 Bl 44	0.4	100	3.8	0
7	Pl 57 Bl 31 Ac 08 Fd 04	3.8	600	5.6	1
8	Pl 98 Sx 01 At 01	6.4	1151	6.5	0
9	Pl 49 At 35 Ac 16	1.0	100	9.9	2
10	Bl 68 Pl 26 Sx 06	12.4	1251	7.3	21
11	Pl 100	15.7	1176	8.0	39
17	Fd 60 Cw 23 Hw 09 Ac 04 Bl 03	28.6	2352	10.1	84
18	Sx 51 Fd 44 At 05	25.0	1976	10.1	77
21	Sx 100	0.8	50	4.2	2
22	Bl 89 Sx 11	4.7	550	5.8	6
23	Sx 56 Pl 44	3.5	525	5.4	1
24	Bl 61 Sx 39	7.6	826	7.0	17
25	Sx 100	0.5	50	5.9	1
26	Bl 100	9.7	1026	6.9	13
27	Bl 71 Sx 29	2.6	325	6.3	1
28	Sx 55 Pl 45	8.5	926	6.5	10
29	Sx 100	3.5	500	5.1	1
30	Pl 60 Bl 40	12.1	1126	8.5	29
102	Sx 55 Bl 45	0.3	55	4.4	0
41	Sx 37 Bl 37 Cw 21 Fd 05	25.2	244	18.6	269
42	Sx 97 Bl 03	42.0	969	22.6	323
43	Bl 77 Sx 23	40.6	825	17.3	316
44	Bl 64 Sx 36	24.0	716	25.0	191
45	Sx 46 Fd 23 Cw 15 Bl 16	23.4	533	25.9	205
46	Sx 75 Bl 25	9.8	174	24.0	100
47	Sx 71 Bl 29	27.0	879	22.4	247
55	Sx 50 Bl 50	20.0	764	15.4	124
56	Sx 64 Bl 36	9.0	493	11.6	39
57	Sx 94 At 06	16.0	179	30.7	174
58	Bl 65 Sx 35	32.2	1072	16.2	210
59	Bl 87 Sx 13	18.2	616	18.9	115
60	Sx 73 Bl 27	16.8	867	7.5	92
65	Bl 80 Fd 20	9.0	870	17.5	39
66	Sx 53 Bl 47	21.0	528	21.6	185
67	Sx 43 Cw 43 Bl 14	33.6	1617	19.7	230
68	Bl 61 Sx 39	41.4	1774	9.4	264
69	Sx 82 Bl 18	14.0	665	17.8	93
70	Sx 82 Bl 18	10.0	577	11.6	55
71	Sx 83 Bl 17	15.4	309	20.9	126
72	Sx 67 Bl 27 Fd 06	21.0	837	23.5	163
80	Sx 74 Bl 22 Fd 04	21.0	2038	7.0	36
81	Sx 50 Bl 50	10.5	667	11.8	47
82	Bl 83 Sx 17	35.0	1857	8.8	172
83	Bl 58 Sx 17 Fd 17 Pl 08	16.8	397	11.2	101
88	Bl 90 Sx 10	14.0	1161	11.6	44

Sample	Species composition At Dbh ≥ 4.0 cm	Basal area (m <sup>2</sup> /ha) Dbh ≥ 7.5 cm	Trees/ha Dbh ≥ 7.5 cm	Lorey height (m) Dbh ≥ 7.5 cm	Live volume net DWB (m <sup>3</sup> /ha) Dbh ≥ 12.5 cm
89	Bl 83 Sx 11 Fd 06	25.2	1184	21.5	144
90	Bl 62 Sx 38	25.2	1012	11.4	155
91	Bl 87 Hw 10 Sx 03	40.6	1690	15.5	226
92	Bl 60 Sx 40	28.0	566	15.1	201
98	Bl 60 Sx 40	57.4	2083	20.7	416
99	Bl 76 Sx 24	30.6	936	16.8	218
101	Bl 67 Sx 33	25.2	1298	17.1	140
103	Bl 52 Fd 33 Sx 11 Cw 04	36.4	1137	16.9	231
104	Bl 57 Sx 38 Pl 05	26.6	954	15.4	183
105	Sx 83 Bl 17	32.2	473	26.1	321
106	Bl 65 Sx 35	28.8	1410	18.6	182
112	Sx 72 Bl 28	23.8	1541	14.0	139
113	Sx 100	18.2	461	30.0	147
114	Sx 50 Bl 38 Fd 12	28.8	821	30.8	256
118	Bl 47 Cw 20 Fd 13 Pl 13 Sx 07	14.0	866	11.3	56
119	Cw 33 Hw 28 Ep 17 Fd 11 Pl 11	22.4	1448	19.8	138
120	Bl 60 Sx 20 Pl 20	4.0	238	13.7	21
121	Sx 88 Bl 12	11.2	337	18.1	76
122	Sx 50 Bl 50	21.6	1177	15.8	123
128	Bl 42 Pl 33 Cw 17 Fd 08	21.6	742	24.1	187
129	Hw 36 Cw 32 Bl 20 Sx 08 Fd 04	33.6	1083	17.8	231
130	Sx 91 Bl 09	15.4	555	16.9	105
131	Fd 27 Cw 27 Ep 19 Pl 19 Bl 08	26.0	2218	14.6	93
132	Fd 61 Sx 19 Cw 14 Bl 06	50.4	3375	16.2	179
133	Fd 59 Cw 29 Pl 06 Ep 06	27.0	566	25.6	229

## 8. 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.

## 9. 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 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	Phase II (ground) leading species attributes						Phase I (Inventory)			
	Species @ 4cm Dbh	Mean Age <sup>5</sup>	Mean Height <sup>6</sup>	Sample size Age <sup>7</sup>	Sample size Height <sup>8</sup>	Leading species	Secondary species	Case of match	Age for match	Height for match
1	Sx	12	5.4	3	3	BL	SX	2	18	2.2
2	Sx	39	13.0	6	4	BL	SX	2	30	3.6
3	Pl	19	4.2	5	4	BL	SX	3	27	5.9
7	Pl	21	6.6	7	7	PL	BL	1	19	6.1
8	Pl	19	7.7	4	4	PL		1	18	5.7
9	Pl	22	10.5	6	5	PL	AT	1	23	11.6
10	Bl	28	8.0	9	7	PL	SX	3	19	7.8
11	Pl	20	9.2	4	2	PL		1	24	7.7
17	Fd	29	11.8	7	6	FD	CW	1	34	7.0
18	Sx	39	14.2	8	8	AT	SX	2	27	5.8
21	Sx	22	7.8	4	2	SX	BL	1	24	3.6
22	Bl	23	7.0	4	3	SX	BL	2	15	0.8

<sup>5</sup> Age = age\_tlxo

<sup>6</sup> Height = ht\_tlxo

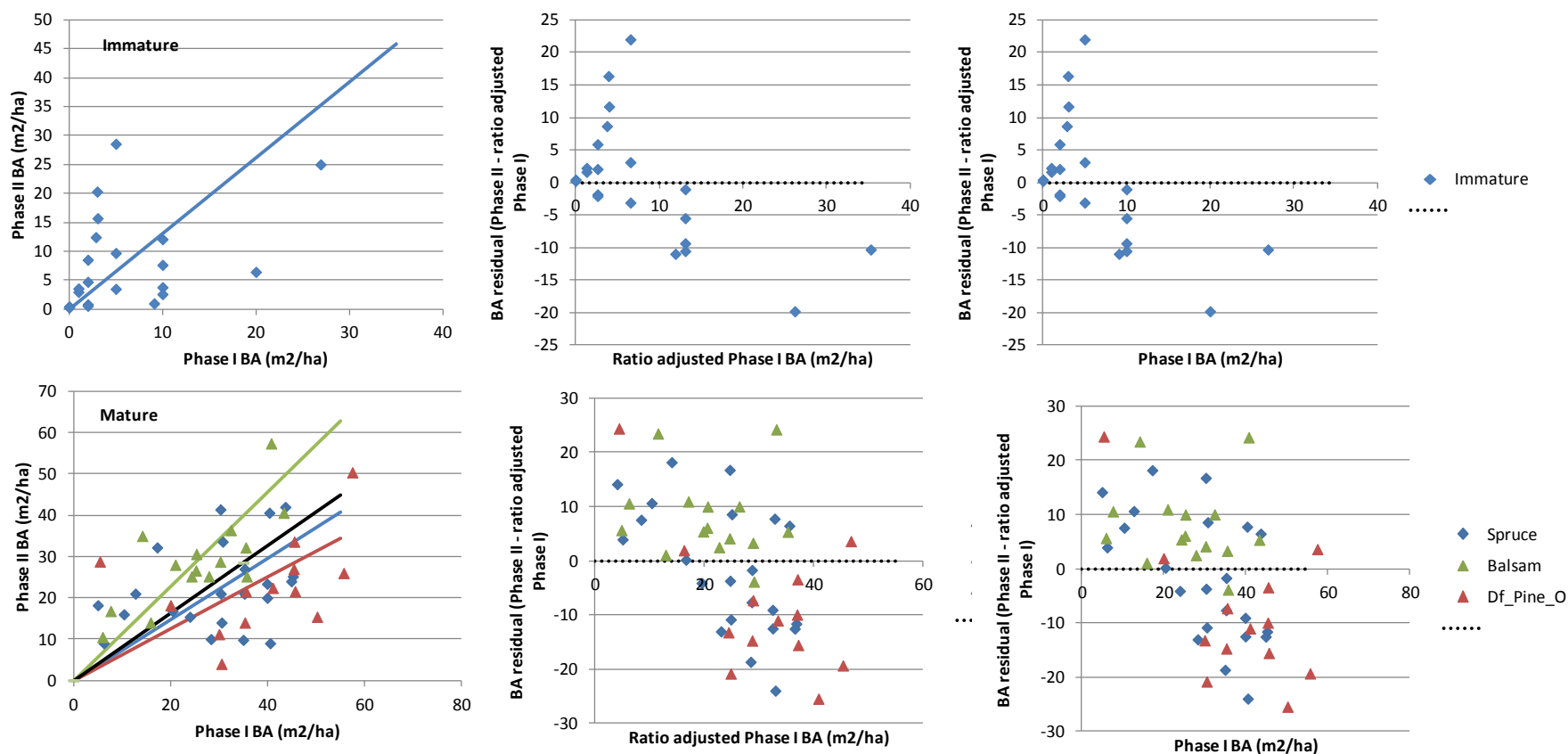
<sup>7</sup> Sample size for age = n\_age\_tlxo

<sup>8</sup> Sample size for height = n\_ht\_tlxo

Sample	Phase II (ground) leading species attributes					Phase I (Inventory)				
	Species @ 4cm Dbh	Mean Age <sup>5</sup>	Mean Height <sup>6</sup>	Sample size		Leading species	Secondary species	Case of match	Age for match	Height for match
				Age <sup>7</sup>	Height <sup>8</sup>					
23	Sx	20	5.7	6	6	SX	PL	1	20	2.8
24	Bl	21	6.2	3	4	SX	BL	2	17	0.0
25	Sx	25	5.9	3	3	SX	BL	1	22	2.3
26	Bl	57	9.1	5	3	SX	BL	2	24	1.4
27	Bl	42	7.3	3	3	SX	PL	3	22	2.3
28	Sx	22	7.9	8	5	SX	BL	1	24	3.4
29	Sx	27	6.0	5	5	SX	BL	1	24	2.4
30	Pl	30	10.4	5	4	SX	PL	2	26	7.8
102	Sx	23	5.9	6	5	SX	BL	1	19	1.7
41	Sx	123	28.6	6	5	SX	PL	1	154	31.4
42	Sx	93	24.4	5	5	SX	PL	1	95	25.2
43	Bl	218	17.7	6	5	SX	BL	2	119	22.5
44	Bl	167	28.4	5	5	SX	BL	2	259	27.7
45	Sx	131	36.2	5	5	SX	BL	1	204	31.3
46	Sx	243	29.5	5	5	SX	BL	1	264	32.2
47	Sx	206	36.2	5	5	SX	BL	1	154	32.4
55	Sx	221	22.0	6	6	SX	PL	1	229	31.2
56	Sx	155	20.6	6	5	SX	PL	1	74	17.0
57	Sx	137	30.8	5	5	SX	AT	1	104	26.7
58	Bl	95	19.0	6	6	SX	BL	2	84	14.7
59	Bl	179	16.2	5	5	SX	BL	2	204	21.3
60	Sx	187	21.2	5	5	SX	BL	1	129	28.5
65	Bl	117	14.1	4	3	SX	BL	2	169	28.4
66	Sx	184	31.3	6	6	SX	BL	1	144	29.4
67	Sx	265	32.2	5	5	SX	BL	1	179	23.9
68	Bl	164	22.0	5	5	SX	BL	2	164	24.3
69	Sx	168	23.9	5	5	SX	PL	1	144	31.4
70	Sx	149	20.8	6	5	SX	BL	1	100	24.9
71	Sx	234	22.8	6	5	SX		1	258	25.7
72	Sx	200	28.2	5	5	SX	BL	1	164	30.4
80	Sx	47	9.9	7	6	BL	SX	2	49	9.7
81	Sx	221	17.3	5	5	BL	SX	2	124	12.5
82	Bl	103	16.4	5	5	BL	SX	1	64	13.0
83	Bl	55	14.1	7	6	BL	SX	1	85	14.7
88	Bl	164	15.9	6	6	BL	SX	1	124	17.5
89	Bl	183	22.8	6	5	BL	SX	1	54	15.3
90	Bl	138	16.7	6	6	BL	SX	1	69	19.2
91	Bl	154	17.6	5	5	BL	SX	1	69	16.8
92	Bl	161	18.0	6	5	BL	PL	1	104	18.6
98	Bl	131	21.0	6	6	BL	SX	1	124	24.5
99	Bl	163	23.1	5	5	BL	SX	1	164	20.3
101	Bl	166	15.0	6	6	BL	SX	1	134	16.5
103	Bl	66	18.8	6	6	BL	FD	1	74	18.9
104	Bl	93	16.4	6	6	BL	PL	1	204	20.3
105	Sx	126	27.5	5	5	BL	SX	2	144	27.5
106	Bl	221	16.4	5	6	BL	SX	1	219	23.2
112	Sx	216	25.5	5	5	PL	BL	3	124	25.2
113	Sx	137	28.0	5	5	PL	SX	2	204	33.2
114	Sx	179	32.0	5	5	FD	SX	2	169	30.7

Sample	Phase II (ground) leading species attributes					Phase I (Inventory)				
	Species @ 4cm Dbh	Mean Age <sup>5</sup>	Mean Height <sup>6</sup>	Sample size		Leading species	Secondary species	Case of match	Age for match	Height for match
				Age <sup>7</sup>	Height <sup>8</sup>					
<b>118</b>	Bl	62	14.8	6	5	PL	BL	2	144	21.4
<b>119</b>	Cw	96	22.2	1	1	PL	FD	3	74	18.6
<b>120</b>	Bl	100	16.3	6	6	PL	SX	3	94	20.4
<b>121</b>	Sx	125	27.3	5	4	PL	SX	2	204	33.2
<b>122</b>	Sx	247	27.0	5	5	PL	BL	3	119	24.3
<b>128</b>	Bl	74	25.8	5	5	FD	PL	3	144	32.4
<b>129</b>	Hw	121	23.2	6	5	PL	FD	3	119	23.3
<b>130</b>	Sx	140	21.9	5	5	PL	SX	2	154	32.4
<b>131</b>	Fd	90	22.0	5	5	PL	FD	2	94	23.6
<b>132</b>	Fd	76	18.5	6	6	FD	CW	1	71	26.8
<b>133</b>	Fd	96	30.6	5	5	PL	FD	2	124	25.4

## 10. 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 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 mature samples.

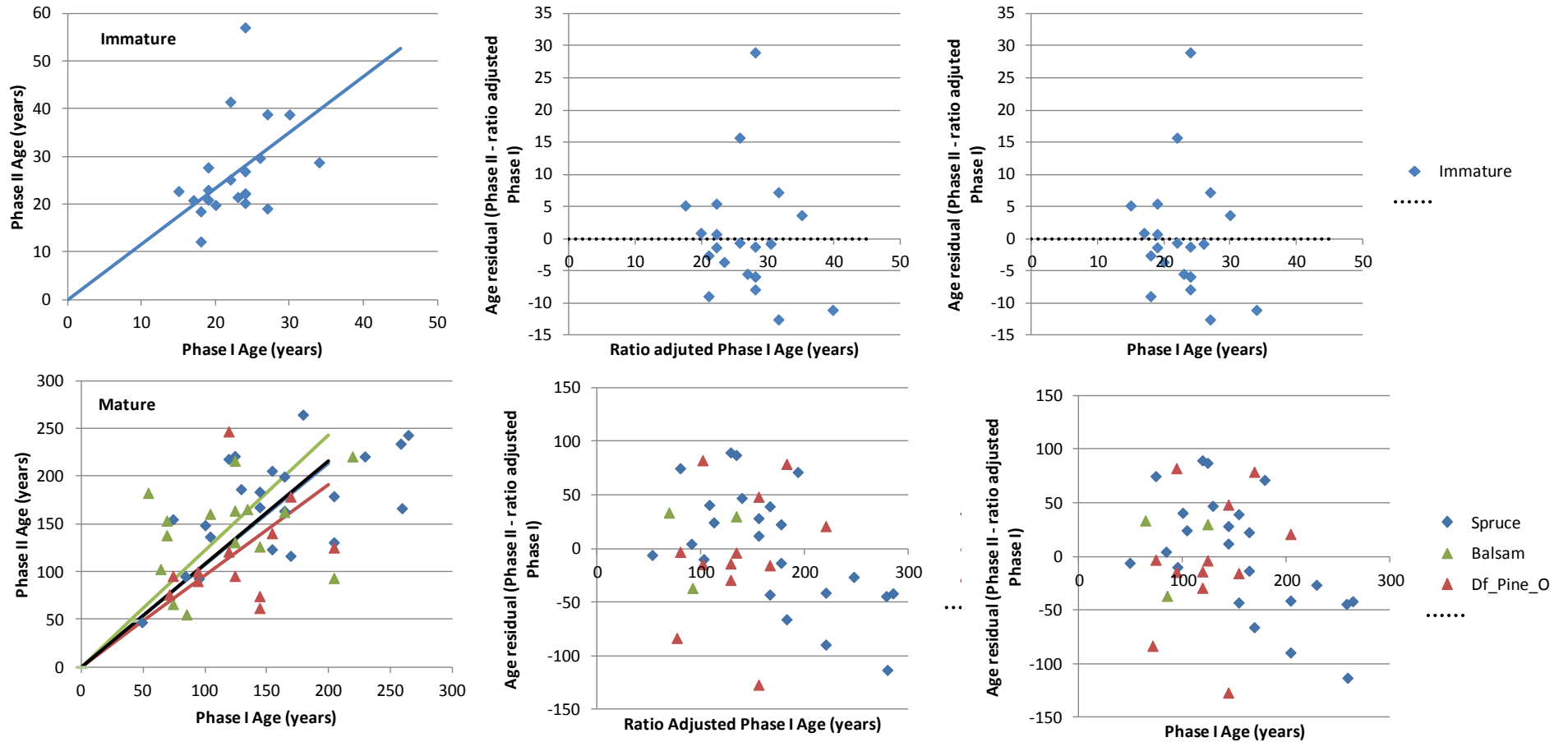


Figure 5. The scatterplots for Age are given.

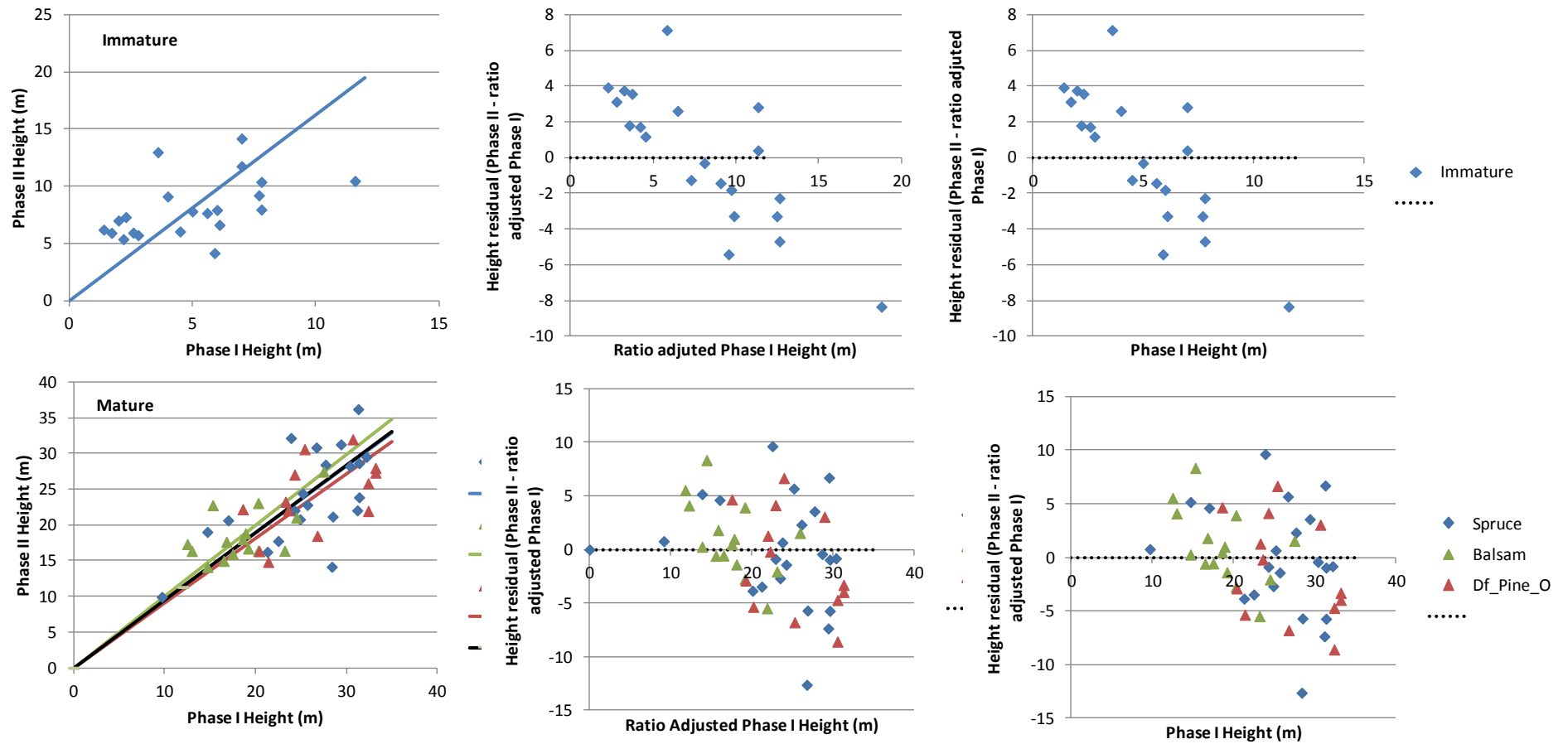


Figure 6. The scatterplots for Height are given.

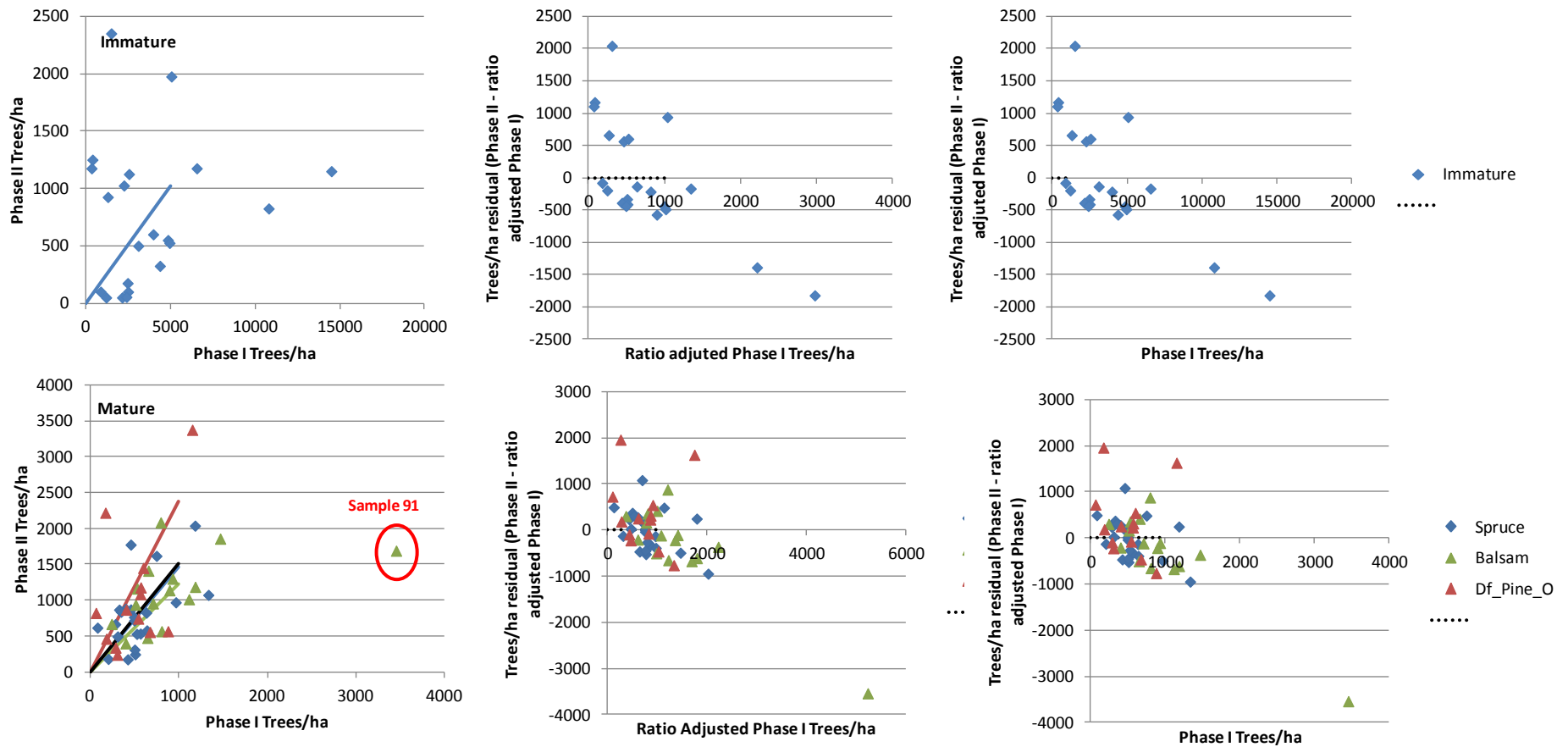
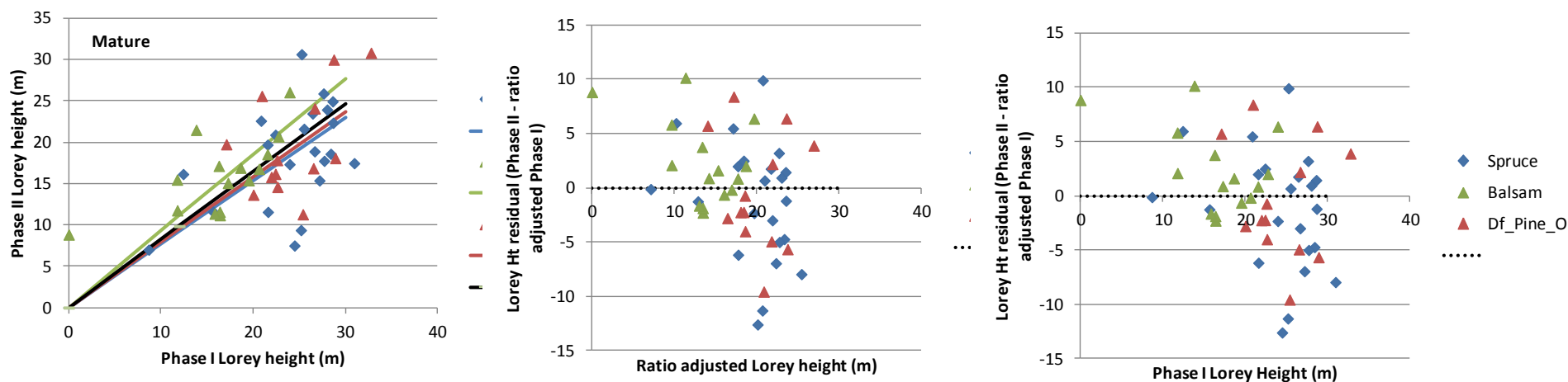
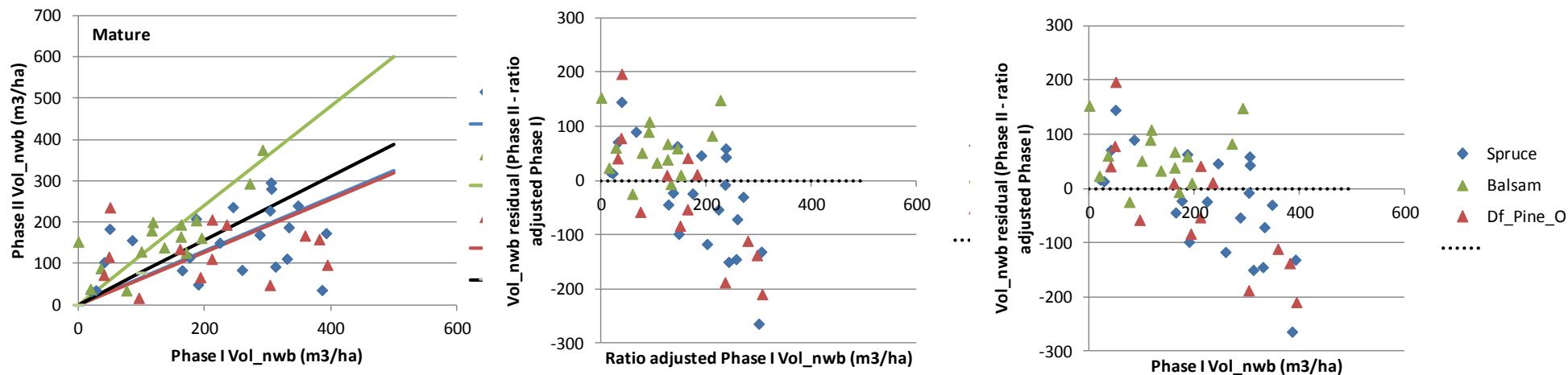


Figure 7. The scatterplots for Trees/ha are given.



**Figure 8.** The scatterplots for Lorey height are given. In the immature stratum, 17 of 21 plots had missing values for Phase I Lorey height. The immature stratum is not plotted.



**Figure 9.** The scatterplots for volume net of decay, waste and breakage (Vol\_nwb) are given. For the immature stratum, 17 of 21 plots had missing values for Phase I volume. The immature stratum is not plotted.

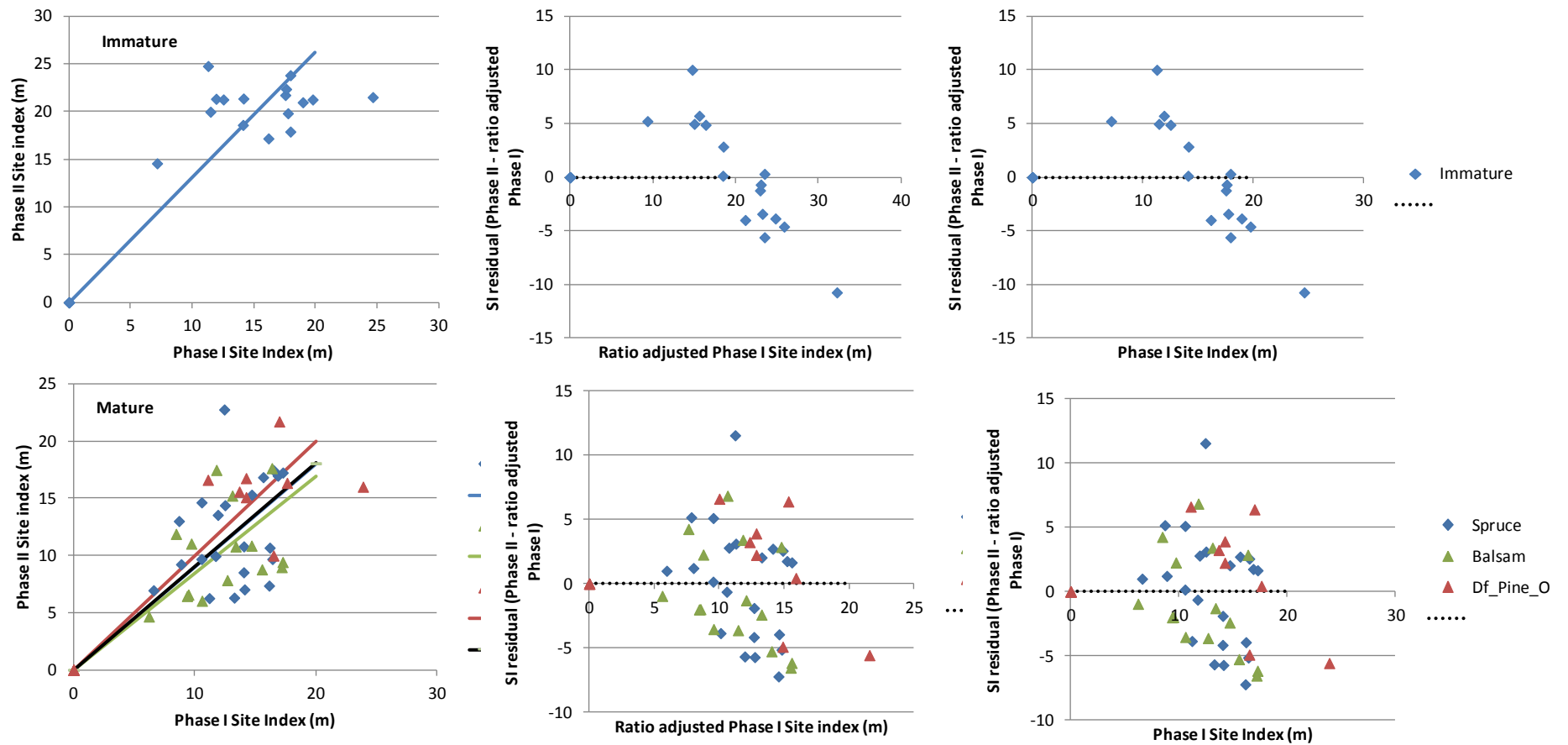
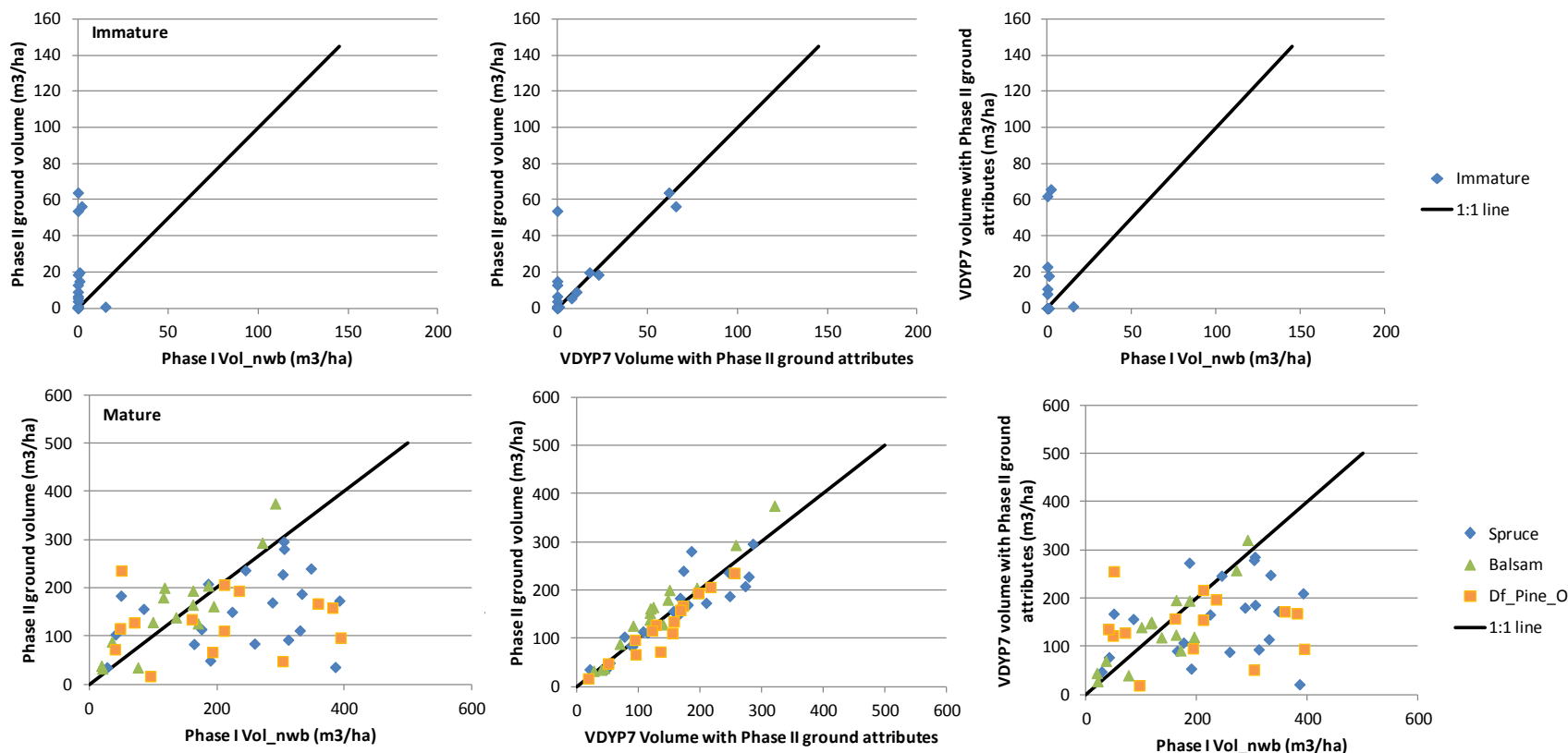


Figure 10. The scatterplots for Site index are given.

## 11. 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 immature stratum, 17 of 21 plots were short and the VDYP7 volumes were missing and set to zero.