Haida Gwaii

Documentation of

Vegetation Resources Inventory Analysis – Volume Audit (Mature)

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

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Revised March 16, 2018

Executive Summary

The objective of this project was to assess the accuracy of the Phase I inventory of Haida Gwaii by completing a statistical analysis of selected Phase I inventory attributes. The target population of interest is the vegetated treed portion of the area, older than 50 years, excluding parks and private land. This is referred to the volume audit population. The analysis is based on current Vegetation Resources Inventory standards.

The inventory (Phase I) estimates of age and height are close to the ground (Phase II) estimates while basal area is lower (Table 1) in Phase I. It is possible the volume audit population includes an understory not included in the photo interpretation summaries. A second layer was only identified in one of the sampled polygons. Volume is also underestimated in the inventory. Much of the underestimation is linked to the underestimation of BA. The ground estimate of volume is higher and assumed to be accurate but it also includes uncertainties associated with estimation of stem volume and net downs. Approximately half of the volume bias is due to attribute bias and the other half to model bias. As a result, the Ministry will be investigating when inventories should be adjusted and how they should be adjusted and will be developing appropriate guidelines.

The ground and inventory estimates of SI are close while the PSPL SI estimates are generally higher than the ground estimates. The ground estimates of SI were restricted to sample trees with breast height ages from 10 to 120 and, as a result, more than half of the samples did not have any suitable SI trees. SI estimates in older stands, whether they originate from ground measurements or Phase I estimates, are unreliable as estimates of site productivity.

Table 1. The sample size (N), mean, ratio of means (Phase II Ground/Phase I Inventory) and sampling error of the ratio expressed as a percent of the ratio (SE of ratio (%)) are given by attribute for the volume audit (mature) portion of Haida Gwaii. Ratios that differ from 1.0 by more than 10% are shaded.

Attribute	Statistic	Volume Audit
Leading species age (years)	N	72
	Mean Phase II Ground	242
	Mean Phase I inventory	236
	Ratio (Phase II/Phase I)	1.027
	SE of Ratio (%)	(7.8%)
Leading species height (m)	N	72
	Mean Phase II Ground	23.9
	Mean Phase I inventory	24.0
	Ratio (Phase II/Phase I)	0.996
	SE of Ratio (%)	(7.2%)
Basal area (m^2/ha) 7.5 cm+	N	74
	Mean Phase II Ground	57.9
	Mean Phase I inventory	47.7
	Ratio (Phase II/Phase I)	1.215
	SE of Ratio (%)	(10.8%)
Trees/ha 7.5 cm+	N	74
	Mean Phase II Ground	1062
	Mean Phase I inventory	648
	Ratio (Phase II/Phase I)	1.638
	SE of Ratio (%)	(20.1%)
Lorey height (m)	N	71
	Mean Phase II Ground	21.2
	Mean Phase I inventory	22.7

Attribute	Statistic	Volume Audit
	Ratio (Phase II/Phase I)	0.932
	SE of Ratio (%)	(7.8%)
Volume	N	74
Net dwb	Mean Phase II Ground	388
(m^3/ha)	Mean Phase I inventory	315
17.5 cm+	Ratio (Phase II/Phase I)	1.228
LF	SE of Ratio (%)	(16%)
Leading	N	28
species	Mean Phase II Ground	17.7
Site index	Mean Phase I inventory	17.2
(m)	Ratio (Phase II/Phase I)	1.029
	SE of Ratio (%)	(11.1%)
Leading	N	21
species	Mean Phase II Ground	19.9
Site index	Mean PSPL	22.4
(m)	Ratio (Phase II/PSPL)	0.892
	SE of Ratio (%)	(12.7%)

The leading species agreement for the Volume Audit population is comparable to results from other TSAs (61% or 45 out of 74).

Acknowledgements

This project was coordinated by Graham Hawkins. Thank you to Rene De Jong, Graham Hawkins, Matt Makar, Tim Salkeld, David Stuart and Wenli Xu for comments and suggestions. Thank you to Bob Krahn, Rene De Jong and Marc Rousseau for providing the data.

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1. Scope and Objectives

This report documents the statistical analysis of the Vegetation Resources Inventory (VRI) for the volume audit portion of Haida Gwaii.

2. Background

2.1 Description of the Target Population Area

The description of the target population is taken from FAIB (2016) available from the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO). Haida Gwaii covers about 1 million ha and is an archipelago located off the west coast of British Columbia (Figure 1). Approximately 50% is in parks, conservancy areas and private land.

The Haida Gwaii inventory covers the entire archipelago and includes Timber Supply areas, Tree Farm Licenses, parks, conservancies and private land. The population of interest for this report is the vegetated treed (VT) landbase that is greater than 50 years old, excluding parks, conservancies and private land. VT is defined as forested polygons having a crown closure greater than 10%. The population of interest covers approximately 340,000 ha. This is a subset of the operating area. The operable area is not considered here but is a subset of the target population with reductions for conditions such as slope, wetness, etc.

Table 2. A summary of the land base (taken from the Haida Gwaii Ground sampling plan (FAIB 2016)). The target population considered in this report is shaded.

Netdown Description	Area (ha)	% of Haida Gwaii	% of Operating Area
Entire Haida Gwaii	***1,006,800***	***100%***	
Parks / Conservancy / Private	487,200	48%	
Lakes / Wetlands	55,291	5%	
	464,309	46%	
Operating Area	***464,309***	***46%***	***100%***
< 15 yrs	15,936	2%	3%
15-50 yrs	98,251	10%	21%
> 50 yrs: forested	336,511	33%	72%
> 50 yrs: non-forest	13,611	1%	3%

Haida Gwaii includes some of the most productive forested areas in the province. It also includes approximately 6,000 polygons dominated by shore pine, the coastal form of lodgepole pine[1], often in a shrubby stunted form. Larger stands are typically found in association with low nutrient, acidic bogs, marshes and fens.

2.2 State of the Inventory

The following is taken from FAIB (2016). Based on 2007 aerial photography, a new forest inventory mapping was completed in 2013 covering the full extent of Haida Gwaii. The new mapping conducted to the VRI standard provides complete, consistent coverage over the Haida Gwaii archipelago. This replaces the previous inventory which was a set of disparate coverages, some very old, with gaps in some areas, and produced to varying inventory standards.

In 2015 the new inventory was compared against the previous old inventory and results were presented to representatives of the Haida Gwaii Management Council (HGMC). Relative to the old inventory, the new inventory estimates of timber volume are lower. Concerns over the magnitude of change and

[1] http://www.sccp.ca/species-habitat/lodgepole-shore-pine

consequences for the Allowable Annual Cut (AAC) were expressed by the HGMC and the Council of the Haida Nation (CHN). The HGMC and CHN requested, and the ministry agreed, to undertake a forest inventory ground sampling program in 2016 in order to determine the magnitude of any change in volume.

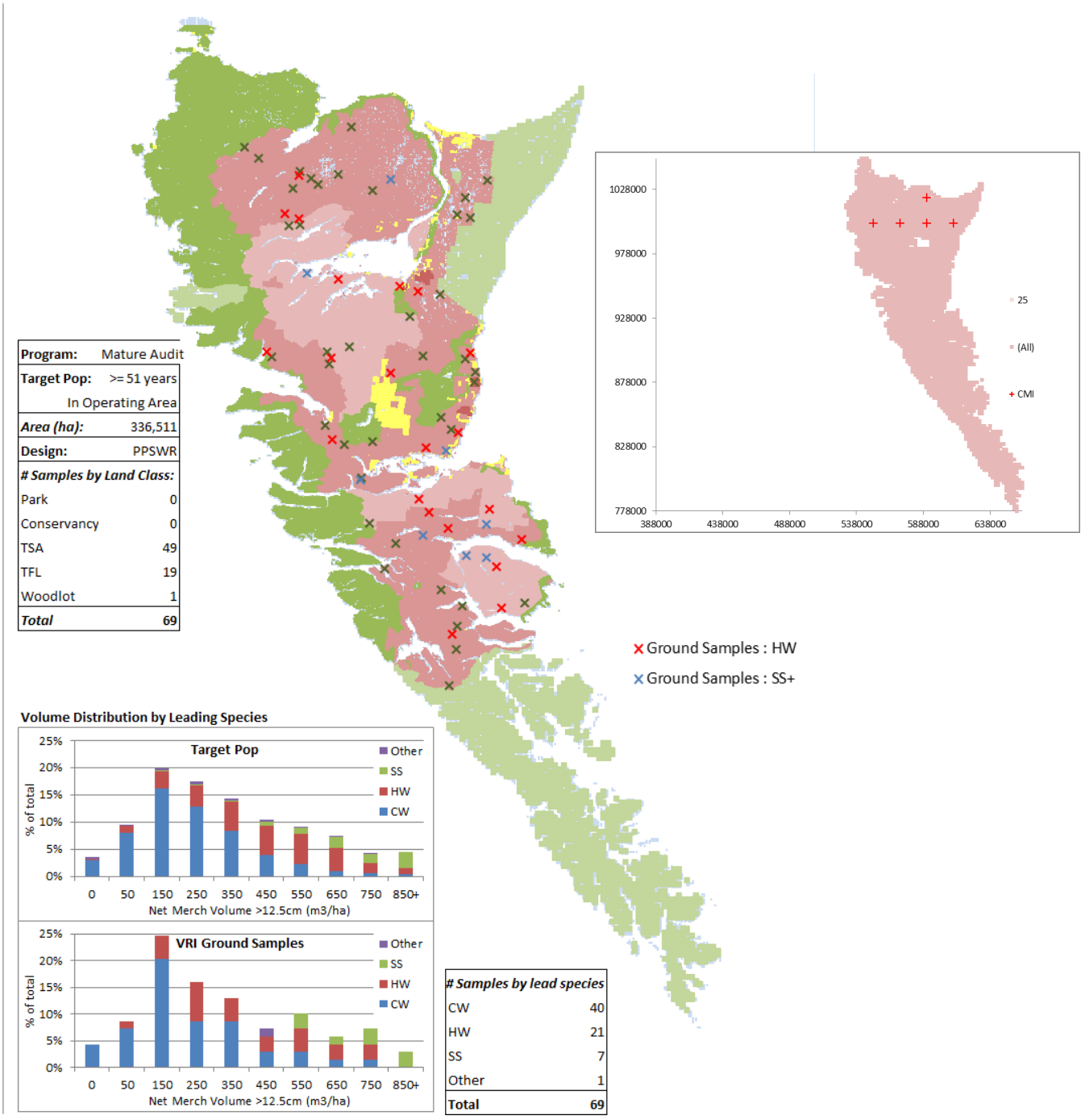

Figure 1. The location of the ground samples within Haida Gwaii (from FAIB 2016). An additional 5 CMI samples were included in the analysis. The operating area is colour-coded (TFL – light pink, TSA – medium pink, Woodlot – dark pink). Parks and conservancy areas are shaded green. Private land is shaded yellow. The map inset gives the location of the CMI plots.

3. Data Sources

3.1 Phase I photo-interpreted inventory data

The VRI input files

- HG_PLOTS_JOIN_VDYP7_LAYER_2017MAY11.csv
- HG_PLOTS_JOIN_VDYP7_POLY_2017MAY11.csv

were provided and projected to the year of ground sampling using VDYP7 Console version 7.14b. VDYP7 allows for layer processing. There was one sample with more than one layer (Table 3). The second layer was not projected by VDYP7. Only layers projected by VDYP7 are considered here and for this project, all projected layers were primary layers. The primary layer is the Rank 1 layer and used to define the target population.

Table 3. The sample with two layers is given.

clstr_id	VDYP7_LAYER_CD	LAYER	Crown Closure (%)	Species	Age	Ht	BA	TPH
0252-0147-TO1	P	1	15	HW	370	38.0	16.0	100
0252-0147-TO1		2	50	HW	70	15.0	40.0	612

For all polygons, the species composition, leading species age, leading species height and leading species site index were taken from the primary layer. VDYP7 does not project the height and age for the second species. In a separate run, the second species and its associated height and age were put as the primary species and projected. This was used to obtain the projected height, age and site index of the second species. Three samples (0252-0107-TO1, 0252-0108-TO1 and 0252-0171-TO1) had VDYP7 projected heights that were too short to have volumes estimated. The Phase I projected volumes for these samples were set to zero. The main volume comparison is the merchantable volume for trees with DBH ≥ 17.5 cm. For the three short samples, there are likely few or no trees with DBH ≥ 17.5 cm and setting the volume to zero is unlikely to add measureable bias.

Generally, the Phase I inventory forest descriptions come originally from photo interpretation, updated to the year of ground sampling. Volumes are estimated using VDYP7. Outputs from VDYP7 have a utilization level specified by the user – usually 7.5 cm for most attributes and 17.5 cm for volume on the coast.

Inventory information for recently disturbed polygons generally comes from the RESULTS (Reporting Silviculture Updates and Land status Tracking System) layer. These are also processed by VDYP7 to project them to the year of ground sampling. For stands less than 7 m tall, VDYP7 will project the age and height until the height is 7 m and then generate the remaining attributes. None of the samples had an inventory height < 8 m.

3.2 Phase II Ground sample data

The target population for ground sampling is the volume audit portion of the operating area, representing 33% of Haida Gwaii (Table 2). The main species group in the target population is cedar followed by hemlock, spruce and other.

3.2.1 Sample Selection

The ground sample data come from two data sources –volume audit (VA) ground samples and Change Monitoring Inventory (CMI, including National Forest Inventory) ground plots. Each data source sampled a specific portion of Haida Gwaii (Table 5). The VA samples were randomly selected from the target population with probability proportional to polygon size with replacement (PPSWR), pre-stratified by leading species group. The CMI samples were selected from a 20 x 20 km grid. As a result, the sampling weights (the area represented by each sample) vary with data source.

Within the VA population, there was no pre-stratification by tenure type or ownership nor was there stratification by operable vs. inoperable.

Table 4. The sampling programs are described.

Abbreviation	Sampling program	Description
VA	Volume Audit	Randomly selected from the VA subpopulation with probability proportional to polygon size with replacement, pre-stratified by leading species. Temporary 5-point variable radius clusters
CMI	Change monitoring inventory	Established on the 20 x 20 km NFI grid. Circular, 0.04 ha fixed area plots. Includes one NFI plot.

Almost all of the ground samples are helicopter access. Usually some reconnaissance of the ground plots is undertaken to identify any plot issues (particularly safety concerns) before giving the sample list to the contractor responsible for field measurements. For this project, the reconnaissance was combined with the field plot measurement. As a result of not having the initial plot screening, there is a higher proportion of replacement samples in this project.

Of the original 69 VA samples, six samples in the CW strata (101, 103, 105, 106, 109, 112) and two in the Hw strata (141, 143) were dropped due to safety concerns. Sample 164 is located within the Spirit Lake Park. The park was not identified during the sample selection process and the plot was dropped as it was not in the target population. Sample 165 in the SS stratum was logged. All were replaced, by strata, from the list of replacement samples. One replacement sample (170) in the CW was also identified as unsafe and removed from the list. In total, 10 of 69 (14%) of the VA samples were replacement samples. The focus here is on the relationship (ratio) between the ground samples and inventory estimates. If the replacement samples have a different relationship than the original samples, replacing the original samples will introduce bias. There is considerable variation in the relationship between Phase I and Phase II for volume (Figure 2) and the relationship for the dropped samples is unknown. The replacement samples and the samples not dropped appear to have similar relationships with the ground data.

Of the original eight CMI samples, two were dropped (4, 11) due to safety and one due to disturbance. These samples were not replaced.

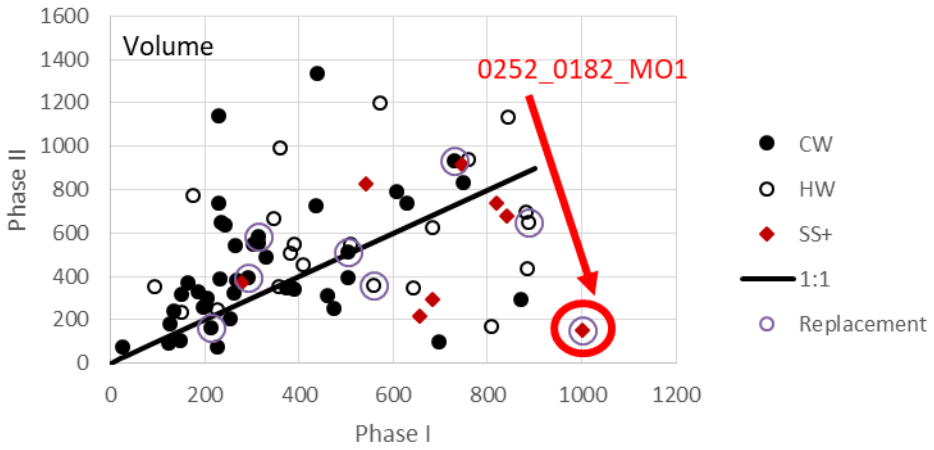

Figure 2. The whole stem volume (DBH ≥ 7.5 cm) is plotted for the Phase II ground vs. Phase I inventory. The replacement samples are indicated. Sample 0252-0182-MO1 is discussed in section 4.2.

3.2.2 Plot Design & Establishment

VRI Phase I polygon-based ground samples were randomly selected from the target population with PPPSWR and pre-stratified by leading species. A total of 69 ground samples were identified, allocated across three leading species strata: 40 in Cw/Yc leading stands, 21 in Hw/Hm leading stands, and 8 in Ss leading plus all other stands (Figure 1).

VRI Mature Audit ground samples are temporary 5-point variable radius clusters, comprising both full measure & count plots. Ground samples were established as ***plot type 'T': Timber-Emphasis plus***

Succession plots'. Ground sample establishment and measurements followed provincial VRI Phase II standards and procedures[2]. Two plots were fixed area plots, established using the CMI protocol.

Five CMI ground plots (including one NFI plot) were established in the VA population. Ground sample establishment and measurement follow provincial CMI standards and procedures[3]. The sample plots are centered at the grid intersection points.

3.2.3 Phase II Sample Selection Pre-Stratification and Weights

The weights based on sample selection probabilities are given in Table 5.

Table 5. The sample weights are given by source and strata. The population weight is used in the analysis.

Source	Strata	Area (ha)	N	Strata weight (area/N)	CF (N subpop/N pop)	population weight (Strata weight * CF)
VA	Cw/Yc	192,949	40	4,824	0.9324	4,497.8
	Hw/Hm	104,129	21	4,935	0.9324	4,601.6
	SS+	39,433	8	4,929	0.9324	4,596.1
	Subtotal	336,511	69			
CMI	N/A	336,511	5	67,302	0.0676	4,547.4
All			74			

The monitoring plots are all in the CW stratum with an average ground volume of 144 m^3/ha (net decay waste and breakage DBH ≥ 17.5 cm) compared to an average volume of 383 m^3/ha for the VA plots in the CW stratum. There are only 5 monitoring plots in the VA population and there are some indications they may not represent the average condition (Figure 3).

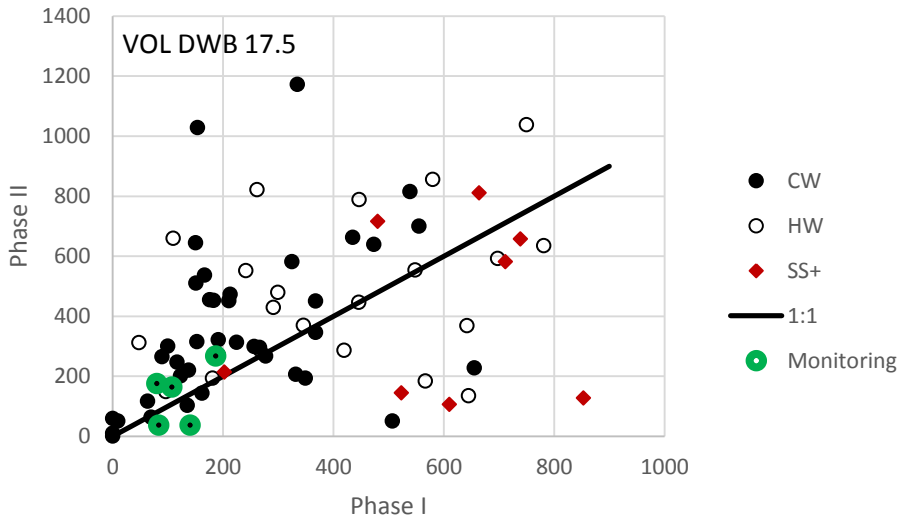

Figure 3. The Phase I inventory and Phase II ground volumes are compared. The monitoring plots (green) appear to have lower average volumes than the VA plots in the CW stratum.

[2] Vegetation Resources Inventory Sample Data Analysis Procedures and Standards, ver. 1.0 June 2011. https://www.for.gov.bc.ca/hts/risc/pubs/teveg/attribute_adjust_2k4/Production_VRI_Analysis_Procedures_Final.pdf

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

4. METHODS

4.1 Overview of VRI Sample Data Analysis

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

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

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

- Age of the leading species,
- Height of the leading species,
- Basal area at 7.5+ cm DBH utilization,
- Trees per hectare at 7.5+ cm DBH utilization,
- Lorey height (LH) with no utilization level,
- Volume net top, stump (CU), decay, waste and breakage at 17.5+ cm DBH utilization, and
- Site index.

Two whole stem volumes were extracted from the ground compiler and reported here.

1 Whole stem volume Raw – The whole stem volume is calculated using provincial taper models. In the ground computer output, this is field VHT_WSV.
2 Whole stem volume GVAF – The raw whole stem volume is adjusted using a Gross Volume Adjustment Factor (GVAF). This is from NVAF sampling in Haida Gwaii undertaken in the late 1990's within the boundaries of TFL 25 at that time consisting of approximately 170 trees. This is the srouce of the GVAF factors. In the ground compiler output, this is field GVL_WSV.

Two net merchantable volumes were extracted from the ground compiler and reported here.

1 Merchantable volume NVAF – The cruiser called net merchantable volume is adjusted using a Net Volume Adjustment Factor (NVAF). This is from NVAF sampling in Haida Gwaii undertaken in the late 1990's within the boundaries of TFL 25 at that time. In the ground compiler output, this is field NVL_NWB.
2 Merchantable volume LF – The merchantable volume is reduced using Loss factors (LFs) estimated from logit functions for decay waste and breakage. Custom LF coefficients were developed from destructive sampling of approximately 750 trees in the Queen Charlotte Islands in the 1990's[4]. In the ground compiler output, this is field VHT_DWB.

The attributes and the field names from the source files are given in Table 6.

Table 6. The field names for the attributes are given.

Attribute	Utilization	Ground file	VDYP7 file

[4] Decay-prediction working notes – Sample based adjustments Volume and Decay for QCI, dated May 3, 2001. TDJF24.doc.

Attribute	Utilization	Ground file	VDYP7 file
Age of leading species	7.5 cm	AGET_TXO	PRJ_TOTAL_AGE
Height of leading species	7.5 cm	HT_TXO	PRJ_DOM_HT
SI of leading species	7.5 cm	See section 4.4	PRJ_SITE_INDEX
Basal area	7.5 cm	Ba_ha	RPJ_BA
Trees per hectare	7.5 cm	Stems_ha	VRI_LIVE_STEMS_PER_HA
Lorey height	N/A	calculated	PRJ_LOREY_HT
Whole stem volume Raw	7.5 cm	Vht_wsv	PRJ_WSV
Whole stem volume GVAF	7.5 cm	Gvl_wsv	PRJ_WSV
Merchantable volume NVAF	17.5 cm	Nvl_nwb	PRJ_VOL_DWB
Merchantable volume LF	17.5 cm	Vht_dwb	PRJ_VOL_DWB

For the ground measurements, Lorey height is calculated as the basal area weighted mean for all live, standing, full measure trees, including broken top trees. For variable radius plots, this is equivalent to HT_MEAN1. It does not have a utilization level (it includes all trees that meet the criteria, regardless of DBH).

4.2 Data issues related to the analysis

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

Plots not meeting the VA population definition or showing evidence of post-inventory disturbance were dropped. CMI sample 280 was logged and was dropped.

Sample 0252_0182_MO1 had a large Phase I volume compared to Phase II (Figure 9). The ground sample is in a silvicultural opening that was not typed out in the inventory. This was identified at the time of sampling and the decision was to keep the sample. Unmapped disturbances are part of the within polygon variation and not a basis for dropping samples.

Trees with breast height ages < 10 or > 120 were not considered suitable SI trees. Trees that were not suitable height trees or suitable age trees were not considered suitable SI trees. As a result of this screening, 46 samples did not have a ground SI estimate. Sample 0252-0156-TO1 was Hw leading and only Cw were sampled.

No age trees were dropped because they were too young. No trees in the VA ground sample were identified as residual trees (resid = “R”).

4.3 Height and Age data matching

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

The objective of the species matching was to choose an inventory height and age (i.e. for either the leading or second species) so that the ground and inventory species “matched”. If a leading species match could not be made at the sp0 (Table 18) level, conifer-to-conifer (or deciduous-to-deciduous) matches were allowed. However, conifer-deciduous matches were not considered acceptable. Appendix E provides the details for the height and age data matching.

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

4.4 Site Index from the Phase II Samples

The Phase II SI was calculated as the arithmetic mean SI, by species, of the T, L, S, X and O trees in the "trees_h" file that met the suitability criteria including being suitable height and age trees and meeting the age criteria. Overmature trees are generally not suitable for estimating site index (SI) as they may not always have been dominant/codominant trees, may have experienced suppression at young ages and may have had broken tops. This leads to lower SI estimates as trees get older (Figure 4). SI estimates may not be reliable for very young trees. The SIBEC standard (BC Ministry of Forests and Range, Research Branch 2009) of excluding trees with breast height age < 10 or > 120 was used here. Note that the Phase I inventory estimates of SI are based on Phase I age and height and there are no restrictions on the age range.

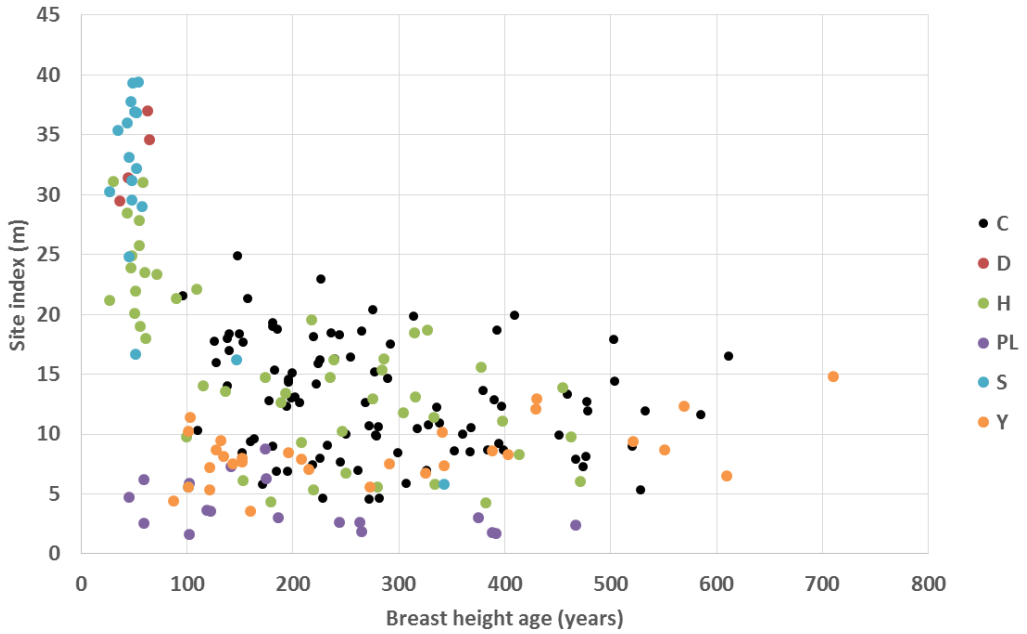

Figure 4. The trees with site estimates in the ground sample are given. There is a tendency for older trees to have falsely low site index estimates. The SIBEC standard of excluding trees with a breast height age > 120 and those with a breast height age < 10 from site index calculations is used here.

4.5 Site Index from the VRI Phase I polygons

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

4.6 Site index from Provincial Site productivity layer

The provincial site productivity layer (PSPL[5]) provides an alternative source of site index estimates, particularly for younger polygons. This layer provides site index estimates for up to 22 species. For Haida Gwaii, the PSPL generally provides SI estimates for 5 to 6 species per polygon. A comparison of the PSPL to Phase I inventory SI is included in the results and discussion.

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

5. RESULTS AND DISCUSSION

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

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

5.1 Attribute bias

Attribute bias is the difference between the Inventory Phase I photo estimated attributes and the ground Phase II attributes measured to known precision on the ground. Attribute bias can be assessed as the ratio of the weighted mean Phase II ground sample attribute to the corresponding weighted mean Phase I inventory attribute, for example leading species height as estimated in Phase I and the corresponding ground measurements. Ratios were computed for the seven key attributes identified in Section 4.1 and additional attributes of interest. The stratification for the Volume Audit population is based on Phase I inventory leading species groups from the primary layer. The means are given in Table 7 and the ratios in Table 8. The attributes were analyzed by leading species strata and overall. The data were also summarized by whether they were in the Timber Harvesting Landbase (THLB) or not (nonTHLB). The assignment to THLB is based on the previous inventory and timber supply review.

The SS+ stratum has a small sample size (n = 8). Six of the samples are SS leading (Phase I inventory) with more than 500 m^3/ha of volume. One sample is DR leading (480 m^3/ha) and one is PLC leading (228 m^3/ha). This is a small, mixed strata. Statistics for a combined Hw/Hm/SS+ stratum were generated. Note that either the Hw/Hm and SS+ ratios should be used or the Hw/Hm/SS+ ratio used.

Overall, the Phase I Inventory and Phase II ground heights and ages are close (with some overestimation of the Phase I inventory heights and ages for the SS+ stratum, n = 8). The Phase II ground BA is about 22% higher than the Phase I Inventory and the Phase II volume is about 23% higher. The basal area underestimation in Phase I is fairly consistent across species strata but the volume bias varies quite a bit by species strata. The effect of broken top trees on this underestimation is discussed later.

When the ground-based SI estimates are restricted to trees with breast height ages of 10 – 120, the sample sizes are very small. For leading species SI and leading species matched SI, a comparison of ground SI using all SI trees is also given. The SI comparison are of limited value in Haida Gwaii due to the age restriction (Nigh 2006) and the large number of trees older than the age cut-off.

Table 7. Sample-estimated weighted means for the Phase I inventory and Phase II ground sample for key inventory attributes, for the volume audit mature strata of Haida Gwaii. The Phase I attributes are from the primary layer only.

		Leading	Species	Strata		THLB	Strata	
Attribute		Cw/Yc	Hw/Hm	SS+	Hw/Hm & SS+	THLB	Non THLB	All
Ground Plots	N	45	21	8	29	44	30	74
Population area	hectares	192,949	104,129	39,433				
Leading	N	44	20	8	28	43	29	72
Species	Phase II Ground	271	220	147	199	252	228	242
Age (years)	Phase I Sample	259	209	178	200	239	231	236

Attribute		Leading Species Strata				THLB Strata		All
		Cw/Yc	Hw/Hm	SS+	Hw/Hm & SS+	THLB	Non THLB	
Leading Species	N	44	20	8	28	43	29	72
Matched	Phase II Ground	271	220	147	199	252	228	242
Age(years)	Phase I Sample	261	209	178	200	240	233	237
Second Species	N	21	11	1	12	23	10	33
Matched Age	Phase II Ground	261	251	61	235	259	232	251
(years)	Phase I Sample	266	189	58	178	243	212	234
Leading	N	44	20	8	28	43	29	72
Species	Phase II Ground	21.6	28.9	24.3	27.6	24.6	22.9	23.9
Height (m)	Phase I Sample	20.5	27.3	34.9	29.5	25.3	22.1	24.0
Leading Species	N	44	20	8	28	43	29	72
Matched	Phase II Ground	21.6	28.9	24.3	27.6	24.6	22.9	23.9
Height (m)	Phase I Sample	20.4	27.1	34.9	29.3	25.1	22.1	23.9
Second Species	N	18	8	1	9	19	8	27
Matched Height (m)	Phase II Ground	19.0	30.1	29.7	30.0	22.1	24.2	22.7
	Phase I Sample	18.4	28.8	29.2	28.8	22.2	21.2	21.9
Basal area	N	45	21	8	29	44	30	74
(m^2/ha)	Phase II Ground	55.6	61.9	60.4	61.5	63.6	49.6	57.9
7.5 cm+	Phase I Sample	43.4	52.1	59.8	54.2	49.5	44.9	47.7
Trees/ha	N	45	21	8	29	44	30	74
7.5 cm+	Phase II Ground	1016	1095	1233	1133	1130	964	1062
	Phase I Sample	713	601	417	551	642	658	648
Lorey	N	42	21	8	29	44	27	71
Height	Phase II Ground	18.8	25.7	21.5	24.5	21.4	20.9	21.2
(m)	Phase I Sample	19.3	26.1	31.7	27.6	22.9	22.4	22.7
Volume net	N	45	21	8	29	44	30	74
Dwb (m^3/ha)	Phase II Ground	356	498	423	478	451	337	404
17.5 cm+ NVAF	Phase I Sample	218	412	598	463	325	301	315
Volume net	N	45	21	8	29	44	30	74
Dwb (m^3/ha)	Phase II Ground	336	483	419	465	430	325	388
17.5 cm+ LF	Phase I Sample	218	412	598	463	325	301	315
Leading species	N	13	10	5	15	16	12	28
Site index (m)	Phase II Ground	10.9	22.8	25.0	23.5	19.3	15.6	17.7
Agebh 10 - 120	Phase I Sample	9.7	20.6	29.5	23.6	19.3	14.4	17.2
Leading species	N	44	20	8	28	43	29	72
Site index (m)	Phase II Ground	10.4	17.9	18.9	18.2	14.0	12.7	13.5
All ages	Phase I Sample	9.8	15.9	22.7	17.9	13.7	12.0	13.0
Leading Species	N	11	10	4	14	15	10	25
Matched SI (m)	Phase II Ground	11.7	22.8	25.9	23.7	20.2	15.9	18.5
Agebh 10 - 120	Phase I Sample	9.4	20.6	28.1	22.7	19.6	12.9	17.0
Second species	N	3	3	1	4	4	3	7
Matched	Phase II Ground	9.9	27.0	27.8	27.2	22.4	16.4	19.9
Site index (m)	Phase I Sample	6.0	30.2	28.0	29.7	24.4	13.2	19.7
Leading Species	N	38	17	4	21	37	22	59
Matched SI (m)	Phase II Ground	11.0	19.1	24.0	20.0	15.0	13.0	14.3
All ages	Phase I Sample	9.8	17.2	28.1	19.3	14.4	11.3	13.2
Site index	N	8	10	3	13	15	6	21
(m)	Phase II Ground	14.9	22.8	23.6	22.9	20.2	19.4	19.9
Site prod	Phase I Sample	19.2	23.7	26.4	24.3	22.4	22.2	22.4

Table 8. Ratio of means comparisons (and sampling error % at a 95% confidence level) are given for the attributes in Table 7. The ratios are based on the Phase I primary layer. The ratios that differ from 1.0 by more than 10% are shaded.

Attribute	Leading Species		Strata		THLB Strata		All
	Cw/Yc	Hw/Hm	SS+	Hw/Hm & SS+	THLB	Non THLB	
Leading Species	1.043	1.051	0.827	0.995	1.054	0.985	1.027
Age (years)	(8.8%)	(19%)	(14.1%)	(15.9%)	(10.9%)	(10.5%)	(7.8%)
Leading Species matched	1.037	1.053	0.827	0.996	1.052	0.978	1.023
Age (years)	(8.8%)	(19%)	(14.1%)	(15.9%)	(10.9%)	(10.7%)	(7.8%)
Second Species matched	0.978	1.328	1.043	1.321	1.066	1.096	1.074
Age (years)	(17%)	(34.8%)	(0%)	(34.1%)	(17.4%)	(39.6%)	(16%)
Leading Species	1.054	1.056	0.697	0.935	0.973	1.035	0.996
Height (m)	(9.5%)	(12.1%)	(22.8%)	(12.9%)	(10.4%)	(12.8%)	(7.2%)
Leading Species matched	1.057	1.066	0.697	0.941	0.979	1.037	1.001
Height (m)	(9.5%)	(12.2%)	(22.8%)	(13.1%)	(10.5%)	(12.8%)	(7.3%)
Second Species matched	1.031	1.044	1.018	1.041	0.994	1.138	1.036
Height (m)	(17.4%)	(25.2%)	(0%)	(22.4%)	(14.4%)	(30.9%)	(13.9%)
Basal area	1.282	1.189	1.011	1.135	1.284	1.104	1.215
(m^2/ha) 7.5 cm+	(12.8%)	(23%)	(30.4%)	(18.8%)	(12.6%)	(19.7%)	(10.8%)
Trees/ha	1.425	1.821	2.957	2.057	1.759	1.465	1.638
7.5 cm+	(18.3%)	(56%)	(27.9%)	(41.3%)	(29.9%)	(22.9%)	(20.1%)
Lorey Height	0.977	0.984	0.676	0.887	0.932	0.932	0.932
(m)	(9.7%)	(14.7%)	(22.6%)	(13.7%)	(11.2%)	(12.5%)	(7.8%)
Volume net Dwb	1.635	1.208	0.708	1.03	1.385	1.118	1.282
(m^3/ha) 17.5 cm+ NVAF	(22.3%)	(26.5%)	(46.2%)	(24%)	(20.3%)	(31.2%)	(15.9%)
Volume net Dwb	1.544	1.17	0.702	1.004	1.323	1.078	1.228
(m^3/ha) 17.5 cm+ LF	(22.9%)	(25.8%)	(47.8%)	(23.8%)	(19.8%)	(32%)	(16%)
Leading Species	1.121	1.102	0.85	0.998	1.001	1.081	1.029
Site index (m) age 10-120	(19.3%)	(13.9%)	(27.8%)	(14.9%)	(14.9%)	(21.3%)	(11.1%)
Leading Species	1.061	1.123	0.833	1.018	1.022	1.063	1.037
Site index (m) All ages	(8.5%)	(8.6%)	(22.9%)	(10.8%)	(8.5%)	(12.4%)	(6.4%)
Leading Species matched	1.245	1.104	0.923	1.041	1.027	1.234	1.09
Site index (m) age 10-120	(20.8%)	(13.7%)	(29.4%)	(13.8%)	(15.4%)	(14.9%)	(11.1%)
Second Species matched	1.652	0.892	0.993	0.916	0.918	1.243	1.011
Site index (m)	(68.2%)	(8%)	(0%)	(7.5%)	(8.9%)	(61.8%)	(16.6%)
Leading Species matched	1.121	1.11	0.855	1.04	1.042	1.155	1.078
Site index (m) All ages	(7.9%)	(8.7%)	(31.6%)	(11%)	(8.7%)	(10.7%)	(6.3%)
Site index (m)	0.78	0.962	0.892	0.945	0.899	0.875	0.892
PSPL	(20.2%)	(18.9%)	(25.2%)	(15.7%)	(16.6%)	(19.4%)	(12.7%)

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

As noted in section 4.1, two net merchantable volumes were extracted from the ground compiler – NVAF and LF. The accuracy of the two methods has not been tested or compared in Haida Gwaii and there is no evidence to prefer the use of one volume over the other. Unless otherwise noted, the LF volumes are presented. The ground volumes are compared to Phase I inventory volumes in Table 9 and Table 10 (NVAF) and then Table 11 and Table 12 (LF).

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.

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

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

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

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

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

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

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

Total bias = VOL A – VOL B

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

Attribute bias = VOL C - VOL B. Does not include VDYP7 volume estimation errors but includes errors in original attributes, errors in attribute projection and sampling errors.

Two samples (0252-0134-TO1 and 0252-0156-TO1) did not have heights for the leading species and were not projected by VDYP7. Three samples (0252-0107-TO1, 0252-0108-TO1 and 0252-0171-TO1) had VDYP7 projected heights that were too short to have volumes estimated so the volumes were set to zero.

The attribute volume bias is 39 m^3/ha, or about 10% of the ground volume (Figure 5 and Table 9). The model bias is 40 m^3/ha.

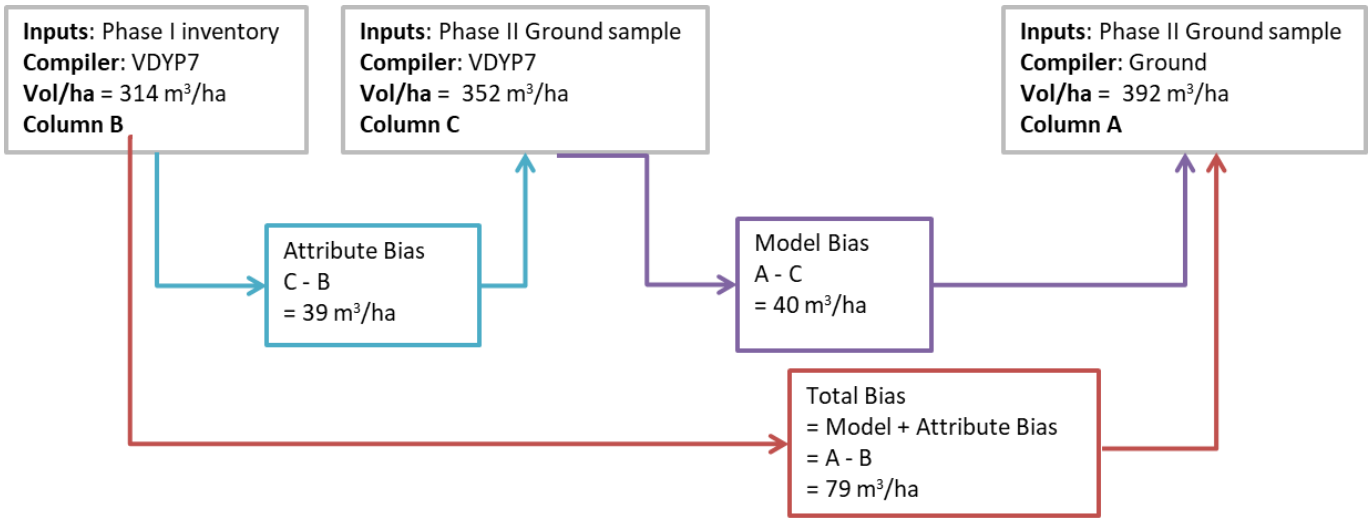

Figure 5. The relationship between the model and attribute components of total volume bias (DBH ≥ 17.5 cm) net of decay waste and breakage) for the mature target population in Haida Gwaii (from Table 9). A negative bias indicates Phase I overestimation whereas a positive bias indicates underestimation. The Phase II LF volumes are used.

First the Phase II NVAF volumes are given (Table 9 and Table 10) and then the LF volumes are given (Table 11 and Table 12). Elsewhere, the LF volumes are used.

Attribute bias is largest in the SS+ strata (n = 8, Table 9). The CW and HW strata have more ground volume than shown in the Phase I inventory while the SS+ stratum has less volume.

Table 9. Volumes for model-related and attribute-related bias comparison. The sample size is less than that in Table 7 and the means are slightly different due to the dropping some samples. The dead whole stem volume (WSV) for DBH ≥ 7.5 cm) is also given. The Phase II NVAF volumes are used.

Stratum	N	Weighted mean Live Volume (m^3/ha) net Dwb at 17.5cm DBH						Dead Volume	
		Phase II Ground	VDYP7 Phase I Inventory	VDYP7 volume with Phase II attributes as input	Model-related volume bias	Attribute-related volume bias	Total volume bias	Phase II Ground WSV at 7.5 cm	Phase I Inventory
		A	B	C	A-C	C-B	A-B		
CW	44	357.0	220.5	293.7	63.2	73.3	136.5	141.8	0
HW	20	515.9	400.9	448.6	67.3	47.7	115.0	99.4	0
SS+	8	423.2	598.0	427.5	-4.3	-170.4	-174.7	125.6	0
HW & SS+	28	489.5	456.9	442.6	46.9	-14.3	32.6	106.9	0
THLB	43	453.6	330.4	377.2	76.4	46.8	123.2	129.3	0
Non THLB	29	343.4	289.1	315.8	27.7	26.6	54.3	126.2	0
All	72	409.3	313.8	352.5	56.8	38.7	95.5	128.0	0

Table 10. Ratios of mean volumes (17.5cm+ 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. The Phase II NVAF volumes are used.

Stratum		Model bias: Ground/VDYP7 (ground attributes)	Attribute bias: VDYP7 (Ground attributes)/ Inventory	Total bias: Ground/Inventory
	N	(Table 9 A/C)	(Table 9 C/B)	(Table 9 A/B)

Stratum	N	Model bias: Ground/VDYP7 (ground attributes) (Table 9 A/C)	Attribute bias: VDYP7 (Ground attributes)/ Inventory (Table 9 C/B)	Total bias: Ground/Inventory (Table 9 A/B)
CW	44	1.215 (±4%)	1.332 (±14.8%)	1.619 (±18.7%)
HW	20	1.15 (±6.5%)	1.119 (±15.2%)	1.287 (±16.3%)
SS+	8	0.99 (±6.4%)	0.715 (±16.9%)	0.708 (±16.7%)
HW & SS+	28	1.106 (±5%)	0.969 (±12%)	1.071 (±12.8%)
THLB	43	1.202 (±4.5%)	1.142 (±11.7%)	1.373 (±14.3%)
Non THLB	29	1.088 (±4.4%)	1.092 (±17%)	1.188 (±18.5%)
All	72	1.161 (±3.3%)	1.123 (±9.7%)	1.304 (±11.5%)

Table 11. Volumes for model-related and attribute-related bias comparison. The sample size is less than that in Table 7 and the means are slightly different due to the dropping some samples. The Phase II LF volumes are used.

Stratum	N	Weighted mean Live Volume (m^3/ha) net Dwb at 17.5cm DBH					
		Phase II Ground	VDYP7 Phase I Inventory	VDYP7 volume with Phase II attributes as input	Model-related volume bias	Attribute-related volume bias	Total volume bias
		A	B	C	A-C	C-B	A-B
CW	44	337.0	220.5	293.7	43.2	73.3	116.5
HW	20	500.0	400.9	448.6	51.4	47.7	99.2
SS+	8	419.5	598.0	427.5	-8.1	-170.4	-178.5
HW & SS+	28	477.1	456.9	442.6	34.5	-14.3	20.2
THLB	43	433.3	330.4	377.2	56.1	46.8	102.9
Non THLB	29	331.3	289.1	315.8	15.5	26.6	42.1
All	72	392.3	313.8	352.5	39.8	38.7	78.5

Table 12. Ratios of mean volumes (17.5cm+ 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. The Phase II LF volumes are used.

Stratum	N	Model bias: Ground/VDYP7 (ground attributes) (Table 9 A/C)	Attribute bias: VDYP7 (Ground attributes)/ Inventory (Table 9 C/B)	Total bias: Ground/Inventory (Table 9 A/B)
CW	44	1.147 (±3.6%)	1.332 (±14.8%)	1.528 (±18.1%)
HW	20	1.115 (±6.2%)	1.119 (±15.2%)	1.247 (±15.2%)
SS+	8	0.981 (±6.3%)	0.715 (±16.9%)	0.702 (±17.1%)
HW & SS+	28	1.078 (±4.8%)	0.969 (±12%)	1.044 (±12.3%)
THLB	43	1.149 (±4.1%)	1.142 (±11.7%)	1.311 (±13.3%)
Non THLB	29	1.049 (±4.1%)	1.092 (±17%)	1.146 (±18.3%)
All	72	1.113 (±3%)	1.123 (±9.7%)	1.25 (±11%)

The two potential sources of volume error in Phase I are illustrated in Figure 6. The total bias (Figure 6a) includes model and attribute error. The Phase I inventory and Phase II ground volumes are positively correlated with evidence of higher ground volumes. There is a great deal of unexplained variation.

The model-related volume error is about half the total bias (based on the Phase II LF volumes) with little variation (Figure 6b). The model bias is an indication of the difference between VDYP7 volume estimates and the ground compiler, using similar attributes. The ground compiler volumes are based on the individual tree measurements and taper models and are considered more accurate than the VDYP7 volumes which are based on stand level estimates of BA, height and age by species. The estimate of model bias is based on the ground plot measurements and does not include any of the variation associated with sampling a small portion of the Phase I polygon. The relationship is strong and could be used to adjust the Phase I attributes.

The attribute-related bias is a much more variable (Figure 6c). The average attribute-related bias is about the same as the average model-related volume bias but the variance of the attribute-related bias dominates to variance of the total bias. Attribute bias includes errors in the original photo estimates, errors in projecting the photo estimates to the year of ground sampling, ground measurement errors and sampling error. The sampling error results from the ground sample representing a small part of the polygon compared to the polygon estimate. The sample plan is designed to provide unbiased estimates so the sampling error should not contribute to the overall attribute bias but it does contribute to the variation in Figure 6c. Although the difference between the Phase I inventory estimate and the Phase II ground measurement is referred to as an “error”, a more correct term is “difference”. The relationship is not strong, with more unexplained variation. The attribute bias should be considered when using the Phase I inventory.

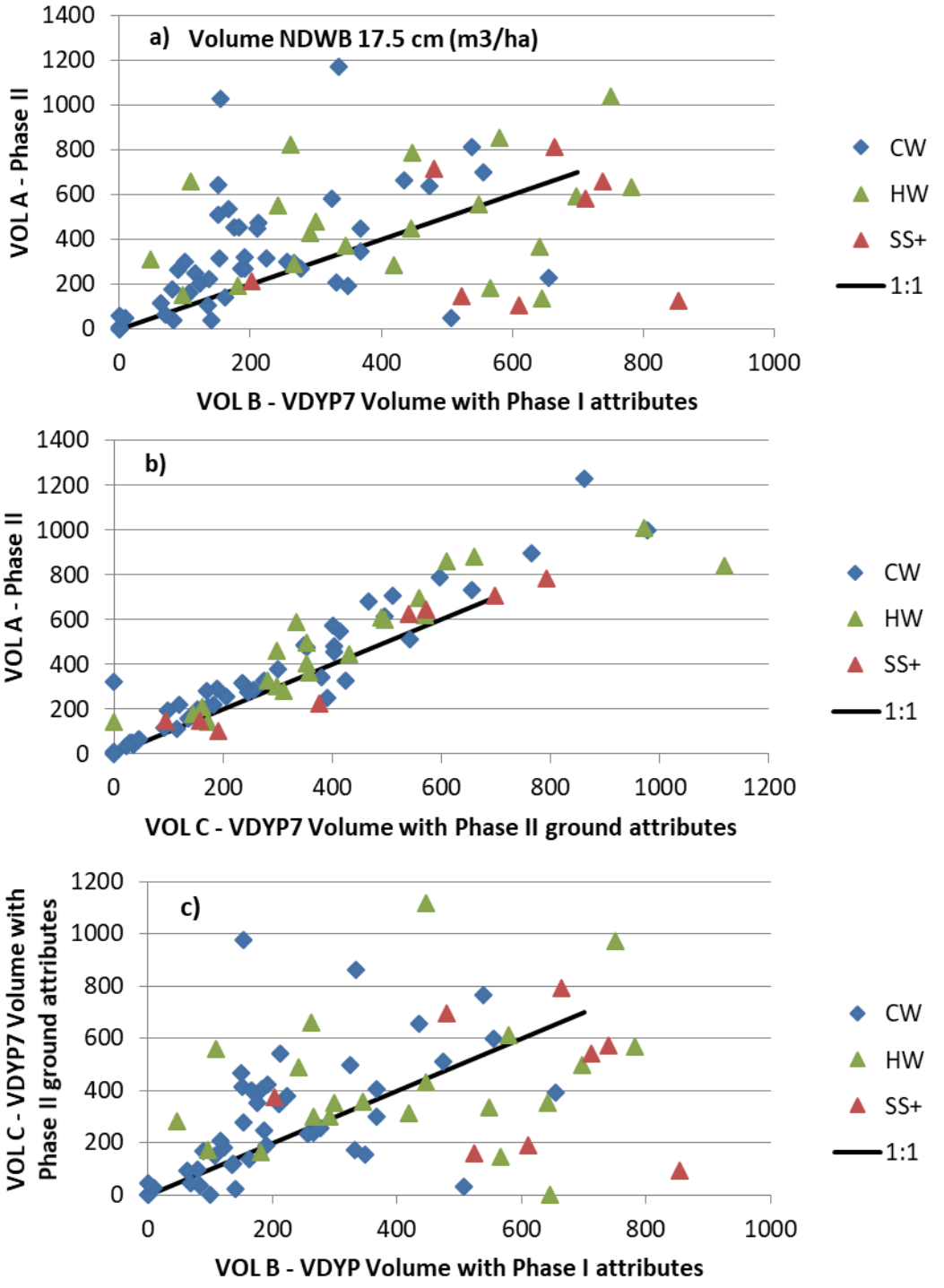

Figure 6. The top graph (a) illustrates the total volume error (Phase I vs. Phase II volume). The middle graph (b) illustrates model-related volume error (VDYP7 volume using Phase II inputs vs. Phase II volume). The bottom graph (c) illustrates the attribute-related volume error (Phase I volume vs. VDYP7 volume using Phase II inputs). The Phase I LF volumes are used.

5.3 Phase I Layers

The VRI can include several live layers including primary, residual, veteran and young layers as well as potentially including a dead layer. The analysis in sections 5.1 and 5.2 included the projected layers and showed the Phase I VRI estimates of BA and volume was lower than the Phase II ground sample. There is only one sample with a non-projected layer (Table 3). If this was included, it would increase the Phase I sample average BA by approximately 0.5 m^2/ha or about 1%. The photo interpretation of layers can be difficult, particularly for areas such as Haida Gwaii with tall, old, mixed species, multi-storied stands. Hemlock and cedar, the main species, are tolerant of shade and may be present in the understory and not visible in aerial photographs. The polygon with two layers (Table 3) had a low crown closure for the primary layer (15%) compared to the average crown closure of 57% for all the sampled polygons.

5.4 Broken Top trees

Broken tops were assessed on all trees on the central plot of the volume audit samples and all trees on the monitoring plots. Broken tops were not assessed on the volume audit auxiliary plots. Heights were measured on all trees. For trees identified as broken top, the intact (projected) height is estimated and then used to estimate the intact volume. Then the volume above the break is estimated and the tree volume estimated as the intact volume minus the volume above the break. For trees not assessed for broken tops (i.e.., on auxiliary plots), the estimated height is treated as the total height (not as the height to the break) and the stem volume estimated. This will lead to an underestimate of the actual volume. This issue has been identified and field procedures will be modified so all trees with measured heights are also assessed for broken tops and the diameter at the break or the projected height estimated.

Based on the subset of trees assessed for broken tops, approximately 9% of the live trees with DBH ≥ 7.5 cm have broken tops, representing approximately 10% of the basal area and 10% of the whole stem volume. The effect of the broken top trees on volume is less. For instance, the first live broken top tree in the data base has a Dbh of 16 cm and a height to break of 5.8 m. The fraction of volume above the break is less than 25% of the total intact volume. Broken top trees may be difficult to see in aerial photos and may contribute to the inventory underestimation of BA and volume. As well, the ground estimates for broken top trees in auxiliary plots likely include more volume estimation error than intact trees, due to not estimating the broken top diameter or projected height.

5.5 Leading species comparison

Table 13 summarizes the agreement between the leading species in the Phase I inventory and the leading species from the Phase II ground sample compilation for the sampled polygons. Of the 74 samples, 45 (61%) were correctly classified. This is similar to other TSAs.

Table 13. The Phase II ground vs. Phase I inventory leading species cross-tabulation for the target population in Haida Gwaii. The shaded cells are correct classifications. The overall correct classification rate is 61%.

Phase I Inventory	Phase II Ground Leading Species @ 4cm DBH utilization							%
leading spp	C	D	H	P	S	Y	Total	Agreement
C	28		5	1		4	38	74%
D		1					1	100%
H	4		11		2	4	21	52%
P	1						1	0%
S	1		1		3	1	6	50%
Y			1	4		2	7	29%
Total	34	1	18	5	5	11	74	
% agreement	82%	100%	61%	0%	60%	18%		61%

Part of the reason for the low agreement is that the ground plot is a small sample within the larger Phase I polygon. The ground plot may be in a small pocket of one species while the photo interpreter is assigning

the species composition for the entire polygon. In addition, the ground species composition includes all trees while the photo interpreter may not see the understory. The agreement may increase if the ground leading species is based on the dominant/codominant trees only.

The previous comparison is important. However, for some polygons the leading species percent is close to the second species percent and varies with utilization level (Table 14).

Table 14. The samples are given which have a 10% difference or less in the leading species based on the Phase II ground species composition at the 4.0 cm utilization.

Clstr_id	Phase II Ground 4.0 cm	Phase II Ground 7.5 cm	Phase I Inventory
0252-0124-TO1	Cw 34 Yc 34 Hw 19 Ss 06 Pl 07	Cw 34 Yc 34 Hw 19 Ss 06 Pl 07	CW 60 HW 40
0252-0126-TO1	Cw 29 Yc 29 Hw 29 Ss 13	Cw 29 Yc 29 Hw 29 Ss 13	CW 50 HW 30 YC 10 SS 10
0252-0129-TO1	Cw 35 Hw 35 Pl 25 Yc 05	Cw 35 Hw 35 Pl 25 Yc 05	CW 75 HW 15 PLC 10
0252-0131-TO1	Pl 50 Yc 50	Pl 58 Yc 42	YC 50 CW 30 HW 10 PLC 10
0252-0134-TO1	Yc 36 Cw 36 Hw 23 Ss 05	Yc 36 Cw 36 Hw 23 Ss 05	CW 40.1 YC 39.9 HW 15 PLC 5
0252-0155-TO1	Yc 44 Hw 44 Hm 12	Yc 44 Hw 44 Hm 12	HW 50 CW 30 SS 20

If the close matches in Table 14 are considered matches, the species agreement rises from 61% to 65%.

5.6 Size class distributions

The ground samples tally trees were used to examine the size class distributions.

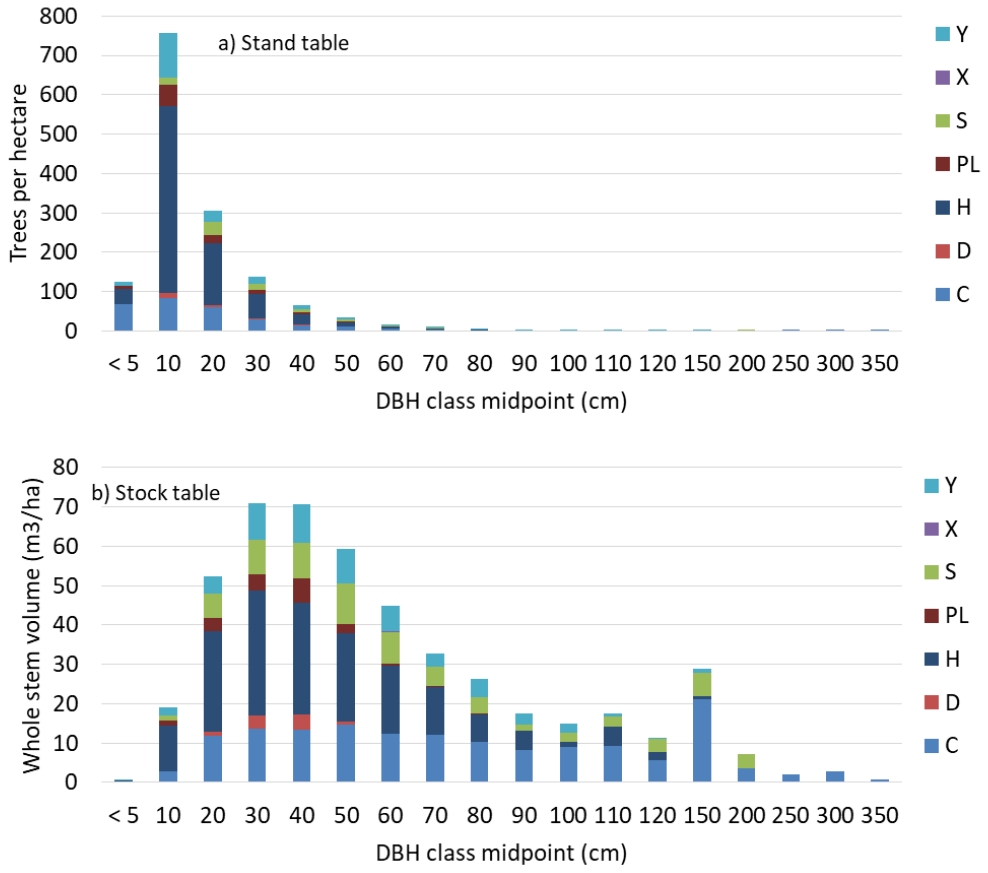

Figure 7. The number of trees (a) and volume (b) are summarized by species and DBH class for live trees with DBH ≥ 4.0 cm. The DBH classes are 10 cm wide up to 125 cm and 50 cm wide for larger DBHs.

About half of the dead trees have DBH < 15 cm and 40% are hemlock (Figure 8). The average dead volume is 128 m^3/ha (Table 9).

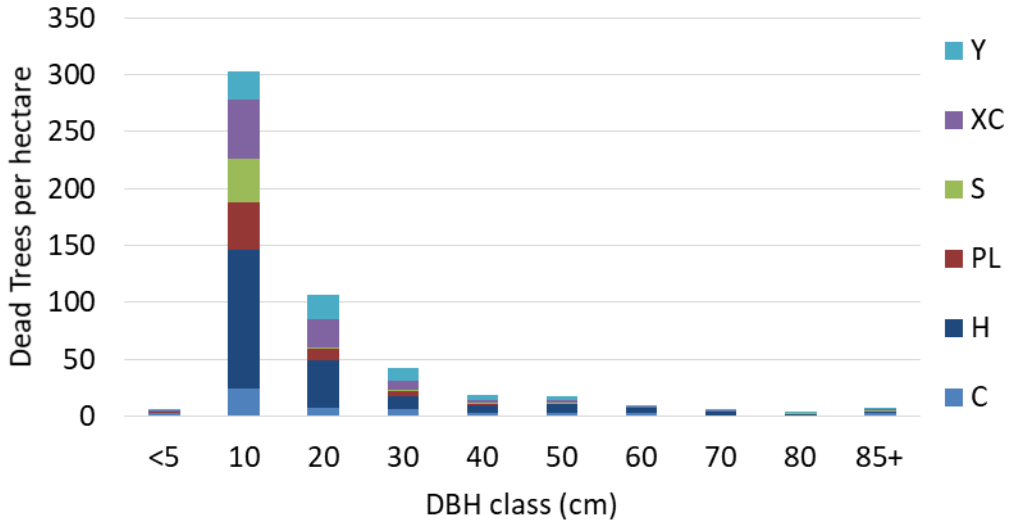

Figure 8. The number of dead trees is given by species and DBH class for trees with DBH ≥ 4.0 cm.

5.7 Limitations of the approach

Utilization limit– The original photo interpreted attributes in Phase I do not have a utilization limit. The photo interpretation procedures for most attributes is to assess the living trees visible to the photo interpreter in the dominant, codominant and high intermediate crown positions for each tree layer in the polygon (FAIB 2014). In Nona Philips Forestry Consulting (2014) (which was not used), sample 93 has BA = 0 and stems = 595 stems/ha, implying the DBH limit is 0cm. When the Phase I attributes are run through VDYP7, the resulting attributes will all have a utilization limit.

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

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 volume – Two methods are available to reduce whole stem merchantable volume to volume net of decay, waste and breakage (DWB), net factoring and loss factors (see section 4.1). Both options are available from the ground compiler and loss factors are used in VDYP7. It is not clear which should be used. The net factoring approach is based on a localized sample from one TFL on Haida Gwaii. The loss factors are based on approximately 750 trees destructively sampled in the Queen Charlotte Islands in the

1990s[6]. Based on the larger sample size and broader geographic coverage, the loss factor approach is recommended.

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

Target population - THLB – The target population for the volume audit (mature) stratum was the vegetated treed portion of the land base. The Timber Harvesting Land Base (THLB) is a subset of this area. If the THLB differs substantially from the larger population (e.g., more productive, younger), the results may not be appropriate for the THLB. The THLB used here is based on an old inventory and will be revised with the new inventory.

6. Conclusions and recommendations

The inventory estimates of age and height are close to the ground estimates while basal area is lower. It is possible the volume audit population includes an understory not included in the photo interpretation summaries of the primary layer. The inventory 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[7]. A second layer was only identified in one of the sampled polygons. Volume is also underestimated in the inventory. Much of the underestimation is linked to the underestimation of BA. The ground estimate of volume is higher and assumed to be accurate. The volume and net down estimates are considered unbiased but have some unexplained variation associated with the estimates. Approximately 10% of the ground volume is associated with broken top trees.

Two options – NVAF and LF – are available for compiling the ground volume. Due to the larger sample size and wider geographic coverage, LF is recommended.

The ground and inventory estimates of SI are close while the PSPL SI estimates are generally higher than the ground estimates. This is not unexpected as the PSPL represents potential productivity which is generally higher than the actual productivity. The ground estimates of SI were restricted to sample trees with breast height ages from 10 to 120. As a result, more than half of the samples did not have any suitable SI trees.

The leading species agreement for the Volume Audit population is comparable to results from other TSA (61% or 45 out of 74).

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

[6] Decay-prediction working notes – Sample based adjustments Volume and Decay for QCI, dated May 3, 2001. TDJF24.doc.
[7] VRI Photo interpretation Procedures, Verion 3.0. April 2014.

The Haida Gwaii monitoring plots will be remeasured and used to estimate change. The sample size of field plots in the volume audit population is small (n = 5) and may not adequately represent the population. All the samples are in the Cw stratum and have lower average volume than the temporary plots in the same strata. The monitoring plot network also includes photo plots and is designed to monitor larger areas than the target population here.

7. Literature cited

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8. Appendix A: Phase I inventory attributes

Table 15. The Phase I inventory projected attributes are given.

Clstr_id	THLB (1 -= THLB)	inventory standard	BEC	Reference year	Input CC%	Polygon area (ha)	sp01	pct1	sp02	pct2	sp03	pct3	sp04	pct4	Age sp1	Height sp1	Age sp2	Height sp2	Basale area (m2/ha)	Trees/ha	Lorey height (m)	Volume NWB 17.5 (m3/ha)	Dead WSV (m^3/ha)	SI SPp1 (m)	SI spp2 (m)
0251-0001-MO1	1	V	CWH	2007	50	131	CW	60	YC	20	HW	15	PLC	5	248	18.2	308	16.1	38.4	976	15.1	140	12	8.8	7.4
0251-0003-MO1	1	V	CWH	2007	45	26.2	CW	50	HW	40	YC	10			258	20.2	233	21.3	40.4	601	17.0	187	43	9.6	8.9
0251-0006-MO1	1	V	CWH	2007	45	16.5	CW	40	HW	30	YC	20	PLC	10	358	16.1	358	14.1	25.0	674	13.6	80	127	7.1	5.2
0251-0007-MO1	0	V	CWH	2007	55	21.6	CW	70	HW	20	PLC	10			308	14.1	308	13.1	32.3	953	11.8	84	15	6.6	5.1
0251-0009-MO1	1	V	CWH	2007	80	78.6	CW	85	HW	15					228	14.2	248	12.1	45.5	1607	11.7	107	57	7.2	5.1
0252-0102-TO1	0	V	CWH	2007	60	16.9	CW	50	YC	30	HW	20			258	21.2	258	20.2	50.6	652	18.1	224	263	10.1	9.6
0252-0104-TO1	0	V	CWH	2007	65	9.3	CW	65	HW	20	YC	15			168	17.3	168	16.4	41.8	1013	14.5	151	128	9.6	8.0
0252-0107-TO1	1	V	CWH	2007	15	4.6	YC	60	PLC	30	CW	10			128	4.1	148	3.1	2.0	600		0	3	3.0	2.0
0252-0108-TO1	1	V	CWH	2007	15	51.3	YC	50	PLC	40	CW	10			108	3.1	108	3.2	1.0	400		0	0	2.5	2.4
0252-0110-TO1	1	V	CWH	2007	55	8.9	CW	60	YC	30	PLC	10			308	20.2	308	19.1	38.4	690	17.1	162	180	9.1	8.7
0252-0111-TO1	0	V	MH	2007	50	14	YC	60	CW	20	HW	10	SS	10	308	19.1	308	17.1	35.4	712	15.2	154	249	8.7	7.8
0252-0113-TO1	0	V	CWH	2007	55	5.8	CW	50	YC	30	HW	15	SS	5	308	21.2	308	18.1	40.4	664	17.9	176	98	9.5	8.2
0252-0114-TO1	1	V	CWH	2007	55	72.2	CW	45	PLC	30	HW	20	YC	5	243	25.3	208	23.2	47.6	563	21.6	277	224	12.2	13.4
0252-0115-TO1	1	V	CWH	2007	60	12.3	CW	55	HW	30	YC	15			308	16.1	338	17.1	35.4	804	13.6	123	284	7.4	6.4
0252-0116-TO1	1	V	CWH	2007	70	23.2	CW	50	HW	30	YC	20			288	22.2	288	21.2	55.6	741	19.0	266	63	10.2	8.2
0252-0117-TO1	1	V	CWH	2007	10	10.2	YC	70	CW	30					308	13.1	308	14.1	5.0	344	9.8	9	23	6.1	6.6
0252-0118-TO1	1	V	CWH	2007	50	21.5	CW	55	HW	35	SS	5	YC	5	308	37.3	308	38.3	58.6	324	33.2	507	83	16.6	15.3
0252-0119-TO1	1	V	CWH	2007	55	76.3	CW	50	HW	40	SS	5	PLC	5	238	34.4	228	32.4	60.8	357	30.4	473	345	16.7	14.1
0252-0120-TO1	1	V	CWH	2007	50	41.1	CW	50	HW	35	SS	15			209	26.3	229	28.4	47.9	540	22.4	334	270	13.4	12.2
0252-0121-TO1	0	V	CWH	2007	70	28.6	CW	60	HW	20	PLC	20			173	23.4	233	22.3	61.9	683	20.1	325	180	12.7	9.4
0252-0122-TO1	1	V	CWH	2007	65	19.2	CW	50	HW	30	SS	10	YC	10	283	30.3	308	34.3	70.8	675	25.9	555	372	13.8	13.4
0252-0123-TO1	0	V	CWH	2007	45	25.1	YC	60	CW	20	HW	15	PLC	5	228	19.2	258	18.2	32.4	599	15.3	137	26	9.6	8.7
0252-0124-TO1	1	V	CWH	2007	60	25.7	CW	60	HW	40					309	22.2	334	21.2	45.6	685	18.9	213	140	10.0	7.8
0252-0125-TO1	1	V	CWH	2007	65	5.6	CW	60	HW	30	YC	10			258	25.3	283	24.2	60.7	701	21.5	332	171	12.0	9.5
0252-0126-TO1	1	V	CWH	2007	70	25.3	CW	50	HW	30	YC	10	SS	10	258	24.3	258	24.3	65.8	602	21.0	367	88	11.5	9.8
0252-0127-TO1	0	V	CWH	2007	55	19.1	CW	60	HW	20	YC	10	PLC	10	408	18.1	358	16.1	65.0	350	16.2	183	141	7.7	5.9

Clstr_id	THLB (1 -= THLB)	inventory standard	BEC	Reference year	Input CC%	Polygon area (ha)	sp01	pct1	sp02	pct2	sp03	pct3	sp04	pct4	Age sp1	Height sp1	Age sp2	Height sp2	Basale area (m2/ha)	Trees/ha	Lorey height (m)	Volume NWB 17.5 (m3/ha)	Dead WSV (m^3/ha)	SI SPp1 (m)	SI spp2 (m)
0252-0128-TO1	1	V	CWH	2007	55	24.7	CW	60	HW	40					218	20.3	228	19.3	38.6	690	17.1	166	359	10.3	8.2
0252-0129-TO1	0	V	CWH	2007	70	9.9	CW	75	HW	15	PLC	10			228	16.2	238	15.2	35.6	832	13.7	117	140	8.2	6.4
0252-0130-TO1	1	V	CWH	2007	60	18.4	CW	60	HW	30	PLC	10			218	18.3	228	16.3	40.6	911	15.2	150	301	9.3	6.9
0252-0131-TO1	0	V	CWH	2007	40	10.1	YC	50	CW	30	HW	10	PLC	10	348	14.1	258	16.2	24.0	774	10.9	70	30	6.3	7.8
0252-0132-TO1	1	V	CWH	2011	65	87.7	CW	70	HW	10	YC	10	PLC	10	104	16.4	104	16.4	55.9	606	14.3	191	128	11.3	10.4
0252-0133-TO1	1	V	CWH	2007	40	12.3	CW	50	HW	30	YC	20			333	21.2	333	20.2	34.0	599	17.7	153	126	9.3	7.5
0252-0134-TO1	1	V	CWH	2007	55	73.3	CW	40.1	YC	39.9	HW	15	PLC	5	308	15.1	358	13.1	35.3	878	12.7	100	131	7.0	5.9
0252-0135-TO1	0	V	CWH	2007	60	39.9	CW	60	HW	30	SS	10			328	30.2	308	28.2	65.0	492	26.3	435	284	13.2	10.8
0252-0136-TO1	1	V	CWH	2007	60	12.8	CW	50	HW	40	PLC	10			188	26.4	208	25.4	57.3	610	22.5	349	83	13.9	11.2
0252-0137-TO1	1	V	CWH	2007	60	35.7	CW	50	HW	30	SS	20			318	35.3	338	34.2	76.0	429	31.1	655	117	15.6	13.0
0252-0138-TO1	0	V	CWH	2012	55	18.7	CW	85	HW	15					254	25.1	274	25.1	48.3	700	21.3	257	124	12.0	10.0
0252-0139-TO1	1	V	CWH	2007	65	37.2	CW	65	HW	20	PLC	15			168	11.2	198	10.2	33.0	1522	9.3	63	182	6.4	4.8
0252-0140-TO1	0	V	CWH	2007	50	145.4	CW	60	HW	30	YC	10			348	14.1	348	13.1	35.0	799	11.9	90	129	6.3	4.9
0252-0142-TO1	0	V	CWH	2007	60	6.4	HW	40.1	YC	39.9	SS	10	PLC	10	208	24.4	208	24.3	45.0	619	21.1	300	193	10.8	12.4
0252-0144-TO1	0	V	CWH	2007	75	43.2	HW	60	SS	40					58	32.4	58	34.8	70.6	508	29.4	750	28	31.2	33.5
0252-0145-TO1	0	V	CWH	2012	80	26.7	HW	60	SS	40					63	34.1	63	31.2	76.4	526	30.8	781	10	31.0	28.3
0252-0146-TO1	0	V	CWH	2007	55	3.1	HW	40.1	CW	39.9	SS	10	YC	10	308	25.2	308	22.2	45.0	557	22.0	262	133	9.6	10.0
0252-0147-TO1	0	V	CWH	2007	15	47.3	HW	60	SS	30	CW	10			379	38.2	399	47.2	16.0	100	34.4	181	302	14.3	16.7
0252-0148-TO1	0	V	CWH	2007	65	10.2	HW	45	CW	40	YC	10	SS	5	338	22.2	328	22.2	46.0	749	19.2	241	100	8.2	9.8
0252-0149-TO1	0	V	CWH	2007	65	11.3	HW	55	YC	30	CW	15			308	16.1	308	16.1	32.1	971	13.8	109	71	6.2	7.4
0252-0150-TO1	1	V	CWH	2007	50	22.8	HW	80	SS	10	CW	10			339	38.3	309	50.3	58.0	318	34.5	580	218	14.8	21.1
0252-0151-TO1	1	V	CWH	2007	60	22.1	HW	65	CW	20	SS	10	YC	5	183	32.6	183	29.5	64.7	427	28.9	548	9	15.7	15.6
0252-0152-TO1	1	V	CWH	2007	80	14.6	HW	75	SS	25					52	28.7	51	29.1	63.5	613	25.7	567	2	29.9	31.0
0252-0153-TO1	1	V	CWH	2007	65	7.8	HW	55	CW	40	SS	5			183	29.6	178	29.5	59.9	494	26.1	447	97	14.0	15.8
0252-0154-TO1	1	V	CWH	2007	65	19.3	HW	50	CW	20	YC	20	SS	10	358	35.2	358	33.2	76.0	397	31.9	642	86	13.2	14.2
0252-0155-TO1	1	V	CWH	2007	60	19.9	HW	50	CW	30	SS	20			308	23.2	308	24.2	45.0	655	20.2	266	19	8.8	10.8
0252-0156-TO1	1	V	CWH	2012	55	23.8	HW	70	SS	25	CW	5			333	31.1	313	38.1	72.0	724	26.7	645	103	11.7	11.9
0252-0157-TO1	1	V	CWH	2007	50	10.6	HW	75	CW	20	SS	5			53	16.1	53	17.5	25.1	965	14.0	97	31	17.2	19.5
0252-0158-TO1	1	V	CWH	2007	65	13.2	HW	65	CW	30	YC	5			124	11.5	119	11.5	23.1	1136	9.9	48	167	6.7	7.5

Clstr_id	THLB (1 -= THLB)	inventory standard	BEC	Reference year	Input CC%	Polygon area (ha)	sp01	pct1	sp02	pct2	sp03	pct3	sp04	pct4	Age sp1	Height sp1	Age sp2	Height sp2	Basale area (m2/ha)	Trees/ha	Lorey height (m)	Volume NWB 17.5 (m3/ha)	Dead WSV (m^3/ha)	SI SPp1 (m)	SI spp2 (m)
0252-0159-TO1	1	V	CWH	2007	65	23	HW	50	SS	40	CW	10			54	23.0	54	27.8	45.0	715	20.3	345	29	23.7	28.7
0252-0160-TO1	0	V	CWH	2007	60	48.4	HW	60	SS	40					58	27.4	58	29.0	49.7	576	24.5	446	121	26.3	28.2
0252-0161-TO1	1	V	CWH	2007	55	11.1	HW	45	CW	35	PLC	15	YC	5	208	25.4	208	24.3	45.0	556	22.0	291	91	11.2	12.4
0252-0162-TO1	0	V	CWH	2007	60	4.8	SS	100							57	36.0	57	36.0	66.3	420	33.6	739	293	35.1	35.1
0252-0163-TO1	0	V	CWH	2007	45	16.5	SS	50	HW	30	CW	20			408	40.2	358	34.2	55.0	249	37.5	523	23	11.3	12.8
0252-0166-TO1	1	V	CWH	2007	55	27.5	SS	60	HW	40					283	38.4	358	32.2	69.7	391	35.1	712	260	12.8	11.9
0252-0167-TO1	0	V	CWH	2007	70	27.3	SS	60	HW	40					58	33.8	58	29.2	68.5	486	31.3	664	54	32.4	28.0
0252-0168-TO1	1	V	CWH	2007	75	70.9	DR	85	SS	15					61	28.0	61	39.7	48.1	517	26.0	480	34	26.7	36.5
0252-0169-TO1	1	V	CWH	2007	55	3.4	SS	70	HW	30					60	34.1	60	32.7	58.4	389	31.8	610	43	31.9	30.7
0252-0171-TO1	0	V	CWH	2007	35	25.5	YC	60	CW	35	PLC	5			188	6.1	188	7.1	7.0	1600		0	21	3.7	4.2
0252-0172-TO1	1	V	CWH	2007	65	3.3	CW	80	HW	20					228	17.2	258	18.2	55.6	903	14.4	192	89	8.6	7.4
0252-0173-TO1	0	V	CWH	2007	55	19.7	CW	60	HW	30	SS	10			258	35.4	228	30.4	70.8	430	30.8	539	179	16.7	13.1
0252-0174-TO1	0	V	CWH	2007	55	6.1	CW	70	HW	30					308	24.2	333	22.2	42.5	589	20.7	211	196	10.8	8.2
0252-0175-TO1	0	V	CWH	2007	70	25.3	CW	50	HW	30	YC	10	SS	10	258	24.3	258	24.3	65.8	602	21.0	367	123	11.5	9.8
0252-0176-TO1	1	V	CWH	2007	55	65.1	CW	40.1	YC	39.9	HW	15	PLC	5	310	18.1	308	16.1	37.4	761	15.3	135	47	8.2	7.4
0252-0178-TO1	0	V	CWH	2007	70	5	HW	50	CW	40	DR	5	SS	5	248	27.3	248	30.3	60.0	597	24.1	419	141	11.3	14.5
0252-0179-TO1	1	V	CWH	2007	55	29.4	HW	55	SS	30	CW	15			359	38.3	359	46.2	65.0	325	34.7	698	139	14.5	16.7
0252-0182-TO1	1	V	CWH	2011	60	47.6	SS	71	HW	15	CW	14			261	48.7	208	30.7	73.8	160	47.1	853	71	21.2	13.8
0252-0183-TO1	0	V	CWH	2007	60	20.6	PLC	40	YC	20	CW	20	HW	20	238	20.1	358	21.1	37.9	732	17.9	203	228	10.4	9.1

9. Appendix B: Phase II compiled ground attributes

Table 16. The Phase II compiled ground attributes are given.

Strata	Sample	Year	Species composition At DBH ≥ 4.0 cm	Basal area (m^2/ha) DBH ≥ 7.5 cm	Trees/ ha DBH ≥ 7.5 cm	Lorey height (m) DBH ≥ 7.5 cm	Live volume net DWB (m^3/ha) DBH ≥ 17.5 cm NVAF	Dead volume net DWB (m^3/ha) DBH ≥ 17.5 cm NVAF
CW	0251-0001-MO1	2015	Pl 73 Yc 25 Hm 02	18.4	1051	7.8	37	4
CW	0251-0003-MO1	2015	Yc 45 Pl 27 Cw 22 Hw 04 Hm 02	63.2	1676	14.1	275	34
CW	0251-0006-MO1	2015	Cw 58 Hw 21 Yc 17 Pl 04	44.8	575	13.0	195	77
CW	0251-0007-MO1	2015	Cw 58 Hw 24 Pl 18	30.4	2252	6.6	39	3
CW	0251-0009-MO1	2015	Cw 38 Yc 23 Hw 20 Pl 19	58.2	2201	11.4	172	31
CW	0252-0102-TO1	2015	Cw 63 Hw 25 Yc 12	76.8	2945	16.4	342	182
CW	0252-0104-TO1	2015	Cw 44 Yc 39 Hw 17	90.0	2092	18.1	546	85
CW	0252-0107-TO1	2015	Pl 71 Cw 26 Yc 03	7.3	560	5.3	10	0
CW	0252-0108-TO1	2015	Pl 48 Yc 46 Hm 06	3.3	380	3.4	0	0
CW	0252-0110-TO1	2015	Cw 50 Yc 40 Hw 10	32.0	577	16.5	157	130
CW	0252-0111-TO1	2015	Hm 50 Hw 29 Ss 21	112.0	866	28.6	997	120
CW	0252-0113-TO1	2015	Cw 52 Yc 39 Hw 09	73.6	695	19.7	477	66
CW	0252-0114-TO1	2015	Cw 50 Hw 22 Yc 17 Hm 11	57.6	1505	16.2	285	170
CW	0252-0115-TO1	2015	Cw 63 Yc 26 Hw 11	45.6	762	15.5	219	193
CW	0252-0116-TO1	2015	Hm 59 Hw 23 Ss 14 Yc 04	52.8	840	17.0	307	28
CW	0252-0117-TO1	2015	Pl 61 Yc 28 Hm 11	16.0	649	10.3	51	16
CW	0252-0118-TO1	2015	Hw 100	19.2	1590	13.0	50	43
CW	0252-0119-TO1	2015	Cw 79 Hw 12 Ss 09	76.8	341	32.3	707	183
CW	0252-0120-TO1	2016	Cw 58 Hw 42	120.0	275	36.2	1232	127
CW	0252-0121-TO1	2015	Cw 52 Pl 24 Hw 24	84.0	1797	21.6	613	101
CW	0252-0122-TO1	2015	Cw 35 Yc 24 Hw 24 Ss 17	85.0	593	29.6	786	239
CW	0252-0123-TO1	2015	Yc 63 Hw 16 Hm 16 X 05	45.6	424	13.9	220	27
CW	0252-0124-TO1	2016	Cw 34 Yc 34 Hw 19 Ss 06 Pl 07	76.8	659	18.8	511	112
CW	0252-0125-TO1	2015	Hw 69 Cw 31	38.4	703	15.9	210	107
CW	0252-0126-TO1	2015	Cw 29 Yc 29 Hw 29 Ss 13	44.8	194	25.5	379	46
CW	0252-0127-TO1	2015	Cw 59 Hw 33 Yc 04 Pl 04	83.2	1569	18.0	482	91
CW	0252-0128-TO1	2015	Cw 74 Hw 22 Ss 04	64.8	1059	26.6	573	220
CW	0252-0129-TO1	2015	Cw 35 Hw 35 Pl 25 Yc 05	48.0	1239	16.6	253	94
CW	0252-0130-TO1	2015	Cw 65 Hw 30 Pl 05	80.0	829	24.5	680	243
CW	0252-0131-TO1	2015	Pl 50 Yc 50	21.6	1021	9.0	67	15
CW	0252-0132-TO1	2015	Cw 47 Yc 29 Hm 24	54.4	896	15.5	290	113
CW	0252-0133-TO1	2015	Cw 50 Hw 42 Pl 08	48.0	612	22.3	330	85
CW	0252-0134-TO1	2015	Yc 36 Cw 36 Hw 23 Ss 05	52.8	665	17.9	321	81
CW	0252-0135-TO1	2015	Cw 90 Hw 10	84.0	503	33.2	734	125
CW	0252-0136-TO1	2015	Cw 60 Pl 32 Hw 08	50.4	2150	13.0	198	31
CW	0252-0137-TO1	2015	Cw 64 Hw 36	44.0	877	23.2	251	65
CW	0252-0138-TO1	2016	Cw 67 Hw 33	48.0	310	22.8	316	30
CW	0252-0139-TO1	2015	Cw 71 Hw 21 Pl 08	44.8	1094	9.7	115	111
CW	0252-0140-TO1	2015	Cw 62 Hw 38	52.0	483	16.1	279	106
HW	0252-0142-TO1	2015	Hw 73 Ss 18 Cw 09	44.0	150	34.5	499	80
HW	0252-0144-TO1	2015	Ss 73 Hw 27	88.0	619	34.6	1010	10
HW	0252-0145-TO1	2015	Ss 59 Hw 41	64.8	642	27.6	620	0
HW	0252-0146-TO1	2015	Yc 63 Ss 17 Hw 13 Hm 07	120.0	1982	21.6	882	58
HW	0252-0147-TO1	2016	Hw 83 Ss 17	32.0	1099	18.2	209	162

Strata	Sample	Year	Species composition At DBH ≥ 4.0 cm	Basal area (m^2/ha) DBH ≥ 7.5 cm	Trees/ ha DBH ≥ 7.5 cm	Lorey height (m) DBH ≥ 7.5 cm	Live volume net DWB (m^3/ha) DBH ≥ 17.5 cm NVAF	Dead volume net DWB (m^3/ha) DBH ≥ 17.5 cm NVAF
HW	0252-0148-TO1	2015	Cw 75 Hw 20 Ss 05	80.0	590	26.0	607	26
HW	0252-0149-TO1	2015	Yc 48 Hw 36 Ss 08 Hm 04 Cw 04	80.0	665	26.5	698	36
HW	0252-0150-TO1	2016	Hw 69 Ss 31	64.0	113	45.0	858	74
HW	0252-0151-TO1	2015	Cw 60 Hw 30 Yc 10	50.0	85	41.3	588	0
HW	0252-0152-TO1	2015	Hw 52 Ss 48	53.7	3744	15.4	178	0
HW	0252-0153-TO1	2015	Cw 45 Hw 42 Pl 13	152.0	6044	22.5	841	72
HW	0252-0154-TO1	2015	Yc 36 Ss 21 Hw 21 Cw 14 Hm 08	44.8	283	27.1	403	36
HW	0252-0155-TO1	2015	Yc 44 Hw 44 Hm 12	51.2	695	17.7	302	0
HW	0252-0156-TO1	2015	Hw 57 Cw 43	24.0	560	18.6	142	99
HW	0252-0157-TO1	2015	Hw 45 Ss 35 Cw 20	36.0	1424	16.7	145	20
HW	0252-0158-TO1	2016	Hw 86 Ss 14	35.0	414	26.8	328	42
HW	0252-0159-TO1	2015	Hw 72 Ss 28	54.0	1139	19.7	365	6
HW	0252-0160-TO1	2016	Hw 82 Ss 18	51.2	1151	24.9	443	32
HW	0252-0161-TO1	2015	Cw 63 Hw 37	76.0	682	19.1	461	67
SS+	0252-0162-TO1	2015	Hw 42 Cw 37 Ss 21	76.0	748	28.3	645	169
SS+	0252-0163-TO1	2015	Yc 50 Cw 33 Ss 17	30.0	694	15.4	149	11
SS+	0252-0166-TO1	2015	Cw 62 Hw 33 Ss 05	80.0	1216	24.2	625	149
SS+	0252-0167-TO1	2015	Ss 85 Hw 15	83.2	975	28.5	784	35
SS+	0252-0168-TO1	2015	Dr 73 Ss 18 Hw 09	70.4	967	28.3	708	13
SS+	0252-0169-TO1	2016	Ss 100	54.0	2186	13.2	102	0
CW	0252-0171-TO1	2015	Yc 52 Hm 27 Pl 12 Hw 09	28.0	1268	7.8	62	11
CW	0252-0172-TO1	2015	Hw 92 Cw 08	54.0	829	19.0	325	45
CW	0252-0173-TO1	2015	Cw 50 Hw 36 Ss 14	88.0	478	33.9	897	76
CW	0252-0174-TO1	2015	Yc 52 Hw 17 Hm 17 Cw 09 Pl 05	92.0	1571	16.0	485	129
CW	0252-0175-TO1	2015	Hw 71 Cw 18 Yc 11	54.4	525	24.9	454	69
CW	0252-0176-TO1	2015	Yc 40 Pl 27 Hm 20 Hw 07 Cw 06	36.0	1504	11.2	110	23
HW	0252-0178-TO1	2015	Hw 53 Cw 33 Dr 14	44.8	691	21.9	283	91
HW	0252-0179-TO1	2016	Hw 94 Ss 06	54.4	222	33.0	597	51
SS+	0252-0182-TO1	2015	Ss 50 Yc 33 Hw 17	19.2	592	21.3	148	32
SS+	0252-0183-TO1	2015	Cw 38 Hw 33 Pl 17 Hm 12	70.4	2486	12.5	224	179

10. Appendix C: Site index

Table 17. Site index (SI) estimates are given by species and source. The ground SI potentially includes old (> 120 years) trees.

	Strata	Ground		Phase I					PSPL					
Clstr_id		**Sp1**	**SI1**		**Sp1**	**Sp2**	**SI1**	**SI2**	**SI_BA**	**SI_CW**	**SI_HM**	**SI_HW**	**SI_PL**	**SI_SS**	**SI_YC**
0251-0001-MO1	CW	Pl	5.9	3	CW	YC	8.8	7.4		20.4	23.5	23.5		27.3	20.4
0251-0003-MO1	CW	Yc		3	CW	HW	9.6	8.9		19.3	22.9	22.9		26.2	19.3
0251-0006-MO1	CW	Cw		1	CW	HW	7.1	5.2		17.1	23.4	23.4		26.4	17.1
0251-0007-MO1	CW	Cw		1	CW	HW	6.6	5.1		17.0	23.1	23.1		26.9	17.0
0251-0009-MO1	CW	Cw		1	CW	HW	7.2	5.1		17.6	23.0	23.0		26.6	17.6
0252-0102-TO1	CW	Cw		1	CW	YC	10.1	9.6		22.4	25.9	25.9		31.3	22.4
0252-0104-TO1	CW	Cw		1	CW	HW	9.6	8.0		22.8	25.6	25.6		29.8	22.8
0252-0107-TO1	CW	Pl	3.5	2	YC	PLC	3.0	2.0		21.1	25.3	25.3		30.7	21.1
0252-0108-TO1	CW	Pl	1.6	2	YC	PLC	2.5	2.4		22.6	23.2	23.2		28.3	22.6
0252-0110-TO1	CW	Cw		1	CW	YC	9.1	8.7		21.9	25.2	25.2		29.4	21.9
0252-0111-TO1	CW	Hm		3	YC	CW	8.7	7.8							
0252-0113-TO1	CW	Cw		1	CW	YC	9.5	8.2		20.8	25.7	25.7		31.5	20.8
0252-0114-TO1	CW	Cw		1	CW	PLC	12.2	13.4		15.2	22.4	22.4	16.0	25.5	16.0
0252-0115-TO1	CW	Cw		1	CW	HW	7.4	6.4		21.2	24.8	24.8		29.4	21.2
0252-0116-TO1	CW	Hm		2	CW	HW	10.2	8.2	10.4	12.0	10.4	12.0			12.0
0252-0117-TO1	CW	Pl	6.2	3	YC	CW	6.1	6.6		12.0	16.0	16.0		20.0	12.0
0252-0118-TO1	CW	Hw	14.7	2	CW	HW	16.6	15.3		16.0	12.0	19.2		24.0	16.0
0252-0119-TO1	CW	Cw	18.8	1	CW	HW	16.7	14.1		18.2	23.5	23.5		26.1	18.2
0252-0120-TO1	CW	Cw		1	CW	HW	13.4	12.2		19.8	23.2	23.2		27.6	19.8
0252-0121-TO1	CW	Cw	15.6	1	CW	HW	12.7	9.4		18.0	23.5	23.5		26.9	18.0
0252-0122-TO1	CW	Cw		1	CW	HW	13.8	13.4		16.0	20.0	20.0		24.0	16.0
0252-0123-TO1	CW	Yc		1	YC	CW	9.6	8.7		16.0	10.4	16.0		24.7	16.0
0252-0124-TO1	CW	Cw		1	CW	HW	10.0	7.8		19.2	23.4	23.4		26.6	19.2
0252-0125-TO1	CW	Hw	12.5	2	CW	HW	12.0	9.5		18.9	22.9	22.9		25.9	18.9
0252-0126-TO1	CW	Cw		1	CW	HW	11.5	9.8		19.5	22.4	22.4		24.8	19.5
0252-0127-TO1	CW	Cw		1	CW	HW	7.7	5.9		17.7	23.4	23.4		26.3	17.7
0252-0128-TO1	CW	Cw	21.6	1	CW	HW	10.3	8.2		17.0	23.1	23.1		26.6	17.0
0252-0129-TO1	CW	Cw		1	CW	HW	8.2	6.4		17.3	22.7	22.7		26.2	17.3
0252-0130-TO1	CW	Cw		1	CW	HW	9.3	6.9		17.5	23.1	23.1		26.6	17.5
0252-0131-TO1	CW	Pl		3	YC	CW	6.3	7.8		19.7	22.4	22.4		25.8	19.7
0252-0132-TO1	CW	Cw		1	CW	HW	11.3	10.4		18.8	22.5	22.5		25.5	18.8
0252-0133-TO1	CW	Cw		1	CW	HW	9.3	7.5		18.7	24.1	24.1		27.9	18.7
0252-0134-TO1	CW	Yc		2	CW	YC	7.0	5.9		18.5	22.6	22.6		25.8	18.5
0252-0135-TO1	CW	Cw		1	CW	HW	13.2	10.8		18.1	23.6	23.6		26.0	18.1
0252-0136-TO1	CW	Cw	9.2	1	CW	HW	13.9	11.2		17.4	22.7	22.7		26.4	17.4
0252-0137-TO1	CW	Cw		1	CW	HW	15.6	13.0		17.5	22.9	22.9		26.6	17.5
0252-0138-TO1	CW	Cw		1	CW	HW	12.0	10.0		17.8	22.6	22.6		26.0	17.8
0252-0139-TO1	CW	Cw		1	CW	HW	6.4	4.8		17.4	22.7	22.7		26.4	17.4
0252-0140-TO1	CW	Cw		1	CW	HW	6.3	4.9		16.9	23.5	23.5		26.9	16.9
0252-0171-TO1	CW	Yc	4.3	1	YC	CW	3.7	4.2			22.7	22.7		27.8	
0252-0172-TO1	CW	Hw		2	CW	HW	8.6	7.4		22.2	26.5	26.5		32.4	22.2
0252-0173-TO1	CW	Cw		1	CW	HW	16.7	13.1		21.4	22.9	22.9		29.2	21.4
0252-0174-TO1	CW	Yc		3	CW	HW	10.8	8.2		19.2	22.6	22.6		25.7	19.2
0252-0175-TO1	CW	Hw	15.8	2	CW	HW	11.5	9.8		19.5	22.2	22.2		24.8	19.5
0252-0176-TO1	CW	Yc	11.4	2	CW	YC	8.2	7.4		18.3	22.7	22.7		25.9	18.3
0252-0142-TO1	HW	Hw		1	HW	YC	10.8	12.4		22.3	24.2	24.2		27.7	22.3
0252-0144-TO1	HW	Ss	37.7	2	HW	SS	31.2	33.5		21.1	25.9	25.9		29.5	21.1

	Strata	Ground		Phase I				PSPL					
Clstr_id		**Sp1**	**SI1**	**Sp1**	**Sp2**	**SI1**	**SI2**	**SI_BA**	**SI_CW**	**SI_HM**	**SI_HW**	**SI_PL**	**SI_SS**	**SI_YC**
0252-0145-TO1	HW	Ss	33.1	2 HW	SS	31.0	28.3		20.8	25.4	25.4		28.8	20.8
0252-0146-TO1	HW	Yc		3 HW	CW	9.6	10.0			23.1	23.1		28.3	
0252-0147-TO1	HW	Hw	9.8	1 HW	SS	14.3	16.7		19.4	24.0	24.0		26.8	19.4
0252-0148-TO1	HW	Cw		2 HW	CW	8.2	9.8		21.7	25.4	25.4		29.9	21.7
0252-0149-TO1	HW	Yc		2 HW	YC	6.2	7.4		16.0	20.0	20.0		24.0	16.0
0252-0150-TO1	HW	Hw	22.1	1 HW	SS	14.8	21.1		13.6	8.0	17.6		24.0	13.6
0252-0151-TO1	HW	Cw		2 HW	CW	15.7	15.6		21.4	22.9	22.9		29.2	21.4
0252-0152-TO1	HW	Hw	27.3	1 HW	SS	29.9	31.0		18.5	21.7	21.7	16.0	28.6	16.0
0252-0153-TO1	HW	Cw		2 HW	CW	14.0	15.8		18.7	23.4	23.4		26.6	18.7
0252-0154-TO1	HW	Yc		3 HW	CW	13.2	14.2		8.0	8.0	12.0		25.1	8.0
0252-0155-TO1	HW	Yc		3 HW	CW	8.8	10.8		20.1	22.8	22.8		25.8	20.1
0252-0156-TO1	HW	Hw		1 HW	SS	11.7	11.9		19.2	22.8	22.8		25.7	19.2
0252-0157-TO1	HW	Hw	18.5	1 HW	CW	17.2	19.5		13.2	18.4	18.4	16.0	24.0	13.2
0252-0158-TO1	HW	Hw	17.7	1 HW	CW	6.7	7.5		19.8	23.2	23.2		27.6	19.8
0252-0159-TO1	HW	Hw	23.9	1 HW	SS	23.7	28.7		17.1	24.4	24.4		27.2	17.1
0252-0160-TO1	HW	Hw	23.5	1 HW	SS	26.3	28.2		17.9	23.9	23.9		26.8	17.9
0252-0161-TO1	HW	Cw		2 HW	CW	11.2	12.4		17.1	22.7	22.7		26.6	17.1
0252-0178-TO1	HW	Hw	14.0	1 HW	CW	11.3	14.5		16.4	25.0	25.0		28.0	16.4
0252-0179-TO1	HW	Hw		1 HW	SS	14.5	16.7		16.0	20.0	20.0		24.0	16.0
0252-0162-TO1	SS+	Hw	21.6	3 SS		35.1	35.1		21.5	26.0	26.0		30.2	21.5
0252-0163-TO1	SS+	Yc		3 SS	HW	11.3	12.8		22.7	24.7	24.7		28.4	22.7
0252-0166-TO1	SS+	Cw		3 SS	HW	12.8	11.9		17.0	23.6	23.6		26.9	17.0
0252-0167-TO1	SS+	Ss	31.6	1 SS	HW	32.4	28.0		21.3	24.7	24.7		27.9	21.3
0252-0168-TO1	SS+	Dr	32.9	1 DR	SS	26.7	36.5		18.7	25.6	25.6		28.9	18.7
0252-0169-TO1	SS+	Ss	16.7	1 SS	HW	31.9	30.7		18.3	23.3	23.3		25.6	18.3
0252-0182-TO1	SS+	Ss	22.4	1 SS	HW	21.2	13.8		20.5	22.7	22.7		25.8	20.5
0252-0183-TO1	SS+	Cw		3 PLC	YC	10.4	9.1		19.3	23.3	23.3		27.1	19.3

11. Appendix D: Scatterplots to find potential outliers

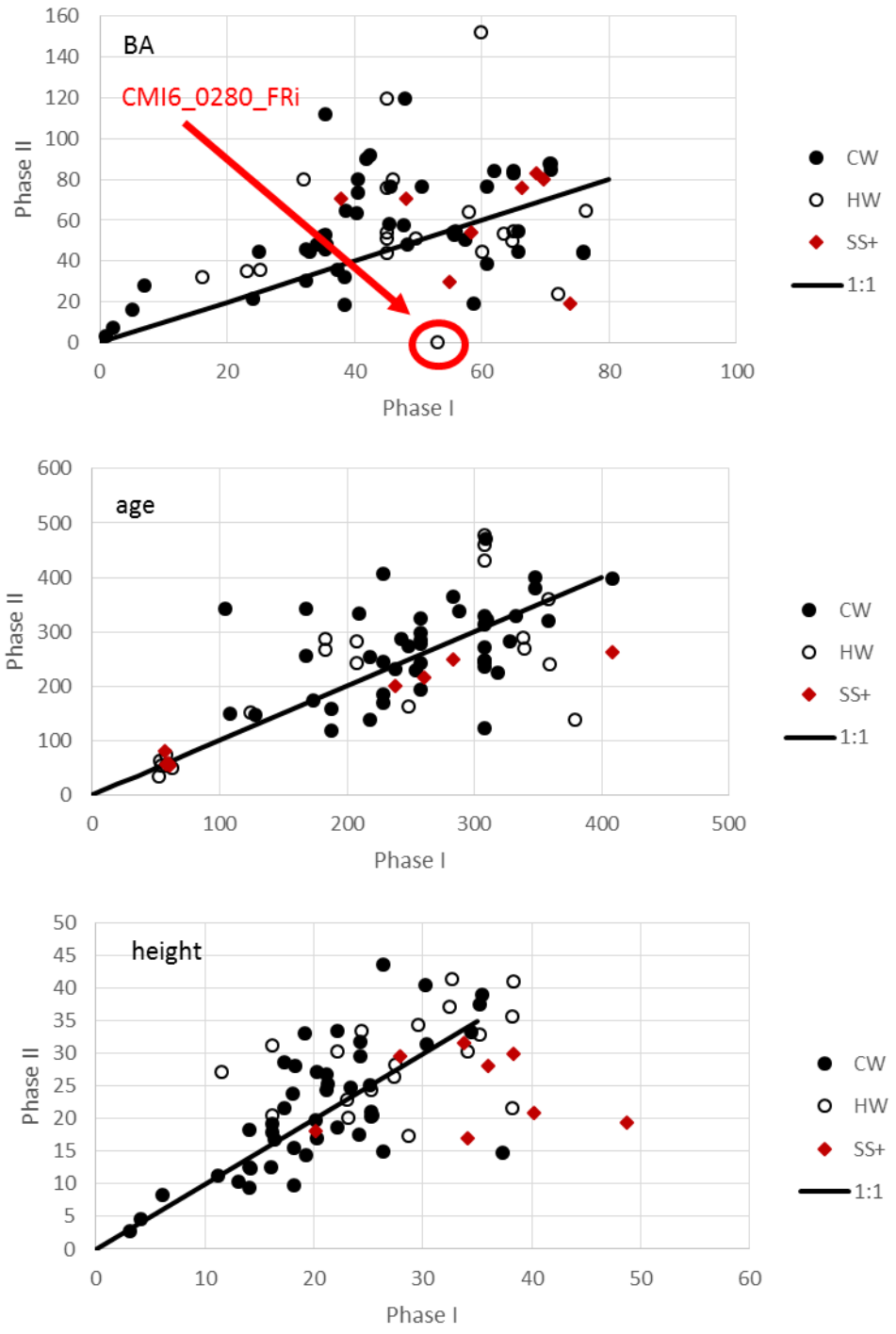

Figure 9. The Phase I inventory and Phase II Ground data are plotted for the seven attributes of interest. .

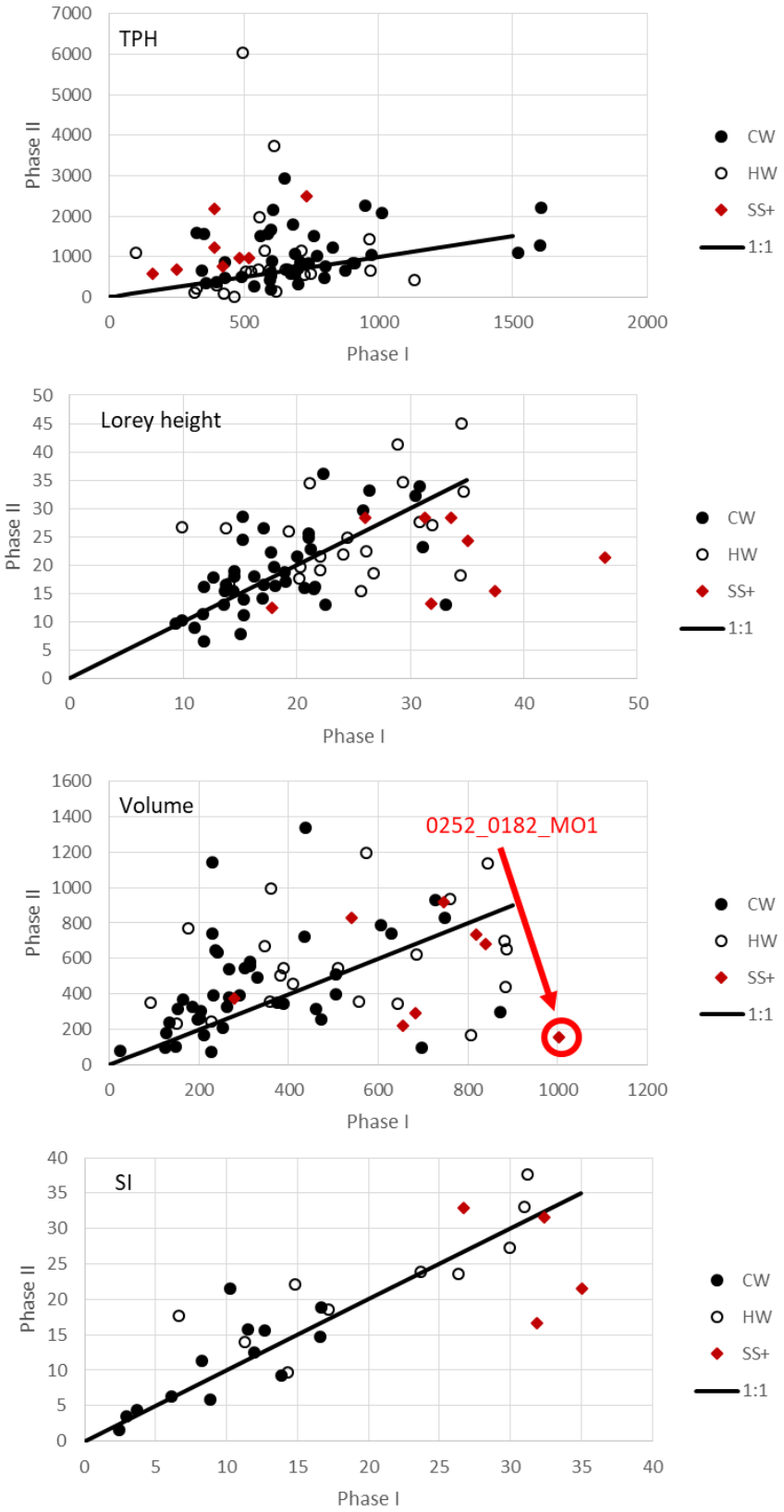

Figure 9 (cont.).

12. APPENDIX E: HEIGHT AND AGE MATCHING

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

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

Table 18. 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 19. The results of matching the Phase I inventory and Phase II ground heights and ages.

Sample	strata	Phase II (ground) leading species attributes						Phase I (Inventory)			
		Species @ 4cm DBH	Mean Age[8]	Mean Height[9]	Sample size Age[10]	Sample size Height[11]	Case of match	leading species	secondary species	Age for match	Height for match
0251-0001-MO1	CW	Pl	274	9.7	5	5	3	CW	YC	248	18.2
0251-0003-MO1	CW	Yc	195	17.1	4	2	3	CW	HW	258	20.2
0251-0006-MO1	CW	Cw	320	12.6	1	1	1	CW	HW	358	16.1
0251-0007-MO1	CW	Cw	236	9.4	3	3	1	CW	HW	308	14.1
0251-0009-MO1	CW	Cw	245	12.4	4	3	1	CW	HW	228	14.2
0252-0102-TO1	CW	Cw	285	25.3	5	5	1	CW	YC	258	21.2
0252-0104-TO1	CW	Cw	343	21.7	5	5	1	CW	HW	168	17.3
0252-0107-TO1	CW	Pl	148	4.6	5	4	2	YC	PLC	148	3.1
0252-0108-TO1	CW	Pl	149	2.8	1	1	2	YC	PLC	108	3.2
0252-0110-TO1	CW	Cw	313	19.8	5	5	1	CW	YC	308	20.2
0252-0111-TO1	CW	Hm	244	33.1	5	5	3	YC	CW	308	19.1

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

Sample	strata	Phase II (ground) leading species attributes						Phase I (Inventory)			
		Species @ 4cm DBH	Mean Age[8]	Mean Height[9]	Sample size Age[10]	Sample size Height[11]	Case of match	leading species	secondary species	Age for match	Height for match
0252-0113-TO1	CW	Cw	329	24.4	5	5	1	CW	YC	308	21.2
0252-0114-TO1	CW	Cw	286	21.0	5	5	1	CW	PLC	243	25.3
0252-0115-TO1	CW	Cw	247	19.1	5	5	1	CW	HW	308	16.1
0252-0116-TO1	CW	Hm	337	18.8	4	4	2	CW	HW	288	21.2
0252-0117-TO1	CW	Pl	247	10.4	5	5	3	YC	CW	308	13.1
0252-0118-TO1	CW	Hw	123	14.7	5	5	2	CW	HW	308	38.3
0252-0119-TO1	CW	Cw	230	33.3	5	5	1	CW	HW	238	34.4
0252-0120-TO1	CW	Cw	334	43.6	3	3	1	CW	HW	209	26.4
0252-0121-TO1	CW	Cw	174	24.7	5	5	1	CW	HW	173	23.4
0252-0122-TO1	CW	Cw	365	31.3	5	5	1	CW	HW	283	30.3
0252-0123-TO1	CW	Yc	407	14.4	5	5	1	YC	CW	228	19.2
0252-0124-TO1	CW	Cw	471	33.4	1	1	1	CW	HW	309	22.2
0252-0125-TO1	CW	Hw	324	20.3	4	4	2	CW	HW	283	24.2
0252-0126-TO1	CW	Cw	242	31.8	3	3	1	CW	HW	258	24.3
0252-0127-TO1	CW	Cw	399	23.9	4	4	1	CW	HW	408	18.1
0252-0128-TO1	CW	Cw	139	27.1	5	5	1	CW	HW	218	20.3
0252-0129-TO1	CW	Cw	186	17.8	5	5	1	CW	HW	228	16.2
0252-0130-TO1	CW	Cw	253	28.0	5	5	1	CW	HW	218	18.3
0252-0131-TO1	CW	Pl	400	12.6	5	5	3	YC	CW	348	14.1
0252-0132-TO1	CW	Cw	342	16.9	6	6	1	CW	HW	104	16.4
0252-0133-TO1	CW	Cw	329	26.8	5	5	1	CW	HW	333	21.2
0252-0134-TO1	CW	Yc					2	CW	YC		
0252-0135-TO1	CW	Cw	283	40.5	5	5	1	CW	HW	328	30.2
0252-0136-TO1	CW	Cw	119	15.0	4	4	1	CW	HW	188	26.4
0252-0137-TO1	CW	Cw	226	37.5	6	5	1	CW	HW	318	35.3
0252-0138-TO1	CW	Cw	230	25.0	5	5	1	CW	HW	254	25.1
0252-0139-TO1	CW	Cw	257	11.2	5	5	1	CW	HW	168	11.2
0252-0140-TO1	CW	Cw	380	18.4	5	5	1	CW	HW	348	14.1
0252-0171-TO1	CW	Yc	159	8.3	5	5	1	YC	CW	188	6.1
0252-0172-TO1	CW	Hw	170	28.7	3	2	2	CW	HW	258	18.2
0252-0173-TO1	CW	Cw	277	39.1	5	5	1	CW	HW	258	35.4
0252-0174-TO1	CW	Yc	271	17.6	5	5	3	CW	HW	308	24.2
0252-0175-TO1	CW	Hw	297	29.6	5	5	2	CW	HW	258	24.3
0252-0176-TO1	CW	Yc	324	15.5	6	5	2	CW	YC	308	16.1
0252-0142-TO1	HW	Hw	282	33.4	5	5	1	HW	YC	208	24.4
0252-0144-TO1	HW	Ss	54	37.1	5	5	2	HW	SS	58	34.8
0252-0145-TO1	HW	Ss	50	30.2	5	5	2	HW	SS	63	31.2
0252-0146-TO1	HW	Yc	430	24.4	4	4	3	HW	CW	308	25.2
0252-0147-TO1	HW	Hw	140	21.7	6	5	1	HW	SS	379	38.2
0252-0148-TO1	HW	Cw	289	30.4	5	5	2	HW	CW	328	22.2
0252-0149-TO1	HW	Yc	478	31.2	5	5	2	HW	YC	308	16.1
0252-0150-TO1	HW	Hw	269	40.9	5	5	1	HW	SS	339	38.3
0252-0151-TO1	HW	Cw	268	41.4	5	5	2	HW	CW	183	29.5
0252-0152-TO1	HW	Hw	34	17.3	3	3	1	HW	SS	52	28.7
0252-0153-TO1	HW	Cw	288	34.3	4	4	2	HW	CW	178	29.5
0252-0154-TO1	HW	Yc	361	32.9	4	4	3	HW	CW	358	35.2
0252-0155-TO1	HW	Yc	461	20.1	5	5	3	HW	CW	308	23.2
0252-0156-TO1	HW	Hw					1	HW	SS		

Sample	strata	Phase II (ground) leading species attributes						Phase I (Inventory)			
		Species @ 4cm DBH	Mean Age[8]	Mean Height[9]	Sample size Age[10]	Sample size Height[11]	Case of match	leading species	secondary species	Age for match	Height for match
0252-0157-TO1	HW	Hw	64	20.5	5	5	1	HW	CW	53	16.1
0252-0158-TO1	HW	Hw	152	27.2	6	5	1	HW	CW	124	11.5
0252-0159-TO1	HW	Hw	54	22.9	5	5	1	HW	SS	54	23.0
0252-0160-TO1	HW	Hw	73	28.4	5	5	1	HW	SS	58	27.4
0252-0161-TO1	HW	Cw	244	20.5	5	4	2	HW	CW	208	24.3
0252-0178-TO1	HW	Hw	163	26.4	5	5	1	HW	CW	248	27.3
0252-0179-TO1	HW	Hw	241	35.7	5	5	1	HW	SS	359	38.3
0252-0162-TO1	SS+	Hw	81	28.1	4	5	3	SS		57	36.0
0252-0163-TO1	SS+	Yc	262	21.0	4	4	3	SS	HW	408	40.2
0252-0166-TO1	SS+	Cw	249	29.9	5	5	3	SS	HW	283	38.4
0252-0167-TO1	SS+	Ss	57	31.7	6	5	1	SS	HW	58	33.8
0252-0168-TO1	SS+	Dr	55	29.5	5	5	1	DR	SS	61	28.0
0252-0169-TO1	SS+	Ss	60	17.0	1	1	1	SS	HW	60	34.1
0252-0182-TO1	SS+	Ss	216	19.3	4	4	1	SS	HW	261	48.7
0252-0183-TO1	SS+	Cw	202	18.0	5	5	3	PLC	YC	238	20.1

13. Appendix F: Scatterplots and residuals

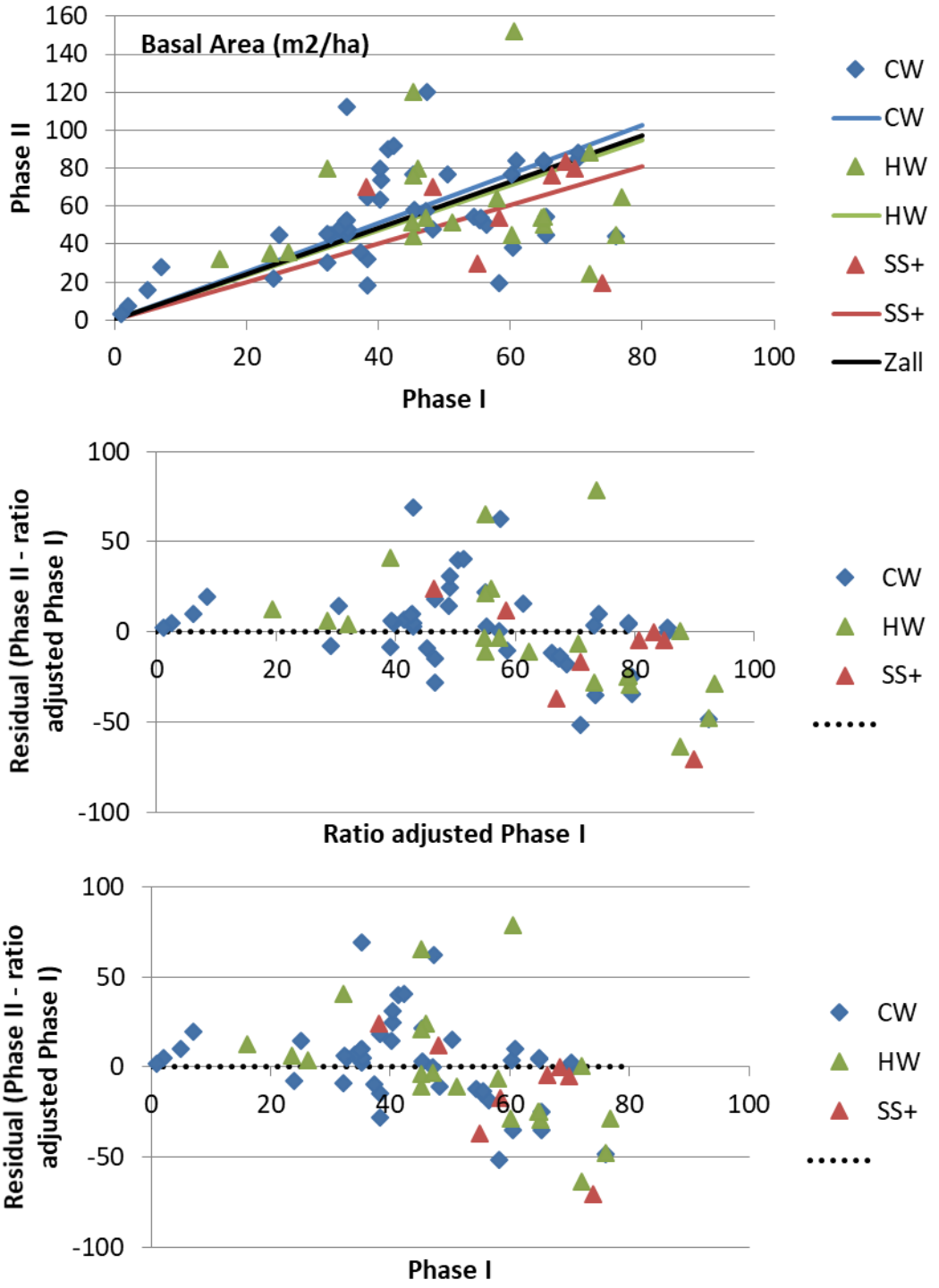

Figure 10. The scatterplots for BA are given. The top graph gives the Phase I photo and Phase II ground estimates of basal area for the Volume audit sub population. The coloured lines give the ratios while the black line is the ratio for all Volume Audit (mature) samples. The middle graph plots the residuals against the adjusted Phase I BA. The bottom graph plots the residuals against the Phase I BA. Ideally the residuals

would be scattered uniformly around the x-axis. The slight downward trend is not uncommon and may indicate the need for a regression estimator rather than a ratio (i.e., the need for an intercept).

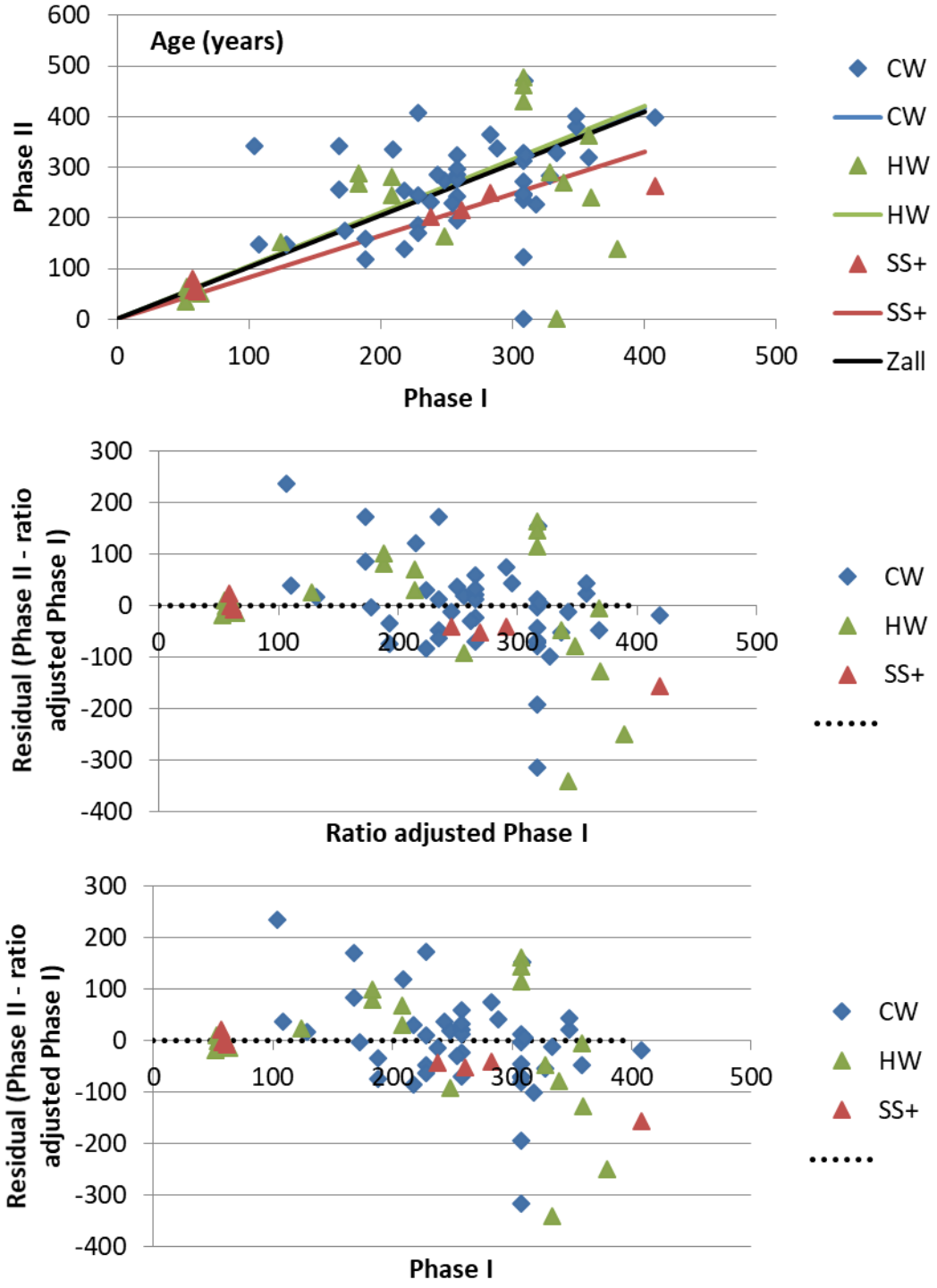

Figure 11. The scatterplots for Age are given.

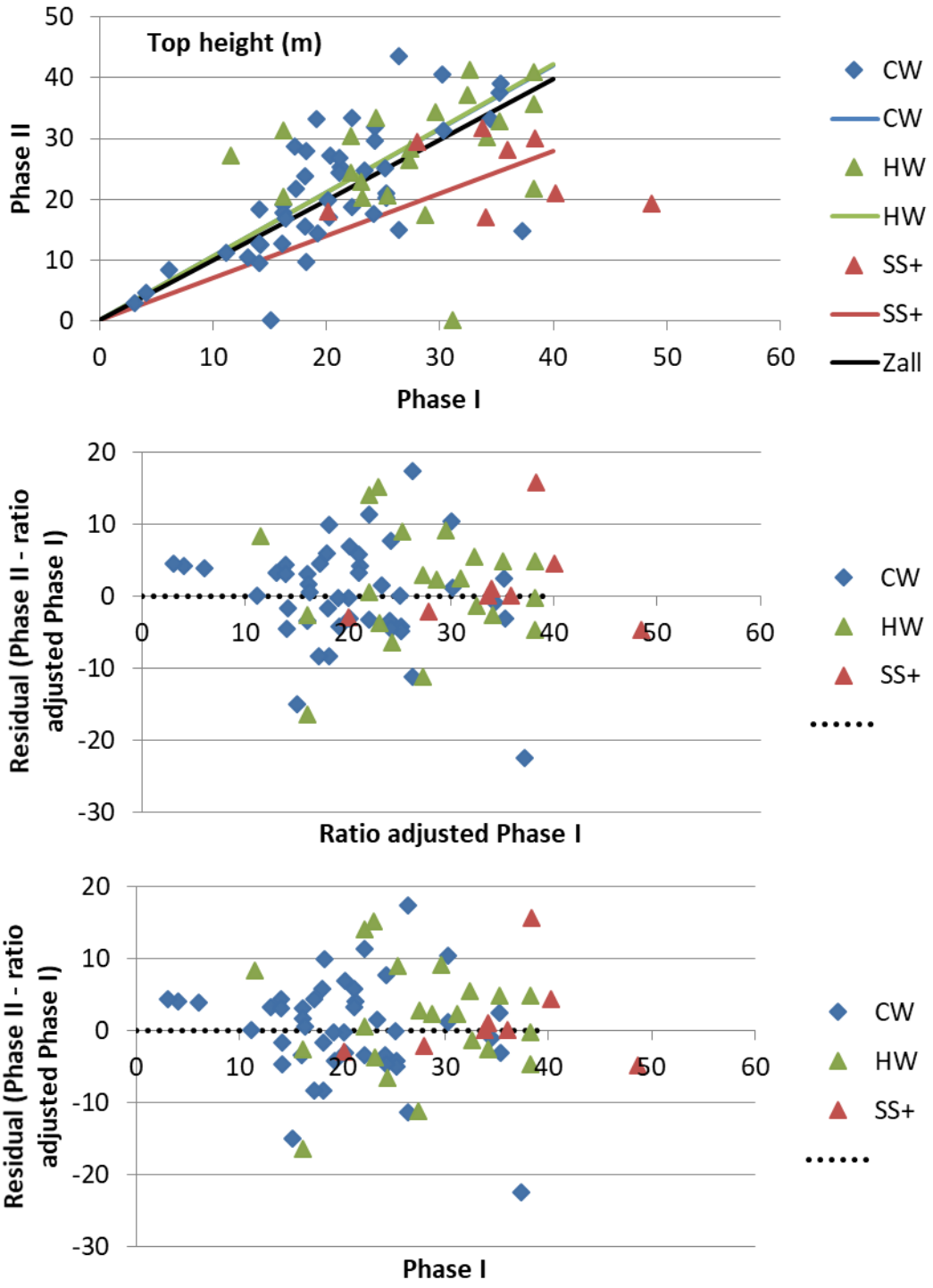

Figure 12. The scatterplots for Height are given.

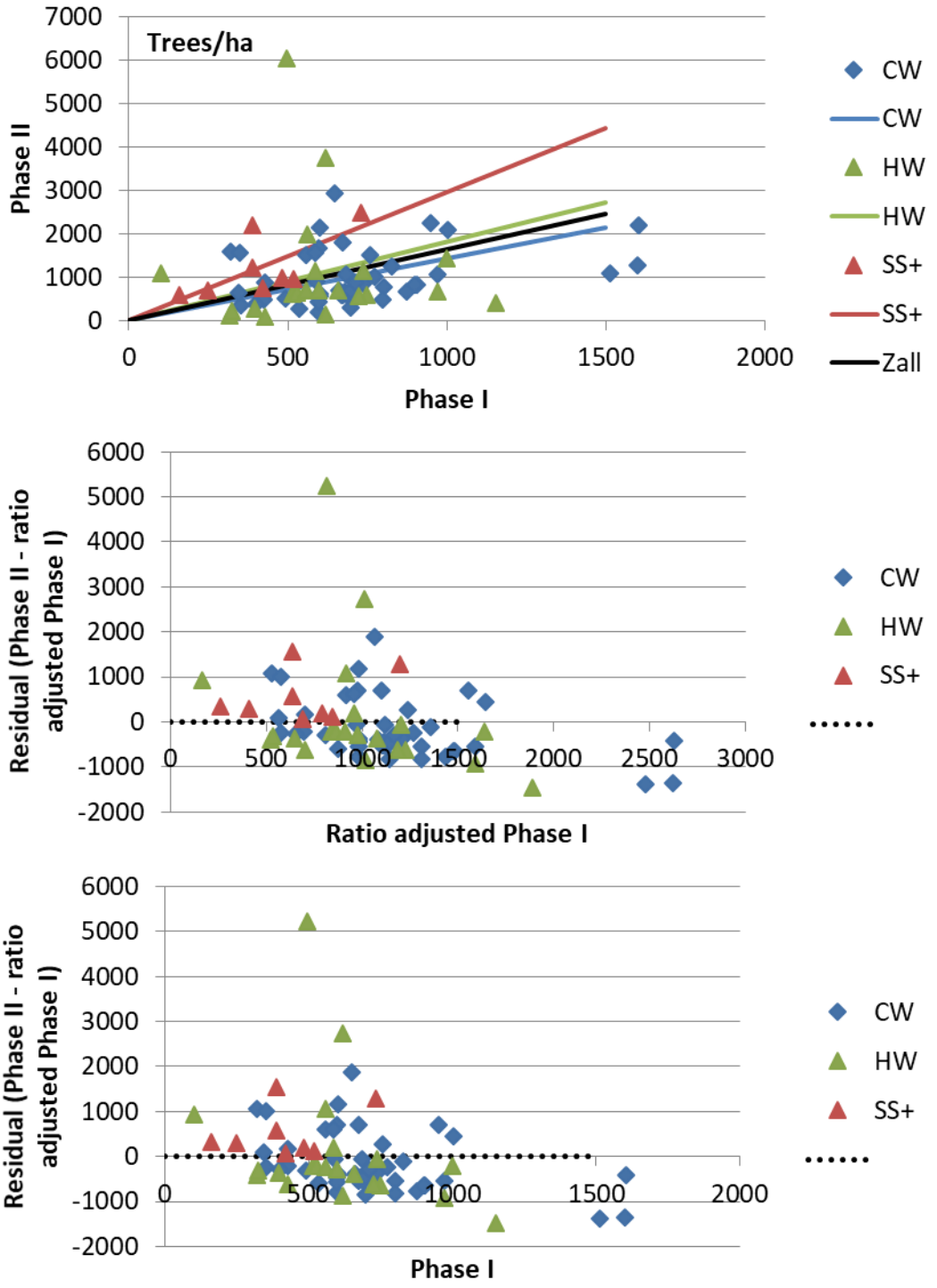

Figure 13. The scatterplots for Trees/ha are given.

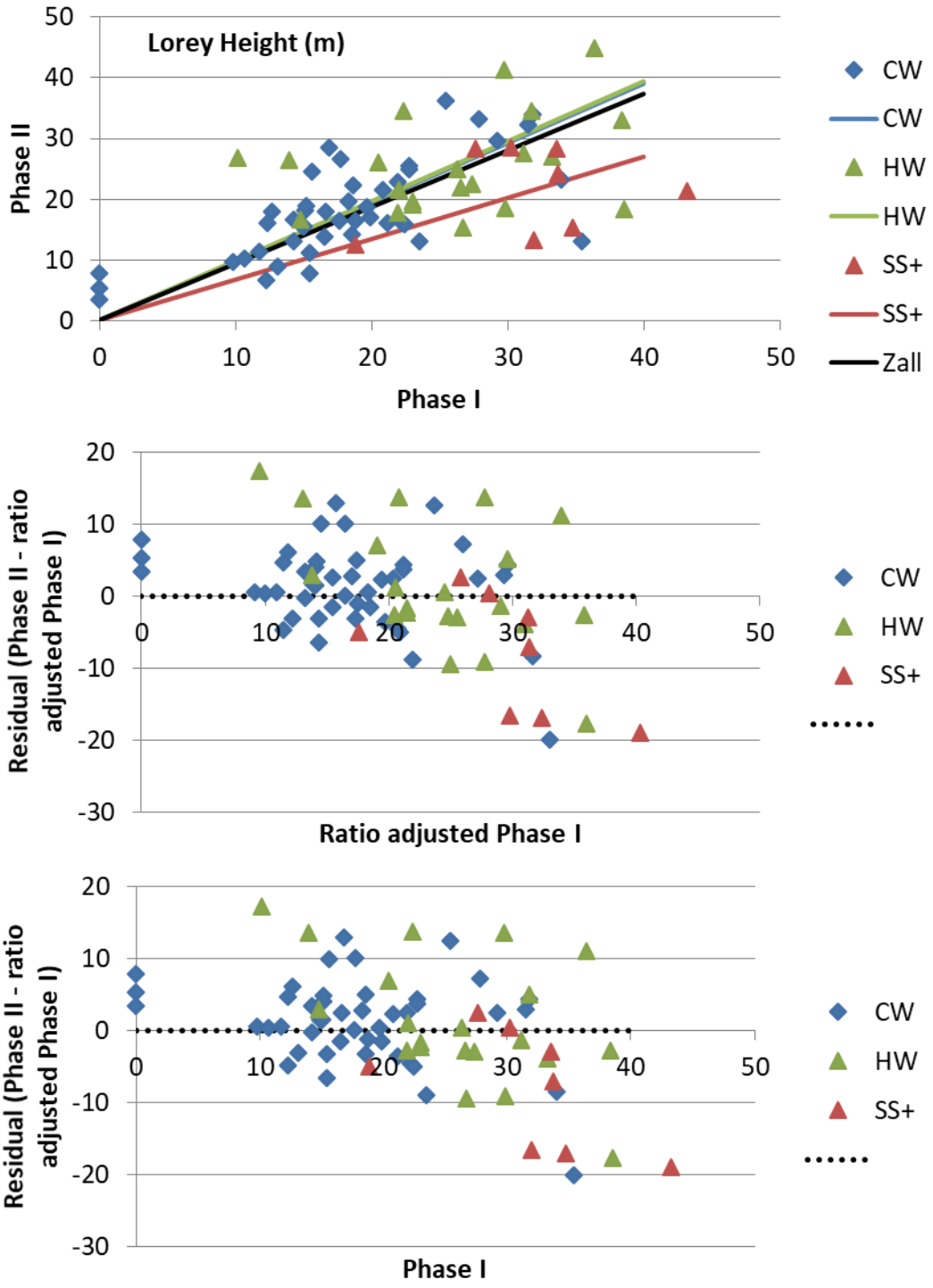

Figure 14. The scatterplots for Lorey height are given.

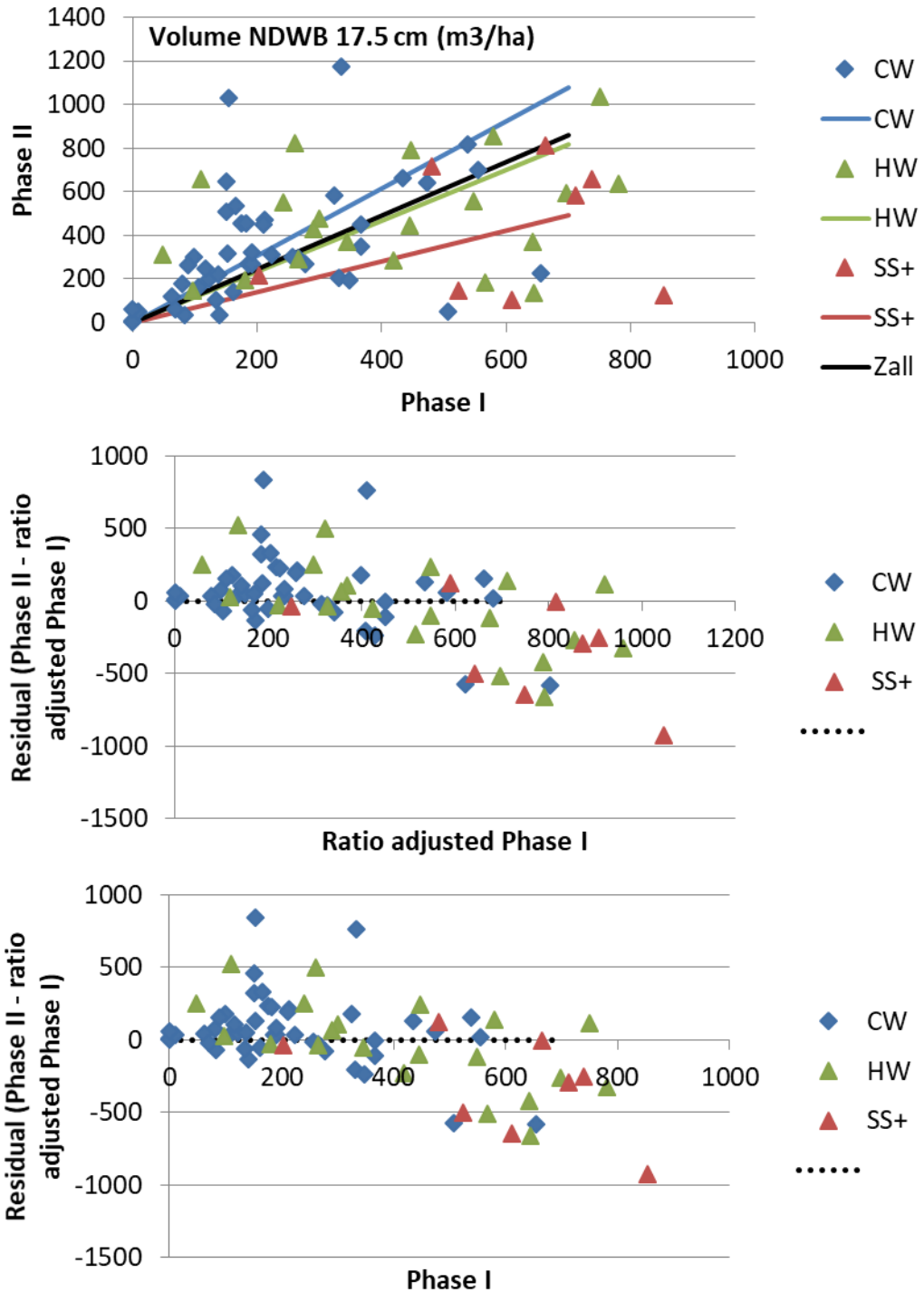

Figure 15. The scatterplots for Volume net of decay, waste and breakage are given. The Phase II LF volumes are used.

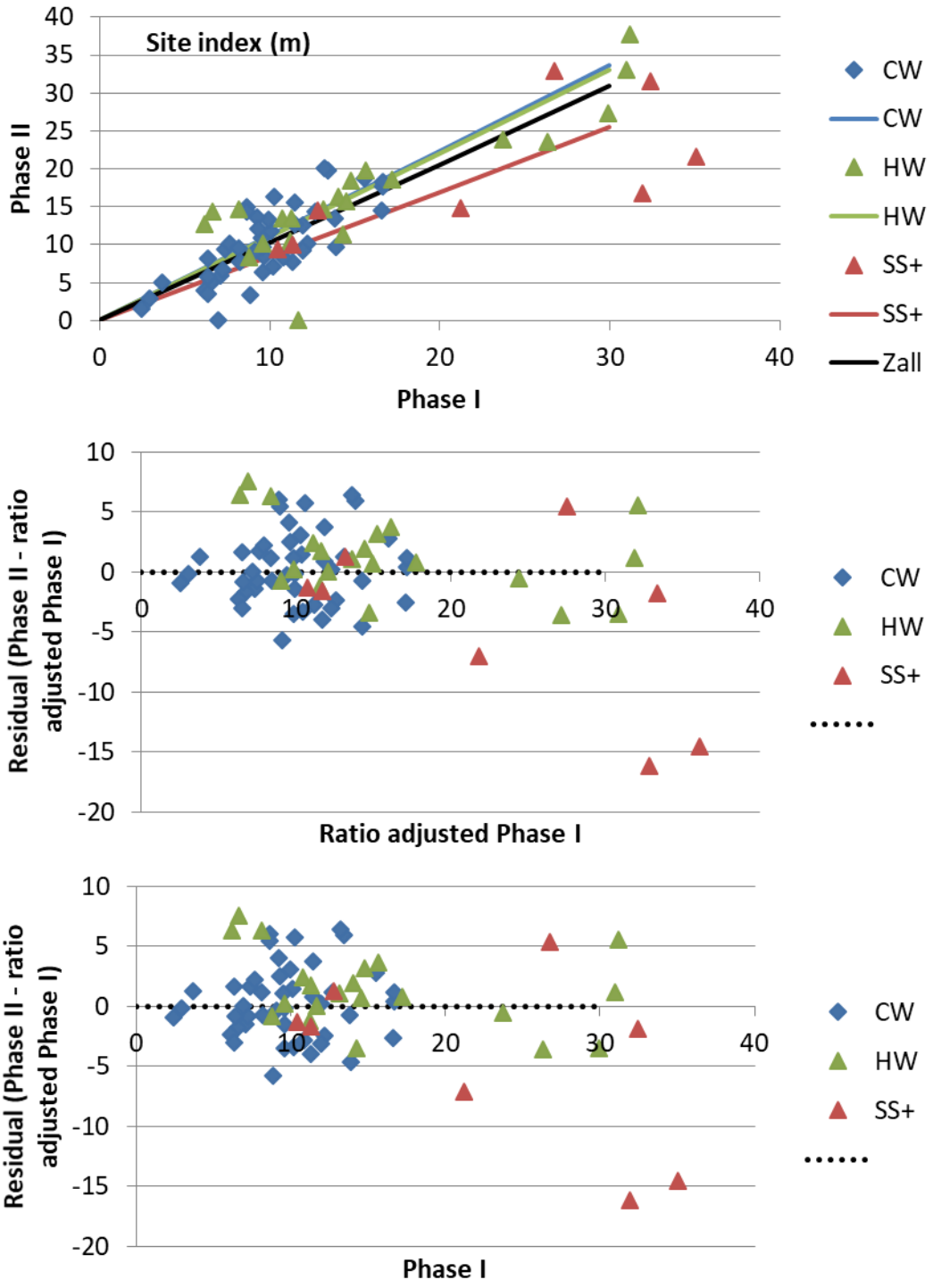

Figure 16. The scatterplots for Site index are given.