INVENTORY ANALYSIS OF THE FT. ST. JOHN TSA

Prepared for:

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Attention: Graham Hawkins

Subject: Inventory Analysis of Fort St. John TSA

Mr. Hawkins:

Please find enclosed the final report for the Inventory Analysis of the Fort St. John TSA as well as the accompanying spreadsheet (fsj_plot_data_20aug2012.xlsx) containing the associated data tables.

Please do not hesitate to call if you have any questions on the report or associated work.

Yours Truly,

[ORIGINAL SIGNED]

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EXECUTIVE SUMMARY

With the completion of the Phase I VRI and the installation of 114 Phase II VRI plots, the Ministry of Forests, Range and Natural Resource Operations initiated this Inventory Analysis of the Fort St John TSA with the goal of quantifying the bias associated with the seven inventory attributes shown in Table i below. Through this analysis, end-users of the VRI can assess the degree of uncertainty associated with the inventory information and be able to understand the implications of this uncertainty on key decisions (such as an AAC determination) that rely heavily on specific attributes in the inventory.

As specified in the *Fort St. John Timber Supply Area Vegetation Resources Inventory Phase II Project Implementation Plan* (Timberline, 2009), the target population for this project is defined as the vegetated-treed (VT) portion of the land base 30 years and older in 2008, representing approximately 3.6 million ha. The land base is divided into the seven strata shown in Table i below which have been grouped into the 'operable' and 'inoperable' portions of the land base according to site index and leading species.

Table i: Analysis Attribute Summary

	ATAC_30to80	ATAC_gt80	PL_30to80	PL_gt80	SXBL_30to80	SXBL_gt80	Overall - Operable Land Base	SI_lt10	Overall - Entire Land Base
N	14	17	12	14	5	18	80	33	113
Age (years)									
Ratio	1.0704	0.8212	1.0557	1.0894	1.0351	0.9946	0.9898	0.9757	0.9812
Sampling Error	21.5%	15.3%	10.0%	22.3%	52.2%	16.3%	8.5%	16.2%	9.6%
Height (m)									
Ratio	1.0697	0.9187	0.9209	1.0036	0.7626	0.9725	0.9697	1.0532	1.0047
Sampling Error	16.6%	11.1%	15.0%	13.7%	18.4%	8.7%	6.1%	11.1%	6.8%
Basal Area (m2/ha) @7.5 cm+ dbh									
Ratio	0.8803	0.9699	0.8321	0.9516	0.8281	1.0317	0.9361	1.0420	0.9810
Sampling Error	25.2%	21.5%	17.2%	18.1%	72.8%	21.5%	10.1%	20.5%	12.5%
Trees / ha @ 7.5cm+ dbh									
Ratio	1.0077	1.4540	1.2889	1.0834	1.4131	1.1620	1.1751	0.5936	0.8009
Sampling Error	30.0%	42.8%	22.6%	32.5%	55.4%	31.3%	15.6%	34.5%	16.1%
Volume / ha (m^3/ha) @ 12.5 cm+ dbh (net dbw)									
Ratio	1.0245	0.9710	0.5390	0.9087	0.5623	0.9429	0.9065	1.6654	1.1066
Sampling Error	44.6%	29.3%	32.1%	24.2%	85.9%	26.6%	16.1%	24.9%	17.9%
Lorey Height (m)									
Ratio	0.9791	1.0205	1.1213	1.0405	1.1647	1.0263	1.0282	0.9933	1.0141
Sampling Error	16.2%	14.5%	14.8%	14.6%	24.3%	12.3%	6.4%	13.2%	7.7%
Site Index (m)									
Ratio	1.0996	1.0764	0.9444	0.9889	0.8529	0.9904	1.0214	1.1259	1.0569
Sampling Error	11.7%	8.3%	11.5%	11.4%	45.5%	12.0%	5.1%	14.5%	8.5%

This analysis demonstrates that on average, net merchantable volume in the operable portion Fort St. John TSA is overestimated by approximately 9%. The sampling error of

+/-16.1% (95% probability) does not meet the stated objective of +/-10%. It is likely that the high percentage of mixed wood stands and corresponding variability within individual stands contributes to the higher sampling error.

In VDYP7, basal area plays a significant role in determining stand volume. With the exception of the SXBL_gt80 and the Sl_lt10 strata, basal area is overestimated in all other strata and is the primary driver in the overestimation of volume in the Phase I.

By calculating the VDYP7 volume using Phase II input attributes we are able to quantify the volume bias introduced by VDYP versus the bias associated with the inventory attributes. This analysis shows that while attribute-related bias consistently overestimates stand volumes in this TSA, model bias appears to be more variable. For the operable portion of the land base the model-related bias underestimates volumes by 8% (+5.6 m^3/ha) while the attribute-related bias overestimates volumes by approximately 12% (-16.7 m^3/ha) resulting in an overall volume bias of approximately 5% (-11.1 m^3/ha).

A comparison of dead volume in the TSA shows that overall the Phase I underestimated dead volume by approximately 3%. However, the overall dead volumes are quite low in this unit with the Phase I and Phase II having only 3% and 6% dead volume respectively. The Phase II data was collected in 2008 / 2009 when there was very little MPB activity in the TSA. In the years since, the MPB infestation has expanded considerably in the TSA.

The following recommendations are provided based on our experience with this and other inventory analysis projects around the Province:

- Update Phase I dead volume estimates using the most up-to-date forest health overview data;

- As funding permits, consider revisiting existing Phase II plot locations to update dead volume estimates in light of the recent expansion of the MPB infestation;

- Given the difficulty in photo-interpreting basal area and the heavy reliance of VDYP 7 on basal area for generating volume estimates, consider modifications to VDYP 7 to reduce its reliance on basal area and / or investigate modifications to inventory procedures to improve the accuracy of this attribute;

- Develop a province-wide analysis data set comprised of all the Phase II plots in the Ministry's data warehouse, linked to the corresponding Phase I polygon. This data set will then be used to assess Phase I volume bias and identify trends in model and attribute bias. These trends can then be used to focus efforts on reducing model bias through improvements to VDYP. Identifying consistent trends in attribute bias, whether tied to specific geographies, specific forest types, or even specific classifiers, inventory procedures can be focussed in areas that have the greatest likelihood of reducing volume errors and improving the overall accuracy of the inventory.

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1 INTRODUCTION

1.1 Background

The original Vegetation Resources Inventory Strategic Inventory Plan (VSIP) for the Fort St. John Timber Supply Area (TSA) was completed by the Ministry of Forests (MoF) in 1999. This VSIP was updated in 2007 (J.S. Thrower and Associates, 2007) and outlines the inventory activities and products required to address the forest management issues identified by stakeholders and provides general strategic direction for implementing the Vegetation Resources Inventory (VRI) program across the TSA. When the 2007 VSIP was completed, the Phase I program had been completed for three of the six geographic units identified in the 1999 VSIP. The 2007 VSIP recommends the completion of the remaining units by March 2008 as well as the installation of 170 VRI Phase II timber emphasis plots and destructive sampling of 100 net volume adjustment factor (NVAF) trees. The objective of the Phase II program is to achieve a sampling error less than or equal to +/-10% (95% probability) for net merchantable volume.

According to the *Fort St. John Timber Supply Area Vegetation Resources Inventory Phase II Project Implementation Plan* (Timberline, 2009) (the Phase II VPIP), the Phase I VRI program for the TSA was completed in May 2008 with the data becoming available for Phase II sample selection in June 2008.

In the 2008 field season, Hatch Woodlands established 80 Phase II plots of which 34 are NVAF-enhanced. An additional 34 plots were established in the 2009 field season for a total of 114 Phase II plots. Phase II plots were audited by Norm Shaw, RFT, ATE with no outstanding issues identified (Timberline, 2010).

1.2 Description of the TSA

As shown in Figure 1 below, the Fort St. John TSA is bordered by the BC-Alberta border to the east and the Rocky Mountains to the west and is located in the Northern Interior Forest Region. The TSA covers approximately 4.7 million ha of which approximately 3.6 million ha is classed as vegetated-treed.

Located in the northeastern portion of the province, the TSA contains four biogeoclimatic zones: Alpine Tundra (AT), Boreal White and Black Spruce (BWBS), Englemann Spruce-Subalpine Fir (ESSF), and Spruce-Willow-Birch (SWB). Stands in the TSA are characterized by a high percentage of mixed conifer and deciduous stands.

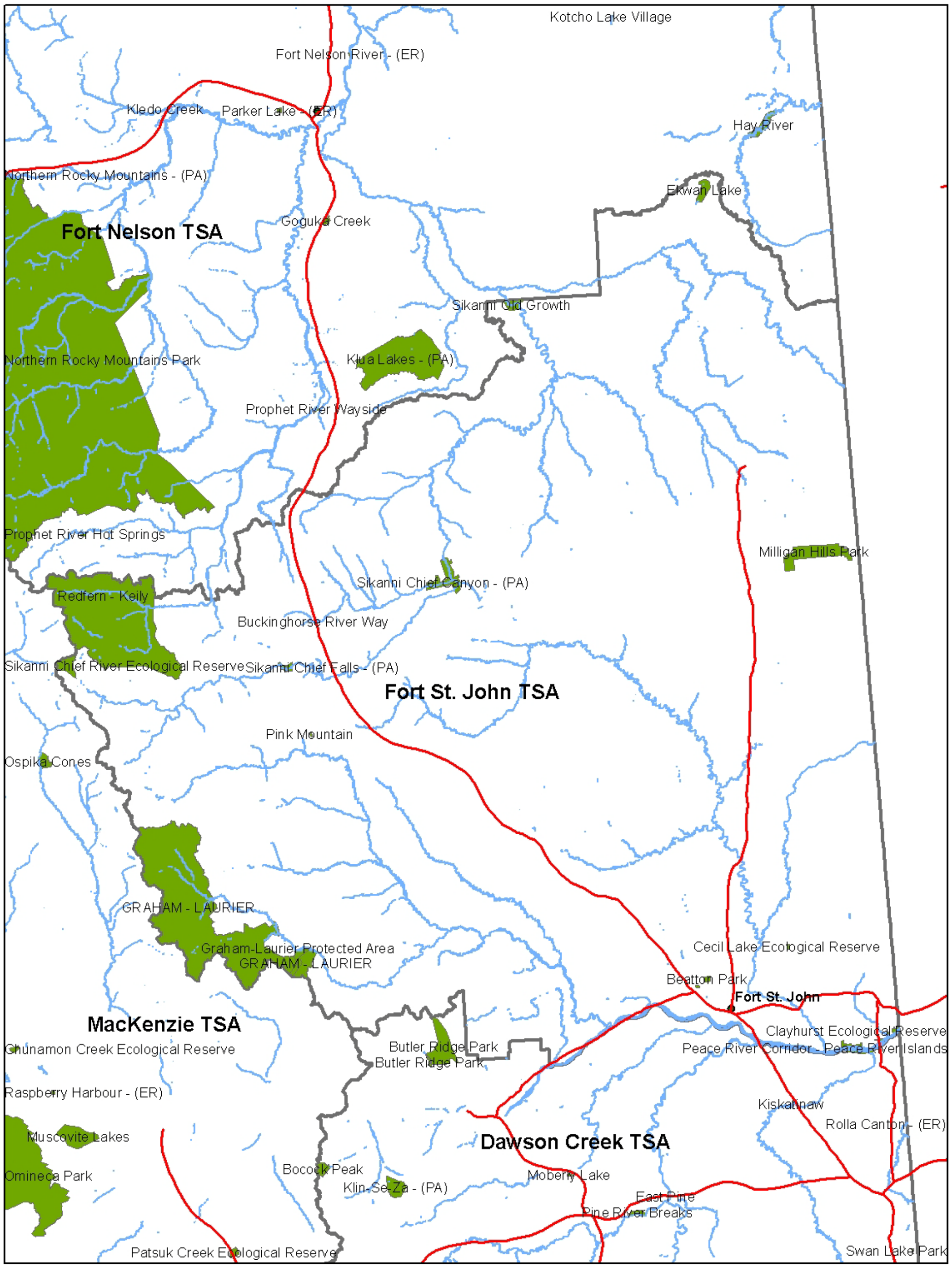

Figure 1: Map of the Ft. St John TSA

1.3 Scope and Objectives

The objective of this project is to provide a statistical analysis of inventory attributes in the Fort St. John TSA as described in the Ministry of Forests, Range and Natural Resource Operations' (MFNRO) *VRI Sample Data Analysis Procedures and Standards (Version 1-June 2011)* (the procedures).

The analysis also includes a comparison of VRI Phase I dead volume estimates with Phase II ground-measured dead volume.

Model and attribute-related bias was assessed according to the procedures included in the contract package (*Appendix B – Quantifying Ground Model Attribute Error*).

The analysis was undertaken using 114 Phase II plots and Phase I VRI data provided by the MFLNRO.

An analysis of site index (SI) was performed based on supplementary SI data and standards and procedures provided by the MFLNRO as described in Appendix VI.

2 Methods

2.1 VRI Statistical Analysis

Vegetation Resources Inventory statistical analysis is undertaken in order to quantify the accuracy of existing Phase I photo interpreted attributes and to provide an understanding of the potential bias associated with the Phase I VRI. By understanding the accuracy of the VRI we can begin to assess the degree of risk associated with incorporating this information into important decision making processes such as timber supply review (TSR).

As described in the procedures, and outlined below, there are six main steps in the VRI analysis process:

1. **Phase II Overlay:** Phase II plot locations are overlain with Phase I VRI polygons such that each plot is tied to the Phase I VRI polygon that was sampled.

2. **Data Screening:** Plot and polygon data are compared to identify any potential overlay or UTM data entry errors. Mapsheet IDs and where possible polygon IDs are compared to identify any potentially mismatched plots. Large discrepancies between polygon and plot data are reviewed to identify any potential errors. Exceptionally large, small or missing values are identified and reviewed to identify any potential errors that may either be corrected or result in the plot being dropped from the analysis.

3. **Project Phase II Data to Year of Ground Sampling:** Phase I VRI data is projected, using the Variable Density Yield Prediction (VDYP) model version 7, to the year in which the majority of ground sampling took place. In this case Phase I data was projected to 2008.

4. **Age – Height Matching:** Age and height matching rules described in the procedures are applied to determine whether Phase II ages and heights are matched to either Phase I species 1 or species 2 ages and heights or dropped from the age-height analysis.

5. **Stratification:** Stratification rules are applied to the Phase I target population as well as to the Phase II plots. Stratum weights are calculated based on the relationship between the number of plots in each stratum and the area occupied by that stratum in the target population.

6. **Ratio of Means (ROM) and Sampling Error Calculation:** ROM and sampling errors are calculated for each stratum and for the land base as a whole according to the procedures and the included MS Excel macro. These statistics provide a direct comparison between the ground measurements and the photo interpreted values for a particular attribute. This phase of the project also includes a secondary data screening process in which potential outliers are identified and further assessed. The following seven attributes were included in this analysis:

i) Species 1 age,
ii) Species 1 height,
iii) Basal area @ 7.5cm+ dbh utilization,
iv) Trees per hectare @ 7.5cm+ dbh utilization,
v) Lorey height @ 7.5cm+ dbh utilization,
vi) Net Merchantable Volume (net top, stump, decay, waste and breakage) @ 12.5cm+ dbh utilization, and
vii) Site Index (see following section).

2.2 Target Population

As specified in the Phase II VPIP (Timberline, 2009), the target population for this project was defined as the vegetated-treed (VT) land base 30 years and older in 2008. The B.C Land Classification System Level 1 and 2 (bclcs_level_1 and bclcs_level_2) was used to define the VT land base. Additionally, any stands without a leading species or having a crown closure less than 10% were also considered non-VT.

As shown in Table 1, the target population represents approximately 3.6 million ha across the TSA. This differs from the target population area figures of 3.2 million ha reported in Table 3 of the Phase II VPIP with all of the difference occurring in the definition of the non-VT land base. This may be attributable to re-definition of polygons through the inventory update process. However, without having access to the same inventory file used in the VPIP, this cannot be confirmed.

Table 1: Land Classification Summary

Land Classification	Area (ha)	% of TSA
Gross Area on File	**4,674,068**	**100%**
Not Vegetated-Treed	1,021,049	22%
Vegetated-Treed	**3,653,019**	**78%**
Age < 30 years	86,981	2%
Target Population	**3,566,038**	**76%**

2.3 Phase II Sample Selection Pre-Stratification and Weights

Several different stratification variations were applied before a final stratification was determined. The initial stratification described in the Phase II VPIP includes separate strata for black spruce / other and stands with a site index less than 6.0m as shown in Table 2. This stratification resulted in a substantial amount of area being included in strata with very few plots thereby receiving a high per plot weighting in the overall statistics. Variability in these strata was also very high due to the low number of plots and diversity of stands. This stratification was re-evaluated in an effort to reduce sampling error and to focus the analysis on the operable portion of the TSA.

Table 2: Initial Stratification

Strata	N	Leading Species	Age Criteria (yrs)	Site Index Criteria	Phase I VRI Area (ha)	Percent of Area (%)
ATAC_30to80	15	AT, AC, ACT, ACB	<=80 & > 30	>6.0	397,477	11%
ATAC_gt80	18		>80	>6.0	361,295	10%
PL_30to80	12	PLI, P, PL	<=80 & > 30	>6.0	259,947	7%
PL_gt80	19		>80	>6.0	354,095	10%
SXBL_30to80	6	SW, S, SE, SX, B, BL	<=80 & > 30	>6.0	80,418	2%
SXBL_gt80	26		>80	>6.0	485,289	14%
SBOT_30to80	5	<> AT, AC, ACT, ACB, PLI, P, PL, SW, S, SE, SX, B, BL	<=80 & > 30	All	578,052	16%
SBOT_gt80	12		>80	All	1,049,464	29%
Total Vegetated-Treed (VT) Area					**3,566,038**	

Grouping the SXBL_30to80 and the SBOT_30to80 strata increased the number of plots within the combined stratum. However, because of the amount of area included in these strata the per-plot weighting remained high. The diversity of stands in this combined stratum resulted in a high sampling error.

In reviewing the initial and subsequent stratifications it was determined that almost all of the SBOT plots had site index values between 6 and 10. Similarly, a large percentage of the land base has a site index less than 10 and was not likely to be included in the timber harvesting land base (THLB). Based on this, the decision was made to create an inoperable stratum consisting of all stands with a site index less than 10. Removing the lower site index stands from the other strata decreased some of the variability in these strata and decreased the sampling error. However, this resulted in only one plot remaining in the two SBOT strata, representing approximately 5% of the land base. Upon further review it was determined that the species composition in these stands would likely result in them being excluded from the THLB and therefore the SBOT strata were grouped into the inoperable stratum.

This resulted in the final stratification shown in Table 3 with the SI_lt10 stratum established as the 'inoperable' stratum including all stands with a site index less than 10 as well as those stands previously included in the SBOT strata. The sampling intensity in the SBOT and low site index stands appears to be slightly lower than the rest of the population. This combined with the fact that there is considerable variability within these stands leads to a higher sampling error. By grouping all the 'inoperable' stands into one stratum we minimize the potential impact of this on the THLB while reducing the uncertainty in the operable (THLB) strata.

Table 3: Final Stratification Summary

Stratum	Leading Species	Site Index Criteria	Age Criteria (yrs)	Phase I VRI Area (ha)	Percent of Area (%)
ATAC_30to80	AT, AC, ACT, ACB	>=10.0	<=80 & >=30	390,567	11%
ATAC_gt80			>80	356,625	10%
PL_30to80	PLI, P, PL		<=80 & >=30	212,959	6%
PL_gt80			>80	264,160	7%
SXBL_30to80	SW, S, SE, SX, B, BL		<=80 & >=30	74,018	2%
SXBL_gt80			>80	329,889	9%
SI_lt10 (inoperable)	<> AT, AC, ACT, ACB, PLI, P, PL, SW, S, SE, SX, B, BL	>=10.0	>=30	1,937,820	54%
	All	<10.0			
Total Target Population Area				**3,566,038**	

The stratum weighting in Table 4 shows that the SI_lt10 stratum occupies approximately 54% of the target population but only contains 29% of the plots leading to a high per plot weighting. To prevent this stratum from impacting the overall statistics for the land base we have summarized the operable and inoperable portions of the land base separately in the results below.

Aside from the SI_lt10 stratum, the operable strata all have relatively consistent per plot weightings. The SXBL_30to80 stratum represents approximately 2% of the land base and has the lowest per plot weighting even though it only contains 5 plots. The ATAC_30to80 stratum has the highest per plot weighting of the operable strata.

Table 4: Stratum Weighting

Stratum	Number of Plots	% of Plots	Land Base Area (ha)	% of Land Base	Area / Plot
ATAC_30to80	14	12%	390,567	11%	27,898
ATAC_gt80	17	15%	356,625	10%	20,978
PL_30to80	12	11%	212,959	6%	17,747
PL_gt80	14	12%	264,160	7%	18,869
SXBL_30to80	5	4%	74,018	2%	14,804
SXBL_gt80	18	16%	329,889	9%	18,327
SI_lt10	33	29%	1,937,820	54%	58,722
	113		**3,566,038**		

2.4 Data Sources

2.4.1 Phase I VRI

The MFLNRO maintains a separate aspatial version of the VRI that contains the interpreted attributes required as inputs to VDYP. As discussed previously there is a discrepancy of approximately 400,000 ha between the total amount of VT area in this version of the inventory file and the figures reported in the Phase II VPIP. The gross areas of the two inventory files are within 600 ha of each other and therefore the discrepancy can be tied to differences in the land cover classifications as opposed to a difference in the TSA boundary file used to clip each version of the VRI. Changes to the land cover classification may be the result of an inventory update but without the original inventory file this cannot be confirmed.

2.4.2 Phase II Data

Several plots were identified as having no age, height, basal area, stems per hectare or volume information. These plots were reviewed by the MFLNRO staff and confirmed to be valid samples.

One plot (0403-0071-DO1) was identified as falling outside of the VT land base and was therefore dropped from the analysis.

The following issue was identified in the Phase II completion report (Timberline, 2010),

> *Weather became a concern on the TSA when the field crews started work in November of 2009. Concerns about the quality of data for CWD, stump, and small tree were discussed between Timberline, the auditor, and the MFR. It was determined that because the first batch of samples was a reasonable sample size and if there was enough snow to result in a reduction in data quality these attributes did not have to be collected. Upon completion of batch 2 only eleven (11) of the thirty-four (34) samples had CWD, stump, and small tree attributes measured (91 samples for batch 1 and 2 combined).*

It is unlikely that these factors will have any significant impact on the results of this analysis.

Site index analysis was conducted using a *trees_h* file was provided by the MFLNRO along with new procedures for analyzing site index described in Appendix VI. This file contains site index measurements for individual trees. Several records did not have site index data and were checked by MFLFNRO staff and confirmed to be valid samples without site index. These trees were not included in the site index analysis.

3 RESULTS AND DISCUSSION

3.1 VRI Statistical Analysis

The results of the inventory analysis are summarized in

Table 5. For each of the seven attributes examined, for each stratum, the table shows the number of included values (n), the mean of the Phase II ground and Phase I inventory values, the ratio of means and the sampling error for that attribute. An overall summary of the operable land base shows that on average net merchantable volume is overestimated in the Phase I VRI by approximately 10% (+/- 16.1% @ 95% probability).

Representing over 54% of the land base, net merchantable volume in the SI_lt10 stratum is underestimated by approximately 66%. When this stratum is included in the overall entire land base summary (operable + inoperable) the Phase I VRI volume underestimates actual volume by approximately 10% (+/- 17.9% @ 95% probability). However, it is important to note that the actual average volume in the SI_lt10 stratum is only 88 m^3/ha and is therefore unlikely to be part of the THLB, confirming the decision to exclude these stands from operable land base. An analysis of site index in this stratum shows that on average, site index in the Phase I is underestimated by approximately 12%. If the Phase I site index values were to be adjusted based on this analysis then site index values within this stratum would increase which may result in less area being excluded from the THLB as low site stands. This underestimation of site index in lower productivity stands should be considered in developing merchantable site index thresholds for the next TSR. The underestimation of site index in this stratum is supported by the fact that age is overestimated and height is underestimated, resulting in a higher site index.

With only five plots, sampling error in SXBL_30to80 stratum is the highest across all attributes analyzed. This is clearly shown in the sample value plots in Appendix II with a wide distribution of both Phase I and Phase II values across all attributes. Representing only 2% of the land base, this does not pose a significant risk to the overall assessment of the Phase I VRI.

Aside from the SI_lt10 stratum, the largest volume difference occurs in the PL_30to80 stratum where net merchantable volume is overestimated by 46% in the Phase I. Mountain pine beetle (MPB) was explored as a potential cause of this discrepancy however an examination of the dead volume (see Section 0) shows that there is very little dead volume (<1%) in the Phase II plot data for this stratum. The 17% overestimation of Phase 1 basal area in this stratum is the primary factor resulting in the substantially higher Phase I volumes.

The PL_gt80 stratum has the highest likelihood of being impacted by MPB given its species composition and age definition. Phase I volume in this stratum is overestimated by approximately 9% which is roughly equivalent to the percentage of dead volume in this stratum according to Phase II (Table 7). However, the Phase I also includes 9% of additional dead volume in this stratum and if you compare total volume (live + dead), the Phase I volumes are still overestimated by 7% suggesting that MPB may only account for a small proportion of the difference. Given that the majority of the Phase II data was collected in 2008 and there has been considerable MPB activity in the TSA since then, it may be worth re-assessing the dead volume component of this analysis using more up-to-date information.

The addition of site index to the list of analyzed attributes provides useful insight into the differences between the Phase I and Phase II populations. As site index plays a considerable role in the development of managed stand yield projections and often factors into the THLB definition of TSR it is important to understand the degree to which the Phase I VRI reasonably reflects site index.

Overall site index is underestimated by approximately 2% in the operable land base and 6% overall. Aside from the SI_lt10 stratum discussed above, the SXBL_30to80 stratum has the largest site index difference with Phase I site index overestimated by 15% (2.3m). But again the high sampling error and small proportion of the land base in this stratum mean that this is not a significant issue.

The original VSIP objective of achieving an overall sampling error of +/- 10% (95% probability) on overall net merchantable volume has not been achieved on either the land base as a whole or the operable portion of the land base. This stands to reason as the number of plots installed was significantly lower than the originally proposed 170 plots required to achieve this target. In reviewing individual plot records there are several instances where the Phase I and Phase II volume estimates vary considerably with individual plot differences as high as 316 m^3/ha (0403-0045-DO1). The larger than average proportion of mixed wood stands within the TSA, resulting in higher variability within individual VRI polygons, likely contribute to the high sampling error.

Table 5: Analysis Attribute Summary

	ATAC_30to80	ATAC_gt80	PL_30to80	PL_gt80	SXBL_30to80	SXBL_gt80	Overall - Operable Land Base	SI_lt10	Overall - Entire Land Base
N	14	17	12	14	5	18	80	33	113
Total Area	390,567	356,625	212,959	264,160	74,018	329,889	1,628,217	1,937,820	3,566,038
Age (years)									
n	12	16	12	14	4	18	80	32	113
Phase II Ground	61.3	82.4	67.2	119.2	69.6	115.9	83.7	111.4	97.0
Phase I Inventory	57.3	100.4	63.7	109.4	67.3	116.5	84.6	114.2	98.8
Ratio	1.0704	0.8212	1.0557	1.0894	1.0351	0.9946	0.9898	0.9757	0.9812
Sampling Error	21.5%	15.3%	10.0%	22.3%	52.2%	16.3%	8.5%	16.2%	9.6%
Height (m)									
n	12	16	12	14	4	18	80	32	113
Phase II Ground	18.6	22.0	14.7	19.0	12.4	23.7	18.6	12.6	15.2
Phase I Inventory	17.4	24.0	16.0	18.9	16.2	24.4	19.2	12.0	15.1
Ratio	1.0697	0.9187	0.9209	1.0036	0.7626	0.9725	0.9697	1.0532	1.0047
Sampling Error	16.6%	11.1%	15.0%	13.7%	18.4%	8.7%	6.1%	11.1%	6.8%
Basal Area (m^2/ha) @7.5 cm+ dbh									
n	14	17	12	14	5	18	80	33	113
Phase II Ground	26.3	30.0	26.0	29.6	19.5	33.9	28.9	19.9	24.0
Phase I Inventory	29.9	30.9	31.3	31.2	23.5	32.8	30.8	19.1	24.4
Ratio	0.8803	0.9699	0.8321	0.9516	0.8281	1.0317	0.9361	1.0420	0.9810
Sampling Error	25.2%	21.5%	17.2%	18.1%	72.8%	21.5%	10.1%	20.5%	12.5%
Trees / ha @ 7.5cm+ dbh									
n	14	17	12	14	5	18	80	33	113
Phase II Ground	1,541	1,068	2,279	1,313	1,324	846	1,346	1,032	1,175
Phase I Inventory	1,529	734	1,768	1,212	937	728	1,146	1,738	1,467
Ratio	1.0077	1.4540	1.2889	1.0834	1.4131	1.1620	1.1751	0.5936	0.8009
Sampling Error	30.0%	42.8%	22.6%	32.5%	55.4%	31.3%	15.6%	34.5%	16.1%
Volume / ha (m^3/ha) @ 12.5 cm+ dbh (net dbw)									
n	14	17	12	14	5	18	80	33	113
Phase II Ground	129.1	198.1	72.9	168.2	63.6	225.3	159.7	88.3	120.9
Phase I Inventory	126.0	204.0	135.3	185.1	113.1	239.0	176.2	53.0	109.2
Ratio	1.0245	0.9710	0.5390	0.9087	0.5623	0.9429	0.9065	1.6654	1.1066
Sampling Error	44.6%	29.3%	32.1%	24.2%	85.9%	26.6%	16.1%	24.9%	17.9%
Lorey Height (m)									
n	14	17	12	14	4	18	80	26	113
Phase II Ground	16.3	20.1	13.1	17.0	14.4	21.3	17.6	12.2	13.3
Phase I Inventory	16.7	19.7	11.7	16.4	12.4	20.7	17.1	12.3	13.1
Ratio	0.9791	1.0205	1.1213	1.0405	1.1647	1.0263	1.0282	0.9933	1.0141
Sampling Error	16.2%	14.5%	14.8%	14.6%	24.3%	12.3%	6.4%	13.2%	7.7%
Site Index (m)									
n	10	13	12	11	4	17	80	25	113
Phase II Ground	18.6	18.6	13.7	12.7	13.3	15.1	13.1	8.2	9.4
Phase I Inventory	16.9	17.3	14.5	12.8	15.6	15.3	12.8	7.3	8.9
Ratio	1.0996	1.0764	0.9444	0.9889	0.8529	0.9904	1.0214	1.1259	1.0569
Sampling Error	11.7%	8.3%	11.5%	11.4%	45.5%	12.0%	5.1%	14.5%	8.5%

3.2 Model and Attribute-Related Volume Bias

Given the assumption that the Phase II compilations of net merchantable volume are correct, there are two primary potential sources of error that can contribute to the differences between Phase I and Phase II net merchantable volumes: errors in the attributes input into VDYP, and errors in how VDYP calculates net merchantable volume. In this section we attempt to quantify each of these sources of error by inputting the Phase II attribute information into VDYP and comparing the volumes produced with the actual Phase II volumes. It should be noted that the Phase II volumes are produced through a compiler which itself may introduce bias however for the purpose of this analysis we assume this to be negligible.

As indicated by the supplied procedures, this analysis is to be carried out using net merchantable volume at the 7.5+ cm dbh utilization level and therefore the volume information does not match with reports from the previous sections.

Overall, as shown in Table 6 and Figure 2, on the operable land base the model-related bias underestimates volumes by 8% (5.6 m^3/ha) while the attribute-related bias overestimates volumes by approximately 12% (16.7 m^3/ha) resulting in an overall volume bias of approximately 5% (11.1 m^3/ha).

With the exception of the Sl_lt10 stratum, the attribute-related bias results in higher Phase I volumes by between 1% and 64% (2.8 m^3/ha and 73 m^3/ha), suggesting that photo interpreters consistently over-estimated the amount of volume on in the operable portion of the this land base. Interestingly, photo interpreters underestimated the net merchantable volume on the lower productivity stands. Model-related bias is less consistent; varying from a 3% overestimate to a 79% underestimate (from +4.4 m^f/ha to -

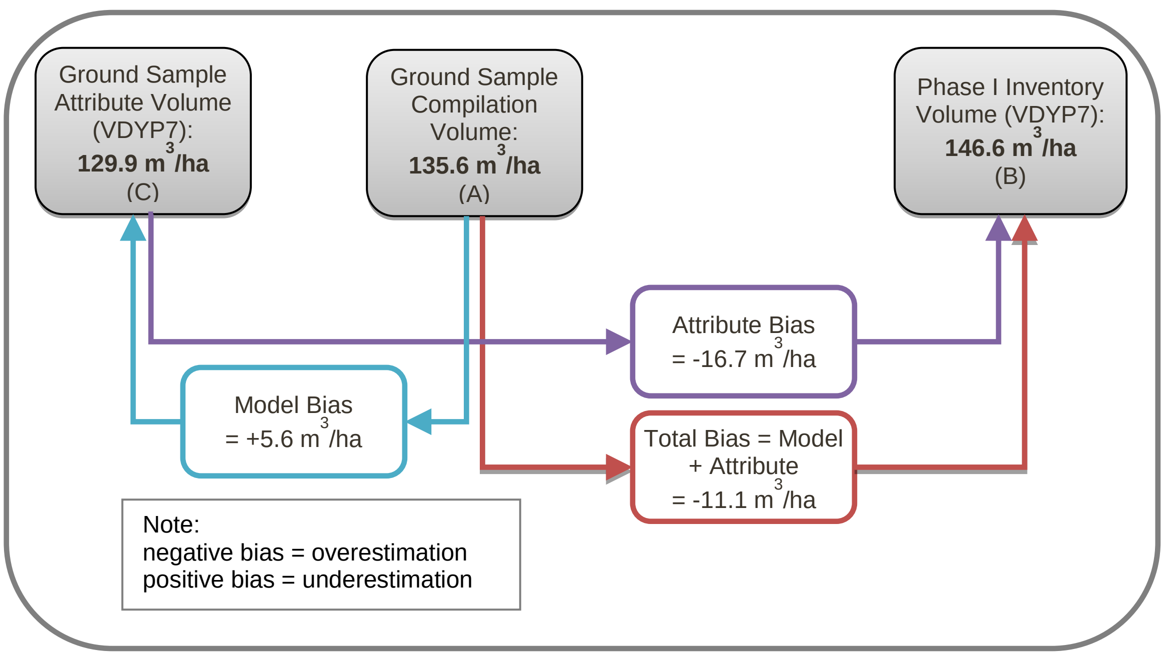

Figure 2: Relationship Between Model and Attribute Bias

27.0 m^3/ha).

Table 6: Analysis of Model and Attribute Bias

	ATAC_30to80	ATAC_gt80	PL_30to80	PL_gt80	SXBL_30to80	SXBL_gt80	Overall - Operable Land Base	SI_lt10	Overall - Entire Land Base
n	14	17	12	14	5	18	80	33	80
Net Merch. Volume @ 7.5cm dbh									
Phase II Ground (A)	137.4	204.7	96.6	174.7	73.0	229.2	135.6	94.2	113.1
Phase I Inventory (B)	127.2	204.3	137.0	186.8	113.9	239.2	146.6	71.1	96.2
VDYP7 with Phase II Attributes (C)	110.5	183.7	83.2	179.1	40.7	236.4	129.9	76.3	100.8
Volume Bias									
Model-Related Volume Bias (A-C)	27.0	21.0	13.5	-4.4	32.2	-7.2	5.6	17.9	12.3
Attribute-Related Volume Bias (C-B)	-16.7	-20.6	-53.9	-7.6	-73.2	-2.8	-16.7	5.2	4.6
Total Volume Bias (A-B)	10.2	0.4	-40.4	-12.1	-41.0	-10.0	-11.1	23.1	16.8
Bias									
Model Bias (A/C)	1.2442	1.1146	1.1618	0.9752	1.7917	0.9694	1.0775	1.2342	1.1350
Sampling Error	22.5%	10.2%	13.6%	4.5%	30.8%	8.7%	7.2%	13.9%	8.4%
Attribute Bias (C/B)	0.8685	0.8990	0.6068	0.9591	0.3574	0.9882	0.8830	1.4162	1.0247
Sampling Error	56.9%	35.2%	35.6%	25.1%	92.7%	26.0%	18.1%	25.4%	17.9%
Total Bias (A/B)	1.0805	1.0020	0.7050	0.9353	0.6404	0.9580	0.9514	1.7479	1.1631
Sampling Error	41.9%	28.3%	25.7%	23.3%	80.3%	26.2%	15.2%	25.5%	18.1%

3.3 Analysis of Dead Volume Estimates

Table 7 compares the amount of dead volume reported in the Phase II ground samples with the overall dead volume reported in the Phase I inventory file. It should be noted that the dead volume information from the Phase I cannot be projected back to the year of ground sampling and therefore we are comparing the dead volume for these stands in 2008 / 2009 with the Phase I dead volume in 2011. In some units where the MPB is very active this could represent a substantial change but in Fort St. John this is likely not the case.

Overall, across the entire land base there is very little dead volume accounted for in either the Phase I or Phase II estimates with an average of 3.3 m^3/ha (3%) and 7.4 m^3/ha (6%) respectively. On the operable land base this amounts to 4.0 m^3/ha (2%) from the Phase I and 7.1 m^3/ha (4%) from the Phase II. The PL_gt80 stratum show this largest percentage of dead volume with 9% and 10% for the Phase I and Phase II respectively – likely attributable to higher MPB activity in this stratum. In general, the inventory tends to underestimate the amount of dead volume by between 1% and 5% with the exception being the PL_30to80 stratum in which the Phase I overestimates the amount of dead volume by 5%.

Table 7: Analysis of Dead Volume Estimates

Stratum	Live Volume (m^3/ha)		Dead Volume (m^3/ha)		% Dead Volume	
	Ground	Inventory	Ground	Inventory	Ground	Inventory
ATAC_30to80	129	126	2.1	1.0	2%	1%
ATAC_gt80	198	204	8.9	0.2	4%	0%
PL_30to80	73	135	0.1	3.5	0%	5%
PL_gt80	168	185	19.7	16.4	10%	9%
SXBL_30to80	64	113	2.4	0.7	4%	1%
SXBL_gt80	225	239	9.0	4.1	4%	2%
Overall - Operable Land Base	**160**	**176**	**7.1**	**4.0**	**4%**	**2%**
SI_lt10	88	53	7.7	2.7	8%	3%
Overall - Entire Land Base	**121**	**109**	**7.4**	**3.3**	**6%**	**3%**

4 CONCLUSIONS AND RECOMMENDATIONS

This analysis demonstrates that on average, net merchantable volume in the operable portion Fort St. John TSA is overestimated by approximately 9%. The sampling error of +/-16.1% (95% probability) does not meet the stated objective of +/-10% and based on the size of the overestimate relative to the sampling error, caution should be exercised in the application of this information.

With the exception of the SXBL_gt80 and the SI_lt10 strata, basal area is overestimated in all strata. Given the importance of basal area in the calculation of VDYP volumes it is likely that this plays a significant role in the overestimation of Phase I volumes. Given the difficulty in photo interpreting basal area consistently and reliably, evident in the relatively high sampling errors for this attribute, the Ministry may wish to consider modifications to VDYP to lessen its reliance on basal area and / or investigate photo interpretation standards to improve the accuracy of this attribute.

Consistent with the above, this analysis quantifies the model versus attribute-related bias reflected in these results and found that while attribute-related bias consistently overestimates stand volumes in this TSA, model bias appears to be more variable. For the operable portion of the land base, model-related bias underestimates volumes by 8% while the attribute-related bias overestimates volumes by approximately 12%.

Interestingly, when examined on the entire land base, model-related bias represents a larger component of the overall Phase I volume error than attribute-related bias. This is not the case on the operable portion of the land base suggesting that VDYP does not perform as well on marginal stand types. In fact, for the majority of the strata on the operable land base the model bias appears to compensate attribute-related bias.

Although the separation of model and attribute-related bias has only been undertaken on a limited number of units to date, the trends in model and attribute-related bias do not appear to be universal. The Quesnel East analysis (Churlish and Jahraus, 2011) found that model-related bias underestimated volumes by 9% while attribute-related bias overestimated volumes by 40%. In the Strathcona TSA Analysis (Churlish and Jahraus, 2011a) model and attribute-related bias both resulted in an underestimate of volumes on the entire land base but when assessed on only the operable portion of the land base the model-related bias resulted in a very small (<1%) overestimation of volume while the attribute-related bias resulted in an 18% underestimation of volume.

As more units complete this type of analysis it will be useful to monitor trends, attribute and model-related bias. Through a more detailed and geographically diverse understanding of the trends in bias in estimating volumes, improvements to both photo interpretation procedures and VDYP can improve provincial volume estimates and reduce the risk associated with key decisions such as allowable annual cut determinations. To this end, the ministry may wish to consider completing a project that examines trends in model and attribute-related bias across the entire Province using all of the Phase II data collected to date. This project would provide useful information on how VDYP might be improved in the future as well as identify consistent trends in attribute-related bias, as well as geographically specific trends in volume estimation bias.

A comparison of dead volume in the TSA shows that overall the Phase I underestimated dead volume by approximately 3%. However, the overall dead volumes are quite low in this unit with the Phase I and Phase II having only 3% and 6% dead volume respectively. The Phase II data was collected in 2008 / 2009 when there was very little MPB activity in the TSA. In the years since, the MPB infestation has expanded considerably in the TSA. Based on this the Ministry may wish to consider updating the existing Phase I dead volume estimates using the latest forest health overview survey data. As funding permits, the Ministry may also consider re-visiting the existing Phase II plots and updating attributes to account for increased pine mortality.

5 REFERENCES

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APPENDIX I – ADJUSTMENT DATA

Table 8: Adjustment Data

Stratum	Cluster ID	Phase II Measured Data								Phase I Interpreted Data (Projected to 2008)									Comment
		SPP1	Age	Height	Basal Area	SPH	Net Vol.	Lorey Height	Site Index	SPP1	SPP2	Age	Height	Basal Area	SPH	Net Vol.	Lorey Height	Site Index	
ATAC_30to80	0403-0001-DO1	SX	54	21.5	11.0	431	63	10.5	21.2	AT	-	38	12.8	8.2	683	13	11.7	-	failed spp match; si dropped no p1 si; si dropped failed si spp match;
ATAC_30to80	0403-0002-DO1	AT	72	22.1	27.0	1,134	150	17.7	21.3	AT	-	40	14.3	18.2	1,144	44	12.7	17.4	
ATAC_30to80	0403-0003-DO1	EP	37	8.1	2.0	70	8	10.5	12.2	AT	EP	48	-	18.2	557	94	18.4	13.8	
ATAC_30to80	0403-0005-DO1	AT	63	25.2	49.0	1,699	285	25.9	23.1	AT	AC	72	17.1	28.1	1,149	105	16.1	14.1	
ATAC_30to80	0403-0008-DO1	AT	59	18.6	35.0	2,218	155	12.6	17.8	AT	PL	67	19.2	47.7	1,967	216	16.6	16.7	
ATAC_30to80	0403-0009-DO1	S	66	17.9	54.0	3,368	219	14.5	16.8	AT	SX	53	-	42.4	2,910	150	15.9	-	si dropped no p1 si; si dropped failed si spp match;
ATAC_30to80	0403-0010-DO1	AT	60	21.9	20.0	929	112	21.1	20.3	AT	SX	63	20.6	36.7	1,177	189	18.2	18.6	
ATAC_30to80	0403-0011-DO1	SX	64	17.4	26.3	1,642	121	16.3	16.7	AT	AC	78	21.4	36.6	983	202	19.7	-	failed spp match; si dropped no p1 si; si dropped failed si spp match;
ATAC_30to80	0403-0012-DO1	EP	26	10.6	1.6	120	3	7.0	18.6	AT	-	38	9.6	16.8	2,317	5	8.3	-	si dropped no p1 si; si dropped failed si spp match;
ATAC_30to80	0403-0013-DO1	AT	51	16.1	35.0	3,966	83	17.3	16.8	AT	PL	53	17.7	33.8	2,237	113	15.5	17.7	
ATAC_30to80	0403-0014-DO1	AT	36	11.8	10.8	1,265	15	14.1	17.5	AT	PL	61	17.1	24.9	1,125	97	15.2	15.6	
ATAC_30to80	0403-0018-DO1	AT	121	21.2	43.4	1,992	265	20.8	13.3	AT	PL	63	15.5	41.8	2,396	129	13.4	14.0	
ATAC_30to80	0403-0019-DO1	AT	53	17.5	21.3	2,253	49	13.8	18.1	AT	PL	58	21.7	39.9	1,662	248	19.1	20.6	
ATAC_30to80	0403-0022-DO1	AT	94	32.9	32.4	486	279	26.3	25.5	AT	SX	71	24.2	25.5	1,102	158	21.4	20.6	
ATAC_gt80	0403-0024-DO1	AT	49	15.2	30.4	2,428	91	13.8	16.5	AT	AC	112	26.7	41.9	703	297	24.8	18.3	
ATAC_gt80	0403-0025-DO1	AT	84	21.8	46.2	1,250	281	20.2	18.1	AT	SX	122	24.0	32.8	682	216	21.8	15.4	
ATAC_gt80	0403-0026-DO1	AC	52	19.4	8.1	143	44	19.1	20.5	AT	-	103	25.3	4.3	104	31	24.4	-	si dropped no p1 si; si dropped failed si spp match;
ATAC_gt80	0403-0027-DO1	AT	58	17.1	43.4	4,158	87	12.1	16.9	AT	-	94	20.0	37.7	1,078	168	17.7	14.3	
ATAC_gt80	0403-0029-DO1	AT	104	23.6	30.6	541	255	19.5	16.1	AT	-	99	25.0	47.3	977	295	22.2	18.0	
ATAC_gt80	0403-0030-DO1	AT	49	16.5	9.1	335	55	14.7	17.6	AT	-	89	19.1	9.8	261	45	17.9	14.0	
ATAC_gt80	0403-0031-DO1	AT	67	13.8	28.0	1,999	84	10.3	12.7	AT	SW	86	16.3	16.7	731	55	14.8	12.0	
ATAC_gt80	0403-0034-DO1	SX	18	4.1	1.0	12	6	17.6	17.8	AT	EP	136	18.7	10.4	230	37	16.4	-	failed spp match; si dropped no p1 si; si dropped failed si spp match;
ATAC_gt80	0403-0038-DO1	AT	93	27.5	74.4	2,181	525	23.8	20.1	AT	SW	96	23.3	48.8	1,137	289	20.8	16.8	
ATAC_gt80	0403-0040-DO1	SX	96	17.3	39.2	1,156	263	17.8	18.3	AT	SW	61	-	40.9	1,235	262	19.4	-	si dropped no p1 si; si dropped failed si spp match;
ATAC_gt80	0403-0041-DO1	PL	117	24.4	32.4	750	241	24.4	14.7	AT	PL	131	-	43.1	1,195	270	20.0	14.2	
ATAC_gt80	0403-0042-DO1	AT	102	29.1	50.4	780	429	23.9	21.5	AT	SW	123	31.2	39.4	841	330	27.8	21.5	
ATAC_gt80	0403-0043-DO1	AT	78	22.3	16.2	734	115	12.0	19.7	AT	SW	123	29.2	14.4	223	117	27.7	19.8	
ATAC_gt80	0403-0045-DO1	AT	77	27.0	24.5	320	242	29.1	22.4	AT	-	92	32.3	58.5	720	558	29.3	25.0	
ATAC_gt80	0403-0046-DO1	EP	95	16.2	4.0	51	21	23.0	11.3	AT	-	91	24.1	10.1	299	64	22.1	-	si dropped no p1 si; si dropped failed si spp match;
ATAC_gt80	0403-0048-DO1	AT	89	30.5	41.4	906	331	26.9	23.9	AT	SW	102	24.2	35.5	1,375	217	21.7	17.1	
ATAC_gt80	0403-0049-DO1	AT	111	30.8	30.6	408	298	32.7	21.9	AT	SW	82	23.3	33.9	692	218	21.8	18.3	
PL_30to80	0403-0072-DO1	PL	57	17.0	28.8	1,884	128	17.5	16.9	PL	SB	57	19.7	34.5	1,187	232	16.8	19.5	
PL_30to80	0403-0073-QO1	SB	89	9.0	22.4	3,210	6	7.5	6.9	PL	SB	96	-	33.6	2,214	86	9.9	6.7	
PL_30to80	0403-0074-DO1	PL	56	18.7	45.0	4,264	114	16.2	18.9	PL	-	62	18.4	35.9	1,985	192	15.4	17.2	
PL_30to80	0403-0075-DO1	PL	58	12.8	27.5	2,704	44	11.9	13.3	PL	-	58	13.5	36.5	1,993	130	11.4	13.4	
PL_30to80	0403-0076-DO1	PL	63	15.6	34.2	3,073	69	9.7	14.6	PL	AT	58	16.6	36.5	1,788	179	13.9	16.2	
PL_30to80	0403-0077-DO1	PL	58	20.3	41.4	3,129	147	18.1	19.2	PL	-	58	15.6	36.6	1,990	158	13.1	15.4	
PL_30to80	0403-0078-DO1	PL	55	10.3	18.2	1,662	44	11.6	12.4	PL	SB	48	10.6	21.9	2,573	20	8.7	12.4	
PL_30to80	0403-0079-DO1	PL	111	14.9	23.8	1,430	101	14.2	9.2	PL	SX	73	15.4	26.0	1,202	121	13.3	13.0	
PL_30to80	0403-0080-DO1	PL	83	20.1	16.8	683	91	17.9	15.5	PL	SB	73	14.4	19.3	1,235	62	11.1	12.2	
PL_30to80	0403-0132-QO1	PL	61	11.4	14.4	1,456	27	9.9	10.8	PL	SB	65	16.9	28.9	2,060	107	12.2	15.5	
PL_30to80	0403-0133-DO1	PL	58	16.7	27.5	2,146	104	14.4	16.9	PL	AT	58	18.6	34.4	1,588	204	15.9	18.2	
PL_30to80	0403-0149-DO1	PL	59	9.8	12.5	1,709	-	8.1	10.0	PL	AT	58	14.6	31.5	1,405	133	12.7	14.4	
PL_gt80	0403-0081-QO1	PL	85	21.4	43.2	1,752	260	17.3	16.4	PL	-	94	16.9	38.2	2,575	155	14.0	12.4	
PL_gt80	0403-0082-DO1	SW	219	26.3	39.0	589	294	20.8	8.7	PL	SW	94	-	23.9	888	114	14.9	11.3	
PL_gt80	0403-0083-QO1	PL	19	4.3	-	-	-	3.0	14.6	PL	SW	129	16.5	3.5	84	17	15.8	10.2	
PL_gt80	0403-0084-DO1	PL	112	18.0	18.2	462	118	15.2	12.1	PL	SW	99	16.3	38.7	815	239	14.4	11.6	
PL_gt80	0403-0088-DO1	PL	105	15.7	30.8	1,678	138	16.7	10.0	PL	-	114	16.1	39.5	1,912	203	13.5	10.6	
PL_gt80	0403-0089-DO1	SB	132	14.3	15.4	800	66	15.5	8.2	PL	SB	99	-	22.2	1,550	82	13.5	9.7	
PL_gt80	0403-0090-QO1	PL	106	18.1	43.2	2,759	162	12.3	11.6	PL	SB	96	18.1	37.9	1,446	190	14.2	13.2	
PL_gt80	0403-0092-QO1	S	120	20.1	41.4	2,969	168	16.7	11.0	PL	AT	114	16.6	26.5	1,269	128	14.9	-	si dropped no p1 si; si dropped failed si spp match;
PL_gt80	0403-0093-DO1	PL	143	21.7	15.2	487	95	18.4	11.9	PL	AT	103	20.3	10.4	203	79	20.0	14.6	
PL_gt80	0403-0094-DO1	SB	133	16.1	33.6	1,931	140	15.3	10.5	PL	SW	91	19.7	31.3	1,181	193	17.2	-	si dropped no p1 si; si dropped failed si spp match;
PL_gt80	0403-0095-DO1	SX	93	13.2	36.0	3,509	74	11.6	10.0	PL	SW	121	17.3	33.8	2,361	132	14.5	-	si dropped no p1 si; si dropped failed si spp match;
PL_gt80	0403-0134-QO1	PL	141	25.3	37.8	474	323	24.7	14.8	PL	SW	134	22.5	44.9	599	347	20.6	14.8	
PL_gt80	0403-0150-DO1	SX	99	26.4	36.8	590	280	25.5	17.7	PL	SX	93	-	45.7	980	382	22.8	16.9	
PL_gt80	0403-0151-DO1	PL	162	25.1	24.5	382	237	25.4	13.6	PL	AT	151	24.5	39.6	1,103	332	21.6	15.9	
SI_lt10	0403-0033-DO1	AC	78	14.6	21.6	841	100	13.9	10.0	AT	SX	119	15.7	21.1	1,054	59	14.4	-	si dropped no p1 si; si dropped failed si spp match;

Stratum	Cluster ID	Phase II Measured Data								Phase I Interpreted Data (Projected to 2008)									Comment
		SPP1	Age	Height	Basal Area	SPH	Net Vol.	Lorey Height	Site Index	SPP1	SPP2	Age	Height	Basal Area	SPH	Net Vol.	Lorey Height	Site Index	
SI_lt10	0403-0035-DO1	EP	82	14.7	13.0	662	40	6.8	11.2	AT	SW	79	8.8	27.5	1,887	27	7.2	-	si dropped no p1 si; si dropped failed si spp match;
SI_lt10	0403-0053-DO1	SB	163	10.6	13.2	1,427	17	10.8	5.3	SW	-	58	7.6	3.0	850	-	-	9.8	no p1 vol; vol set to zero;
SI_lt10	0403-0056-DO1	SX	124	25.2	49.0	1,101	326	20.9	13.7	SW	PL	212	23.0	40.1	1,388	242	18.0	6.9	
SI_lt10	0403-0061-DO1	PL	84	14.2	18.0	377	119	10.1	10.2	SW	-	169	22.0	25.1	452	143	18.4	-	si dropped no p1 si; si dropped failed si spp match;
SI_lt10	0403-0063-DO1	SX	100	13.5	33.8	838	187	12.4	8.2	SW	-	209	24.7	19.8	444	130	20.7	7.9	
SI_lt10	0403-0064-DO1	SX	89	12.0	21.0	347	138	14.4	10.4	SX	-	129	13.1	5.9	278	16	10.7	6.2	
SI_lt10	0403-0085-DO1	PL	81	16.8	29.3	678	193	17.7	12.9	PL	AT	99	12.7	29.9	835	141	11.2	8.8	
SI_lt10	0403-0087-DO1	PL	84	13.1	8.0	379	34	11.9	10.8	PL	SB	99	13.8	11.5	785	32	11.1	9.6	
SI_lt10	0403-0091-DO1	SB	142	19.1	22.4	750	122	15.9	9.8	PL	SB	134	-	46.3	2,671	167	12.5	8.1	
SI_lt10	0403-0097-DO1	SB	56	4.3	-	-	-	3.0	6.4	SB	PL	57	3.1	25.0	6,000	-	-	4.2	no p1 vol; vol set to zero; lht dropped no vdyp lht;
SI_lt10	0403-0098-DO1	SB	53	5.9	0.5	80	-	5.2	8.0	SB	-	62	4.2	5.0	3,000	-	-	5.0	no p1 vol; vol set to zero; lht dropped no vdyp lht;
SI_lt10	0403-0099-DO1	SB	72	6.6	-	-	-	5.5	6.6	SB	-	58	5.3	3.0	-	-	-	6.6	no p1 vol; vol set to zero; lht dropped no vdyp lht;
SI_lt10	0403-0100-DO1	SB	53	7.3	1.0	147	-	5.0	9.5	SB	-	62	8.3	8.8	1,586	-	6.4	9.0	
SI_lt10	0403-0101-DO1	S	55	7.1	2.0	337	-	4.2	9.3	SB	LT	62	6.2	5.0	1,900	-	-	-	no p1 vol; vol set to zero; lht dropped no vdyp lht; si dropped no p1 si; si dropped failed si spp match;
SI_lt10	0403-0106-DO1	S	89	8.6	2.0	52	7	8.1	6.7	BL	-	129	6.6	2.0	125	-	-	-	no p1 vol; vol set to zero; si dropped no p1 si; si dropped failed si spp match;
SI_lt10	0403-0107-DO1	PL	168	11.3	25.2	1,869	86	8.2	4.9	PL	SB	119	7.9	11.8	2,217	-	7.0	4.7	
SI_lt10	0403-0108-DO1	0	-	-	-	-	-	-	-	SX	AT	159	15.0	1.5	73	5	13.3	-	failed spp match; p2 ba blank - ba set to zero; p2 sph blank - sph set to zero; lht dropped no p2 lht si dropped no p1 si; si dropped failed si spp match;
SI_lt10	0403-0109-DO1	SB	51	6.9	10.1	1,178	11	6.3	8.9	SB	PL	91	8.6	6.8	1,027	3	7.6	6.5	
SI_lt10	0403-0110-DO1	SX	155	9.8	21.3	1,741	51	9.9	3.9	PL	SB	114	9.5	18.1	2,240	14	7.3	-	si dropped no p1 si; si dropped failed si spp match;
SI_lt10	0403-0111-DO1	SB	140	17.1	46.2	2,648	180	12.4	8.8	SB	PL	99	9.9	35.7	2,823	72	9.0	6.8	
SI_lt10	0403-0112-DO1	SB	144	7.9	4.0	516	-	5.9	4.5	SB	LT	163	7.1	12.0	1,300	-	-	3.4	no p1 vol; vol set to zero;
SI_lt10	0403-0113-DO1	SB	223	8.7	9.6	1,041	19	5.0	3.7	SB	LT	93	8.3	21.2	3,966	5	6.9	6.1	
SI_lt10	0403-0115-DO1	SB	148	8.1	3.4	480	-	7.7	3.7	SB	-	93	5.2	5.0	2,500	-	-	4.1	no p1 vol; vol set to zero; lht dropped no vdyp lht;
SI_lt10	0403-0116-DO1	SX	102	17.5	32.4	1,978	123	17.5	10.8	SB	PL	61	-	46.4	3,953	104	11.3	16.3	
SI_lt10	0403-0117-DO1	SB	78	17.5	37.3	3,485	92	11.6	15.1	SB	AT	122	14.2	14.5	1,015	40	12.9	8.1	
SI_lt10	0403-0118-DO1	SB	192	14.4	32.0	2,265	91	12.6	5.0	SB	LT	127	13.7	17.6	2,008	24	10.8	7.5	
SI_lt10	0403-0135-QO1	PL	166	17.3	55.8	2,361	285	16.1	7.5	PL	SW	129	13.5	31.3	2,842	75	11.4	8.0	
SI_lt10	0403-0136-QO1	S	121	13.2	32.4	2,321	101	11.0	6.8	PL	SB	131	15.0	31.8	4,051	33	11.2	-	si dropped no p1 si; si dropped failed si spp match;
SI_lt10	0403-0143-QO1	PL	121	11.2	27.0	1,629	109	14.2	6.1	SW	PL	119	-	16.3	1,905	17	9.2	6.0	
SI_lt10	0403-0146-QO1	S	149	21.3	41.4	1,085	267	19.3	9.2	SW	-	149	19.1	30.9	599	162	16.1	8.0	
SI_lt10	0403-0147-QO1	S	120	16.8	27.0	527	162	17.1	8.6	SX	PL	149	21.1	34.0	1,020	177	16.6	9.0	
SI_lt10	0403-0148-QO1	S	88	11.4	16.3	901	51	10.2	7.4	SX	-	159	17.0	15.6	554	61	13.5	6.4	
SXBL_30to80	0403-0051-DO1	S	41	9.8	18.2	1,873	27	7.0	16.5	SW	PL	65	9.6	3.7	412	3	7.6	10.2	lht dropped no vdyp lht;
SXBL_30to80	0403-0052-DO1	AC	46	17.0	6.0	97	31	18.3	19.2	SW	PL	64	17.3	37.3	711	187	15.5	-	failed spp match; si dropped no p1 si; si dropped failed si spp match;
SXBL_30to80	0403-0066-DO1	SX	67	12.4	19.2	1,380	70	12.1	11.9	SW	AC	79	20.3	23.1	845	122	17.6	16.4	
SXBL_30to80	0403-0128-QO1	SX	123	12.5	25.2	1,242	113	14.1	6.9	SW	PL	66	16.8	14.0	1,250	44	14.5	16.2	
SXBL_30to80	0403-0141-QO1	SX	48	14.7	28.8	2,029	77	13.3	17.8	SW	AT	59	18.2	39.6	1,466	210	16.6	19.5	
SXBL_gt80	0403-0054-DO1	SW	66	23.4	32.2	551	241	21.4	21.3	SX	AT	117	24.1	36.7	827	261	22.2	13.9	
SXBL_gt80	0403-0055-DO1	SX	183	28.9	46.8	1,409	300	22.4	12.3	SX	AC	132	26.3	40.3	891	293	21.9	14.0	
SXBL_gt80	0403-0057-DO1	SX	87	21.2	27.5	227	243	19.2	20.0	SX	AT	113	24.5	12.5	281	95	22.4	14.6	
SXBL_gt80	0403-0058-DO1	SX	154	26.1	48.6	1,628	272	19.3	11.9	SX	AT	88	21.7	30.2	853	185	19.0	16.0	
SXBL_gt80	0403-0059-DO1	SW	93	24.3	37.8	682	278	22.4	16.8	SW	AT	94	17.8	6.8	490	27	16.3	12.1	
SXBL_gt80	0403-0060-DO1	PL	103	22.4	29.4	856	197	23.2	15.4	SW	-	129	24.2	35.8	765	246	19.9	-	si dropped no p1 si; si dropped failed si spp match;
SXBL_gt80	0403-0062-DO1	SW	188	27.3	36.0	573	274	24.1	12.0	SW	AC	169	30.8	39.7	627	350	25.8	14.6	
SXBL_gt80	0403-0065-DO1	SX	86	15.2	21.6	357	139	13.9	11.0	SW	PL	94	15.4	18.1	1,005	67	13.1	10.3	
SXBL_gt80	0403-0067-QO1	SW	147	33.6	52.8	647	416	34.3	18.7	SW	-	151	33.1	49.6	426	478	28.8	18.1	
SXBL_gt80	0403-0068-QO1	SW	147	25.1	30.6	884	185	19.0	12.5	SW	AC	96	25.3	38.5	619	281	22.0	17.6	
SXBL_gt80	0403-0069-DO1	SX	77	23.7	31.3	643	209	23.8	19.2	SW	-	122	28.3	8.1	150	74	25.5	16.6	
SXBL_gt80	0403-0070-DO1	AC	41	16.3	2.6	80	11	14.0	20.6	SX	AC	101	-	31.1	491	296	28.5	23.7	
SXBL_gt80	0403-0129-QO1	S	135	26.8	46.8	1,713	250	23.2	13.9	SX	SB	117	22.1	62.8	1,651	345	17.4	12.4	
SXBL_gt80	0403-0130-QO1	AT	78	17.9	36.0	2,368	156	14.9	12.9	SX	AT	136	-	37.1	609	301	25.5	18.1	
SXBL_gt80	0403-0131-QO1	S	194	31.0	40.8	839	311	34.5	13.7	SW	AT	123	30.4	52.3	779	459	26.0	18.4	
SXBL_gt80	0403-0142-QO1	SX	115	28.0	16.2	389	128	25.9	16.7	SX	AT	127	26.9	35.9	619	291	24.5	15.0	
SXBL_gt80	0403-0144-QO1	S	96	15.8	35.0	575	217	12.0	10.0	SW	PL	94	16.6	31.7	1,232	133	13.7	11.3	
SXBL_gt80	0403-0145-QO1	SW	95	20.1	37.8	801	230	15.7	13.4	SW	AT	94	18.8	23.7	784	120	16.4	12.7	
drop not VT	0403-0071-DO1	AT	61	12.9	10.0	980	18	10.8		PL		53.9	11.9	8.0	1,174	-	9.8		Not VT;

APPENDIX II – PHOTO VS. GROUND PLOTS

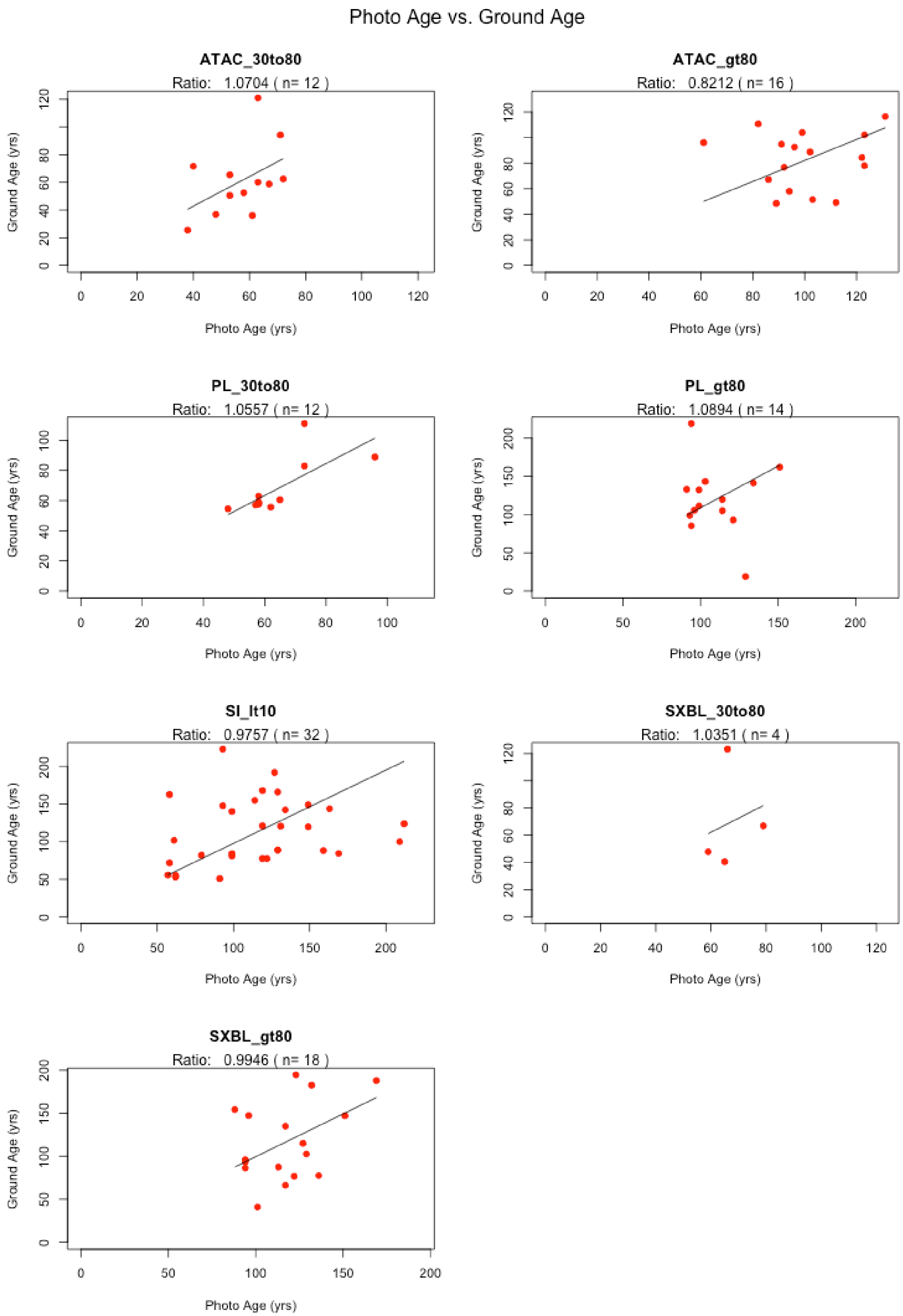

Figure 3: Ground Age vs. Photo Age

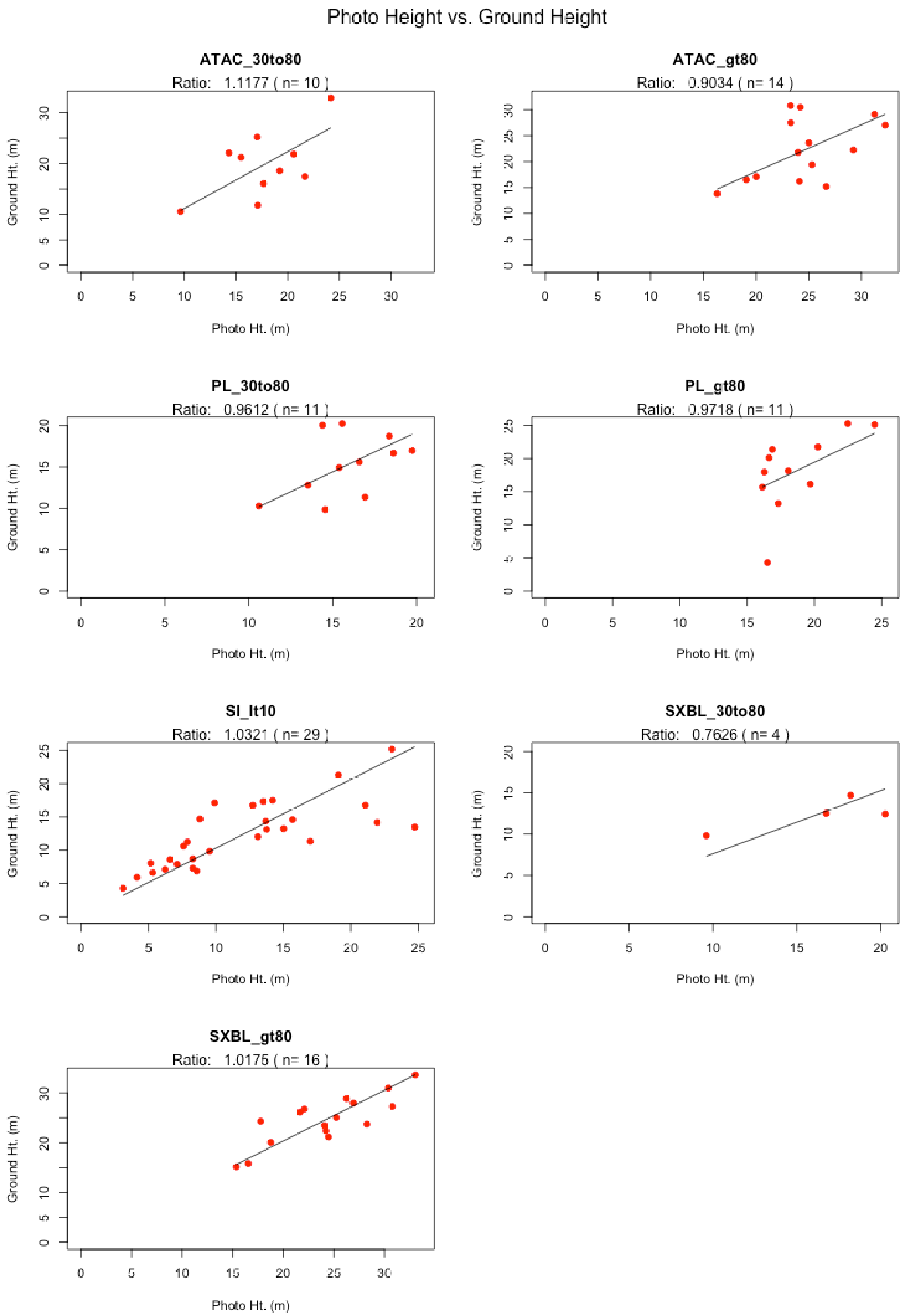

Figure 4: Ground Height vs. Photo Height

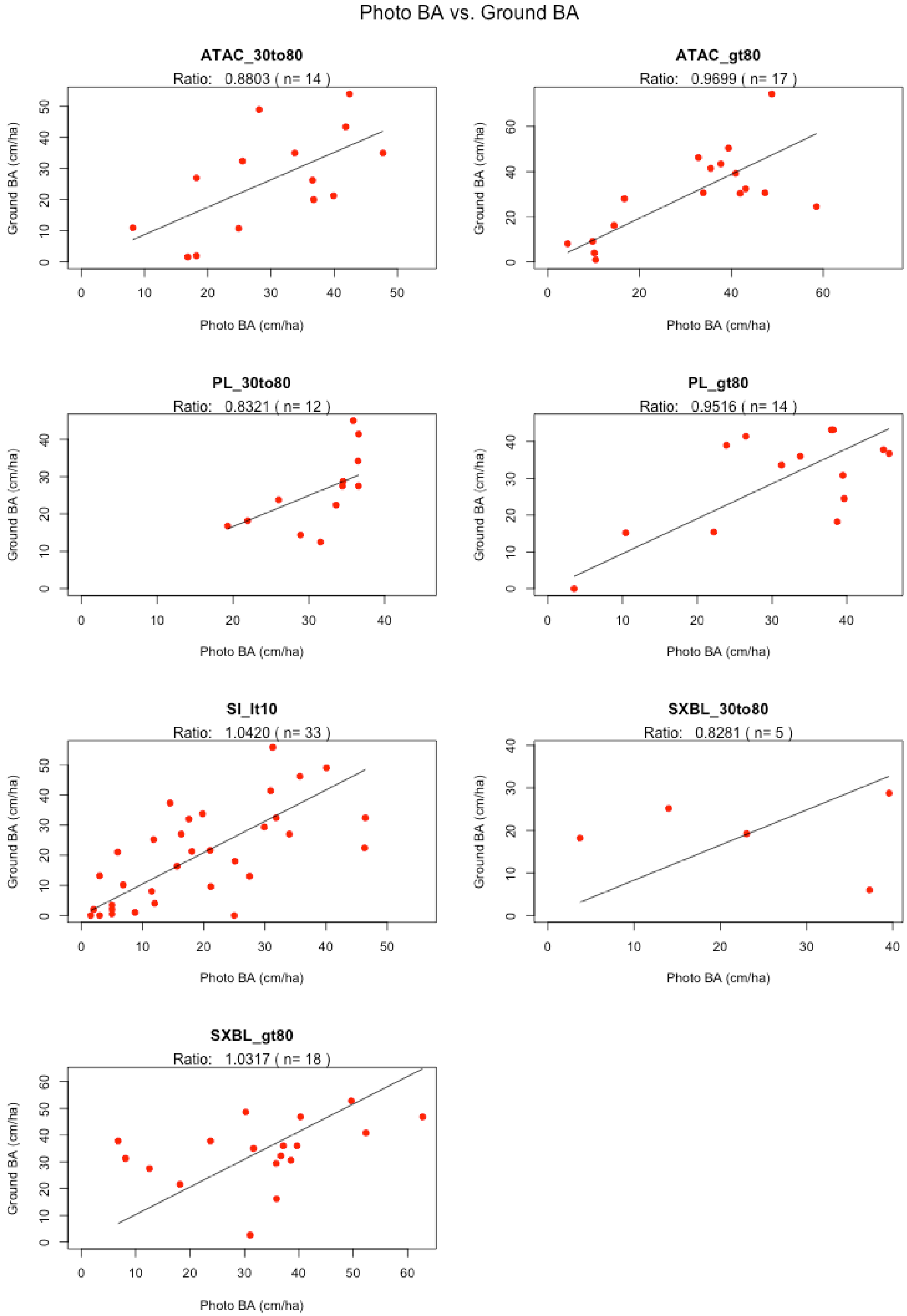

Figure 5: Ground BA vs. Photo BA

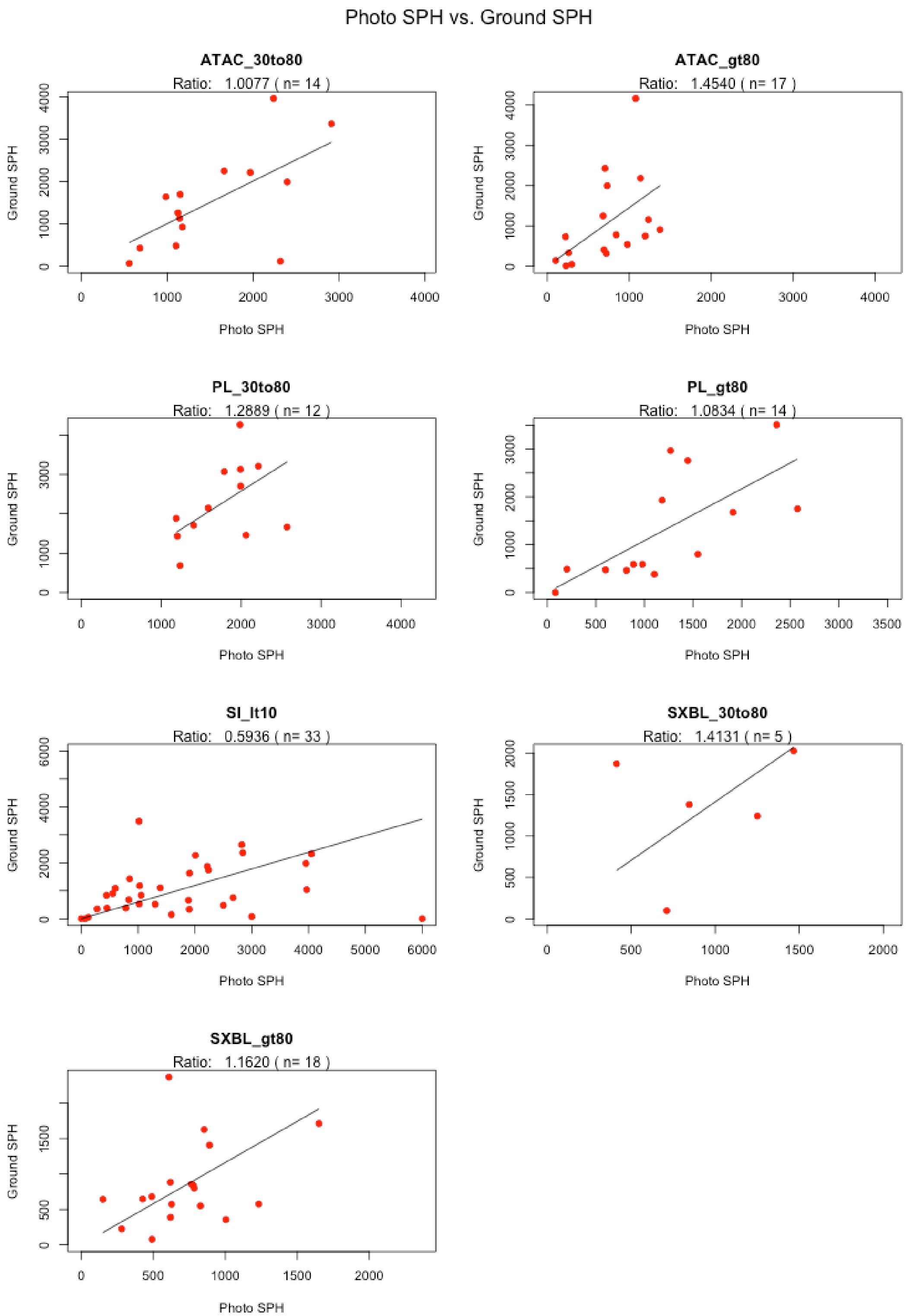

Figure 6: Ground Stems per Hectare vs. Photo Stems per Hectare

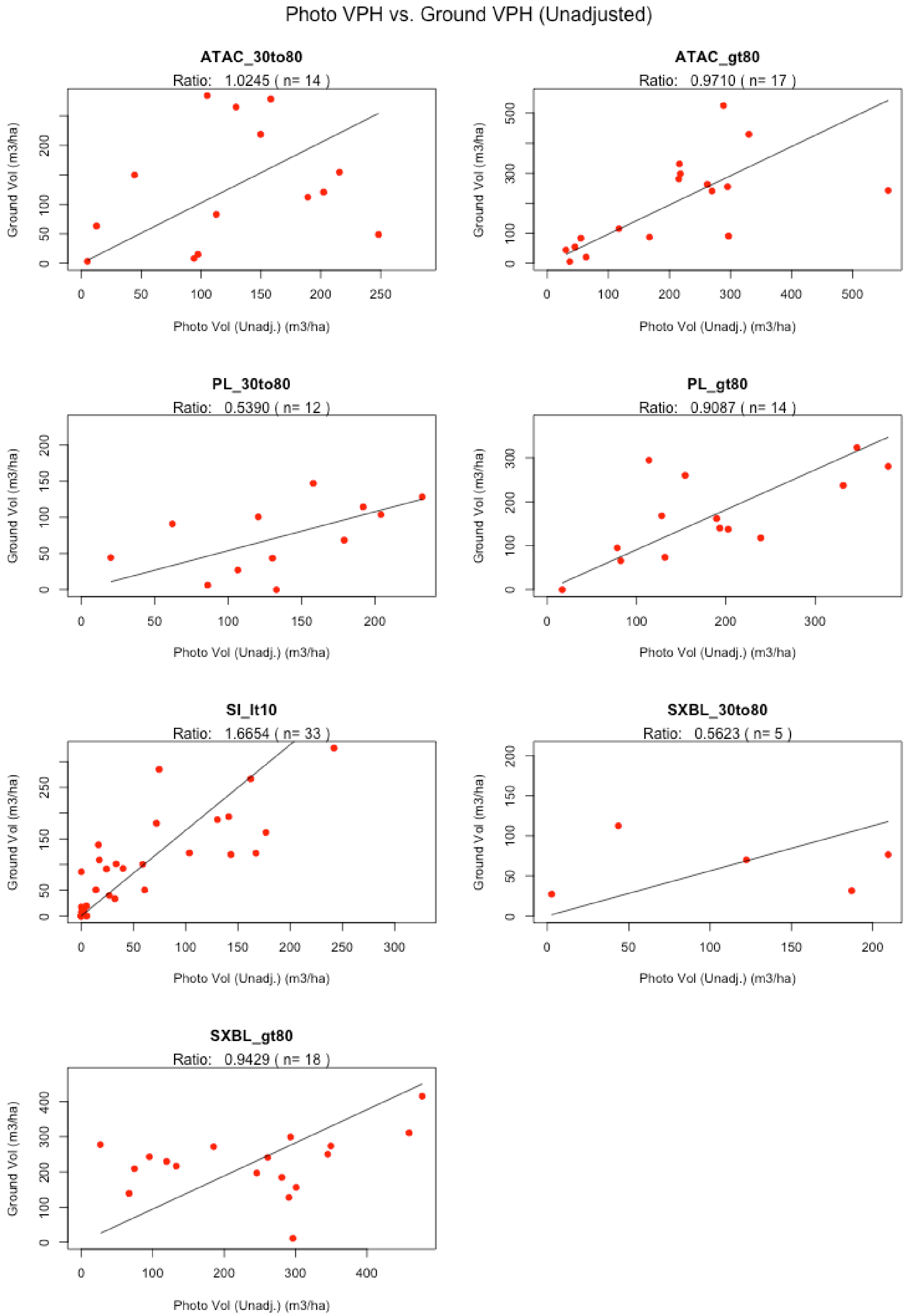

Figure 7: Ground Net Volume vs. Unadjusted Photo (VDYP 7) Volume

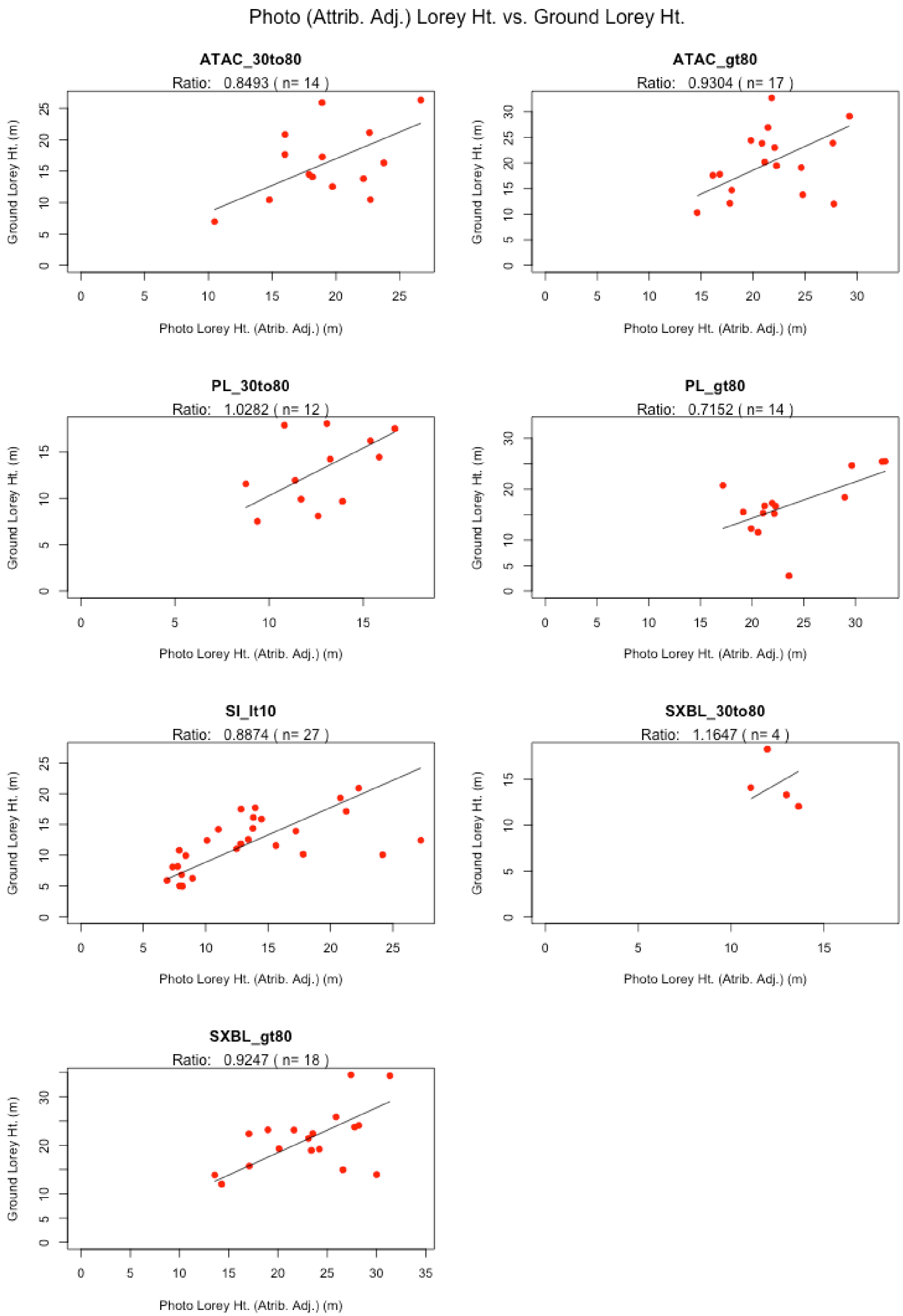

Figure 8: Ground Lorey Height vs. Photo (VDYP 7) Lorey Height Using Adjusted Attributes

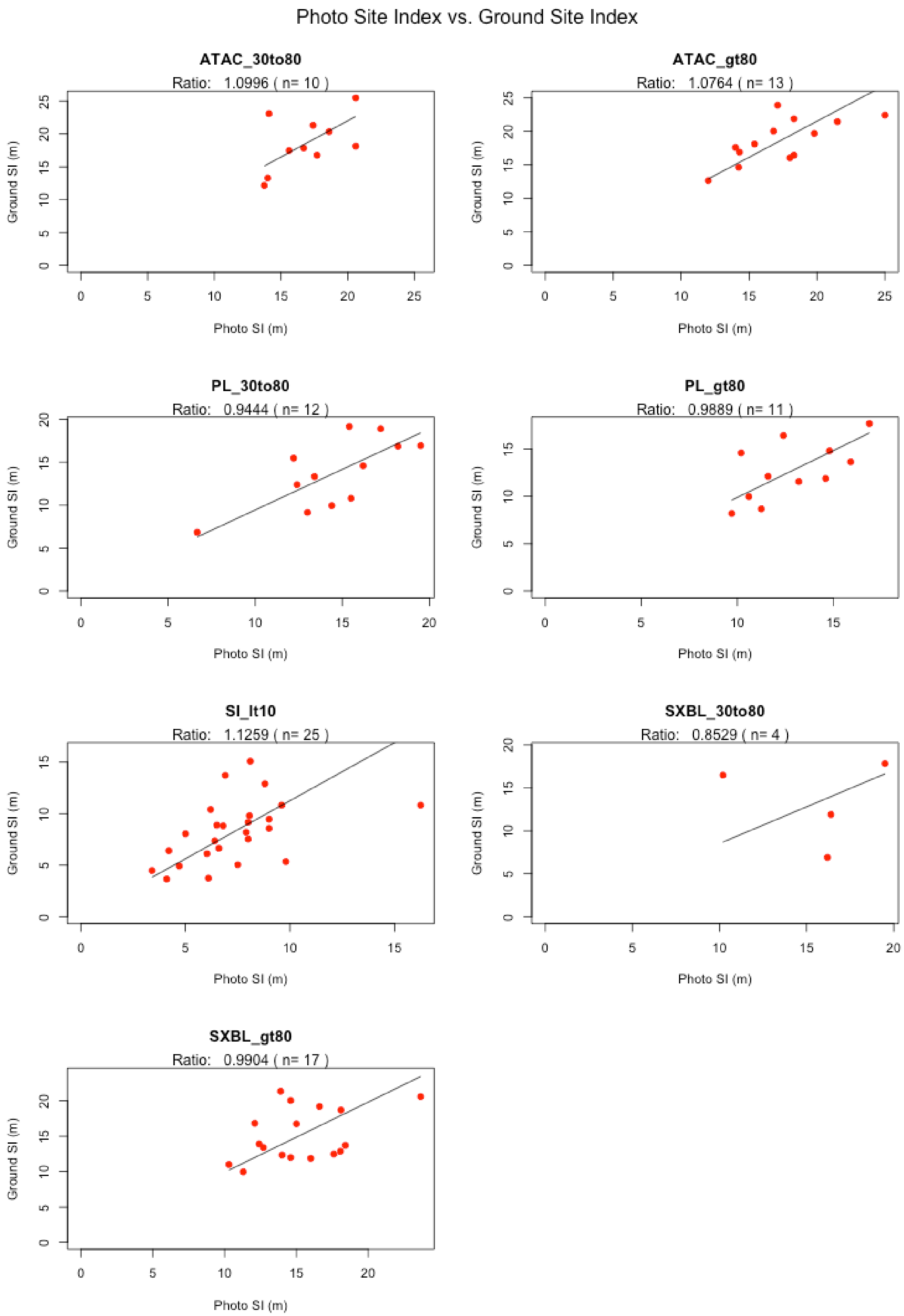

Figure 9: Ground Site Index vs. Photo (VDYP 7) Site Index

APPENDIX III – PLOT RATIOS AND POTENTIAL OUTLIERS

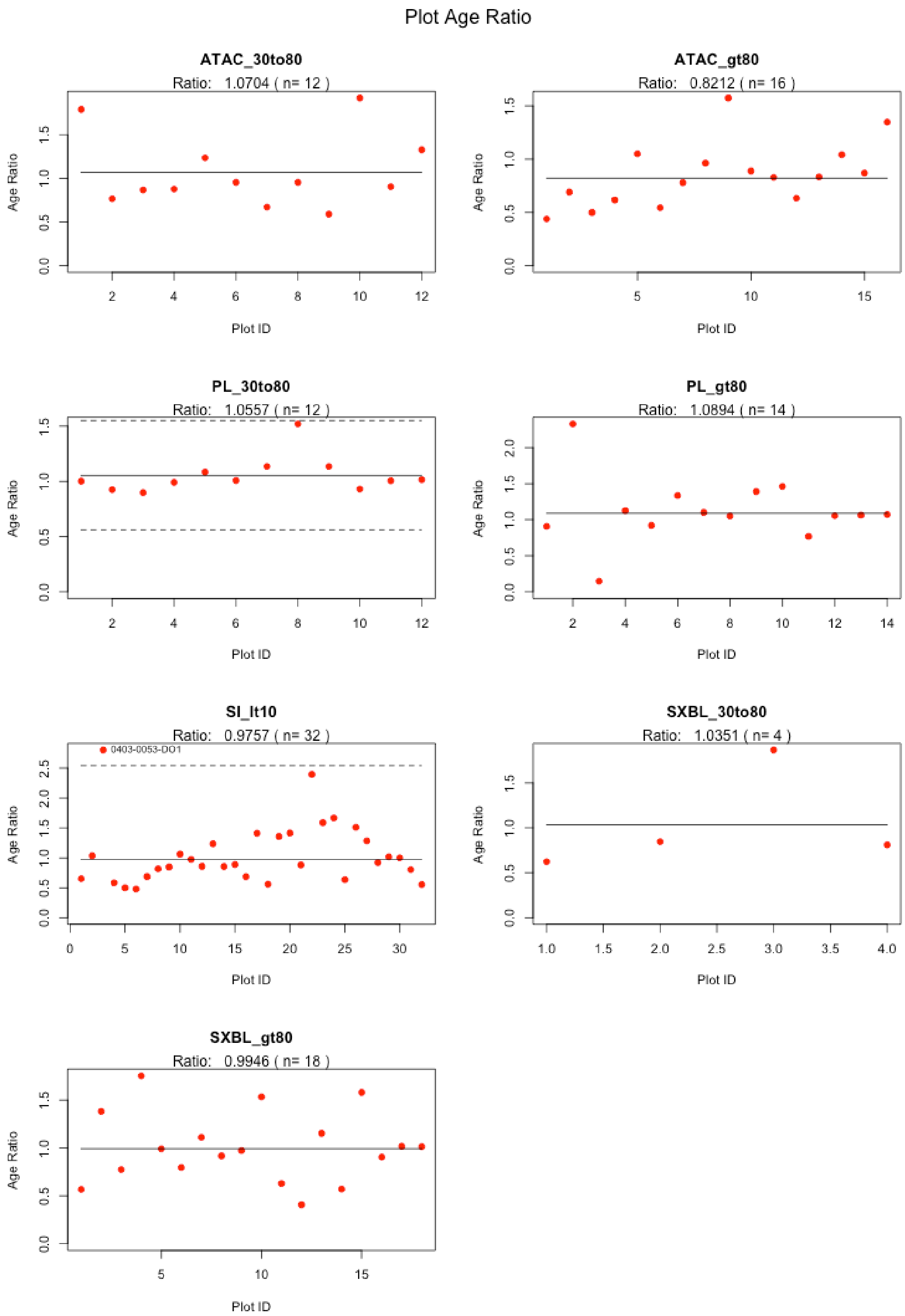

Figure 10: Age Ratios.

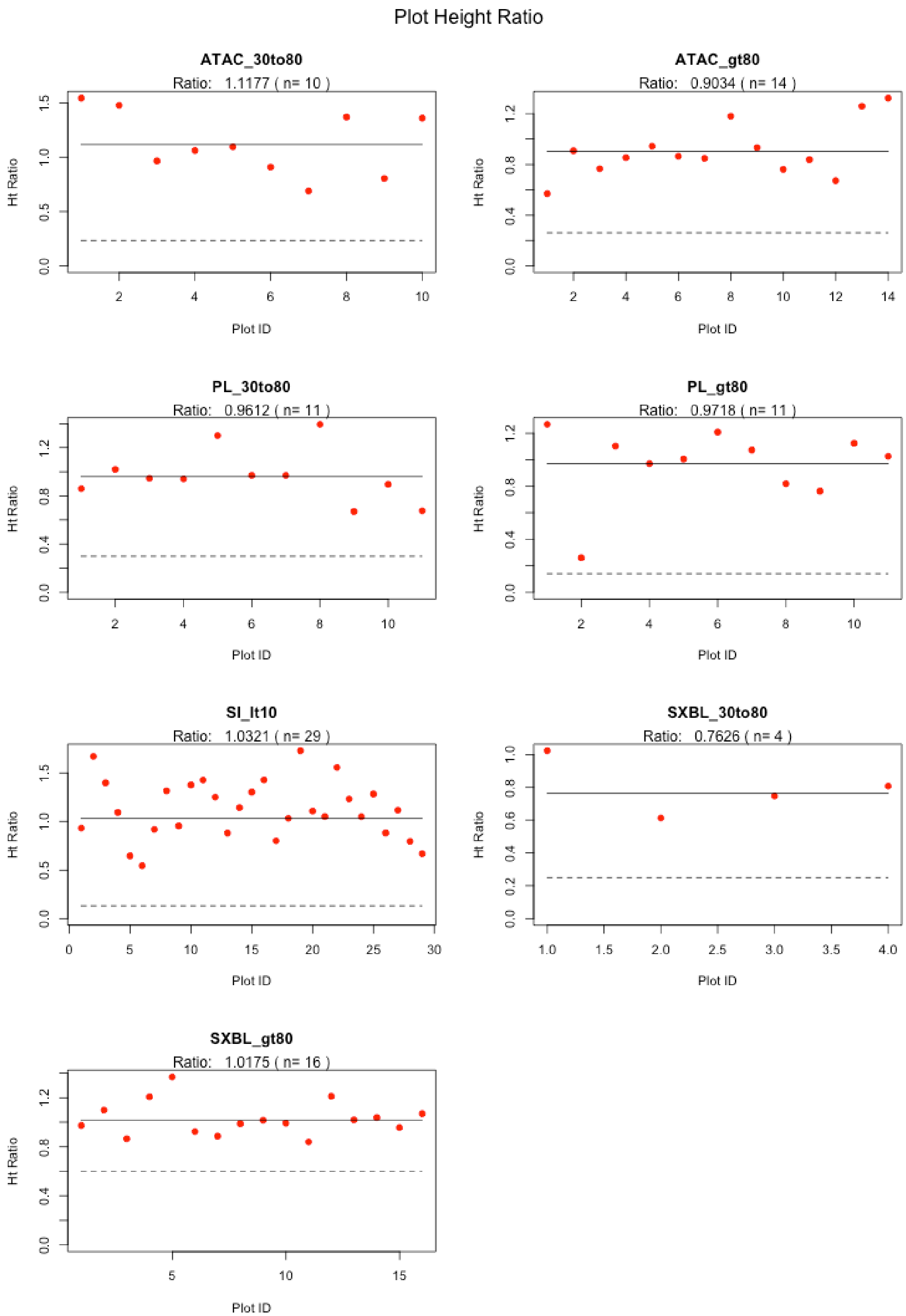

Figure 11: Height Ratios.

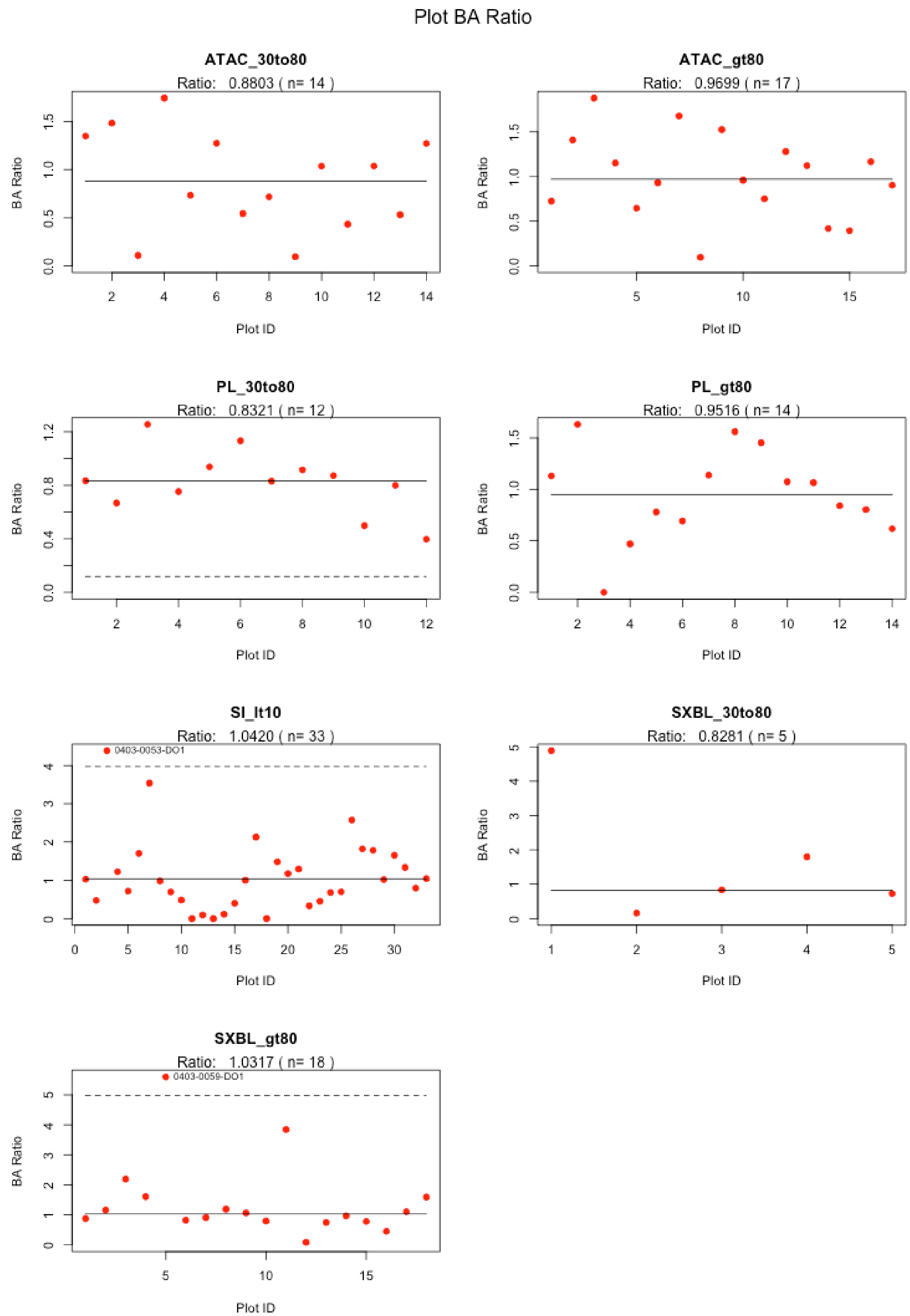

Figure 12: BA Ratios.

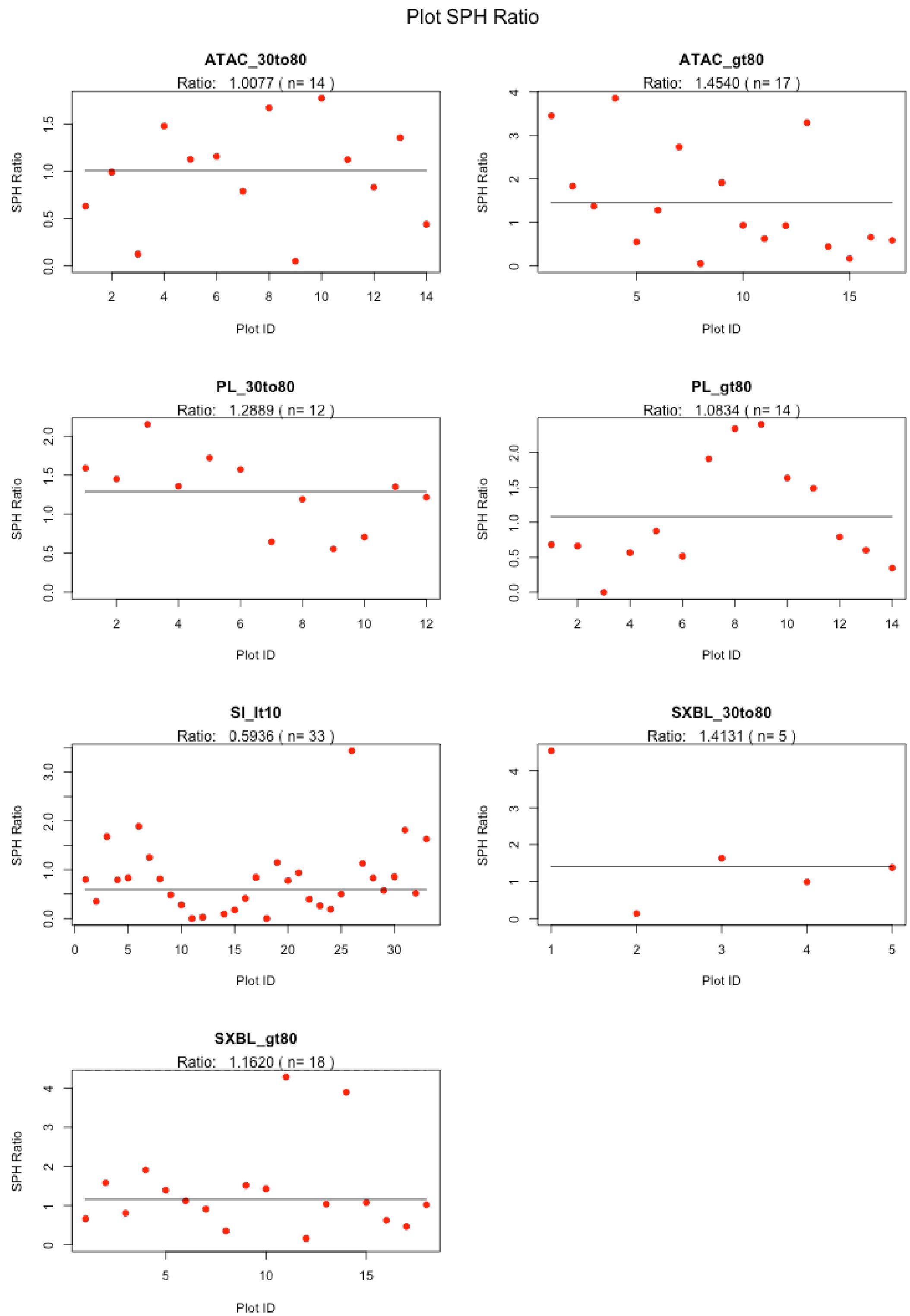

Figure 13: Stems per Hectare Ratios.

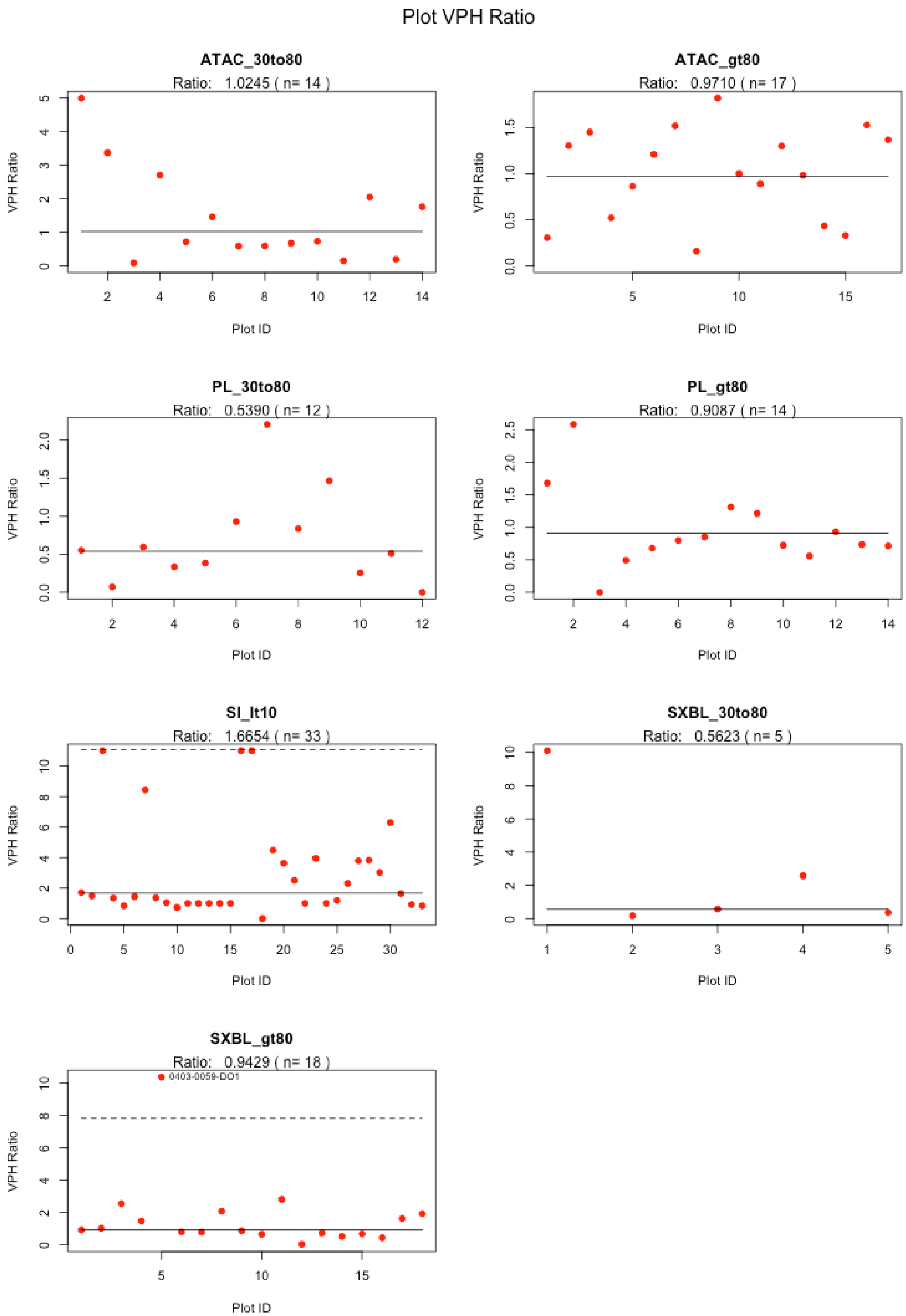

Figure 14: Unadjusted Volume Ratios.

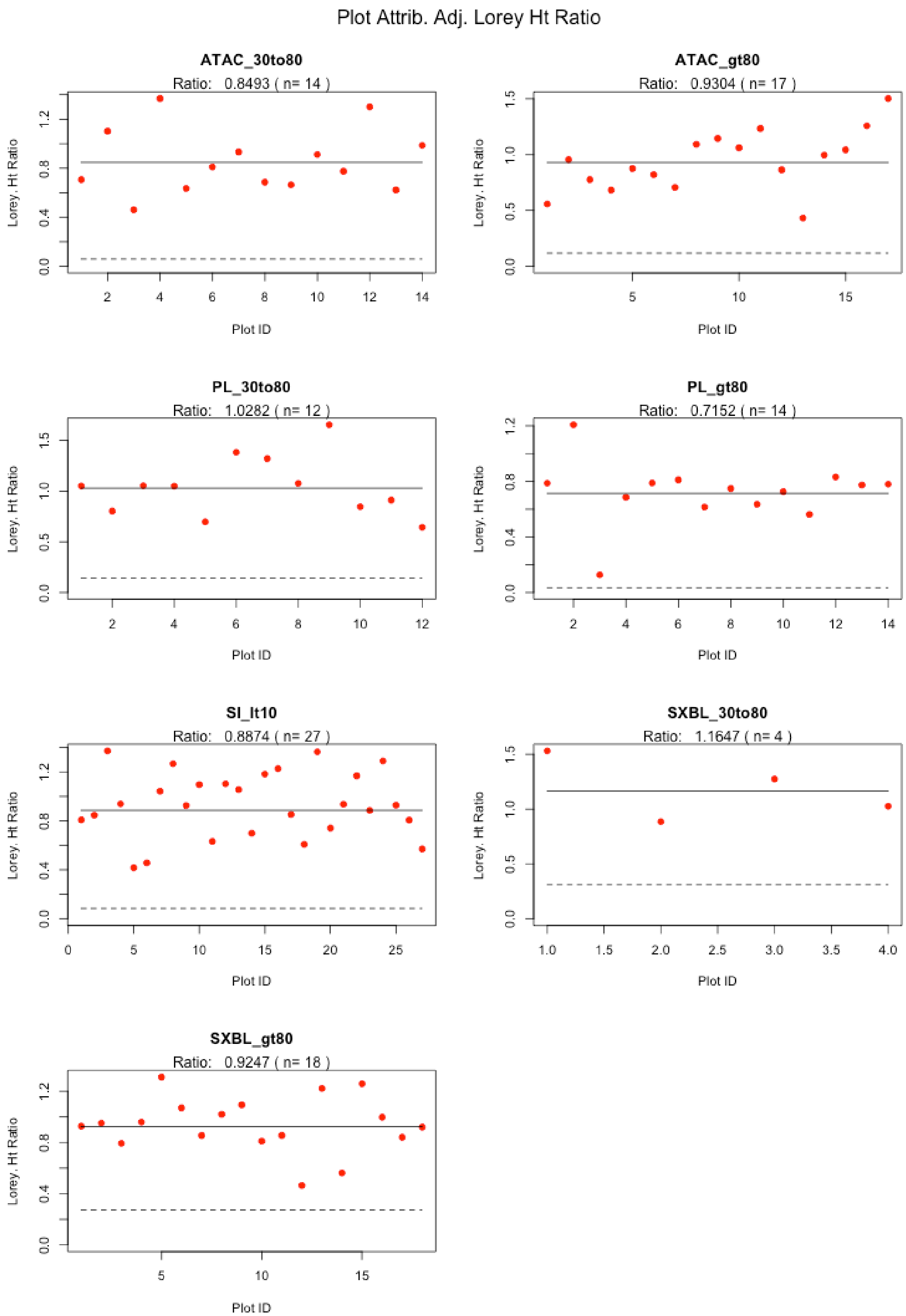

Figure 15: Lorey Height Ratios.

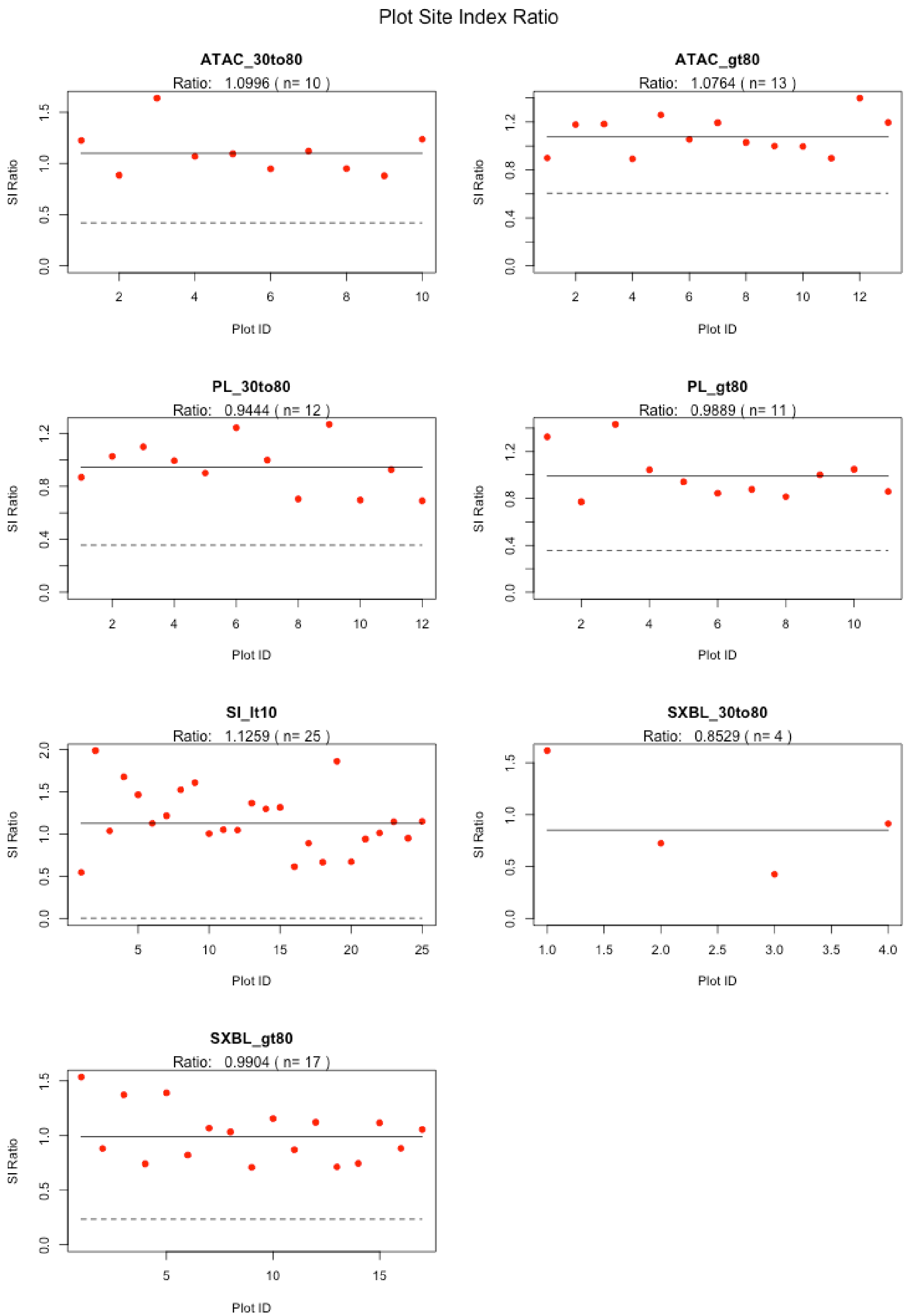

Figure 16: Site Index Ratios.

APPENDIX IV – RESIDUAL VALUES

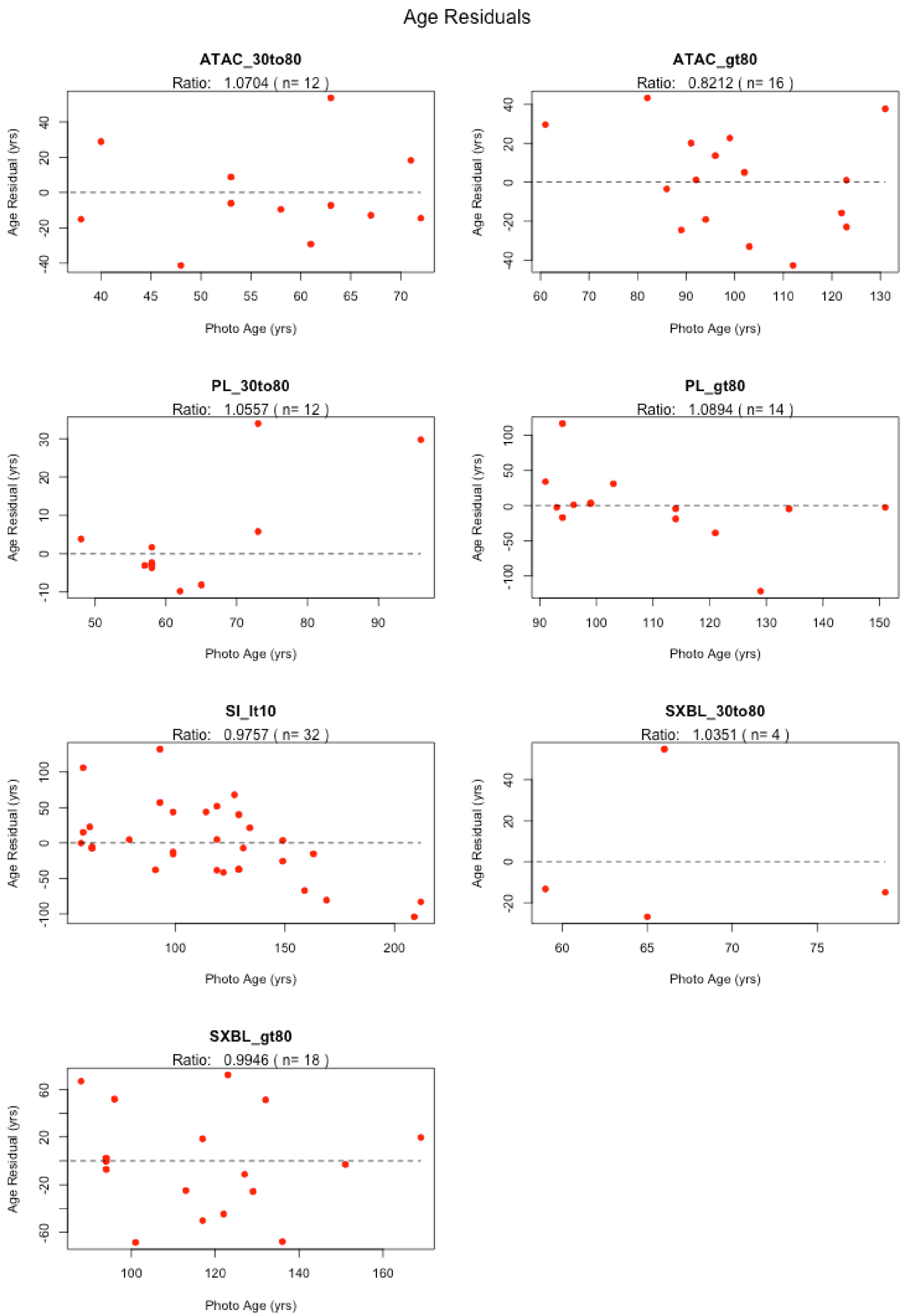

Figure 17: Age Residuals.

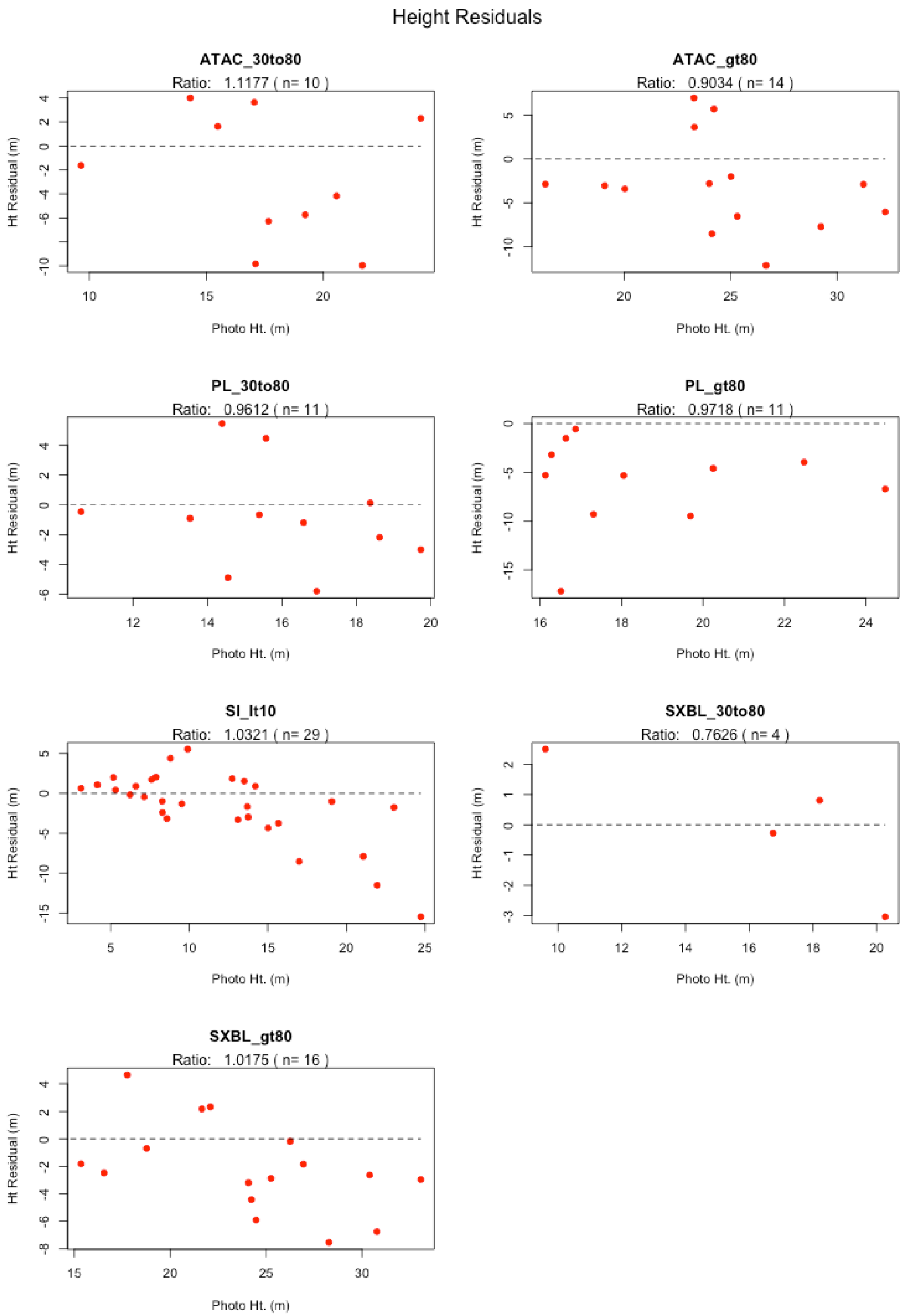

Figure 18: Height Residuals.

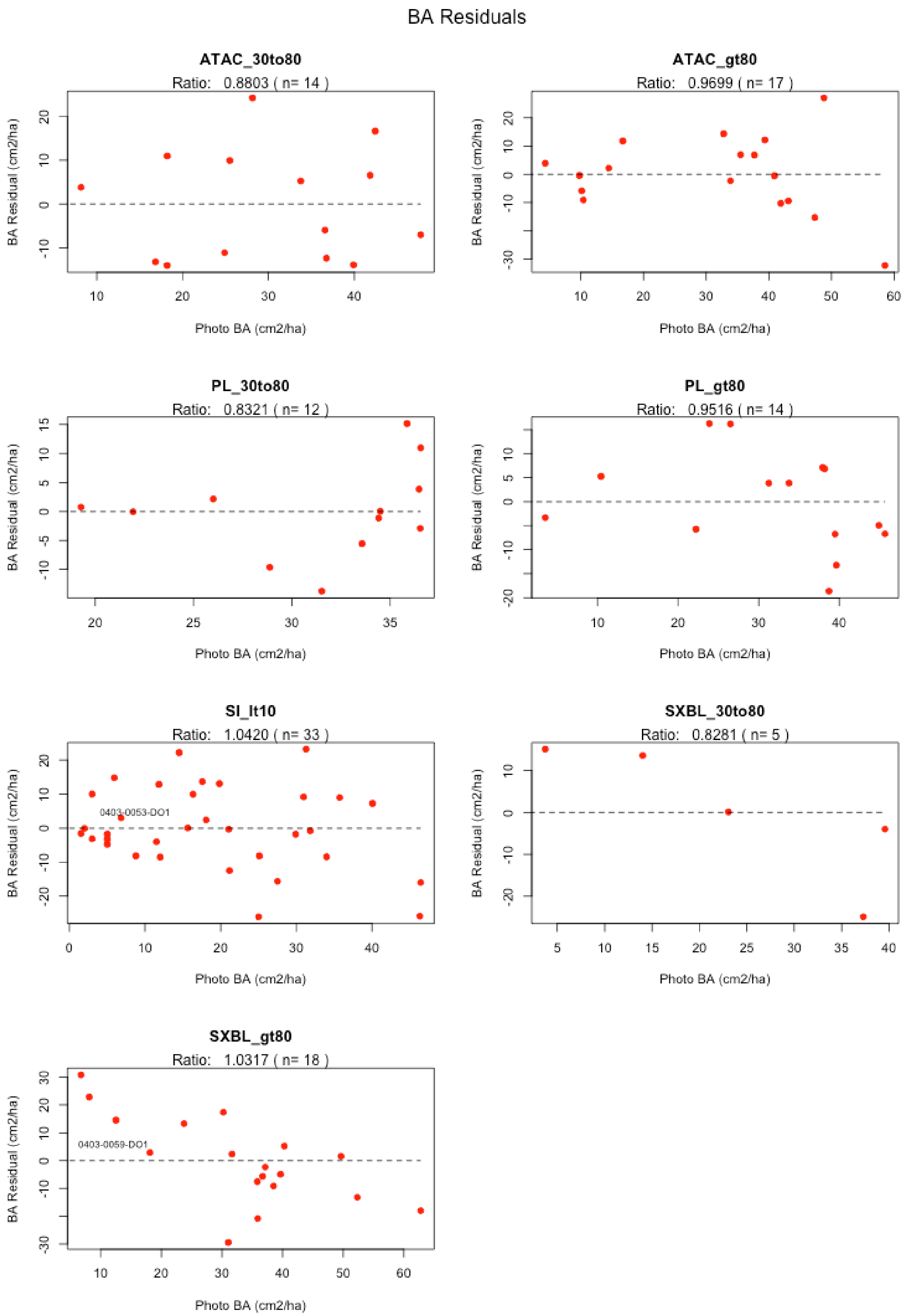

Figure 19: BA Residuals.

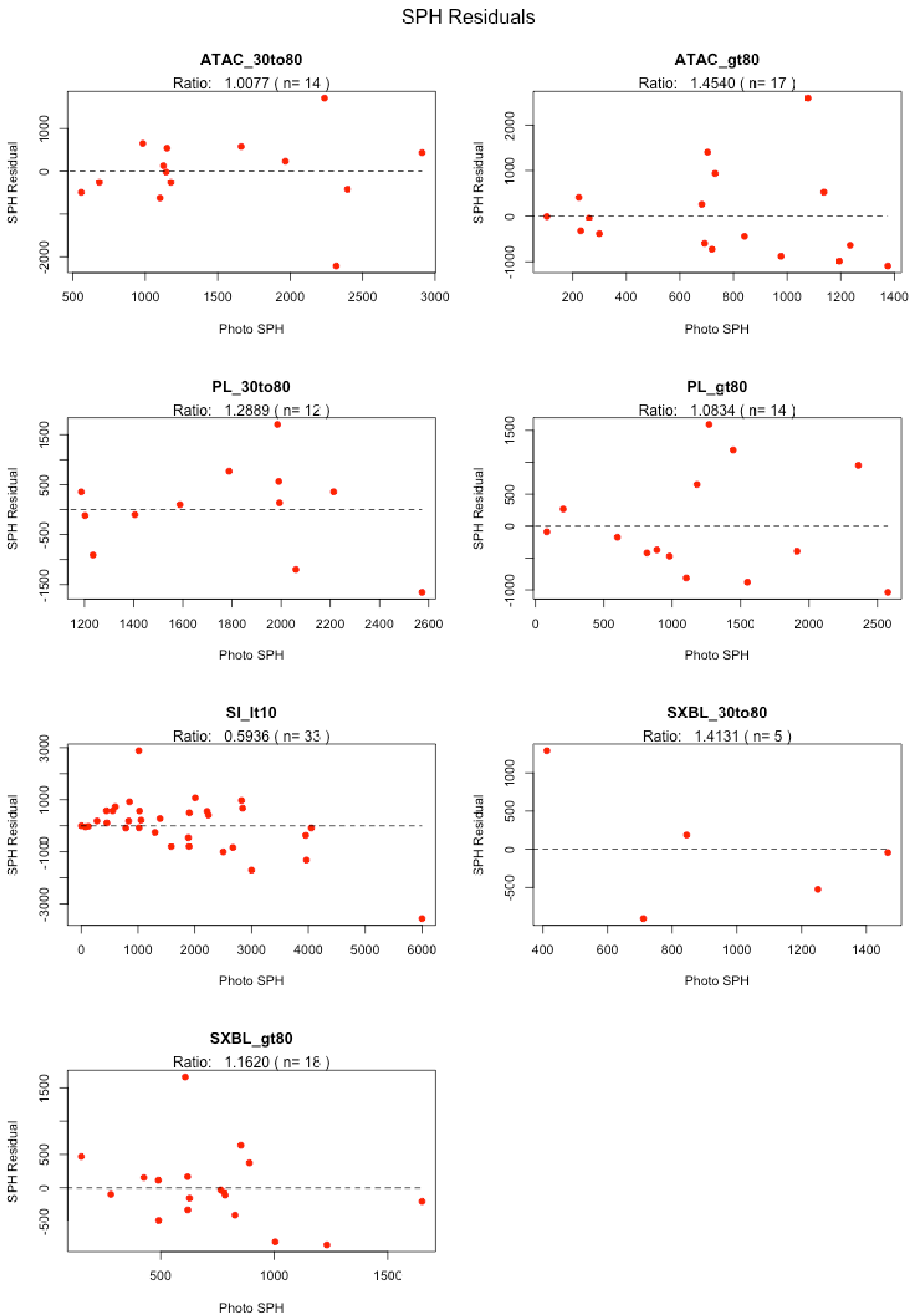

Figure 20: Stems per Hectare Residuals.

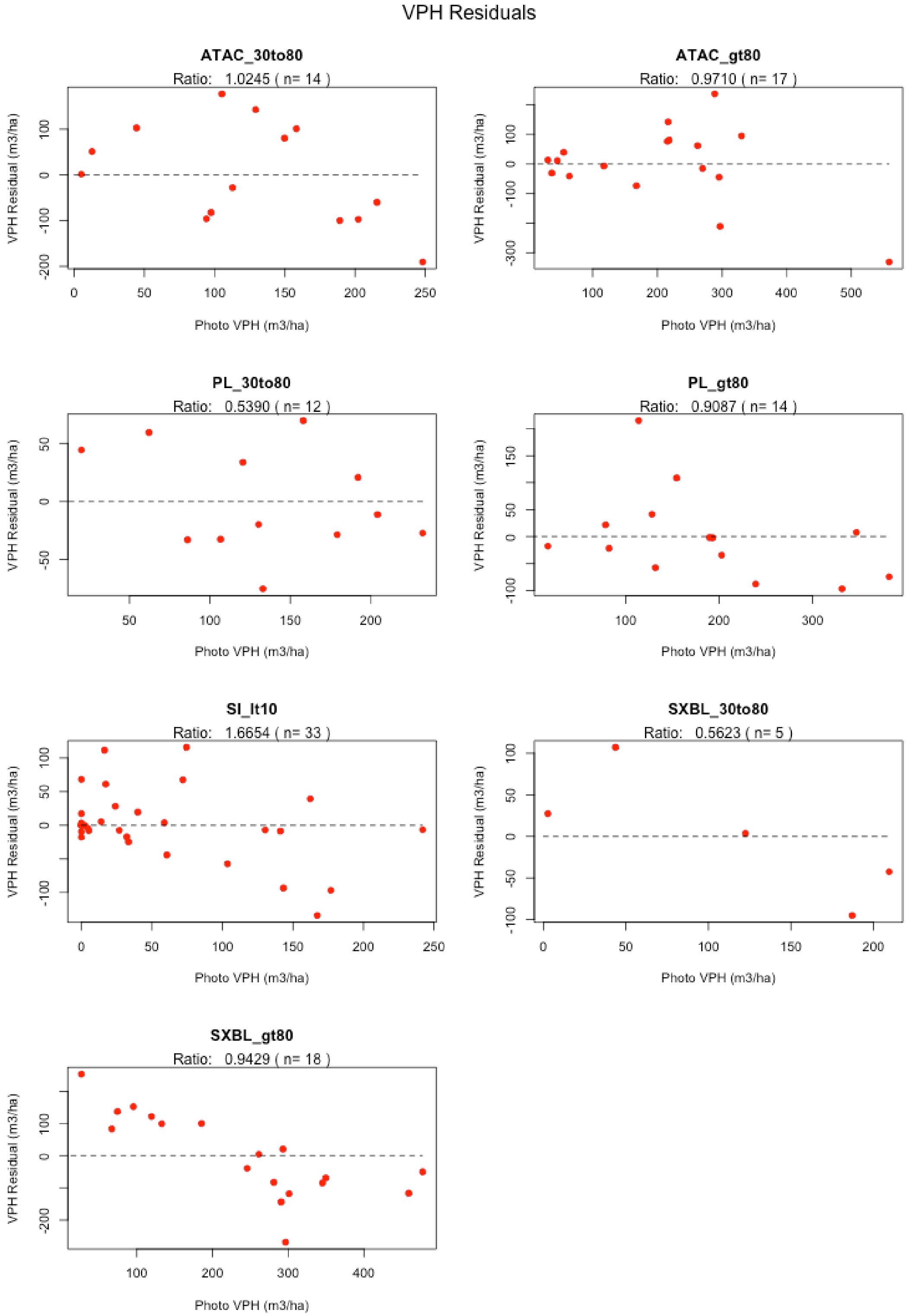

Figure 21: Unadjusted Volume Residuals.

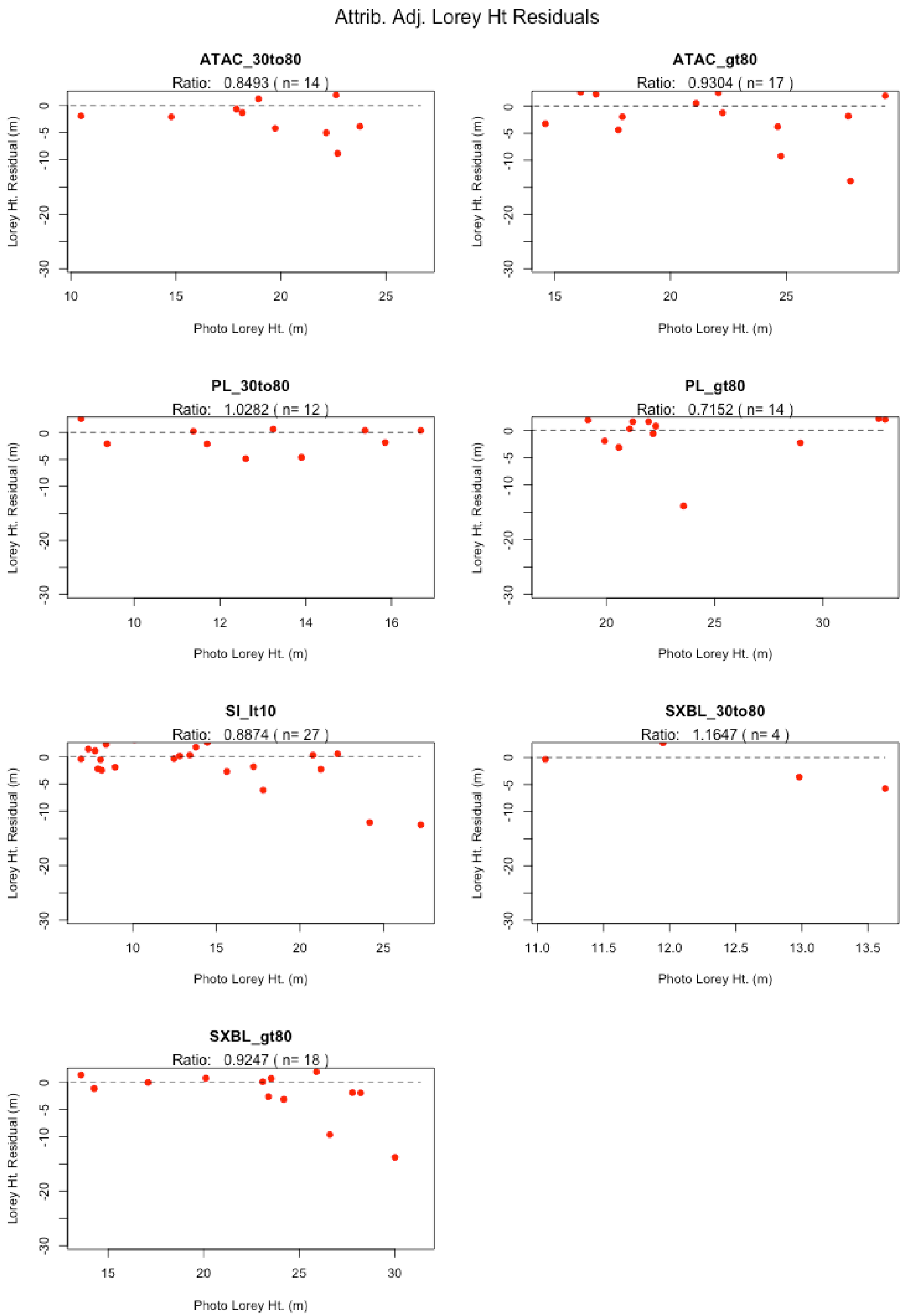

Figure 22: Lorey Height Residuals.

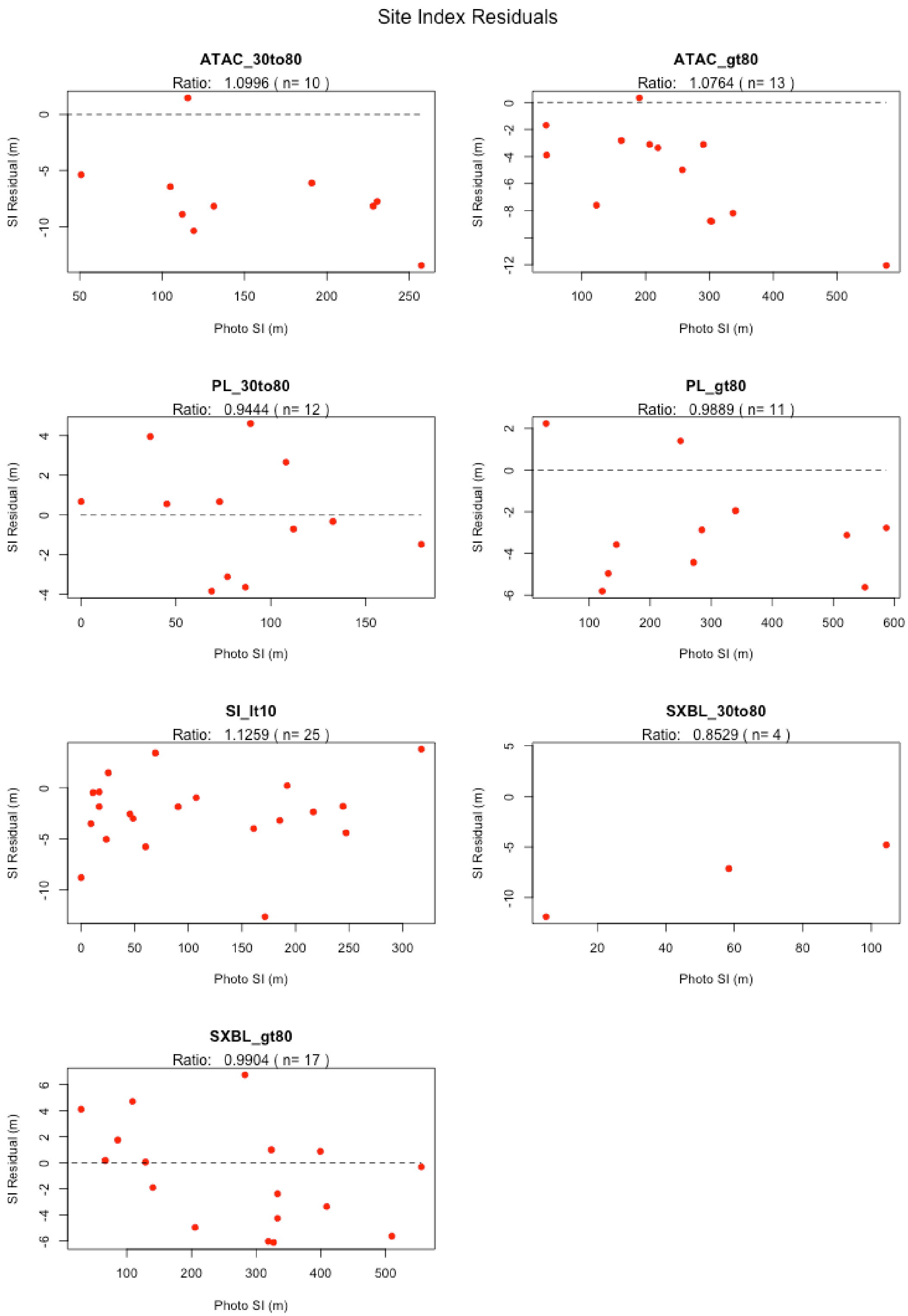

Figure 23: Site Index Residuals.

APPENDIX V – MODEL BIAS VOLUME PLOTS

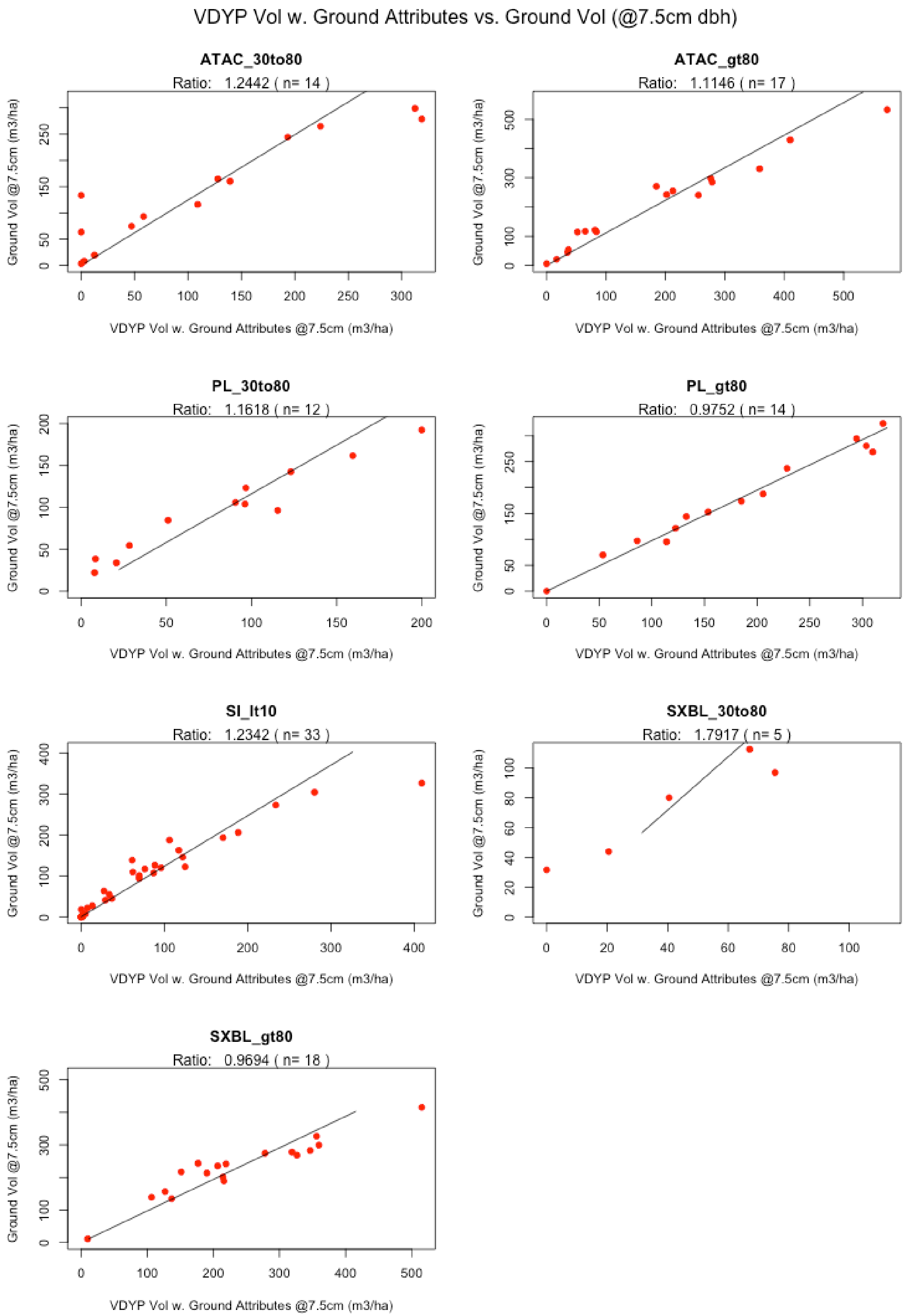

Figure 24: VDYP Volume Using Ground Attributes versus Ground Volume (@7.5cm dbh)

APPENDIX VI – SITE INDEX ANALYSIS PROCEDURES

Supplemental procedures and input data were provided for the analysis of site index as described below:

1. A *trees_h* file was provided that contains the site index measurements for each tree in each Phase II plot cluster.

2. Leading species was determined for each Phase II plot cluster using the first species from the spb_cpct field in the 4.0+ cm utilization table.

3. An average site index was calculated for each Phase II plot using the trees matching the plot clusters leading species where *treetype* in ('T','L','X','O') and *si_tree* IS NOT NULL and *si_tree* > 0.

4. Site index for the leading species was taken from the Phase I VRI. SiteTools was used to calculate a site index for the second species using the species 2 age, height and species.

5. The Phase II site index for each plot was matched to the Phase I species 1 site index if the leading species were the same. If the Phase II leading species was the same as the Phase I species 2 then the Phase II site index was matched with the Phase I species 2 site index. If neither matched then the plot and polygon were both dropped from the site index analysis. In all matching, 'S', 'SX', and 'SW' were considered to be matches as were 'PL' and 'PLI'.

6. ROM and sampling error calculations were carried out as described in the procedures and in Section above.

APPENDIX VII – ANALYSIS OF INVENTORY SPECIES

Table 9 presents an assessment of the accuracy of the Phase I leading species with correct values highlighted in green. Overall, if SW / SX / S values are considered matches then leading species is correct 71% of the time.

Table 10 shows the percent distribution of Phase I species composition while Table 11 shows the percent distribution of Phase II species composition.

Table 9: Leading Species Comparison

Phase II Leading Species	Phase I Leading Species						Total	% Correct
	AT	BL	PL	SB	SW	SX		
AC	2				1	1	4	0%
AT	21					1	22	95%
EP	4						4	0%
PL	1		23		3		27	85%
S	1	1	2	1	4	3	12	58%
SB			4	11	1		16	69%
SW			1		5	1	7	86%
SX	4		3	1	7	5	20	60%
(blank)						1	1	0%
Total	**33**	**1**	**33**	**13**	**21**	**12**	**113**	71%

Table 10: Leading Species Comparison – Percent Distribution of Phase I Species (Column)

Phase II Leading Species	Phase I Leading Species						Total	Total %
	AT	BL	PL	SB	SW	SX		
AC	50%	0%	0%	0%	25%	25%	4	100%
AT	95%	0%	0%	0%	0%	5%	22	100%
EP	100%	0%	0%	0%	0%	0%	4	100%
PL	4%	0%	85%	0%	11%	0%	27	100%
S	8%	8%	17%	8%	33%	25%	12	100%
SB	0%	0%	25%	69%	6%	0%	16	100%
SW	0%	0%	14%	0%	71%	14%	7	100%
SX	20%	0%	15%	5%	35%	25%	20	100%
(blank)	0%	0%	0%	0%	0%	100%	1	100%
Total	**33**	**1**	**33**	**13**	**21**	**12**	**113**	
Total %	**29%**	**1%**	**29%**	**12%**	**19%**	**11%**		**100%**

Table 11: Leading Species Comparison – Percent Distribution of Phase II Species (Row)

Phase II Leading Species	Phase I Leading Species						Total	Total %
	AT	BL	PL	SB	SW	SX		
AC	6%	0%	0%	0%	5%	8%	4	4%
AT	64%	0%	0%	0%	0%	8%	22	19%
EP	12%	0%	0%	0%	0%	0%	4	4%
PL	3%	0%	70%	0%	14%	0%	27	24%
S	3%	100%	6%	8%	19%	25%	12	11%
SB	0%	0%	12%	85%	5%	0%	16	14%
SW	0%	0%	3%	0%	24%	8%	7	6%
SX	12%	0%	9%	8%	33%	42%	20	18%
(blank)	0%	0%	0%	0%	0%	8%	1	1%
Total	**33**	**1**	**33**	**13**	**21**	**12**	**113**	
Total %	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**		**100%**

APPENDIX VIII – SAMPLE SELECTION DOCUMENTS

FORT ST. JOHN TIMBER SUPPLY AREA VEGETATION RESOURCES INVENTORY PHASE II PROJECT IMPLEMENTATION PLAN

VERSION 2.1

Prepared for
John Rowe, RPF
Canadian Forest Products Ltd.
Fort St. John, BC

On Behalf Of
Forest Licencees in the
Fort St. John Timber Supply Area

Prepared by
Hugh Carter, MSc, RFT
Timberline Natural Resource Group Ltd.

Project: BC0108245

March, 2009

FORT ST. JOHN TIMBER SUPPLY AREA
VEGETATION RESOURCES INVENTORY
PHASE II POST-PROJECT DOCUMENTATION & DELIVERABLES

Prepared for:
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Project: BC0108245

March 2010